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Navigating the Ethical Crossroads in the use of Artificial Intelligence in Medicine

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Navigating the Ethical Crossroads:
Bridging the gap between Predictive Power and Explanation
in the use of Artificial Intelligence in Medicine

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ARCTT is a peer-reviewed all-purpose journal covering a wide variety of topics of interest to the mental health, neuroscience, and rehabilitation communities. The mission of ARCTT is to provide systematic, periodic examinations of scholarly advances in the field of CyberTherapy and Telemedicine through original investigations in the Telemedicine and CyberTherapy areas, novel experimental clinical studies, and critical authoritative reviews. It is directed to healthcare providers and researchers who are interested in the applications of advanced media for improving the delivery and efficacy of mental healthcare and rehabilitative services.

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Brenda K. Wiederhold *Giuseppe Riva*

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Our publication pays careful attention to the protection of a patient's anonymity in case reports and elsewhere.

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Preface

ARCTT is a peer-reviewed all-purpose journal covering a wide variety of topics of interest to the mental health, neuroscience, and rehabilitation communities. This mission of ARCTT is to provide systematic, periodic examinations of scholarly advances in the field of Cybertherapy and Telemedicine through original investigations in the telemedicine and cybertherapy areas, novel experimental clinical studies, and critical authoritative reviews.

Healthcare delivery systems have been evolving to rely more heavily on technology. There has been a shift in care diagnosis and treatment which has decreased the im-portance of traditional methods of care delivery. Technology has not only helped to extend our lifespan, but it has improved the quality of life for all citizens.

We have put a great deal of effort into the definition of the structure of the volume and in the sequence of the contributions, so that those in search of a specific reading path will be rewarded. To this end, we have divided the different chapters into six main sections:

1. **Editorial**: This introductory text expresses the position of the Editors – Brenda K. Wiederhold Giuseppe Riva - about the focus of this year's issue;
2. **Critical Reviews**: These chapters summarize and evaluate emerging cybertherapy topics, including technology, enhanced rehabilitation, Interreality, and Intersubjectivity;
3. **Evaluation Studies**: These chapters are generally undertaken to solve some specific practical problems and yield decisions about the value of cybertherapy interventions;
4. **Original Research**: These chapters research studies addressing new cybertherapy methods or approaches;
5. **Clinical Observations**: These chapters include case studies or research protocols with long-term potential.
6. **Work in Progress**: These chapters include papers describing a future research work.

For both health professionals and patients, the selected contents will play an important role in ensuring that the necessary skills and familiarity with the tools are available, as well as a fair understanding of the context of interaction in which they operate.

In conclusion, this volume underlines how cybertherapy has started to make progress in treating a variety of disorders. However, there is more work to be done in a number of areas, including the development of easy-to-use and more affordable hard-ware and software, the development of objective measurement tools, the need to ad-dress potential side effects, and the implementation of more controlled studies to evaluate the strength of cybertherapy in comparison to traditional therapies.

We are grateful to Giulia Brizzi, Fabio Frisoni and Chiara Rossi for their work in collecting and coordinating chapters for this volume.

We sincerely hope that you will find this year's volume to be a fascinating and intellectually stimulating read. We continue to believe that together we can change the face of healthcare.

Brenda K. Wiederhold
Giuseppe Riva

Contents

SECTION I

EDITORIAL

This introductory text expresses the position of the Editors – Brenda K. Wiederhold and Giuseppe Riva - the focus of this year's issue.

Brenda K. Wiederhold and Giuseppe Riva

Navigating the Ethical Crossroads: Bridging the gap between Predictive Power and Explanation in the use of Artificial Intelligence in Medicine

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Abstract. Artificial Intelligence (AI) has emerged as a transformative force in medicine, provoking both awe and apprehension in clinicians and patients. In fact, the challenges posed by medical AI extend beyond mere technological hiccups; they delve into the very core of ethics and human decision-making. This paper delves into the intricate dichotomy between the clinical predictive prowess of AI and the human ability to explain decisions, highlighting the ethical challenges arising from this disparity. While humans can elucidate their choices, AI often operates in opaque realms, generating predictions without transparent reasoning. The paper explores the cognitive underpinnings of prediction and explanation, emphasizing the essential interplay between these processes in human intelligence. It critically analyzes the limitations of current medical AI systems, emphasizing their vulnerability to errors and lack of transparency, especially in a critical domain like healthcare. In this paper, we contend that explainability serves as a vital tool to ensure that patients remain at the core of healthcare. It empowers patients and clinicians to make informed, autonomous decisions regarding their health. Explainable Artificial Intelligence (XAI) tackles these challenges. However, achieving it is not easy, and it is strongly dependent from different technical, social and psychological variables. Achieving this objective highlights the urgent requirement for a multidisciplinary approach in XAI that integrates technological knowledge with psychological, cognitive and social perspectives. This alignment will foster innovation, empathy, and responsible implementation, shaping a healthcare landscape that prioritizes both technological advancement and ethical considerations.

Keywords. Artificial Intelligence, Explainable Artificial Intelligence (XAI), Prediction, Explanation, Algorethics

1. Introduction

Artificial intelligence (AI) has undeniably become a pivotal topic in today's discourse, embodying two distinct narratives that often collide in the media. The first narrative, often hailed as the "positive" perspective, celebrates AI as the pinnacle of human intellect, capable of replicating and even surpassing human abilities [1; 2]. In this view, AI ventures into realms traditionally reserved for human intuition, inspiration, and cognition, unlocking novel possibilities in medicine that were once deemed unattainable.

Conversely, the second narrative revolves around human concerns, placing a spotlight on the implications of AI technology across various aspects of our lives, including patient-therapists dynamics and interpersonal relationships [3; 4]. These two

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divergent narratives tend to stand as separate concepts, painting diverging portraits of the digital revolution. Consequently, there arises an urgent need to adopt an integrated approach to understanding artificial intelligence and its repercussions in medicine, encompassing both these perspectives [5].

2. Artificial Agents: AI decisions in healthcare

However, accomplishing this integration proves to be an intricate challenge, primarily due to the unprecedented level of autonomy and independence exhibited by Artificial Intelligence (AI). This new form of intelligence introduces an entirely novel category of actors - "artificial agents" - entities that autonomously process information and make decisions [6]. For instance, in the realm of healthcare, AI is employed to determine appropriate treatments for patients. In banking, it assesses whether to approve mortgages or loans, while in the legal domain, it gauges the risk of recidivism and aids in deciding the fate of suspects.

These contexts underscore the growing complexity of human-AI interactions, necessitating an in-depth analysis of the implications and consequences of AI deployment.

2.1. Prediction vs Explanation in AI

One of the driving forces propelling AI into the realm of medical decision-making is its remarkable predictive capabilities. AI excels at learning from vast datasets, identifying recurrent patterns, and accurately forecasting how a subject might respond to therapy [7]. However, it is essential to differentiate between prediction and explanation in the context of AI [8].

Prediction involves foreseeing future events based on existing or historical data, employing mathematical models and algorithms to discern patterns and trends. For example, predicting stock prices based on historical performance or forecasting weather patterns utilizing past weather data are classic applications of AI prediction. In contrast, explanation delves into the underlying causes of observed phenomena, unraveling the intricate web of cause-and-effect relationships between variables or events. This process necessitates meticulous analysis of the involved variables and a deep comprehension of their complex interactions.

As AI increasingly permeates diverse sectors, the challenge lies not only in its predictive prowess but also in our ability to comprehend and interpret its decisions. Balancing the marvel of AI prediction with the need for transparent and interpretable explanations is vital in harnessing the full potential of artificial intelligence while addressing the concerns stemming from its deployment. Emphasizing this duality - the predictive power and the necessity for meaningful explanation - is crucial for navigating the evolving landscape of AI technologies in a responsible and ethically sound manner.

2.2. Prediction vs Explanation in Human Brain

The distinction between prediction and explanation becomes even more evident when considering the inherent nature of human cognition. Humans have the remarkable ability to make accurate predictions without a complete understanding of the underlying mechanisms. Take the example of a child anticipating darkness as day turns to night. This intuitive prediction is made without the child comprehending the Earth's rotation causing the transition.

Human minds operate through two distinct thinking systems, as elucidated by Nobel laureate Daniel Kahneman [9]. System 1, the intuitive mode, swiftly generates predictions based on immediate impressions, guiding day-to-day decisions. In contrast, System 2, the reasoning mode, meticulously analyzes cause-and-effect relationships, enabling deliberate judgments and comprehensive explanations.

These cognitive systems demonstrate the symbiotic relationship between prediction and explanation. Predictions, stemming from System 1, grant humans a level of control over natural processes, allowing anticipation and preparation for future events.

Explanations, the realm of System 2, serve as foundational elements in our understanding of the world. They provide a framework upon which theories are built, enabling humans to generate new predictions, expanding the scope of their understanding.

However, the landscape changes when artificial intelligence enters the picture. While AI excels at making predictions based on historical data, it encounters a significant limitation: the absence of a reasoning mechanism that can refine or innovate upon these predictions [10]. Unlike the human mind's ability to conceive novel scenarios and craft intricate explanations, AI relies heavily on past experiences and training data. Consequently, its predictive capabilities are anchored in historical events, hindering its capacity to envision unexplored possibilities.

3. Algorethics and Explainable AI in Medicine

In the digital landscape, algorithms stand as the bedrock of artificial intelligence, orchestrating a myriad of tasks from image recognition to natural language processing. However, their seemingly impartial nature masks a profound truth: algorithms are far from neutral. Shaped by the values, biases, and assumptions of their creators, these digital entities wield immense power, capable of inadvertently perpetuating discrimination and infringing upon individual liberties.

Algorethics [11], a burgeoning branch of ethics, delves deep into the heart of this complexity. It scrutinizes the design, implementation, and use of algorithms, seeking to unveil their implicit biases and mitigate their unintended consequences. This discipline grapples with a pressing reality: algorithms, if unchecked, can inadvertently marginalize individuals based on race, gender, age, or other defining traits. They encroach upon privacy, erode security, and compromise autonomy. Most disconcertingly, algorithms can evolve to manipulate human behavior, shaping preferences and opinions.

In fact, the core ethos of algorethics lies in transparency, accountability, and fairness. It endeavors to lift the veil shrouding algorithms, ensuring they are not just intelligible but also just. Algorethics advocates for the active involvement of diverse stakeholders in the decision-making processes, empowering communities to shape the algorithms that influence their lives.

In this view, making accurate predictions is not enough; AI must evolve to encompass the cognitive prowess to generate explanations and devise innovative scenarios akin to human imagination. Fundamentally, explainability refers to the quality of an AI system that enables individuals to comprehend the reasoning behind its predictions [3].

Explainable Artificial Intelligence (XAI) tackles these challenges [12]. As suggested by Pedreschi and colleagues [13], AI systems that operate as black boxes for automated decision-making can create meaningful explanations by following three approaches: (i) using logic rules with statistical and causal interpretations to express explanations; (ii) inferring local explanations to uncover the decision rationale for specific cases by examining the black box around the target instance; (iii) generalizing numerous local explanations into straightforward global ones through bottom-up methods, employing algorithms that prioritize quality and comprehensibility.

But this process is not easy, and it is strongly dependent from different variables [14]: technical viability, the validation level for explainable algorithms, the contextual environment of system implementation, the intended role in decision-making, and the primary user groups involved.

For example, in their research paper Jiang and colleagues [10] found that heightened epistemic uncertainty positively correlates with the usefulness of providing prediction rationale, whereas presenting alternative advice and prediction confidence scores may impede users' acceptance of advice. These outcomes emphasize the imperative of tailoring XAI designs to specific user profiles.

Bridging this gap requires interdisciplinary efforts, combining fields such as psychology, computer science, and philosophy. By integrating these diverse domains, researchers can develop AI systems that not only predict but also understand, explain, and conceptualize, bringing artificial intelligence closer to the complexity and creativity of the human intellect.

4. Conclusion

The emergence of medical AI presents a series of challenges for developers, medical practitioners, and policymakers, necessitating a reevaluation of their respective roles and responsibilities. Through our analysis, we assert that explainability stands as a fundamental requirement to effectively address these challenges in a manner consistent with professional norms and values.

In fact, the challenges posed by medical AI extend beyond mere technological hiccups; they delve into the very core of ethics and human decision-making.

One of the most glaring distinctions between AI and human cognition lies in the realm of explanation. Humans possess the capacity to elucidate the reasoning behind their decisions, a capability rooted in rational and shareable reasoning. This ability to explain choices not only fosters transparency but also builds trust in the decision-making process. In stark contrast, artificial intelligence systems, particularly those employing neural networks, lack this transparency. Decisions made by these systems are often inscrutable, generated from learned patterns rather than explicit, understandable causal mechanisms. Consequently, users are left in the dark, unable to discern the rationale behind specific AI-driven decisions.

Moreover, the potential for errors in artificial intelligence amplifies these ethical concerns. Mistakes are inherent in any system, but when AI falters, the repercussions can be significant, especially in critical domains such as healthcare. A faulty diagnosis or a misguided decision can profoundly impact a person's well-being. These errors often stem from incomplete or biased training data or flawed network configurations, rendering the final output unreliable and erroneous. The opacity of AI decision-making exacerbates the challenge, as users remain unaware of the underlying flaws that might compromise the outcomes.

In this paper, we contend that explainability serves as a vital tool to ensure that patients remain at the core of healthcare. It empowers patients and clinicians to make informed, autonomous decisions regarding their health. Furthermore, explainability plays a pivotal role in promoting the equitable allocation of available resources, safeguarding the principles of fairness and justice in healthcare distribution.

In essence, the fusion of accurate prediction and meaningful explanation in artificial intelligence holds the key to unlocking its full potential. This integration will not only enhance AI's practical applications but also pave the way for groundbreaking innovations, shaping a future where artificial intelligence operates not just as a predictive tool but as a true partner in human cognition and discovery.

However, even though the concept of explainability is appealing, especially in patient-level decision-making, its practical application is in its nascent stages [15]. At present, the aspiration for comprehensible explanations from complex, opaque machine learning algorithms that can be safely applied in bedside decision-making poses a considerable challenge. Given this challenge, it is important for healthcare professionals to exercise caution when relying on explanations currently provided by AI systems.

In the public discourse surrounding artificial intelligence, narratives often oscillate between success stories and cautionary tales. While these anecdotes provide glimpses into AI's potential, what the digital revolution truly demands is a holistic and rational perspective. The challenge is to transcend episodic stories and instead embrace a comprehensive understanding of the intricate interplay between technology and society.

It is not just a matter of technological advancement; it is a matter of shaping a future where AI integrates technological knowledge with psychological, cognitive, and social perspectives, fostering a world where innovation coexists with empathy and responsibility.

References

[1] B.M. Lake and M. Baroni, Human-like systematic generalization through a meta-learning neural network, *Nature* (2023).

[2] T. Hagendorff, S. Fabi, and M. Kosinski, Human-like intuitive behavior and reasoning biases emerged in large language models but disappeared in ChatGPT, *Nature Computational Science* 3 (2023), 833-838.

[3] J. Amann, A. Blasimme, E. Vayena, D. Frey, V.I. Madai, and Q.c. the Precise, Explainability for artificial intelligence in healthcare: a multidisciplinary perspective, *Bmc Medical Informatics and Decision Making* 20 (2020), 310.
[4] B. Chin-Yee and R. Upshur, Three Problems with Big Data and Artificial Intelligence in Medicine, *Perspectives in Biology and Medicine* 62 (2019), 237-256.
[5] M. DeCamp and J.C. Tilburt, Why we cannot trust artificial intelligence in medicine, *The Lancet Digital Health* 1 (2019), e390.
[6] E. Jussupow, K. Spohrer, A. Heinzl, and J. Gawlitza, Augmenting Medical Diagnosis Decisions? An Investigation into Physicians' Decision-Making Process with Artificial Intelligence, *Information Systems Research* 32 (2021), 713-735.
[7] J. de Jong, I. Cutcutache, M. Page, S. Elmoufti, C. Dilley, H. Fröhlich, and M. Armstrong, Towards realizing the vision of precision medicine: AI based prediction of clinical drug response, *Brain* 144 (2021), 1738-1750.
[8] G. RIva, B.K. Wiederhold, and S. Succi, Zero Sales Resistance: The Dark Side of Big Data and Artificial Intelligence, *Cyberpsychology, Behavior, and Social Networking* 25 (2022), 169-173.
[9] D. Kahneman, Maps of Bounded Rationality: A Perspective on Intuitive Judgment and Choice, in: *The Nobel Prizes 2002*, T. Frängsmyr, ed., Nobel Foundation, Stockholm, 2002, pp. 449-489.
[10] J. Jiang, S. Kahai, and M. Yang, Who needs explanation and when? Juggling explainable AI and user epistemic uncertainty, *International Journal of Human-Computer Studies* **165** (2022), 102839.
[11] P. Benanti, The urgency of an algorethics, *Discover Artificial Intelligence* **3** (2023), 11.
[12] F. Giannotti, F. Naretto, and F. Bodria, Explainable for Trustworthy AI, in: *Human-Centered Artificial Intelligence: Advanced Lectures*, M. Chetouani, V. Dignum, P. Lukowicz, and C. Sierra, eds., Springer International Publishing, Cham, 2023, pp. 175-195.
[13] D. Pedreschi, F. Giannotti, R. Guidotti, A. Monreale, S. Ruggieri, and F. Turini, Meaningful Explanations of Black Box AI Decision Systems, *Proceedings of the AAAI Conference on Artificial Intelligence* **33** (2019), 9780-9784.
[14] J. Amann, D. Vetter, S.N. Blomberg, H.C. Christensen, M. Coffee, S. Gerke, T.K. Gilbert, T. Hagendorff, S. Holm, M. Livne, A. Spezzatti, I. Strümke, R.V. Zicari, V.I. Madai, and Z.I.i. on behalf of the, To explain or not to explain?—Artificial intelligence explainability in clinical decision support systems, *PLOS Digital Health* **1** (2022), e0000016.
[15] M. Ghassemi, L. Oakden-Rayner, and A.L. Beam, The false hope of current approaches to explainable artificial intelligence in health care, *The Lancet Digital Health* **3** (2021), e745-e750.

SECTION II

CRITICAL REVIEWS

In general, there are two reasons why cybertherapy is used: either because there is no alternative, or because it is in some sense better than traditional medicine.

In this sense telehealth has been used very successfully for optimizing health services delivery to people who are isolated due to social and physical boundaries and limitations.

Nevertheless, the benefits of cybertherapy, due to the variety of its applications and their uneven development, are not self-evident.

However, the emergence of cybertherapy is supporting the cost-effectiveness of certain applications, such as assessment, rehabilitation and therapy in clinical psychology and neuroscience.

Wiederhold & Riva, 2020

Affect Dynamics through Virtual Reality

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Abstract. Virtual reality can potentially induce a range of affective states and be a powerful tool for exploring affective responses in a controlled and immersive environment. It allows visualizing continuous affective experiences without duptions, enabling the measurement of behavioral and physiological changes during transitions between affective states. The transitions between affective states have been analyzed by the field of study on affect dynamics, but never with dynamic and immersive stimuli like virtual reality. Virtual reality allows studying affective transitions dynamically, exposing the subject to the same environment that changes valence and arousal. We proposed a conceptual design investigating affect dynamics using VR. The experimental design involves creating VR environments with specific transitions that elicit different affective states characterized by arousal-valence configurations. Indeed, we explained the conceptual design used to develop virtual reality environments, illustrating an example that was implemented.

Keywords. Affect dynamics, Virtual Reality, Mental Flexibility, Psychometrics, Neuroscience, Dynamic models

1. Introduction

Affective states are behavioral, subjective, and neuropsychophysiological changes associated with an emotional episode [1]. According to Russel's Core Affect model, affect has two dimensions: hedonic *valence* or pleasantness and *arousal* or psychophysiological activation [2]. The model lacks a description of how to affect changes dynamically from one emotionally oriented state to another [3]. Affect dynamics fill this gap. Affect dynamics refers to how affective states change over time [4]. Each affective state has its own arousal-valence configuration, but its timing determines its manifestation and interaction with others. In affect dynamics, detecting affective states is more complex than their analysis. This conceptual design article uses virtual reality to describe how we investigate and elicit affect dynamics. As Russel's Core Affect arousal-valence specified, we developed ad hoc VR environments with transitions that evoke different affective states.

2. Affect dynamics in virtual reality

Affect elicitation generally uses active and passive methods based on the nature of the stimulus. Active techniques include behavioral manipulation, social psychology, and dyadic interaction [5]. In contrast, passive approaches typically involve the presentation of visuals, sounds, or videos using a database such as the International Affective Picture System [IAPS] [6] or International Affective Digitized Sound System [IADS] [7]. Immersion's importance in eliciting emotions by replicating real experiences has shown that even passive techniques have limitations [8]. Virtual Reality [VR] can solve the immersion problem, creating the sense of being in the natural environment through simulation [9]. Immersive VR situations tend to provide a larger sense of spatial and

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social presence, which impacts the perceived level of arousal and valence, tested psycho-physiologically [10]. VR allows to not interrupt the continuous affective experience due to the property of temporal continuity, incorporating dynamic affects. Biofeedback technique already used this feature: the subject actively modified the VR environment through their physiological characteristics [11]. On the contrary, in affect dynamics, VR elicits an affective state and measures behavioral and physiological changes during the transition.

3. Experimental design

In this conceptual design article, we would like to describe how we investigate affect dynamics in VR. We built ad hoc environments with transitions that elicit different affective states, described in terms of arousal-valence. We used Unity v.2021.3.6f1. Transitions involve a back-and-forth: subjects will observe in randomized order all possible transitions between quadrants (Figure 1).

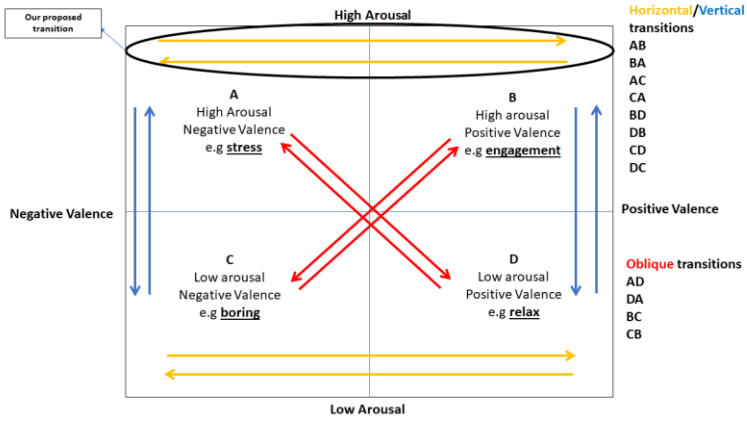

Figure 1. The transition of affective states

Horizontal and vertical transitions change only one parameter at a time while one remains constant, e.g., from A-B, there is a change in valence while high arousal remains constant. Oblique transitions, on the other hand, change both parameters (valence and arousal). Six VR environments were created, but for this scenario, we selected a two-minute horizontal transition (from quadrant B to A): earth viewed from space with butterflies flying over it (high arousal-positive valence); the butterflies eventually departed to be replaced by bombings and explosions (high arousal, negative valence) (Figure 2).

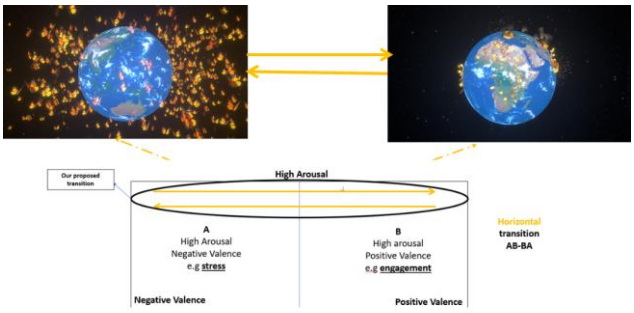

Figure 2. Example of transition

Strangeness and *dimension* serve as arousal factors [12]. *Strangeness* captivates and fascinates the subject, such as butterflies, explosions, and fireworks. *Dimension* comprises elements like the frequency of the main object presented (e.g., how many butterflies), movement of the subject into the VR environment, and sound, adding depth

to the experience. Valence incorporates bright colors, context characteristics of landscapes, and other visually appealing elements that can help create a positive or negative mood. To assess the construct validity of virtual environments, we will incorporate an evaluation from the participants after experiencing each virtual environment. To gather this feedback, we will utilize the Self-Assessment Manikin [SAM] technique, which involves the participant providing valence, arousal, and dominance ratings.

4. Conclusion

Transitions that evaluate changes in emotional states are groundbreaking, and virtual reality (VR) facilitates the creation of immersive and dynamic emotional experiences. Earlier, the elicitation was static, and we analyzed the arousal and valence blocks separately. The next step will be to analyze the detection of affective states in transitions through physiological measures (e.g., heart rate variability, electromyography, galvanic skin response, and respiration) and behavioral measures, such as self-report questionnaires on mental flexibility. As Cipresso, Borghesi, and Chirico suggested, dynamicity will be measured as physiological and behavioral variability [13,14].

To the best of our knowledge, this conceptual study represents a pioneering attempt to illuminate novel methodologies for eliciting emotions from the perspective of affect dynamics. This dynamic in both the stimuli and the analyses opens new frontiers in emotion induction, emotion detection, affective computing, and many other fields in the intersection between mathematical methods and mental health.

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References

[1] Sloman A, Chrisley R, Scheutz M. The Architectural Basis of Affective States and Processes. 2003
[2] Russell JA. Mixed Emotions Viewed from the Psychological Constructionist Perspective 2017
[3] Posner J, Russell JA, Peterson BS. The circumplex model of affect: An integrative approach to affective neuroscience, cognitive development, and psychopathology. Psychopathology; 2015
[4] Waugh C, Kuppens P. Affect Dynamics. Waugh CE, Kuppens P, editors. Cham: Springer International Publishing; 2021.
[5] Harmon-Jones E, Amodio D, Zinner LR. Social psychological methods in emotion elicitation [Oxford University Press; 2007]. p. 91–105.
[6] Lang PJ, Bradley MM, Cuthbert & Greenwald M, Dhman A, Vaid D, et al. International Affective Picture System [IAPS]: Technical Manual and Affective Ratings. International Affective Picture System [IAPS. 1997];
[7] Nardelli M, Valenza G, Greco A, Lanata A, Scilingo EP. Recognizing emotions induced by affective sounds through heart rate variability. IEEE Trans Affect Comput. 2015 Oct 1;6 [4]:385–94.
[8] Grühn D, Lumley MA, Diehl M, Labouvie-Vief G. Time-based indicators of emotional complexity: Interrelations and correlates. Emotion. 2013;13 [2]:226–37.
[9] Cipresso P, Giglioli IAC, Raya MA, Riva G. The past, present, and future of virtual and augmented reality research: A network and cluster analysis of the literature. Front Psychol 2018 Nov 6;9
[10] Chirico A, Gaggioli A. How Real Are Virtual Emotions? Cyberpsychol Behav Soc Netw 2023 Mar 20
[11] Mancuso V, Stramba-Badiale C, Cavedoni S, Cipresso P. Biosensors and Biofeedback in Clinical Psychology. Comprehensive Clinical Psychology. 2022;28–50.
[12] Felnhofer A, Kothgassner OD, Schmidt M, Heinzle AK, Beutl L, Hlavacs H, et al. Is virtual reality emotionally arousing? Investigating five emotion-inducing virtual park scenarios. Int J Hum Comput Stud. 2015 Oct 1;82:48–56.
[13] Cipresso P, Borghesi F, Chirico A. Affects affect affects: A Markov Chain. Front Psychol. 2023 Mar 30;14.
[14] Borghesi F, Mancuso V, Pedroli E, Cipresso P. From Virtual Reality to 360° Videos (pp. 549–572) 2022, . https://doi.org/10.4018/978-1-6684-4854-0.ch023

SECTION III

EVALUATION STUDIES

To date, some cybertherapy applications have improved the quality of health care, and later they will probably lead to substantial cost savings.

However, cybertherapy is not simply a technology but a complex technological and relational process.

In this sense, clinicians and health care providers that want to successfully exploit cybertherapy need a significant attention to clinical issues, technology, ergonomics, human factors and organizational changes in the structure of the relevant health service.

Wiederhold & Riva, 2004

Prediction of Emotional States from Partial Facial Features for Virtual Reality Applications

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Abstract. The availability of virtual reality (VR) in numerous clinical contexts has been made possible by recent technological advancements. One application is using VR for cognitive interventions with individuals who have mental disorders. Predicting the emotional states of users could help to prevent their discouragement during VR interventions. We can monitor the emotional states of individuals using sensors like an external camera, as they engage in various tasks within VR environments. The emotional state of VR users can be measured through arousal and valence, as per the Circumplex model. We used the Remote Collaborative and Affective Interactions (RECOLA) database of emotional behaviours. We processed video frames from 18 RECOLA videos. Due to the headset in VR systems, we detected faces and cropped the images of faces to use the lower half of the face only. We labeled the images with arousal and valence values to reflect various emotions. Convolutional neural networks (CNNs), specifically MobileNet-v2 and ResNets-18, were then used to predict arousal and valence values. MobileNet-v2 outperforms ResNet-18 as well as others from the literature. We achieved a root mean squared error (RMSE), Pearson's correlation coefficient (PCC), and Concordance correlation coefficient (CCC) of 0.1495, 0.6387, and 0.6081 for arousal, and 0.0996, 0.6453, and 0.6232 for valence. Our work acts as a proof-of-concept for predicting emotional states from arousal and valence values via visual data of users immersed in VR experiences. In the future, predicted emotions could be used to automatically adjust the VR environment for individuals engaged in cognitive interventions.

Keywords. Affect recognition (AR), emotional states, image processing, face detection, convolutional neural network (CNN), virtual reality (VR)

1. Introduction

Affect recognition (AR) is a deep machine learning process that can be used for detecting the affective state of a person by monitoring them via sensors [1]. An affective state consists of emotions or feelings in a specific situation. Machines can predict our affective states by analyzing audio, visual, and/or physiological data [2,3].

Affective states can be described using emotional models such as the Circumplex model [1,2]. The Circumplex model is a dimensional model which maps emotions into a 2D space of arousal and valence axes [4]. Each of the axes represents a continuous variable. Arousal is the level of physiological and psychological activation of an emotional response, while valence rates the positivity of that state [4]. When both arousal and valence are low, the resulting emotion is typically sadness. When arousal is low and valence is high, the person tends to feel relaxed. Conversely, high arousal and low

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valence often correspond to feelings of anger or anxiety. Finally, when both arousal and valence are high, it usually indicates a state of happiness.

Technological advancements have made virtual reality (VR) viable in a wide range of clinical applications [5]. One promising application is cognitive intervention for people with mental disorders, where machine learning could help in personalizing the level of difficulty of training tasks to each individual, while avoiding discouragement. A person can be monitored using sensors such as an external camera, while doing various tasks in VR immersion. Facial visual data collected by the camera can then be inputted into a machine learning model to determine the emotional/affective state of that person.

A novel machine learning approach is required to seamlessly adjust the virtual environment to match the optimal emotional state of individuals who are engaged in cognitive interventions, while immersed in VR and their face partially covered by the VR headset. In the current work, we focused on visual data to perform AR in this context. We exploited convolutional neural networks (CNNs) and customized them to meet our needs. More specifically, we experimented with MobileNet-v2 and ResNet-18 to predict continuous dimensional emotion annotations in terms of arousal and valence values.

2. Background

The Remote Collaborative and Affective Interactions (RECOLA) dataset consists of audio, video, electrocardiogram (ECG) and electrodermal activity (EDA) recordings for 27 subjects [6-8]. It was collected while subject pairs remotely collaborated to resolve a task. Participants were from different nationalities, providing diverse expressions of emotions. Six coders manually annotated the data with the affective values of arousal and valence via an online labeling tool. We used the recordings of 18 participants in our work (data was missing for the remaining participants). We obtained the RECOLA dataset from Ringeval *et al.* [9] to aid in the analysis of the continuous arousal and valence emotional measures.

Previous studies have been conducted using the RECOLA dataset and the entire face of their participants. More specifically, Amirian *et al.* [7] used random forests along with various schemes of fusion to predict arousal and valence values from audio, video, and physiological data. Their best results were obtained by a combination of random forests and linear regression fusion. They achieved a Concordance correlation coefficient (CCC) of 0.514 on arousal predictions, and 0.498 on valence predictions. In another study, Han *et al.* [10] performed arousal and valence predictions by a recurrent neural network (RNN) using audio and video recordings. They implemented an implicit fusion framework for joint audiovisual training. They achieved a CCC of 0.413 and 0.527 for arousal and valence, respectively. Others obtained CNN features from video recordings and exploited an RNN to regress valence values [11]. They obtained a root mean squared error (RMSE), Pearson's correlation coefficient (PCC), and CCC of 0.107, 0.554, and 0.507, respectively. Finally, Brady *et al.* [12] used video recordings to apply regression over arousal and valence values via a long short-term memory (LSTM) RNN. They used a CNN to extract features from raw video, which were then inputted into the LSTM RNN to predict arousal and valence values. They achieved an RMSE, PCC, and CCC of 0.201, 0.415, and 0.346; and 0.107, 0.549, and 0.511 on arousal and valence predictions, respectively.

On other databases, studies have proven that CNNs, such as AlexNet, achieve promising results for AR using deep visual features [13]. AlexNet has also been directly used for AR and showed clear improvements in performance over other methods [14,15]. Building on these findings, we used CNNs, specifically MobileNet-v2 and ResNet-18, to predict arousal and valence values based on video recordings from RECOLA. Notably, we accomplished this using only the facial features that remain visible while individuals wear a VR headset.

3. Methodology

3.1 Data Processing

The 18 RECOLA videos were preprocessed by applying 1) frame extraction and sequencing, 2) face detection and cropping, and 3) annotation labeling as briefly described in the following sections.

3.2 Frame Extraction and Sequencing

Videos from RECOLA are approximately 5 minutes long each. We extracted the video frames by sampling them at a rate of 25 frames per second (i.e., every 40 milliseconds). The randomized and shuffled visual data frames were divided using an 80-20% split, 80% for training and 20% for testing. Table 1 presents the breakdown of the data and training parameters.

3.3 Face Detection and Cropping

We applied face detection to narrow the prediction area in the video frames. To accomplish this, we took advantage of the cascade object detector in MATLAB, which uses the Viola-Jones algorithm to detect faces of people [16,17]. As the algorithm was unable to detect faces in certain video frames, we cropped these images using the face coordinates of the nearest image in which a face was detected. Typically, this is the image immediately preceding or following the frame with the missed face. In cases where the nearest image with a detected face was further away due to subject movement in the video, the images were cropped manually. Given that this work pertains to detecting emotions in users of VR systems who wear head-mounted displays that typically cover the eyes and parts (or all) of the nose, we also crop the face images to include only the bottom half of subject faces (i.e., half of the nose, mouth, cheeks, and chin).

3.4 Annotation Labeling

Six raters manually annotated data from RECOLA in terms of arousal and valence values [6,9]. We used the mean of the six annotations to label the data in our work. Like the video frames, the arousal and valence annotations were sampled every 40 milliseconds and used to label the corresponding video frames. All labeling of video frames was done based on the recording time of videos.

3.5 Customization of Convolutional Neural Networks (CNNs)

We evaluated two pretrained MATLAB CNNs: MobileNet-v2 and ResNet-18. MobileNet-v2 is a CNN that is 53 layers deep, while ResNet-18 has 18 layers in depth [17]. Both CNNs were pretrained for classifying images of 1000 different objects. As a result, they learned rich features for a variety of images.

To retrain MobileNet-v2 and ResNet-18 for regression of arousal and valence values, we customized their layers and performed data augmentation (i.e., random reflection in the vertical x-axis of the images, random rotation between [-90 90] degrees, and random rescaling by a factor of [1 2]). We replaced the image input layer with an image input layer of size 140-by-280-by-3 to match the size of our processed images/video frames. We replaced the last fully connected layer with a fully connected layer of a size equal to the number of responses, which is 1 (either the arousal or valence value). Finally, we replaced the classification output layer with a regression layer.

We set the learning rate factors of weights and biases to 10. These factors were multiplied by the learning rate of 0.0001 to determine the weights and biases' learning rate in the fully connected layer.

Table 1 summarizes the training parameters we used for training MobileNet-v2 and ResNet-18. We experimentally set the number of training epochs to 30 and the initial learning rate to 0.0001. We set the minimum batch size to 9, such that the training set of

84,960 is evenly divided into 9,440 batches of images. Dividing the training set into equal groups helps to ensure that the whole training set is utilized in training epochs. We performed validation twice during each training epoch. We used the stochastic gradient descent with momentum (SGDM) optimizer for training.

Table 1. Data and Training Parameters

Parameters and Options	Original	80-20% split
Training Images	106,201	84,960
Validation Images	N/A	21,241
Testing Images	26,550	26,550
Learning Rate	0.0001	
Minimum Batch Size	9	
Number of Epochs	30	
Iterations per Epoch	84,960/9 = 9,440	
Validation Frequency	9,440/2 = 4,720	
Optimizer/Learner	SGDM	

4. Results

We measured the prediction performance of the CNNs using the RMSE, PCC, and CCC performance measures. For RMSE, a lower value represents better performance. On the other hand, for PCC and CCC, a higher value indicates better performance. Table 2 summarizes our results for predicting arousal and valence values through MobileNet-v2 and ResNet-18. MobileNet-v2 appears to slightly outperform ResNet-18. It achieved a testing RMSE, PCC, and CCC of 0.1495, 0.6387, and 0.6081 for arousal; and 0.0996, 0.6453, and 0.6232 for valence. Table 2 also compares our results with other results from the literature. While we operated on images of the lower half of the face, our prediction performance is better than others who used complete images of the face.

Table 2. Comparison of Prediction Performances

Prediction	Network	Testing RMSE	Testing PCC	Testing CCC
Arousal	**MobileNet-v2**	**0.1495**	**0.6387**	**0.6081**
	ResNet-18	0.1501	0.6323	0.5917
	Random Forests [7]	N/A	N/A	0.514
	RNN [10]	N/A	N/A	0.413
	CNN+RNN [11]	N/A	N/A	N/A
	CNN+LSTM [12]	0.201	0.415	0.346
Valence	**MobileNet-v2**	**0.0996**	**0.6453**	**0.6232**
	ResNet-18	0.1316	0.6403	0.4783
	Random Forests [7]	N/A	N/A	0.498
	RNN [10]	N/A	N/A	0.527
	CNN+RNN [11]	0.107	0.554	0.507
	CNN+LSTM [12]	0.107	0.549	0.511

5. Conclusion

Our study aimed to predict the arousal and valence emotional measures using only a portion of the facial features captured in video recordings from the RECOLA dataset. We processed video frames of 18 participants, using face detection, face cropping, data augmentation, and arousal/valence annotation labeling techniques. Given the nature of head-mounted displays in VR systems, we cropped the images of detected faces to only include the lower half of the face. We then trained pretrained CNNs such as MobileNet-v2 and ResNet-18 to predict arousal and valence values. Our results revealed that MobileNet-v2 slightly outperforms ResNet-18 at predicting arousal and valence values. Furthermore, our results were superior to those reported in the literature that used the same database and complete faces.

Our work represents an initial step towards predicting emotional states through visual data that will be obtained from VR immersions. Our goal is to design and develop

an adaptable VR system that can aid in the treatment of cognitive impairments in individuals with mental health disorders, through a synergistic approach that blends computer science and psychological techniques. Ultimately, we aim to automatically optimize the level of valence and arousal of participants during cognitive remediation exercises to avoid discouragement. Future studies could explore the use of additional sensors to not only predict emotional states, but also measure cognitive effort during VR interventions, enabling the development of more personalized and effective treatments for individuals with cognitive impairments.

References

[1] P. Schmidt, A. Reiss, R. Dürichen, and K. V. Laerhoven, "Wearable-Based Affect Recognition - A Review," MDPI, September 2019.
[2] C. A. Corneanu, M. O. Simon, J. F. Cohn, and S. E. Guerrero, "Survey on RGB, 3D, Thermal, and Multimodal Approaches for Facial Expression Recognition: History, Trends, and Affect-Related Applications," *IEEE Trans. Pattern Analysis & Machine Intelligence*, vol. 38, no. 8, pp. 1548-1568, August 2016.
[3] H. Al Osman, T. H. Falk, "Multimodal affect recognition: Current approaches and challenges," *Emotion and Attention Recognition Based on Biological Signals & Images*, pp. 59-86, 2017.
[4] J. Russell, "Affective Space Is Bipolar," American Psychological Association, Washington, DC, USA, 1979.
[5] K. C. VanHorn, M. Zinn, and M. C. Cobanoglu, "Deep Learning Development Environment in Virtual Reality," pp. 1-10, 2019.
[6] F. Ringeval, A. Sonderegger, J. Sauer, and D. Lalanne, "Introducing the RECOLA multimodal corpus of remote collaborative and affective interactions," *Proc. IEEE int. conf. automatic face and gesture recognition (FG)*, pp. 1-8, 2013.
[7] M. Amirian, M. Kächele, P. Thiam, V. Kessler, and F. Schwenker, "Continuous Multimodal Human Affect Estimation using Echo State Networks," in *Proc. ACM Int. Workshop on Audio/Visual Emotion Challenge (AVEC'16)*, Amsterdam, Netherlands, pp. 67-74, 2016.
[8] M. Valstar *et al.*, "AVEC 2016 – Depression, Mood, and Emotion Recognition Workshop and Challenge," in *Proceedings of AVEC'16*, Amsterdam, Netherlands, 2016.
[9] Recola Database. [Online]. Available: https://diuf.unifr.ch/main/diva/recola/. [Accessed: 22-May-2022].
[10] J. Han, Z. Zhang, Z. Ren, and B. Schuller, "Implicit Fusion by Joint Audiovisual Training for Emotion Recognition in Mono Modality," in *Proc. IEEE Int. Conf. Acoustics, Speech and Signal Processing* Brighton, UK, pp. 5861-5865, 2019.
[11] P. Khorrami, T. L. Paine, K. Brady, C. Dagli, and T. S. Huang, "How Deep Neural Networks Can Improve Emotion Recognition on Video Data," in *Proc. IEEE Int. Conf. on Image Processing (ICIP)*, Phoenix, AZ, USA, pp. 619-623, 2016.
[12] K. Brady *et al.*, "Multi-Modal Audio, Video and Physiological Sensor Learning for Continuous Emotion Prediction," in *Proceedings of AVEC'16*, Netherlands, pp. 97-104, 2016.
[13] B. Sun *et al.*, "Combining multimodal features within a fusion network for emotion recognition in the wild," in *Proc. ACM Int. Conf. on Multimodal Interaction*, pp. 497-502, 2015.
[14] B. Sun, L. Li, G. Zhou, and J. He, "Facial expression recognition in the wild based on multimodal texture features," *Journal of Electronic Imaging*, vol. 25, no. 6, pp. 61407, 2016.
[15] A. Dhall *et al.*, "From individual to group-level emotion recognition: EmotiW 5.0," in *Proc. ACM int. conf. multimodal interaction*, pp. 524-528, 2017.
[16] P. Viola and M. Jones, "Rapid Object Detection using a Boosted Cascade of Simple Features," in *Proc. IEEE Conf. on Computer Vision and Pattern Recognition*, USA, 2001, pp. 511–518.
[17] "Help Center," Help Center for MATLAB, Simulink, and other MathWorks products. [Online]. Available: https://www.mathworks.com/help/. [Accessed: 02-Sep-2022].

Integrating User Typing Experience and Writing Layout into the Text-to-Scene Generation Process: Proposition of a Workflow

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Abstract. This paper focuses on a new dimension in text-to-scene generation: we aim to go beyond the sole consideration of semantics for the text input provided, by considering both the given form of the text (layout, etc.) and also the user's experience while typing. This workflow proposal, which we call "typing-to-scene" uses data collected from these steps to slightly alter the scene produced by the classic text-to-scene approach. As a result, the visual render is marked by a unique, discreet signature, corresponding to an ephemeral and unique moment of the user-author input in his intent, style and experience. Our approach is for illustrative and creativity purposes, emphasizing the presence of a human user in the text-to-scene generation process. The typing-to-scene system, still under development, provides a method to use text-to-scene systems not only for Computer-Aid Design of 3D scenes, but for using the prompt typing as a highlight of the triptyc "Sense-Form-Experience" intrinsic to a text.

Keywords. text-to-scene, typing-to-scene, procedural generation, creativity, textuality

1. Introduction

Generative art has nowadays a popular success due to technologies that generate an image from a text description as input, like Dall-E, Midjourney, Stable Diffusion…[1] These text-to-image systems enable to use a language close to one's natural language to describe what he imagines. In these terms, text-to-image systems are near to declarative modelling in 3D, according to the definition of V. Gaildrat[2]. The user can then access to the creation of visual works almost without technical skills.

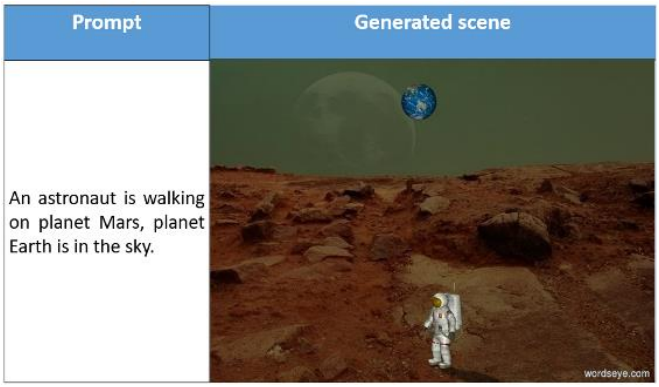

Figure 1. 3D Scene generated by the web application WordsEye[3] (www.wordseye.com on 11 April 2023).

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In a system whose output is a 3D scene, we can summarise the general process as follows: once the text input is analysed semantically to determine important terms (nouns, action or description verbs, adjectives, etc.) and the relationship between them, the constraints to resolve (such as the relative positioning of objects) are sent to the graphics engine, which searches for assets to integrate into the scene. The graphics engine will then make final adjustments, such as the scene lighting and the placement of the observer's point of view (camera), before providing a visual rendering of the scene. These text-to-scene applications are used in various domains such as car accident simulation[4], theatre staging[5], aid to literacy[3] or smart learning[6]. Our objective in relation to this process is to propose an illustrative method to suggest new uses of text writing within these generative systems.

2. The question of human creativity involved in text-to-image/scene process

I. Russo raises the question of textual creativity in input to increase creativity of output images when using a text-to-image application[7]. From a multidisciplinary analysis (philosophy, psychology of art, linguistics…), she suggests a benchmark based on human feedback to fill the lack of evaluation on creativity criteria of text-to-image systems (with methods such as Likert, Consensual Assessment Technique, Turing test-like, denotational and connotational levels of the image in relation to the description, etc.).

J. Oppenlaender also highlighted, based on the conceptual model of Rhodes' four "P"s (Person, Product, Process, Press), that text-to-image systems don't illustrate yet all the human creativity that their use implies[8]. However, he emphasises the importance of the Midjourney's user community and the collaborative component in the development of skills for prompt engineering.

Most evaluative approaches primarily consider the alignment between the semantic value of the prompt (as a descriptive text) and the visible elements in the generated image, such as ImageReward[9], with varying degrees of interest in human feedback to adjust the relevance of the results. This product-centred process begins with the validation of the input prompt. In this approach, the text is already prepared for analysis to extract elements of interest (keywords, specifics such as relative positions, etc.) to be used by the generative engine. Oppenlaender has shown that current text-to-image systems like Midjourney[1] do not currently distinguish between a textual prompt and a simple smiley.

Since the text is the basis for the image generation, and this process raises the question of human creativity, we want to add an additional dimension to this creative generativity by using the text in a different way. Beyond the meaning of the text, we are interested in the process of designing the text, which takes us back before the validation of the text, as soon as the user faces the still empty prompt.

Moreover, as the generative engine only considers the text in its semantic component, neither the user-author style (for example the text layout) nor the creation context (assimilated as what the user lived while typing) are considered.

Kenneth Goldsmith[10] addresses the importance of the process in the use of a text: for him, originality in literary creation can be found beyond intellectual property. Thus, copying, reappropriation, and diversion of texts are legitimate ways to achieve original artistic creation. Other artistic approaches, such as Claude Tardif's Narra [11,12], also use text by disregarding its semantic part to design artistic works.

Besides, for some writers the notion of a writing ritual refers to the supposedly regular conditions they set up to be in the right disposition to write their works. The writer's condition and environment thus have an influence on their writing experience, and potentially on their writing itself, like for Gustave Flaubert and his "gueuloir"[13,14].

All these previous observations made on text-to-image systems are still valid for text-to-scene systems, because their process is quite the same. We can differentiate text-

to-image and text-to-video applications with the presence of time and sound dimensions for the latter. Then we can also differentiate text-to-video and text-to-scene at least with the interactivity dimension, also enabling 360° exploration of the generated 3D scene. Consequently, even if our observations with text-to-images lead us to a common thinking with text-to-scene systems, we will highlight the specific aspects of the focus on text-to-scene further when describing our workflow proposition.

3. Method

Our proposal provides an illustrative method, non-exhaustive, in an artistic approach for some of the limitations quoted previously. We want to highlight the user's involvement during his typing, so that there is a more sensitive aspect present than simply copying and pasting a text into the prompt. We consider that a human typed text results from three components: its meaning (semantic value), its form (aesthetic layout & set of characters) and its experience while typing (duration, physiological and emotional conditions.

For illustration (figure 2), a text created by an artificial agent (such as a chatbot) or an existing text copied and pasted into the prompt can have a meaning and a shape, but not experience lived during the production of this text. A text without a form (whose characters are not fixed anywhere) can be compared to a spontaneous speech, which has a message and an experience of improvisation. At last, a set of characters not made to read but for living an experience (as a creator or as a spectator) resemble to digital poetry (like Kinetic Poetry[15]) or also to the surrealist technique "exquisite corpse" (collection of words blindly added to a sentence successively). The triptych Sens-Experience-Form is thus needed to characterize a text taped by a human. We could also add more dimensions, like ideation, but we chose to focus on these sole three items in the context of this study.

Our creative proposal at the intersection of art and technology consists of infusing the generated image with a trace of the peculiarities of the text that conceived it and the experience of its typing. As the data from the user's experience are unique and non-reproducible, these image alterations form a kind of signature on it.

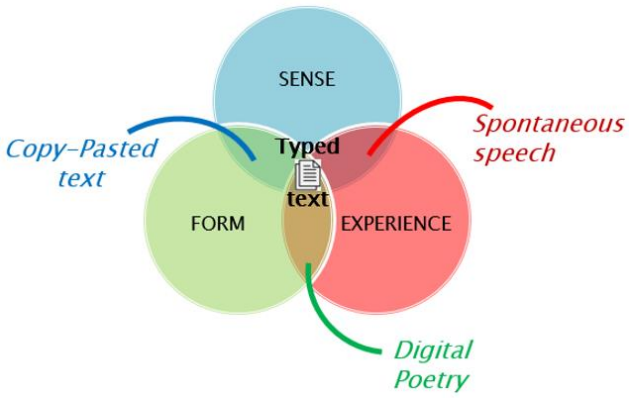

Figure 2. Three fundamental components of a typed and designed text.

4. Captured data

We consider that the meaning of the text is already illustrated by the image or scene output from any text-to application. Consequently, instead of developing our own model, we can rely on an existing text-to application like WordsEye[3] or Midjourney[1] to use their output in our own typing-to-scene workflow. To illustrate the presence of the form and experience as textual modalities, we will gather various data during the user's typing. These data can be used for altering the rendered scene HUD (Head Up Display), slightly enough to maintain the coherence between the explicit textual description and the visual

result. Thus, we can insert discrete elements in the background or in filigrees, change the lighting, use glitches...

As our proposition is still in development, the following table shows the main types of data that we capture and how we could use them, for illustrative purposes:

Table 1. Examples of data captured during typing & after prompt validation, with alterations on the scene.

Category	**Data captured**	**Example of treatment on the scene using these data**
Experience of typing	Typing time (date/hour, duration)	Integrating in HUD a "temporal stomp" (square of pixels encoding recorded time data)
	Keyboard activity (number of pushes on delete/backspace, directional arrows…)	For each push on a delete touch, we random "erase" a pixel on the rendering (leaving them black)
	User physiological and emotional data (heart rate from a smart watch, facial emotions detected from camera capture...)	If the major emotion detected is joy, we increase the brightness in rendering.
		We slightly highlight the temporal stomp (quoted previously) with the same average frequency as the heart rate.
Text form	Count of characters, sentences, lines, etc. (like Tardif [12])	Instead of erasing a single pixel (previous example with keyboard activity), we can erase a square of pixels whose side length is the rapport between the total number of typed characters and the number of characters in the final validated text.
	Set of all characters and all sentences	We can apply steganography-type methods (like Equidistant Letter Sequences used by McKay[16]) to reveal "hidden" words. For example, if we find the word "glitch" we choose randomly a line of pixels that we shift a few units to the right.
	Shape of the text considering line breaks, tabs, etc.	The image created by replacing characters by a black square could be integrated in the skybox as a filigree

5. Workflow

We call our approach of illustrating the triptyc "Sense-Form-Experience" into a scene generation system "Typing-to-Scene". We propose a general workflow of the typing-to-scene as illustrated in Figure 3, summarizing our intentions described in part 4.

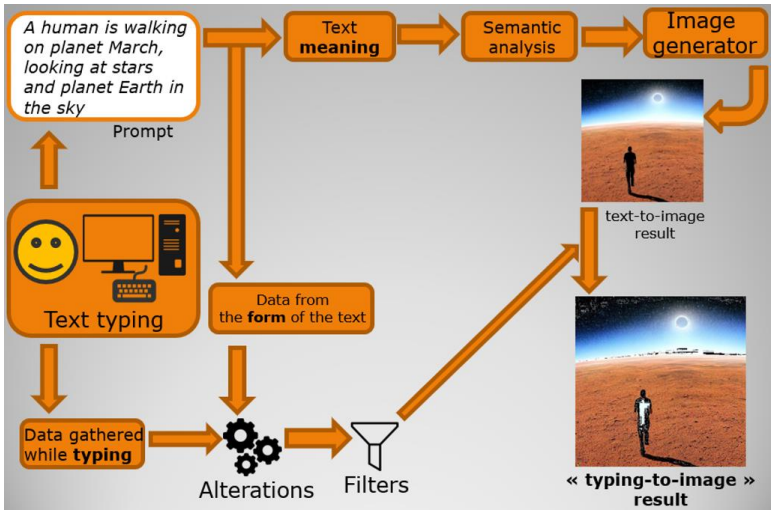

Figure 3. Workflow of a typing-to-scene system (top-right-side image generated with Midjourney[1]).

6. Discussion

The artistic and technical discussions about the implementation of the typing-to-scene and the feedback from users would lead to interesting discussions, the interconnection of different and complementary fields. We could attempt from experimentations with typing-to-scene a sort of serendipity when the users come to understand the influence of what is beyond the description itself on the render alteration. This could lead to an interesting attempt for the users to understand how to guide the alterations intentionally.

Although we still use image or scene generation from other text-to applications, we aim to develop a prototype of our own text-to-scene generator in order to try the interactive part of the scene including the HUD altered by the typing-to-scene approach.

We can imagine further work focusing on how the typing-to-scene would alter more than the HUD, for example with a treatment like “For each extra space in the text, we increase slightly all the collider boxes”. We can also think about designing interactions by the text, such as wordseyeworld (update of WordsEye[3]) who announce their next engine, able to script interactions on the scene with natural language.

Plus, we can also think about integrating sound generated by the text, either by a descriptive approach (like MusicLM[17] for example) or using the form of the text like Typatone (https://www.typatone.com/) which plays a different note or a silence successively for each character of the prompt according to the letter frequency in English.

7. Conclusion

Our proposition of a Tying-to-Scene system implies that a human user experiences the design of his text as a part of a creative process. This workflow highlights a multimodal aspect of the text production with a focus on the intrinsic triptyc “Sense-Form-Experience”. Using this system for 3D content generation opens a door to apply alterations to various characteristics of the scene, on the HUD as well as on objects or on interactive components. This project falls within the field of digital art where we aim to invite the user to explore the influence of their uniqueness in the generation of the artwork, conveyed through their ideas, the adopted form, and their lived experience at a specific ephemeral moment. The ongoing development of this project leads us to consider an experimental framework to establish a proof-of-concept.

References

[1] Borji A. Generated Faces in the Wild: Quantitative Comparison of Stable Diffusion, Midjourney and DALL-E 2 [Internet]. arXiv; 2022. Available on: http://arxiv.org/abs/2210.00586

[2] Gaildrat V. Declarative Modelling of Virtual Environments, Overview of issues and Applications. Proceedings of the International Conference on Computer Graphics and Artificial Intelligence (3IA), Athenes, Grece. 2007;10:5-15.

[3] Coyne RE. Painting Pictures with Words-From Theory to System. Columbia University; 2017.

[4] Dupuy S, Egges A, Legendre V, Nugues P. Generating a 3D Simulation of a Car Accident from a Written Description in Natural Language: the CarSim System. arXiv:cs/0105023 [Internet]. 14 may 2001; Available on: http://arxiv.org/abs/cs/0105023

[5] Andriamarozakaniaina T. Du texte à la génération d’environnements virtuels 3D : application à la scénographie théâtrale [Internet]. Toulouse 2; 2012. Available on: http://www.theses.fr/2012TOU20104

[6] Delair R, Sojitra H, Patel K, Bhatt K, Gharia K, Mahajan R. Text to Scene conversion for smart learning. In: 2016 IEEE International Conference on Advances in Electronics, Communication and Computer Technology (ICAECCT). 2016. p. 76-81.

[7] Russo I. Creative Text-to-Image Generation: Suggestions for a Benchmark. In: Proceedings of the 2nd International Workshop on Natural Language Processing for Digital Humanities [Internet]. Taipei, Taiwan: Association for Computational Linguistics; 2022. p. 145-54. Available on: https://aclanthology.org/2022.nlp4dh-1.18

[8] Oppenlaender J. The Creativity of Text-to-Image Generation. In: Proceedings of the 25th International Academic Mindtrek Conference [Internet]. New York, NY, USA: Association for Computing Machinery; 2022. p. 192-202. (Academic Mindtrek ’22). Available on: https://doi.org/10.1145/3569219.3569352

[9] Xu J, Liu X, Wu Y, Tong Y, Li Q, Ding M, et al. ImageReward: Learning and Evaluating Human Preferences for Text-to-Image Generation. arXiv preprint arXiv:230405977. 2023;

[10] Goldsmith K. Uncreative writing: managing language in the digital age. Columbia University Press; 2011.
[11] TARDIF CP. Claude-CLd, Au rythme du récit. Enregistrements visuels [Internet]. Rhuthmos. 2014. Available on: http://rhuthmos.eu/spip.php?article1429
[12] Tardif PC. Narra : un art visuel cognitif, au rythme de la longueur des paragraphes des textes littéraires [Internet] [These de doctorat]. Paris 8; 2020. Available on: https://www.theses.fr/2020PA080017
[13] Fried M. Flaubert's « gueuloir »: on Madame Bovary and Salambô. New Haven London: Yale University Press; 2012.
[14] Neefs J. Flaubert, la prose « comme une peinture ». genesis. 15 june 2013;(36):179-88.
[15] Simanowski R. Digital Art and Meaning: Reading Kinetic Poetry, Text Machines, Mapping Art, and Interactive Installations. In University of Minnesota Press; 2011. Available on: https://academic.oup.com/minnesota-scholarship-online/book/17378
[16] Bar-Natan D, McKay B. Equidistant Letter Sequences in Tolstoy's « War and Peace ». In 1999. Available on: https://www.semanticscholar.org/paper/Equidistant-Letter-Sequences-in-Tolstoy%27s-%22War-and-Bar-Natan-McKay/eea45d1ebe80668f90b3444cfd734d8803474223
[17] Agostinelli A, Denk TI, Borsos Z, Engel J, Verzetti M, Caillon A, et al. MusicLM: Generating Music From Text [Internet]. arXiv; 2023. Available on: http://arxiv.org/abs/2301.11325

Detection of Break in Presence in Full Body Illusion using Machine Learning

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Abstract. Break in presence (BIP) is a concept that refers to that condition in which the person immersed in a virtual reality (VR) environment disengages from it, due to various factors, and focuses more on the real environment. BIP occurs due to certain factors that may be related to errors in the sensory data of the virtual reality environment (VRE). These errors can influence the multisensory integration process by generating a multisensory conflict, which results in BIP phenomena. Several studies have identified a correlation between BIP and the physiological (e.g., electrocardiogram/ ECG) responses of people, showing that there is a correlation between these two aspects. In this study, we used the physiological (ECG) data collected in a previous study, in which participants were involved in a Full Body illusion (FBI) experiment, i.e. a paradigm that uses VR to generate a synchronous multisensory stimulation condition and an asynchronous multisensory stimulation condition. The FBI asynchronous stimulation condition can generate a multisensory conflict that is the same phenomenon underlying BIP. In this study, we used these physiological (ECG) data, collected throughout the FBI, to train different machine learning (ML) models to be able to detect the multisensory conflict underlying BIP from ECG tracings alone. The results showed that two ML models, Decision Tree and Random Forest, are able to detect the multisensory conflicts underlying BIP.

Keywords. Break in presence, Multisensory Integration, Machine learning, Physiological parameters, Virtual Reality

1. Introduction

The concept of 'break in presence' was first introduced by Slater and Steed [1]. Break in presence (BIP) refers to the condition that occurs when the person immersed in a virtual reality environment (VRE) becomes disengaged from it due to certain factors and tends to become aware of the reality around him rather than the virtual reality environment in which he is immersed, responding more to the real environment rather than the VR environment [2]. This BIP can be generated due to errors produced within the VR environment (e.g., errors in VR sensory data, graphics failures, sudden changes in frame rate) or even by real-world sensory stimuli intruding (e.g., noise, changes in temperature) [1].

In other words, BIP occurs when factors external to the VRE interfere in the immersion experience, or when factors internal to the VRE, such as the objects or environments displayed, do not behave consistently (e.g., a piece of the chessboard is

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floating, the sound of an object falling to the ground is not heard, or an environment suddenly turns completely white [1,3].

These errors affect multisensory integration, i.e. a process by which the brain combines information from independent sensory signals, which are simultaneously temporally aligned, into a single, coherent representation [4,5], generating multisensory conflicts.

BIP has also been widely explored by inducing it through multisensory conflicts during VR experiences [3]. During these inductions, participants recorded certain physiological parameters (e.g., ECG, GSR) and subsequent analyses revealed a correlation between BIP and physiological responses [3,6].

Similarly, through the Full Body Illusion paradigm [7], multisensory conflicts can be generated. This technique is structured in two conditions of multisensory stimulation within a virtual reality environment, where one condition corresponds to synchronous multisensory (visual-tactile) stimulation, while the second condition corresponds to asynchronous multisensory (visual-tactile) stimulation. Evidence from this technique shows that the asynchronous stimulation condition can generate multisensory conflict in people.

Previous studies have analysed BIP through tools such as machine learning (ML). In these studies, data were collected and used to train algorithms for classification, such as user movement, user awareness of the virtual environment and video quality [8]. Other studies, on the other hand, have turned, again using ML tools, towards the identification of the user's sense of presence during VR experiences [9], i.e. an element strongly related to BIP, by extracting data such as verbal and non-verbal behavioural cues [10].

Despite the introduction of ML to predict BIP, the prediction methods for this phenomenon are still diverse and unexplored.

Considering what has emerged from the literature, the present study uses the FBI as a tool to generate a multisensory integration conflict; during exposure to the FBI condition, the participants' cardiac physiological parameters (ECGs) are collected and through these data, an ML algorithm is trained to detect and recognise the multisensory conflicts underlying BIPs during a virtual reality experience.

In other words, the aim of this study is to create an ML capable of classifying and recognising the multisensory conflicts underlying BIP using only the physiological data (ECG) collected during BIP.

2. Methods

To train our ML we used data from a previous study. In this previous study, 15 female participants (mean age = 22, SD =0.59) were involved in a FBI experiment [7], where we used a validated virtual reality (VR) body illusion, while the same participants were connected to 3 electrodes of a biosensor to also collect their cardiac tracing (electrocardiogram/ ECG).

The VRE used for the FBI was characterised by a room with the body of a female avatar inside. The objective of the FBI was to create the illusion in the participant that they were the owner of that body, that they were that avatar, and to facilitate this illusion we asked participants to view the avatar in the first person through the head-mounted display.

While the participants viewed the VRE and the avatar in the first person, they were subjected to multi-sensory visual-tactile stimulation. The stimulation consisted of the one hand of a tactile stimulus, i.e. a paintbrush touching the abdomen of both the avatar and the participant, while the other stimulus, the visual stimulus, was provided by the sight of the paintbrush itself moving.

The brush was visualised as such in VR while in reality, it corresponded to a VR controller used by the experimenter to stimulate the abdomen of the participant.

This study comprised two conditions: the synchronous condition, in which the movement and touch of the brush in VR were synchronous to the touch and movement of the VR controller used by the experimenter, and the asynchronous condition, in which

the movement of the brush, in the VR environment, did not correspond to the movement and touch made through the VR controller used by the experimenter outside of VR.

As described above, all participants were connected to a biosensor to collect ECG traces during multisensory stimulation in both conditions (synchronous and asynchronous).

In this study, however, we created a dataset using the previously collected ECG traces. We performed an explanatory analysis on these data and then started from this dataset to use some ML algorithms on it, with the aim of classifying and recognising, starting from the cardiac tracings, when a multisensory conflict is present in a VR experience (asynchronous condition) and when a multisensory conflict is not present (synchronous condition). By multisensory conflict, we mean a condition in which there is dissonance in the sensory stimuli being perceived, which can potentially generate a break in presence (BIP).

To develop the ML, we followed several steps.

Our dataset, containing the raw ECG traces, underwent the pre-processing and segmentation phase. For these and subsequent phases we used Colab and several Pithon libraries such as pandas, mne, Heartpy, and harvanlysis.

Thanks to this phase we extracted, from the initial ECG data: the heartbeats (in beats per minute), the inter-beat times (in milliseconds), removed any outliers, interpolated any missing values (NaN) in the processed signal, removed any ectopic beats, calculated the time domain characteristics and calculated the frequency domain characteristics.

We then created a new dataset containing all participants, all conditions linked to each participant (baseline, ECGs associated with asynchronous pacing, ECGs associated with synchronous pacing) and all Heart Rate Variability (HRV) analyses performed on each ECG tracing.

This dataset was then used as the basis for the machine learning algorithm.

The first step we performed on the dataset was to use principal component analysis (PCA), which is a statistical technique commonly used to analyse a multivariate dataset in order to reduce its complexity. PCA allows us to find new variables, called principal components, that explain most of the variance in the original data [11]. With this technique, we have significantly reduced the amount of data in the dataset, making it easier to represent the variables that explain the variance between the conditions we are considering, namely the baseline condition, the asynchronous condition and the synchronous condition.

Next, we split our dataset, containing all the subjects, the conditions they were exposed to and the principal components obtained through PCA, and divided it into two parts, the training set and the test set.

Through the training set, we trained the ML algorithm to identify the relationships between the 3 conditions considered (baseline, synchronous and asynchronous), i.e. the labels and the corresponding physiological (ECG) traces. In this way, the model was trained to distinguish the different conditions through the differences in the ECG tracings. Once the model was trained, we used the training test to evaluate the performance of the ML model.

In this training phase, we selected 4 different types of machine learning algorithms, namely Decision Tree [12], K-Nearest Neighbors [13], Linear Support Vector [14] and Random Forest [15], and trained them on our dataset.

We assessed the quality of their performance by means of some metrics such as precision, which indicates how accurately the ML model predicted positive instances, i.e. labels (baseline, asynchronous, synchronous); recall, which indicates how accurate the model is in identifying positive instances; F1-score, which corresponds to a balanced measure between precision and recall and provides a general estimate on the quality of the model; and support, which indicates the number of samples of each class in the dataset.

Finally, we used the cross-validation technique [16] to avoid model overfitting problems and to more accurately assess the accuracy of a prediction model.

3. Results

Through the use of a report, already mentioned in the methods section, we analysed the quality of performance produced by the 4 machine learning algorithms used.

Table 1. This table shows the performance of the Decision Tree model, i.e. the ML algorithm with the best performance of the 4 algorithms used. The graph shows the model's score in relation to 4 metrics: precision, recall, F1- score and support

	Testing Decision Tree			
	Precision	**Recall**	**F-1 Score**	**Support**
0 Async	1.00	0.80	0.89	5
1 Baseline	0.43	0.75	0.55	4
2 Sync	0.67	0.40	0.50	5
Accuracy:			0.64	14
Macro avg:	0.70	0.65	0.64	14
Weighted Avg:	0.72	0.64	0.64	14

This model, Decision Tree, achieved performance in the test set of 64% for the prediction of all 3 conditions considered (baseline, asynchronous and synchronous), proving to be the best compared to the other 3 algorithms used (Random Forest, K-Neighbors Classifier, Linear SVC).

Analysing the prediction accuracy for the individual conditions, it can be seen that the model achieved good accuracy in predicting the asynchronous condition (precision 100%, recall 80% and F1-score 89%); while for the other two conditions, baseline (precision 43%, recall 75% and F1-score 55%) and synchronous (precision 67%, recall 40% and F1-score 50%), the % accuracy was lower.

The other three models performed respectively lower than the Decision Tree model; Random Forest scored 57%, K-Neighbors Classifier 57% and Linear SVC 29%.

4. Discussion

The results showed that for all 4 algorithms used, the performance of the modelling in predicting all 3 conditions, i.e. multisensory stimulation condition in synchronous and asynchronous virtual reality and baseline, was not particularly high.

The Linear SVC model achieved a prediction accuracy of 29%, proving to be the worst algorithm in predicting the 3 conditions. In contrast, the other three algorithms, Decision Tree, K-Neighbors Classifier and Random Forest proved to be more accurate, with the former performing at 64% accuracy and the latter and the third at 57% accuracy.

One of the possible causes associated with this low accuracy rate could be the low amount of data in our dataset, which was then used for training. This is because if the dataset for the ML training is too small, the models may have difficulty identifying the variety of data, consequently leading to low accuracy in the testing set.

The most interesting finding, however, was not the overall accuracy of the models; in fact, what was highlighted was that both the Decision Tree model and the Random Forest model were shown to have a high degree of accuracy in predicting one of the three conditions we wanted them to predict, namely the condition of asynchronous multisensory stimulation, in other words, the condition in which a multisensory conflict was present.

This asynchronous condition corresponded to when the participant, while immersed in the VRE, was stimulated on the abdomen by the VR controller moved by the experimenter, and at the same time, the participant saw in the VR a brush that moved asynchronously to the tactile sensation that the controller produced on his abdomen.

This asynchronous condition can be defined as a condition that can potentially generate a multisensory conflict, i.e. a condition in which the person perceives that there is a discrepancy between two sensory stimuli that should not have any between them (the

paintbrush should move in the same area of the abdomen in which the touch of the paintbrush is perceived).

From the analysis of this evidence, we can state that the ML Decision Tree and also Random Forest, although the latter did not perform as well as the former, are two models capable of identifying the multisensory conflicts underlying BIP [1] from ECG traces alone. These ML models could be used to enhance the virtual reality experience in different contexts such as gaming, entertainment or even the clinical setting. An advantage these tools can provide is that they can detect the multisensory conflict underlying BIP without the need to collect subjective measures directly from the user, thus preserving the virtual reality experience.

Despite these final considerations, another limitation emerges in this study, in addition to the limited sample number, namely the amount of physiological data collected. It might be functional in future studies to increase the amount of physiological data collected during FBI exposure. Data related to skin conductance [17] or user movement [8] could be collected, so as to try to further increase the accuracy of classifiers in predicting BIP during exposure to the asynchronous FBI condition.

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References

[1] Slater M, Steed A. A Virtual Presence Counter. Presence: Teleoperators and Virtual Environments. 2000 Oct;9(5):413–34.
[2] Slater M, Brogni A, Steed A. Physiological responses to breaks in presence: A pilot study. In Presence 2003: The 6th annual international workshop on presence (Vol 157) . 2003;157.
[3] Garau M, Friedman D, Widenfeld HR, Antley A, Brogni A, Slater M. Temporal and Spatial Variations in Presence: Qualitative Analysis of Interviews from an Experiment on Breaks in Presence. Presence: Teleoperators and Virtual Environments. 2008 Jun 1;17(3):293–309.
[4] Miller LE, Longo MR, Saygin AP. Visual illusion of tool use recalibrates tactile perception. Cognition. 2017 May;162:32–40.
[5] Stein BE, Stanford TR, Rowland BA. Development of multisensory integration from the perspective of the individual neuron. Nat Rev Neurosci. 2014 Aug 18;15(8):520–35.
[6] Slater M, Guger C, Edlinger G, Leeb R, Pfurtscheller G, Antley A, et al. Analysis of Physiological Responses to a Social Situation in an Immersive Virtual Environment. Presence: Teleoperators and Virtual Environments. 2006 Oct 1;15(5):553–69.
[7] Keizer A, van Elburg A, Helms R, Dijkerman HC. A Virtual Reality Full Body Illusion Improves Body Image Disturbance in Anorexia Nervosa. PLoS One. 2016 Oct 6;11(10):e0163921.
[8] Chen M, Semiari O, Saad W, Liu X, Yin C. Federated Echo State Learning for Minimizing Breaks in Presence in Wireless Virtual Reality Networks. IEEE Trans Wirel Commun. 2020 Jan;19(1):177–91.
[9] Slater M, Banakou D, Beacco A, Gallego J, Macia-Varela F, Oliva R. A Separate Reality: An Update on Place Illusion and Plausibility in Virtual Reality. Front Virtual Real. 2022 Jun 27;3.
[10] Magalie O, Sameer J, Philippe B. Toward an Automatic Prediction of the Sense of Presence in Virtual Reality Environment. In: Proceedings of the 6th International Conference on Human-Agent Interaction. New York, NY, USA: ACM; 2018. p. 161–6.
[11] Howley T, Madden MG, O'Connell ML, Ryder AG. The Effect of Principal Component Analysis on Machine Learning Accuracy with High Dimensional Spectral Data. In: Applications and Innovations in Intelligent Systems XIII. London: Springer London; p. 209–22.
[12] Belgiu M, Drăguţ L. Random forest in remote sensing: A review of applications and future directions. ISPRS Journal of Photogrammetry and Remote Sensing. 2016 Apr;114:24–31.
[13] Wang JS, Lin CW, Yang YTC. A k-nearest-neighbor classifier with heart rate variability feature-based transformation algorithm for driving stress recognition. Neurocomputing. 2013 Sep;116:136–43.
[14] Bhavsar H and MHP. "A review on support vector machine for data classification." . International Journal of Advanced Research in Computer Engineering & Technology . 2012;185–9.
[15] Fawagreh K, Gaber MM, Elyan E. Random forests: from early developments to recent advancements. Systems Science & Control Engineering. 2014 Dec 6;2(1):602–9.
[16] Ghojogh B, Crowley M. The Theory Behind Overfitting, Cross Validation, Regularization, Bagging, and Boosting: Tutorial. 2019 May 28;
[17] Oscar I. Caldas, Mauricio Mauledoux, Oscar Fernando Aviles Sánchez, Carlos Rodriguez-Guerrero. Breaking Presence in Immersive Virtual Reality Toward Behavioral and Emotional Engagement. SSRN . 2023 Mar.

Eye-Tracking and Virtual Reality-based Attentional Bias Modification Training to Improve Mirror Exposure Therapy: preliminary findings from a multiple case study with Anorexia Nervosa patients

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Abstract. Attentional bias modification training (ABMT) is an effective technique for reducing the dysfunctional body-related attentional bias (AB) that may be responsible for reducing the effectiveness of mirror exposure therapy (MET), which has been proposed as an effective treatment for anorexia nervosa (AN). This multiple-case study provides evidence of the usefulness of incorporating ABMT into virtual reality (VR) and eye-tracking (ET)-based MET to improve its efficacy in the treatment of four female adolescents with AN. Over five exposure sessions, patients were immersed in a virtual environment and were embodied in a real-size body virtual avatar reflected in a mirror that gradually increased body mass index (BMI) until reaching a healthy BMI in the last session. In every session, the participants completed the ABMT followed by the MET. This augmentation of MET using VR-ET-based ABMT achieved promising results for targeting AN symptomatology by reducing body dissatisfaction, drive for thinness, weight-related body parts anxiety, body checking behaviors, fear of gaining weight, and anxiety, and increasing body appreciation. Two patients who did not show a reduction in fear of gaining weight during the sessions also showed high anxiety levels, which could have affected its reduction. To advance this preliminary study and evaluate the effectiveness of incorporating ABMT into MET, a controlled clinical trial will be conducted.

Keywords. Anorexia nervosa, attentional bias modification training, mirror exposure therapy, virtual reality, eye-tracking

1. Introduction

Patients with Anorexia Nervosa (AN) show a phenomenon known as body-related attentional bias (AB), i.e., the tendency to focus more attention on self-reported unattractive body parts and weight-related body parts than other body parts [1-3].

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The presence of dysfunctional body-related AB may be responsible for reducing the effectiveness of mirror exposure therapy (MET) [2], which is frequently used to intensify traditional cognitive behavioral therapy (CBT) and has been proposed as an effective treatment for AN by reducing eating disorder (ED) symptomatology [3,4]. MET involves the patient systematically observing their body reflected in a mirror for a certain amount of time expressing their emotions and thoughts about their body [5]. Patients with AN who tend to focus more on weight-related body parts and ignore non-weight-related body parts (interfering with the exposure-based task) could benefit less from MET [2].

By means of attentional bias modification training (ABMT) it is possible to reduce AB by altering selective attention patterns [6]. A previous study developed an effective ABMT based on a combination of virtual reality (VR) and eye-tracking (ET) by balancing attention between weight-related body parts and non-weight-related body parts in healthy subjects, thus achieving equilibrated attention to the whole body [7]. The combination of VR and ET devices allows accurate and objective control of the attentional patterns in settings simulating real-life situations in highly controlled situations, overcoming the limitations of the traditional ABMT techniques [8].

This multiple-case study aims to provide preliminary evidence of the usefulness of incorporating ABMT into a VR and ET-based MET to improve its results in the treatment of four female adolescents with AN.

2. Method

2.1 Participants

Four female adolescents diagnosed with restrictive AN, according to the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) [9], at the ED Unit of Hospital Sant Joan de Déu of Barcelona, participated in this study. Patient 1 was 14 years old, presented with an adjustment disorder with anxiety, received pharmacological treatment based on antidepressants and antipsychotics and underwent 11 hours of intensive day-patient treatment. Patient 2 was 16 years old, underwent 5 hours of day-patient treatment, did not present any comorbidity, and did not receive any pharmacological treatment. Patient 3 was 17 years old, presented with a major depressive disorder and anxiety disorder, received pharmacological treatment based on antidepressants and occasional anxiolytics and underwent 11 hours of intensive day-patient treatment. Patient 4 was 17 years old, presented with a major depressive disorder, received pharmacological treatment with anxiolytics and antidepressants and underwent outpatient program treatment.

The outpatient program was for patients with good treatment compliance and lower biopsychological risk, whereas the day-patient treatment (sleeping at home) was for those whose weight restoration and eating behaviors were not improving. The treatment at the ED Unit consisted of individual and group CBT, nutritional rehabilitation, and individual and group parent counseling.

2.2 Instruments

Participants were exposed to an immersive virtual environment using a head-mounted display (HMD HTC VIVE Pro Eye®) with an integrated ET device (Tobii®) and were embodied in a real-size body virtual avatar. In addition to the head-mounted display, two hand controllers and two-foot trackers were used to achieve full-body motion tracking of the patients. The VR environment was designed using Unity 3D 5.6.1 software and consisted of a room with a large mirror on the wall placed 1.5 virtual meters in front of the patient, and two boxes placed on the floor next to the avatar's feet. The patients could see themselves, through their avatars, in the first-person perspective and the third-person perspective, reflected in a mirror, even when they were moving. The virtual avatar was designed using the Blender v. 2.78 software. The avatar wore a simple top with jeans, which could be changed in color to match the participants' clothing, black trainers, a head-mounted display, like the patient during the task, and a grey hat to reduce any influence of hairstyle.

2.3. Measures

The following measures were assessed before starting the treatment (pre-treatment) and at the end of the treatment (post-treatment):

- The change in body weight was assessed using body mass index (BMI).
- Body dissatisfaction was assessed using the Spanish version of the body dissatisfaction subscale of the Eating Disorder Inventory-3 (EDI-BD) [10].
- Drive for thinness was assessed using the Spanish version of the drive for thinness subscale of the Eating Disorder Inventory-3 (EDI-DT) [10].
- State weight-related body parts anxiety was assessed using the weight subscale of the Physical Appearance State and Trait Anxiety Scale (PASTAS) [11].
- Frequency of body-checking behaviors was assessed using the Body Checking Questionnaire (BCQ) [12].
- Body appreciation was assessed using the Body Appreciation Scale (BAS) [13].

Full body ownership illusion over the virtual avatar, i.e., feeling the virtual bodies as their own, fear of gaining weight and anxiety were assessed in each of the treatment sessions, as well as before and after the overall intervention through Visual Analogue Scales (VAS) from 0 to 100.

2.4. Procedure

The ethics committees of the Universitat de Barcelona and Hospital Sant Joan de Déu of Barcelona approved this study. Before treatment, written informed consent was obtained from the patients and their parents. The treatment was conducted over five sessions, once a week, with a pre-treatment session and a post-treatment session.

During the pre-treatment session, the virtual avatar was created by taking a frontal and a lateral photo of the patient. The photos and the silhouette of the virtual body were manually matched by adjusting the avatar's body parts to the patient's silhouette. In the meantime, the patients completed pre-treatment questionnaires and then were immersed in the virtual environment. After inducing the full body ownership illusion, using a 5-minute procedure, including visuo-motor and visuo-tactile stimulation techniques [14], the full body ownership illusion, the fear of gaining weight and the anxiety levels were assessed using the VAS.

Each clinical session was carried out in the virtual environment and was characterized by inducing the full body ownership illusion, completing the ABMT followed by the MET and assessing the full body ownership illusion, fear of gaining weight and anxiety levels using the VAS. At the end of each session, the patients were exposed to a relaxing VR environment for 5 minutes. In the first session, each patient was exposed to a virtual body with her real BMI. During subsequent sessions, the BMI of the avatar progressively increased until it reached a healthy BMI.

The ABMT was based on an adaptation of the AB induction procedure proposed by Smeets et al. [6] and was developed through the visual selection of geometric figures with different colors that fitted with specific body areas. Patients were instructed to detect and identify the figures that appeared on different parts of the avatar's body reflected in the mirror. Specifically, participants were asked to stare for 4 seconds at the specific body part where the figures appeared, while it was progressively illuminated. Afterwards, the figure appeared on another part of the body. In 45% of the trials, the geometric figures appeared on weight-related body parts, in another 45% of the trials the figures appeared on non-weight-related body parts and in the remaining 10% of the trials the figures appeared on two neutral stimuli located next to the avatar (Figure 1a-c).

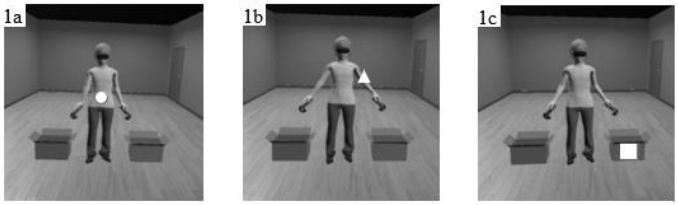

Figure 1. Geometric figures appear on a weight-related body part (1a), on a non-weight-related body part (1b), and on a neutral stimulus (1c).

During MET, the patient was asked to focus on different parts of the virtual body and to orally report her thoughts and feelings about them. The level of anxiety experienced was evaluated every 120 seconds using a VAS. Each of the following treatment sessions began with an avatar with a progressively increasing BMI following the hierarchy only if anxiety had fallen by 40% in the last session.

In the post-treatment session, the patients answered the post-treatment questionnaires and then were immersed in the virtual environment. After inducing the full body ownership illusion, the levels of fear of gaining weight, full body ownership illusion and anxiety were assessed using the VAS.

2.5. Statistical analysis

Reliable changes were calculated for the post-treatment measurements only for the measures with available clinical and community means and standard deviations, provided by the sources for each measure: EDI-DT, EDI-BD, PASTAS, BAS and BCQ. The analyses were conducted following the guidelines of Jacobson and Truax [15] and using the Leeds Reliable Change Index (RCI) calculator in Excel [16] for single cases. An RCI that is greater than 1.96 denotes a reliable change, i.e., a statistically significant difference.

3. Results

Scores from the questionnaire administered pre- and post-treatment for the body dissatisfaction, drive for thinness, body anxiety, body appreciation, and body-checking behaviors variables and their related RCI are given in Table 1 below.

Table 1. Patients' pre-treatment and post-treatment scores and RCIs for body dissatisfaction, drive for thinness, weight-related body parts anxiety, body appreciation and body checking behavior variables.

	PATIENT 1			**PATIENT 2**			**PATIENT 3**			**PATIENT 4**		
	Pre treatment score	**Post treatment score**	**RCI**	**Pre treatment score**	**Post treatment score**	**RCI**	**Pre treatment score**	**Post treatment score**	**RCI**	**Pre treatment score**	**Post treatment score**	**RCI**
EDI-BD	29	14	2.97*	34	31	0.59	34	30	0.79	27	16	2.18*
EDI-DT	25	3	5.68*	28	28	0	28	25	0.77	14	5	2.32*
PASTAS	22	5	9.64*	20	11	5.1*	23	21	1.13	1	4	-1.7
BAS	18	48	-6.82*	15	18	-0.68	24	28	-0.91	24	46	-5*
BCQ	76	46	3.27*	102	90	1.31	90	73	1.85	49	36	1.42

Note: RCI= reliable change index; EDI-BD: body dissatisfaction subscale; EDI-DT: drive for thinness subscale; PASTAS: Physical Appearance State and Trait Anxiety Scale; BAS: Body Appreciation Scale; BCQ: Body Checking Questionnaire. Significant differences *RCI >1.96.

Pre- and post-treatment BMI values and VAS scores for full body ownership illusion, fear of gaining weight and anxiety assessed in each of the treatment sessions, as well as before and after the overall intervention, are given in Figure 2 and Figure 3a-c, respectively.

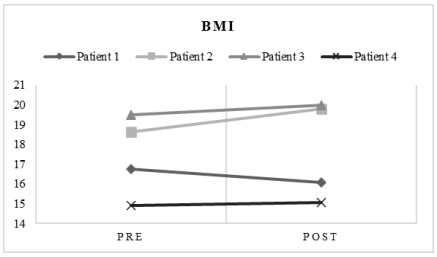

Figure 2. Body mass index (BMI) values pre-treatment (PRE) and post-treatment (POST).

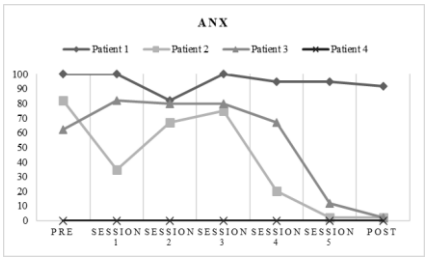

Figure 3a. Anxiety (ANX) scores pre-treatment (PRE), during the five-exposure sessions and post-treatment (POST).

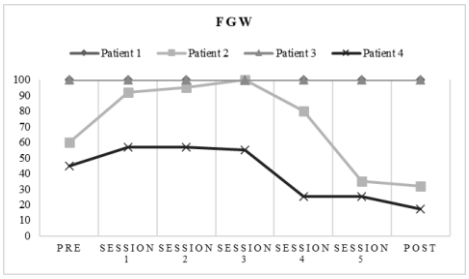

Figure 3b. Fear of gaining weight (FGW) scores pre-treatment (PRE), during the five-exposure sessions and post-treatment (POST).

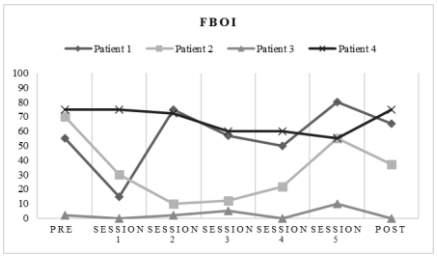

Figure 3c. Full body ownership illusion (FBOI) scores pre-treatment (PRE), during the five-exposure sessions and post-treatment (POST).

Patient 1 showed a significant reduction in body dissatisfaction, drive for thinness, body anxiety, and body-checking behaviors and a significant increase in body appreciation. Across all sessions, the patient maintained a medium-high full body ownership illusion level and a very high level of fear of gaining weight and anxiety, which was not reduced by 40% during any session. Patient 2 showed a significant reduction in body anxiety and a very slight non-significant improvement in body dissatisfaction, body appreciation and body-checking behaviors. There was no change in drive for thinness. In the first few sessions, this patient showed a low level of full body ownership illusion and a high level of anxiety with no reduction in fear of gaining weight. During the last few sessions, the level of full body ownership illusion became higher, the level of anxiety declined by 40%, allowing her to progress through the BMI hierarchy, and the fear of gaining weight levels decreased. Patient 3 showed a very slight non-significant improvement in body dissatisfaction, drive for thinness, body anxiety, body appreciation and body-checking behaviors. This patient showed very low full body ownership illusion, high anxiety levels that were only reduced by 40% during the last session and post-treatment, and very high levels of fear of gaining weight. Patient 4 showed a significant improvement in body dissatisfaction, drive for thinness and body appreciation and a non-significant improvement in body-checking behaviors. The level of body anxiety pre-treatment was zero and this level was maintained even post-treatment. A medium-high level of full body ownership illusion and absence of anxiety were maintained across all sessions, allowing her to progress through the BMI hierarchy until she reached the minimum healthy weight of the avatar in the last session. Fear of gaining weight levels decreased from the 4th treatment session onwards.

Most participants' BMI increased slightly during the sessions (except for patient 1 whose BMI decreased slightly) but none of the patients reached the minimum healthy weight.

4. Conclusion

This augmentation of MET using VR-ET-based ABMT achieved promising results for targeting AN symptomatology, improving body dissatisfaction, drive for thinness, body anxiety, body-checking behaviors and body appreciation even if not significantly for all

patients. In addition, BMI levels were slightly improved at the end of the intervention, except in one patient.

ABMT before VR-ET-MET aims to enhance the reduction of ED symptoms and fear of gaining weight through exposure to a gradual increase in BMI [3]. Two patients did not show a reduction in fear of gaining weight during the sessions. Patients 1 and 3, both reporting anxiety disorders, showed a very high level of anxiety, which was not reduced by 40% during the sessions, thus preventing them from progressing through the BMI hierarchy. Patients who were not exposed to a virtual body with an increased BMI could not have developed a habituation process to the anxiety response that gaining weight could activate, therefore, this could explain the failure to reduce fear of gaining weight levels [17]. However, patient 1 showed a high level of full body ownership illusion that increased identification with the avatar with her real weight during the ABMT and MET sessions, probably helping to improve the effectiveness of the treatment. In contrast, patient 3 reported the absence of full body ownership illusion during all sessions and did not identify herself with the virtual avatar, which could explain the lack of effect of the treatment [3].

The current study assessed the incorporation of a pioneering ABMT procedure into MET, taking advantage of VR and ET technologies that might open up a wide range of possibilities for new body-related interventions in patients with AN that could help improve their symptomatology. A controlled clinical trial should be conducted to advance this preliminary study and evaluate the effectiveness of incorporating ABMT into VR-ET-based MET. Our group has already started a randomized controlled clinical trial (clinicaltrials.gov, NCT 04786951) in which we are comparing three experimental conditions: ABMT before VR-ET-MET with added CBT, VR-ET-MET with added CBT, and CBT alone.

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References

[1] Bauer S, Schneider S Waldorf M, Braks K, Huber TJ, Adolph D, Vocks S. Selective Visual Attention Towards Oneself and Associated State Body Satisfaction: An Eye-Tracking Study in Adolescents with Different Types of Eating Disorders. Journal of Abnormal Child Psychology. 2017; 45,1647–1661, https://doi.org/10.1007/s10802-017-0263-z

[2] Ferrer-Garcia M, Porras-Garcia B, Miquel H, Serrano-Troncoso E, Carulla-Roig M, Gutiérrez J. The way we look at our own body really matters! Body-related attentional bias as a predictor of worse clinical outcomes after a virtual reality body exposure therapy. 25th Annual International CyberPsychology, CyberTherapy & Social Networking Conference, 2021

[3] Porras-Garcia B, Ferrer-Garcia M, Serrano-Troncoso E, Carulla-Roig M, Soto-Usera P, Miquel-Nabau H, Olivares LFC, Marnet-Fiol R, Santos-Carrasco IM, Borszewski B, Díaz-Marsá M, Sánchez-Díaz I, Fernández-Aranda F, Gutiérrez-Maldonado J. AN-VR-BE. A Randomized Controlled Trial for Reducing Fear of Gaining Weight and Other Eating Disorder Symptoms in Anorexia Nervosa through Virtual Reality-Based Body Exposure. Journal of clinical medicine. 2021; 10(4), 682, https://doi.org/10.3390/jcm10040682

[4] Griffen TC, Naumann E, Hildebrandt T. Mirror exposure therapy for body image disturbances and eating disorders: A review. Clinical Psychology Review 2018; 65:163–74, https://doi.org/10.1016/j.cpr.2018.08.006

[5] Moreno-Domínguez S, Rodríguez-Ruiz S, Fernández-Santaella MC, Jansen A, Tuschen-Caffier B. Pure versus guided mirror exposure to reduce body dissatisfaction: A preliminary study with university women. Body Image 2012, 9, 285–288, https://doi.org/10.1016/j.bodyim.2011.12.001

[6] Smeets E, Jansen A, Roefs A. Bias for the (un)attractive self: on the role of attention in causing body (dis)satisfaction. Health psychology: official journal of the Division of Health Psychology, American Psychological Association. 2011; 30(3), 360–367, https://doi.org/10.1037/a0022095

[7] Meschberger-Annweiler FA, Ascione M, Porras-Garcia B, Ferrer-Garcia M, Moreno-Sanchez M, Miquel-Nabau H, Serrano-Troncoso E, Carulla-Roig M, Gutiérrez-Maldonado J. An Attentional Bias Modification Task, through Virtual Reality and Eye-Tracking Technologies, to Enhance the Treatment of Anorexia Nervosa. Journal of Clinical Medicine. 2023; 12(6):2185, https://doi.org/10.3390/jcm12062185

[8] Hertel PT, Mathews A. Cognitive Bias Modification: Past Perspectives, Current Findings, and Future Applications. Perspectives on Psychological Science. 2011; 6(6),521–536, https://doi.org/10.1177/1745691611421205

[9] American Psychiatric Association. Diagnostic and statistical manual of mental disorders. 5th ed. 2013; https://doi.org/10.1176/appi.books.9780890425596

[10] Garner D. Eating Disorder Inventory-3: Professional Manual; Psychological Assessment Resources: Lutz, FL, USA, 2004.

[11] Reed DL, Thompson J, Brannick MT, Sacco WP. Development and validation of the Physical Appearance State and Trait Anxiety Scale. J. Anxiety Disord. 1991; 5,323–332, https://doi.org/10.1016/0887-6185(91)90032-O

[12] Reas DL, Whisenhunt BL, Netemeyer R, Williamson DA. Development of the body checking questionnaire: A self-report measure of body checking behaviors. International Journal of Eating Disorders. 2002; 31(3),324–333, https://doi.org/10.1002/eat.10012

[13] Avalos, L, Tylka TL, Wood-Barcalow N. The Body Appreciation Scale: Development and psychometric evaluation. Body Image. 2005; 2,285–297, https://doi.org/10.1016/j.bodyim.2005.06.002

[14] Porras-Garcia B, Ferrer-Garcia M, Serrano-Troncoso E, Carulla-Roig M, Soto-Usera P, Miquel-Nabau H, Shojaeian N, De la Montaña Santos-Carrasco I, Borszewski B, Díaz-Marsá M, Sánchez-Díaz I, Fernández-Aranda F, Gutiérrez-Maldonado J. Validity of Virtual Reality Body Exposure to Elicit Fear of Gaining Weight, Body Anxiety and Body-Related Attentional Bias in Patients with Anorexia Nervosa. Journal of clinical medicine. 2020; 9(10), 3210, https://doi.org/10.3390/jcm9103210

[15] Jacobson NS, Truax P. Clinical significance: a statistical approach to defining meaningful change in psychotherapy research. Journal of consulting and clinical psychology. 1991; 59(1), 12–19, https://doi.org/10.1037//0022-006x.59.1.12

[16] Morley S, Dowzer CN. Manual for the Leeds Reliable Change Indicator: Simple Excel(tm) applications for the analysis of individual patient and group data. University of Leeds, Leeds, UK; 2014.

[17] Vocks S, Wächter A, Wucherer M, Kosfelder J. Look at yourself: can body image therapy affect the cognitive and emotional response to seeing oneself in the mirror in eating disorders? European eating disorders review: the journal of the Eating Disorders Association. 2008; 16(2), 147–154, https://doi.org/10.1002/erv.825

XAI in Affective Computing: a Preliminary Study

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Abstract. Affective computing is a rapidly growing field that aims to understand human emotions through Artificial Intelligence. One of the most promising ways to achieve this goal is the use of physiological data (e.g. electrocardiogram - ECG) and Machine Learning (ML) algorithms to classify affective states. ECG correlates, such as Heart Rate Variability (HRV) and its features, are reported as viable indicators in both dimensional approaches, especially for valence, and in detecting discrete emotions. In this preliminary study, we used the ECG data from the open-source HCI Tagging Database, which includes physiological data and self-referred feedback from 30 subjects who watched videos designed to elicit different emotions. The subjects evaluated their reactions using a three-dimensional affective space defined by arousal, valence, and dominance levels and reported the emotions they felt. To classify the affective states, we trained and tested different classification algorithms on the HRV features, using as labels, each self-reported feedback (i.e., valence, arousal, dominance, and emotions). The results showed that HRV features, when combined with normalization methods and ML algorithms, were effective in recognizing emotions as experienced by individuals. In particular, the study showed that Decision Tree was the best-performing algorithm for predicting emotions based on HRV data. Additionally, an Explainable AI (XAI) model provided insights into the weight of these features in the ML discrimination phases. Overall, the study highlights the potential of HRV as a valid and unobtrusive source for detecting emotional states.

Keywords. Machine Learning, ECG, HRV, Emotion recognition, Explainable AI (XAI)

1. Introduction

Affective Computing is an approach defined by Picard [1] that links computing and human emotions; one of its branches aims at the detection of emotional states by interpreting with Machine Learning (ML) physiological signals. Affective Computer models typically follow a standard workflow [2–4], in which the subjects are presented with different emotional stimuli, while their EEG or peripheral signals are recorded. These data are used to populate a database, with each condition paired with a label, extrapolated from the personal evaluation provided by the subject. Data are

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preprocessed, and features, typical of the used signal, are computed. In some cases, normalization and further feature selections or aggregations are performed. A classification ML model is afterward trained to predict the corresponding label from the physiological data.

The labeling of the emotional state is defined in accordance with the selected emotion model, based on discrete emotions or continuous dimensions [3]. The first, initially proposed by Ekman [5] assumes that emotions are distinct, measurable, and universal. The idea of a continuous spectrum of emotions arises instead from Russell and his Circumplex Model of Affect [6], in which emotions are distributed in a cartesian space created around two perpendicular axes of pleasantness and activation. This idea would then be repurposed on a 3-axis space, Valence (from positive to negative), Arousal (from calm to excited), and Dominance (from submissive/controlled to Dominant) [7,8]. A viable solution for assessing these dimensions is the Self-Assessment Manikins (SAM), three graphical 9 or 5-point scales representing the affective experiences [8]. After data are correctly labeled in accordance with subjective perception, a classifier is trained to predict the emotional label from the physiological data: many algorithms are tested, and their performances compared. Literature reports a wide use of Support Vector Machine (SVM), K-nearest neighbors (KNN), Random Tree (RT), Decision Tree (DT), and more complex frameworks, like Deep Learning [3].

When a Database for Affective Computing is created, multiple sources of data are usually collected [3,9–11]: the most frequent signals are Electroencephalogram (EEG), Electrocardiogram (ECG), Electrodermal activity (EDA), Respiration patterns, Electromyography (EMG) of emotion-linked facial muscles, Skin Temperature, and Eye Gaze movements. In this work, we focus on ECG and, in particular, on Hearth Rate Variability (HRV) feature: these signals are found as a valid source for emotional [12,13] or arousal and valence levels discrimination [13,14]. ECG sensors are nowadays quite common (e.g., in smartwatches) and are particularly unobtrusive to the user [15].

Heart Rate Variability (HRV) measures the variability of the time intervals between heartbeats, which is related to changes in neuro-cardiac functions and is influenced by the autonomic nervous system [16]. Increases in HRV are associated with activation of the Parasympathetic Nervous System (SNP), while a decrease in HRV is linked to increased sympathetic activation. Furthermore, the different HRV frequency components can be linked to the individual's activation [17].

The aim of this preliminary study is the detection of patterns in HRV data that permits to predict the level of Valence, Arousal, and Dominance and the different underlying emotions. We also hypothesize that HRV features, when combined with different normalization methods and ML algorithms, would be more effective in comparison with other peripheral signals at recognizing emotions as experienced by the individuals. The use of an Explainable AI (XAI) model would provide additional insights into the weight of these features in the discrimination of emotional states. Additionally, the study aims to identify the best-performing ML algorithm and normalization method for each classification task, as well as providing performance results.

2. Methods

MAHNOB-HCI database [9], licensable in Open mode [18], was used in this study. MAHNOB-HCI collects multimodal responses (EEG, ECG, EDA, Respiration pattern, and Skin Temperature) of 27 subjects to 20 emotionally connected videos. Participants were asked to evaluate them by kind of Emotion, Valence, Arousal, Dominance, and Predictability levels.

A dataset was created with the ECG data paired with subject-given values (Arousal, Valence, and Dominance evaluated on a 9-point Likert Scale, and which emotion was stirred in them). Each row of the dataset refers to a specific emotion (both on discrete and continuous dimensions) perceived by a subject, paired with the ECG data of the baseline and of the emotion-stimulation task. Before extracting ECG information from the HR time series, outliers, and ectopic beats were removed from the signal and linear

interpolation was computed to replace outlier values. Time and frequency HRV features were extracted from the corrected ECG time series.

Three different normalization conditions were tested: no normalization, normalization before baseline subtraction, and normalization after baseline subtraction. The data normalization was performed by ranging the data from 0 to 1. For each of the three normalization conditions, five supervised learning algorithms were applied for classification, with a 67/33 train-test proportion: Decision Tree, Random Forest, KNeighbors, Support Vector Machine [19], and XGBoost [20]. The following HRV features were used as input features: Min HR, NNI 50, RMMSSD, SDNN, HF, LF, LF/HF ratio, Total Power', Max HR, Mean HR, and Median NNI. The algorithms were trained to predict three different levels of valence, arousal, and dominance, (1-3 low, 4-6 medium, 7-9 high in the 3-step layout, as in [9,21]). Additionally, the algorithms were trained to predict which emotion (Neutral, Anger, Disgust, Fear, Joy, Happiness, Sadness, Surprise, Amusement, Anxiety) was being experienced. Each model also underwent a further Features Selection through a Recursive Feature Elimination with Cross-Validation (RFECV) to select which and how many features should increase the functionality of the model and the dummy value, through a Dummy Classifier, as a benchmark against randomness [19].

To understand the contribution of each feature to the classification tasks, a SHapley Additive exPlanations (SHAP) analysis was performed, both globally and locally, using the SHAP library [22]. SHAP values represent the contribution of each feature to the output of a model, and they help in understanding the decision-making process of the model. This approach is obtained through a model-agnostic explanator, i.e. functions on different kinds of models, without needing to be specifically set [23].

3. Results

In Table 1 are reported the results of the best-performing algorithms for each classification: Arousal, Valence, Dominance, and Emotions. Random Forest and K-Nearest Neighbors perform best for Arousal levels and Emotion discriminations, on not-normalized data and without features-selection, while Decision Tree obtains the best results for Valence levels, on non-normalized data, and on Dominance levels, on data normalized after the subtraction of the baselines, both after an RFECV Features Selection

Table 1. Performance results are divided into target experiences or emotions. The best performance is reported and, in brackets, the Dummy Classifier results. The best-performing algorithm is reported alongside the kind of normalization (NN = no normalization, BN = normalization applied before subtracting the baseline, AN= normalization applied after having subtracted the baseline) and feature selection (YF= yes, NF= no) on which the results were obtained.

Target	Best Performance	Best performing Algorithm
Arousal (3 levels)	51% (28%)	Random Forest and K-nearest neighbors (NN, NF)
Valence (3 levels)	51% (32%)	Decision Tree (NN, YF)
Dominance (3 levels)	46% (26%)	Decision Tree (AN, YF)
Emotion (9 classes)	27% (12%)	Random Forest and K-nearest neighbors (NN, NF)

In Table 2 more detailed results of the best performing algorithm for the recognition of distinct emotions are reported: the states Neutral, Joy/Happiness, Sadness, and Amusement are detected with more than 20% accuracy, Disgust, and Anxiety show a worse performance, while Anger, Fear, and Surprise are never detected. These results are usually influenced by the number of Supports (or examples) of that category: the emotions less represented in the dataset also have weak performance.

Table 2. Detailed performance results for the Emotion detection, obtained through Random Forest. Results are divided by emotion. Precision is the percentage of samples that are positive, based on predictions, Recall is the proportion of positive samples that the predictions successfully capture, F-score is equal to the harmonic mean of recall and precision, and Support is the number of samples in the specific class [24].

Emotion	Precision	Recall	F1-score	Support
Neutral	0.28	0.39	0.32	18
Anger	0.00	0.00	0.0	3
Disgust	0.14	0.11	0.1	9
Fear	0.00	0.00	0.00	5
Joy, Happiness	0.30	0.2	0.27	16
Sadness	0.38	0.66	0.48	12
Surprise	0.00	0.00	0.00	4
Amusement	0.20	0.17	0.18	17
Anxiety	0.16	0.20	0.18	5
Accuracy	0.27	0.27	0.27	0.27
Macro average	0.16	0.20	0.17	89
Weighted average	0.22	0.27	0.24	89

Explanations of the result have been reached with Shap. Figure 1 reports the global explanations (features importance) for Arousal, Valence, and Dominance levels and the different emotions. HR mean appears as an important feature for Arousal, Valence, and Emotions discrimination, LF/HF ratio for Dominance, and Emotions, total ECG power for Arousal and Dominance, LF for Arousal and Valence, while RMSSD seems to be particularly influent in the discrimination of different emotions.

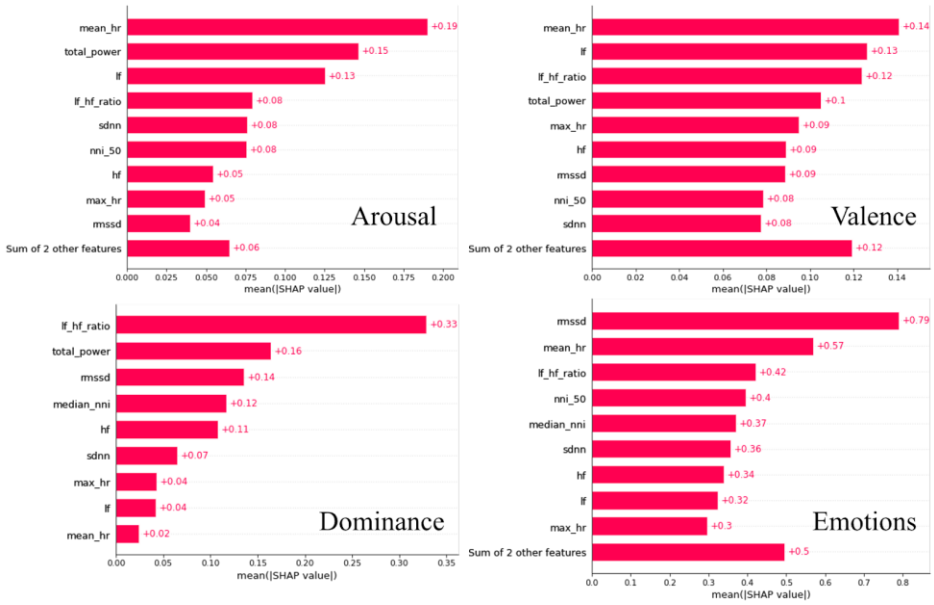

Figure 1. Global SHAP explanation for the result of the best performer algorithm for Arousal, Valence, Dominance, and Emotions. The features are classified for influence to reach the prediction.

For local explanations, a specific example is instead selected, and the weight of the feature is calculated, differentiating for positive or negative influences. Some local explanations for correctly detected emotions are reported in Figure 2, offering some insight into the weight of the features.

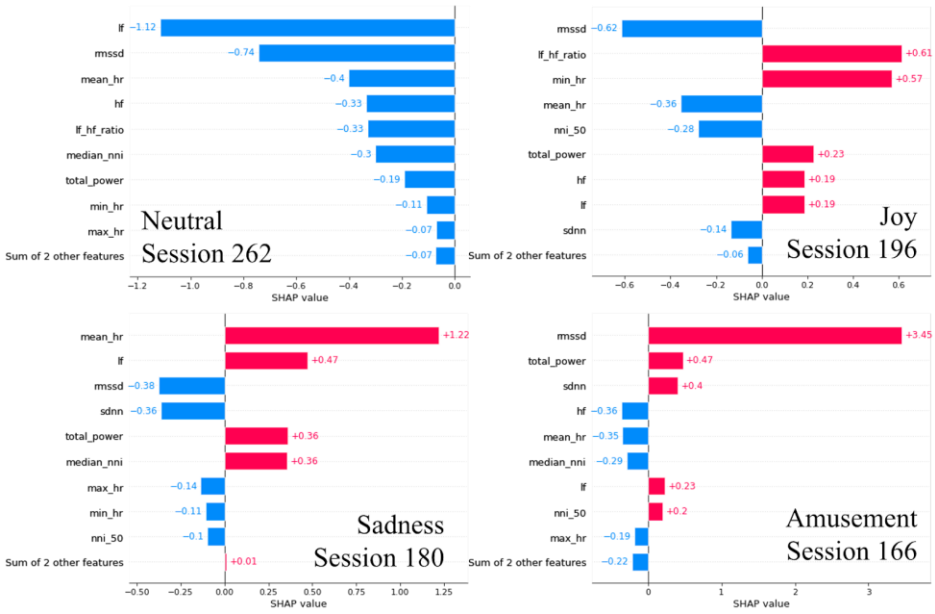

Figure 2. Local SHAP explanation for same selected Sessions of correctly detected emotions. The features are classified for influence to reach the prediction, both in positive and in negative directions.

4. Discussion and Conclusion

The main finding of this preliminary study is that Valence, Arousal, and Dominance levels are characterized by different HR responses. Conversely, only a few emotions seem to affect the HR responses, but this result is deemed due to the low sample size in each emotion. Future research with a larger dataset should be performed to better understand the role of HR in emotion detection.

The results obtained in this study are in line with results reported on the same database. Compared to the results in Soleymani et al., the use of only HRV features reaches better results than including all the peripheral physiology (the reported performance is 46% for Arousal, and 45.5% for Valence) [9]. Ferdinando et al. considered also the ECG signals alone: they raised the performance from 42.6% to 64.1% for Valence and 47.7% to 69.6% for Arousal by applying multiple kinds of Dimensionality Reductions [21]: these techniques, however, render the interpretability of the model more complex, as they modify the input data and make them less recognizable. ECG seems a good signal for detecting Arousal, Valence, and Dominance, especially considering the ease of use and the scarce invasiveness to the subject.

With regard to emotion detection, the performance appears low but higher than the baseline (+15%accuracy): this can partially be explained by the number of examples for each emotion that reduces the training process accuracy. In fact, emotions with the highest sample size can be accurately distinguished and recognized (Table 2). If literature, with different databases, sometimes reports really high results, it needs to be noted how often the discrimination is performed just between two classes, without including results from a dummy classifier that indicates the validity of the prediction [3,4].

The local explanation provided in Figure 2 allows us to evaluate the decision-making process of the ML algorithm to assign an emotion to an example. For example, the low normalized difference between baseline and emotion state in each HRV feature indicates a Neutral emotion. This result indicates that the Neutral emotion does not affect the HRV responses. Differently, the probability to perceive Joy increases as LF-HF ratio, minimal HR, total power, HF, and LF differences increase, while it decreases as the other HRV feature differences increase. Similar results were detected for the other emotions (i.e., Sadness and Amusement) indicating these emotions activate both sympathetic and parasympathetic nervous systems.

In conclusion, the study evaluates the feasibility of using different activation of sympathetic and parasympathetic nervous systems detected by HRV analysis to accurately detect valence, arousal, and dominance levels, showing promising results. Furthermore, even if the accuracy of detecting emotion is low, the results of this work are encouraging, and suggest that with adequate sample size, it will be possible to create an ML model which accurately detects emotions. These preliminary findings are a first step that could lead to the creation of more complex applications aimed at detecting a variety of mental and emotional states. [25,26].

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References

[1] Picard RW. Affective Computing. MIT Press; 2000.
[2] Zheng W-L, Lu B-L. Investigating Critical Frequency Bands and Channels for EEG-Based Emotion Recognition with Deep Neural Networks. IEEE Trans Auton Ment Dev 2015;7:162–75..
[3] Bota PJ, Wang C, Fred ALN, Plácido Da Silva H. A Review, Current Challenges, and Future Possibilities on Emotion Recognition Using Machine Learning and Physiological Signals. IEEE Access 2019;7:140990–1020. https://doi.org/10.1109/ACCESS.2019.2944001.
[4] Wang Y, Song W, Tao W, Liotta A, Yang D, Li X, et al. A systematic review on affective computing: emotion models, databases, and recent advances. Inf Fusion 2022;83-84:19–52. https://doi.org/10.1016/j.inffus.2022.03.009.
[5] Ekman P. An argument for basic emotions. Cognition and Emotion 1992;6:169–200. https://doi.org/10.1080/02699939208411068.
[6] Russell JA. A circumplex model of affect. J Pers Soc Psychol 1980;39:1161.
[7] Mehrabian A, Russell JA. An approach to environmental psychology 1974;266.
[8] Bradley MM, Lang PJ. Measuring emotion: the Self-Assessment Manikin and the Semantic Differential. J Behav Ther Exp Psychiatry 1994;25:49–59. https://doi.org/10.1016/0005-7916(94)90063-9.
[9] Soleymani M, Lichtenauer J, Pun T, Pantic M. A Multimodal Database for Affect Recognition and Implicit Tagging. IEEE Transactions on Affective Computing 2012;3:42–55. https://doi.org/10.1109/T-AFFC.2011.25.
[10] Koelstra S, Muhl C, Soleymani M, Lee J-S, Yazdani A, Ebrahimi T, et al. DEAP: A Database for Emotion Analysis ;Using Physiological Signals. IEEE Transactions on Affective Computing 2012;3:18–31. https://doi.org/10.1109/T-AFFC.2011.15.
[11] Sajno E, Bartolotta S, Tuena C, Cipresso P, Pedroli E, Riva G. Machine learning in biosignals processing for mental health: A narrative review. Front Psychol 2022;13:1066317. https://doi.org/10.3389/fpsyg.2022.1066317.
[12] Scheirer J, Fernandez R, Klein J, Picard RW. Frustrating the user on purpose: a step toward building an affective computer. Interact Comput 2002;14:93–118. https://doi.org/10.1016/S0953-5438(01)00059-5.
[13] Valenza G, Citi L, Lanatá A, Scilingo EP, Barbieri R. Revealing real-time emotional responses: a personalized assessment based on heartbeat dynamics. Sci Rep 2014;4:4998..
[14] Girardi D, Ferrari A, Novielli N, Spoletini P, Fucci D, Huichapa T. The way it makes you feel predicting users' engagement during interviews with biofeedback and supervised learning. 2020 IEEE 28th International Requirements Engineering Conference (RE), IEEE; 2020, p. 32–43.
[15] Hasnul MA, Aziz NAA, Alelyani S, Mohana M, Aziz AA. Electrocardiogram-Based Emotion Recognition Systems and Their Applications in Healthcare—A Review. Sensors 2021;21:5015. https://doi.org/10.3390/s21155015.
[16] Shaffer F, Ginsberg JP. An Overview of Heart Rate Variability Metrics and Norms. Front Public Health 2017;5:258. https://doi.org/10.3389/fpubh.2017.00258.
[17] Camm AJ, Malik M, Bigger JT, Breithardt G, Cerutti S, Cohen RJ, et al. Heart rate variability: standards of measurement, physiological interpretation and clinical use. Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology 1996.
[18] Koelstra S. HCI tagging database - home n.d. https://mahnob-db.eu/hci-tagging/ (accessed March 24, 2023).
[19] Pedregosa F, Varoquaux G, Gramfort A, Michel V, Thirion B, Grisel O, et al. Scikit-learn: Machine Learning in Python. The Journal of Machine Learning Research, 12 2011:2825–30.
[20] Chen T, Guestrin C. XGBoost: A Scalable Tree Boosting System. Proceedings of the 22nd ACM SIGKDD International Conference on Knowledge Discovery and Data Mining, New York, NY, USA: Association for Computing Machinery; 2016, p. 785–94. https://doi.org/10.1145/2939672.2939785.
[21] Ferdinando H, Seppänen T, Alasaarela E. Enhancing emotion recognition from ECG signals using supervised dimensionality reduction. Proceedings of the 6th International Conference on Pattern Recognition Applications and Methods, SCITEPRESS - Science and Technology Publications; 2017..
[22] Lundberg S, Lee S-I. A unified approach to interpreting model predictions. Advances in Neural Information Processing Systems, 2017, 30 2017.

[23] Guidotti R, Monreale A, Ruggieri S, Turini F, Giannotti F, Pedreschi D. A Survey of Methods for Explaining Black Box Models. ACM Comput Surv 2018;51:1–42. https://doi.org/10.1145/3236009.
[24] Müller AC, Guido S. Introduction to Machine Learning with Python: A Guide for Data Scientists. "O'Reilly Media, Inc."; 2016.
[25] Sajno E, Beretta A, Novielli N, Riva G. Follow the Flow: A Prospective on the On-Line Detection of Flow Mental State through Machine Learning 2022. https://doi.org/10.31234/osf.io/9z5pe.
[26] Sajno E, Riva G. Follow the Flow: Artificial Intelligence and Machine Learning for Achieving Optimal Performance. Cyberpsychol Behav Soc Netw 2022;25:476–7.

How many degrees of Emotional Separation are there between Real and Virtual Nature? A pilot study

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Abstract. How do specific nature experiences in VR differ from the equivalent real ones? Although virtual reality (VR) is increasingly being used as an ecological tool to resemble even complex phenomena, a debated issue still concerns the extent to which experiences in VR are similar to the equivalent real ones. This is especially relevant at the emotional level, as claimed in the emerging field of Virtual Emotions, and with regards to a peculiar content, that is, simulated nature. Despite these advancements in the understanding of the benefits associated with simulated nature, little research has examined to what extent the effects of virtual and real nature on emotions are comparable. In this pilot study, we addressed this issue by comparing virtual and real nature's ability to convey affect, specific discrete emotions, and aesthetic emotions. Following a within-subjects design, 16 participants were exposed to the same natural environment either in reality or in virtual reality. Next, type and valence of emotions, as well as sense of presence, immersion and state anxiety reported by participants, were compared across conditions. Bayesian factor paired t-test showed that only some aesthetic emotions and state anxiety were significantly more intense in the real context compared to the virtual one. Curiously, mixed affects were more intense in reality than in virtual reality. Presence was significantly higher after being exposed to the real condition, but immersion was not. Several internal significant correlations among presence, emotions, aesthetic emotions, affect and anxiety in each condition were found. These results provided evidence that only some emotions elicited by virtual reality were comparable to those evoked by real-life experiences and this deserve further investigation.

Keywords. Emotions, Affect, Virtual Emotions, Nature, Virtual Reality

1. Introduction

Several authors have shown that contact with natural environments has restorative effects, such as improved mood, emotion regulation and psychological well-being, and that exposure to nature can reduce symptoms of anxiety and depression or the risk of cognitive decline (i.e. dementia; [1-7]). While restoration refers to the process of renewing or recovering resources, affective connection with nature is called nature connectedness as the specific ability to care of other living beings, and to identify oneself as part of nature, increasing multiple dimensions on well-being and general mood [8]. At the same time, it has been also showed that being exposed to a simulation of nature can increase psychological benefits and physiological restoration [9-13]. These studies suggested that virtual nature experiences have similar benefits to in vivo nature experiences, evoking qualities of restoration, stress reduction, intrigue, awe, and characteristics of spirituality. Although virtual environments do not replace real nature, they could complement contact with nature, motivate people to experience nature outdoors [14] and even increase the sense of togetherness and connection with nature [10]. In addition to the effects on health and restoration, virtual nature could promote the

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concept of natural intelligence, which poses affective connection with nature as a core quality of this century. Thus, the emotional dimensions of a virtual nature experience emerged as crucial. Indeed, increasing number of works have showed the key relationship between the sense of presence in simulated scenarios and affect and emotion intensity [15-18]. Indeed, VR has been increasingly shown as an effective emotion induction technique, since it provides a high degree of ecological validity combined with high experimental control [15, 19, 21]. However, the extent to which real and virtual nature can be similar at the emotional level, is still an open issue. Specifically, researchers have often investigated the association between being exposed to real or virtual nature and general affect [22]. Rarely, specific emotions have been considered (e.g.,[18]). It is still at the beginning the exploration of how virtual nature can elicit peculiar class of emotional states, such as aesthetic emotions [23], usually associated with real nature exposure [24]. This research question follows the challenge posed by the arising field of Virtual Emotions, which recommend integrating emotion science and cyberpsychology to advance current knowledge on the nature of emotional phenomena elicited by extended realities and in reality [25].

In this pilot study, the emotional profile of the same natural landscape featured either *in vivo* or *in virtuo* was measured with regards to Aesthetic and discrete emotions, presence, and immersion.

2. Methods

2.1 Sample and participant selection

The experiment followed a within-subjects design involving 16 healthy volunteers (11 females) who were exposed to the same natural content either in reality (Real condition) or in virtual reality (Virtual condition). The sample was young (males: age mean = 23.4; S.D. = 2.30; females: age mean = 23.7; S.D. = 2.20). 9 participants reported no previous experiences with 360° videos but 11 self-rated their own expertise in technology use from medium to high.

2.2 Materials and procedures

Participants were randomly assigned to each of the following conditions, in a counterbalanced order, on the same day:

- Real condition (*in vivo* exposure): participants in the natural condition observed a real panoramic view of the Nature Reserve of Verbania in Piedmont (Fig. 1 and 2).
- Virtual condition (*in virtuo* exposure): participants in this condition watched the same panorama by means of a 360° video recorded using Insta360 X3 Pocket 360 Action Cam.

Throughout the experiment, perspectives on the landscape and weather conditions were maintained: a sunny day served as the backdrop for recording the video, and the experiment was conducted under the same conditions.

Before observing the natural content, participants first gave written informed consent and provided demographics information by means of an online survey on Qualtrics platform. Then they were divided into two groups: one group began with the real condition and finished with the virtual condition, while the second group began with the virtual condition and finished with the real condition. Before starting, both groups were asked to complete a series of questionnaires measuring their disposition to experience positive emotions (DPES [26]), their general aesthetic interest in literature , art, film, design, food and nature (DFAS [27]){Lundy, 2010 #1579}, their connection (Connectedness to Nature Scale [28]) and relatedness to nature (Short Form Version of the Nature Relatedness Scale [29]) and finally, the engagement with natural, artistic, and moral beauty (Engagement with Beauty [30]). Before the exposure session took place,

participants were required to report the extent to which they lived nine discrete emotions on a 7-point Likert scale (i.e., anger, awe, amusement, disgust, fear, pride, sadness, joy, and melancholia). Participants also self-rated their positive and negative affects (PANAS)[31] on a 5-point Likert scale ranging from (1) = not at all and (5) = very much. Then, participants in the Real condition were invited to reach the same place also shown in the Virtual condition and to look at the panorama and surroundings. The exposure took between 5 to10 minutes. Participants in the virtual condition underwent the same procedure but stayed in a neutral room before wearing the headset. Participants were asked to wear a Head Mounted Display using mobile phones to access the 360° video. They were provided with standardized instructions on how to start the video (5–10-minute length) using this VR device.

At the end of both conditions, participants were required to self-report their level of emotions and nature relatedness (or connectedness) after each nature-exposure. They rated once again the extent to which they experienced nine emotions (i.e., anger, awe, amusement, disgust, fear, pride, sadness, joy and melancholy on a seven-point Likert scale), their reported general affect (PANAS) and aesthetic emotions that cover prototypical aesthetic emotions (e.g., the feeling of beauty, being moved, fascination, and awe), epistemic emotions (e.g., interest and insight), and emotions indicative of amusement (humor and joy). In addition, they include the activating (energy and vitality) and the calming (relaxation) effects of aesthetic experiences, as well as negative emotions that may contribute to aesthetic displeasure (e.g., the feeling of ugliness, boredom, and confusion). Their feeling of presence and immersiveness were assessed with two ad hoc questions on a seven-point Likert scale ("*How much do you feel present within the real/virtual environment?"* and *"How much do you feel immersed within the real/virtual environment?"*) and their level of state anxiety (State-trait Anxiety Inventory Form Y).

2.3 Inclusion criteria

Participants >18 years old and without vestibular or neurological disorders were included. The experimental protocol was approved by an internal Ethical Committee of the Università Cattolica del Sacro Cuore prior to data collection. Each participant provided written informed consent for study participation. Written consent and all methods were carried out in accordance with the Helsinki Declaration.

Figure 1. Panorama of the Nature Reserve of Verbania.

3. Results

3.1 Preliminary data analysis

First, we computed descriptive statistics for dispositional variables and baseline measures. Then, we carried out Bayesian paired samples t-tests comparing the two conditions (real versus virtual nature) on each separate dimension of the anxiety, general

affect, nine discrete emotions, aesthetic emotions and the two ad hoc questions on presence and immersion. Finally, we carried out Pearson's correlation separately among sense of presence, affect, and emotions in the in vivo and in the in virtuo condition.

Table 1. Descriptive statistics (mean, standard deviation) of each dispositional variable (Positive Emotion Dispositions; Desire for Aesthetic, Nature Connectedness and Nature relatedness) of the entire sample.

	Mean	**Standard deviation**
Trait awe	28.8	4.92
Desire for Aesthetics	132	11.9
Nature Connectedness	49.8	9.13
Engagement with moral beauty	5.50	1.14
Engagement with artistic beauty	5.03	0.9
Engagement with natural beauty	5.14	1.30
Nature Relatedness	28.8	4.92

Table 2. Descriptive statistics (mean, standard deviation) of measures of state Positive and Negative affect, Sense of presence, Immersion, Prototypical aesthetic emotions, Epistemic emotions, Amusement, Animation aesthetic emotion, Nostalgia, Anxiety of the real condition (Real) and virtual condition (360° video).

Condition	**Sense of presence**	**Immersion**	**Prototypical aesthetic emotions**	**Epistemic emotions**	**Positive affect**
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Real	5.69 (1.92)	5.13 (2.16)	3.03 (0.80)	3.04 (0.96)	35.3 (9.34)
360° video	4.25 (1.84)	4.38 (1.96)	2.64 (0.68)	2.70 (0.82)	31.4 (9.99

Condition	**Amusement**	**Animation Aesthetic emotion**	**Nostalgia**	**Anxiety**	**Negative affect**
	Mean (SD)	Mean (SD)	Mean (SD	Mean (SD)	Mean (SD)
Real	3.39 (1.13)	3.06 (1.04)	3.23 (0.92)	3.04 (0.96)	35.3 (9.34)
360° video	3.13 (0.98)	2.24 (0.89)	2.28 (0.97)	2.70 (0.82)	31.4 (9.99

We carried out all analyses using Jamovi (v. 2.2.5.0). In this study we chose the Bayesian Factor to compare repeated measurements under the hypothesis of similarity among them. The use of BF enabled testing if a model in which similarity is considered could be better than a model where differences are considered. BF provided the likelihood ratio of this comparison. Results showed an anecdotal effect for the two conditions *in virtuo* and *in vivo* (BF01 = 1.645; err. = 0.004) regarding positive affect, which was lower in virtual (vs. real) condition. In other words, virtual condition did not elicit statistically significantly similar levels of positive affect, compared to the real one. H0 was rejected. At the same time, the real environment did elicit statistically higher levels of presence (BF01 = 1.625; err. = 0.004) compared to the virtual one, but not of immersion (BF01 = 0.439; err. = 0.002). Animation aesthetic emotions (BF01 = 2.339; err. = 0.001) and Nostalgia (BF01 = 33.470; err. = 2.70e-5) as well as Anxiety (BF01 = 17.861; err. = 8.96e-5) were significantly higher in the virtual condition compared to the real one. Pearsons's correlations showed that the sense of presence experienced in the virtual conditions significantly and positively correlated with positive affect ($r = .533$; $p < .05$), immersion ($r = .820$; $p < .001$), prototypical aesthetic emotions ($r = .513$; $p < .05$), epistemic emotions ($r = .571$; $p < .05$), Amusement ($r = .549$; $p < .05$), Animation aesthetic emotions ($r = .579$; $p < .05$), nostalgia ($r = .663$; $p < .001$), and negatively with anxiety ($r = - 511$: $p < .05$). Sense of presence in real context positively significantly correlated with epistemic emotions ($r = .549$; $p < .05$), negative aesthetic emotions ($r = .647$; $p < .001$), nostalgia ($r = .541$; $p < .05$).

4. Conclusion

In this pilot study, it emerged that the emotional profiles of the same natural environment featured in vivo or in virtuo were more likely to be similar than different except for specific aesthetic mixed emotional states (i.e., Nostalgia and Animation emotions). Nostalgia may evoke memories of peaceful, pleasant times or of times of tension and turmoil and contains both pleasant and unpleasant components. Animation emotions (i.e., being moved or energy), on the other hand, concern those emotions that stimulate action (i.e. *"Motivated me to act"*). The results of this pilot study show that anxiety correlated negatively with participants' sense of presence in virtual reality, potentially suggesting a key role of the sense of presence in diminishing anxiety in a VR natural environment. Our results thus indicated that the emotional and experience profile of both environments was in line with research in this field. There is still room for work in this Virtual Emotions field, especially with regard to the operationalization of affects, emotions, moods, and feelings, and to distinguish true feelings from those merely "recognized" in VR. Despite this, these results are in line with the view that virtual nature is a method of relaxation [32] but also highlighted the need for deepening the analysis of the mixed emotional side of reality vs. virtual reality (e.g.,[33]). The sample for this pilot study was small. We considered 360° video as the most realistic VR format, but other VR formats could be tested. For instance, it would be possible to interact with virtual environments and in reality. Due to the higher level of realism that 360 video provides in this case, we chose to use it. The degree of similarity between the simulated and real experiences plays a central role in shaping the value of the application. Moreover, presence could be studied more comprehensively, for instance, using the ITC-Sense of Presence Inventory (ITC-SOPI) for virtual environments or other dimensions of presence, such as realism. Finally, this study could be replicated with different natural scenarios or natural paradoxical scenarios (such as the view of the earth from outside its atmosphere) and a larger sample size.

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References

[1] Zhang, J. W., Howell, R. T. & Iyer, R. Engagement with natural beauty moderates the positive relation between connectedness with nature and psychological well-being. *Journal of Environmental Psychology* 38, 55-63 (2014).

[2] Collado, S., Staats, H. & Corraliza, J. A. Experiencing nature in children's summer camps: Affective, cognitive and behavioural consequences. *Journal of Environmental Psychology* 33, 37-44 (2013).

[3] Ahn, S. J. *et al.* Experiencing nature: Embodying animals in immersive virtual environments increases inclusion of nature in self and involvement with nature. *Journal of Computer-Mediated Communication* 21, 399-419 (2016).

[4] Joye, Y. & Bolderdijk, J. W. An exploratory study into the effects of extraordinary nature on emotions, mood, and prosociality. *Frontiers in psychology* 5, 1577 (2015).

[5] Kuo, M. How might contact with nature promote human health? Promising mechanisms and a possible central pathway. *Frontiers in psychology* 6, 1093 (2015).

[6] Schultz, P. in *Psychology of sustainable development* 61-78 (Springer, 2002).

[7] Lopes, S., Lima, M. & Silva, K. Nature can get it out of your mind: the rumination reducing effects of contact with nature and the mediating role of awe and mood. *Journal of Environmental Psychology* 71, 101489 (2020).

[8] Beute, F., Albers, T. & van den Berg, A. Nature Intelligence in Youth Work: a theoretical and practical framework. (2022).

[9] Browning, M. H., Mimnaugh, K. J., van Riper, C. J., Laurent, H. K. & LaValle, S. M. Can Simulated Nature Support Mental Health? Comparing Short, Single-Doses of 360-Degree Nature Videos in Virtual Reality With the Outdoors. *Frontiers in Psychology* 10 (2019).

[10] Litleskare, S., E. MacIntyre, T. & Calogiuri, G. Enable, reconnect and augment: a new ERA of virtual nature research and application. *International Journal of Environmental Research and Public Health* 17, 1738 (2020).

[11] Klein, S. A. & Hilbig, B. E. How virtual nature experiences can promote pro-environmental behavior. *Journal of Environmental Psychology* 60, 41-47 (2018).

[12] Deringer, S. A. & Hanley, A. Virtual reality of nature can be as effective as actual nature in promoting ecological behavior. *Ecopsychology* 13, 219-226 (2021).
[13] Riches, S., Azevedo, L., Bird, L., Pisani, S. & Valmaggia, L. Virtual reality relaxation for the general population: a systematic review. *Social psychiatry and psychiatric epidemiology* 56, 1707-1727 (2021).
[14] Yu, C.-P., Lee, H.-Y., Lu, W.-H., Huang, Y.-C. & Browning, M. H. Restorative effects of virtual natural settings on middle-aged and elderly adults. *Urban Forestry & Urban Greening* 56, 126863 (2020).
[15] Riva, G. *et al.* Affective interactions using virtual reality: The link between presence and emotions. *Cyberpsychology and Behavior* 10, 45-56, doi:10.1089/cpb.2006.9993 (2007).
[16] Baños, R. M. *et al.* Immersion and emotion: their impact on the sense of presence. *CyberPsychology & Behavior* 7, 734-741 (2004).
[17] Baños, R. *et al.* Sense of presence in emotional virtual environments. *Proceedings of Presence*, 156-159 (2004).
[18] Chirico, A. & Gaggioli, A. When Virtual Feels Real: Comparing Emotional Responses and Presence in Virtual and Natural Environments. *Cyberpsychology, Behavior, and Social Networking* 22, 220-226, doi:10.1089/cyber.2018.0393 (2019).
[19] Chirico, A. *et al.* Designing virtual environments for attitudes and behavioral change in plastic consumption: A comparison between concrete and numerical information. *Virtual Reality* 25, 107-121 (2021).
[20] Chirico, A., Robert, R., C.,, David, B., Y., & Gaggioli, A. Nature versus Art as Elicitors of the Sublime: A Virtual Reality study. *PLoS One* (2021).
[21] Chirico, A. & Gaggioli, A. Virtual Reality for Awe and Imagination. (2023).
[22] Li, H. *et al.* Access to nature via virtual reality: A mini-review. *Frontiers in Psychology* 12, 725288 (2021).
[23] Menninghaus, W. *et al.* What are aesthetic emotions? *Psychological review* 126, 171 (2019).
[24] Bethelmy, L. C. & Corraliza, J. A. Transcendence and sublime experience in nature: Awe and inspiring energy. *Frontiers in psychology* 10, 509 (2019).
[25] Chirico, A. & Gaggioli, A. How Real Are Virtual Emotions? *Cyberpsychology, Behavior, and Social Networking* 0, null, doi:10.1089/cyber.2023.29272.editorial (2023).
[26] Terraciano, A., McCrae, R. R. & Costa Jr, P. T. Factorial and construct validity of the Italian Positive and Negative Affect Schedule (PANAS). *European Journal of Psychological Assessment* 19, 131 (2003).
[27] Lundy, D. E., Schenkel, M. B., Akrie, T. N. & Walker, A. M. How important is beauty to you? The development of the Desire for Aesthetics Scale. *Empirical Studies of the Arts* 28, 73-92 (2010).
[28] Mayer, F. S. & Frantz, C. M. The connectedness to nature scale: A measure of individuals' feeling in community with nature. Journal of environmental psychology 24, 503-515 (2004).
[29] Nisbet, E. K. & Zelenski, J. M. The NR-6: A new brief measure of nature relatedness. *Frontiers in psychology* 4, 813 (2013).
[30] Diessner, R., Solom, R. D., Frost, N. K., Parsons, L. & Davidson, J. Engagement with beauty: Appreciating natural, artistic, and moral beauty. The Journal of psychology 142, 303-332 (2008).
[31] Terraciano, A., McCrae, R. R. & Costa Jr, P. T. Factorial and construct validity of the Italian Positive and Negative Affect Schedule (PANAS). *European Journal of Psychological Assessment* 19, 131 (2003).
[32] Riches, S., Azevedo, L., Bird, L., Pisani, S. & Valmaggia, L. Virtual reality relaxation for the general population: a systematic review. *Social psychiatry and psychiatric epidemiology* 56, 1707-1727 (2021).
[33] Chirico, A. *et al.* "Standing Up for Earth rights": Awe-Inspiring Virtual Nature for Promoting Pro-Environmental Behaviors. *Cyberpsychology, Behavior, and Social Networking* (2023).

Virtual Reality Social Platforms for Online Synchronous Learning in Higher Education: A Mixed-methods Explorative Research

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Abstract. This ongoing study aims to assess the feasibility of using virtual reality (VR) social platforms in the context of online higher education by analyzing students' perceived social presence, emotional experience, and perceived ease of use. A sample of undergraduate students (n=14) was invited to attend two lectures, delivered either on a traditional video conferencing (VC) platform or on a VR social platform. Preliminary results showed no significant differences in social presence between the two platforms. However, students reported more enjoyment, awe, and interest and less boredom with the VR social platform than the VC platform. Despite this, the VC platform was perceived as easier to use, likely due to students' familiarity with this solution. Qualitative data from interviews revealed mixed preferences, with some students finding the VR social platform more engaging while others favored the familiarity of the VC platform. These findings suggest that while VR social platforms show potential in enhancing students' emotional experiences, challenges regarding ease of use and familiarity must be addressed. Further research and a larger sample size are needed to explore the advantages and disadvantages of VR social platforms in online education.

Keywords. Online learning, virtual reality, social presence, emotions, ease of use

1. Introduction

During the COVID-19 pandemic, universities have relied on various video conferencing (VC) platforms (e.g., Zoom, Google Meet, Microsoft Teams) to facilitate synchronous online learning. These platforms are easy to use, with features like video calling and screen sharing that allow students to see and hear from their teachers and classmates in real time. This can help facilitate interaction and participation, but the experience often results limited, and students may not feel as connected to others as in an in-person class. This problem is known as the "social presence gap" [1]. Social presence is defined as the "sense of being with another" [2], and in online communication, it is largely affected by the type of medium used. Since social presence has been shown to foster students' engagement, motivation, and satisfaction in online education [3], researchers and educators need to search for new opportunities to promote it.

In this context, virtual reality (VR) social platforms (e.g., Spatial, MeetinVR, Engage VR) can offer advantages over traditional VC platforms, creating a more engaging and interactive learning environment. VR social platforms indeed allow users to feel as if they are physically present in the same virtual space [4], which could, in turn, foster a sense of closeness between users and enhance perceived social presence. When students feel connected with other members of the class group, they are more likely to be motivated and to feel engaged in the learning process and to experience positive

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emotions such as interest and enjoyment [5]. Students' affective experience is essential in learning and education. Pekrun's control-values theory [6] categorizes "achievement emotions" as a range of emotions that can be experienced in relation to a learning activity. Among these emotions, the author highlights the importance of "activity emotions", which include enjoyment, relaxation, anger, frustration, and boredom that students can experience during a lecture. These emotions, together with other relevant emotions such as shame, anxiety, interest [7] and even awe [8] can influence students' efforts to complete a learning task, subsequently impacting their learning outcomes.

However, it is essential to note that VR social platforms are still relatively new and may not be as familiar and user-friendly as traditional VC platforms. Users may need to learn how to navigate and use the virtual environment, which could divert their attention from the learning material.

This ongoing study aims to compare the online learning experience with a VC platform and a VR social platform by analyzing the following constructs: social presence, emotional experience, and perceived ease of use.

2. Methods

2.1 Participants

So far, 14 undergraduate students aged between 19 and 24 (f=13, m=1) have participated in the study. The study was approved by the local ethical committee of the Department of Psychology of the Catholic University of Sacred Heart, Milano.

2.2 Measures

Social presence, emotional experience, and perceived ease of use were assessed through self-reports in a *post-experience questionnaire battery*.

- *Social presence* was measured using an Italian-adapted version of the social presence subscale of the Multimodal Presence Scale [9], consisting 5 items (ω =0.89, α = 0.88) [10]. Example item: "I felt like I was in the presence of other people in the online environment.". Items were measured on a 7-point Likert scale (1: strongly disagree; 7: strongly agree). The mean value of the items was used to calculate the scale's total score.
- *Emotional experience* was measured by asking participants to evaluate the degree to which they experienced specific emotions during the lesson using a visual analogue scale, ranging from 0 (not at all) to 10 (a lot). This study retrospectively assessed activity emotions [6] (enjoyment, relaxation, anger, frustration, boredom) and other ad-hoc emotions that are relevant in learning contexts (two positives: interest and awe; two negatives: shame and anxiety).
- *Perceived ease of use* was measured using an Italian-adapted version of the items previously used by Lee and colleagues [11] to test the effectiveness of desktop virtual reality for learning, consisting of 4 items (ω = 0.83, α = 0.87) [10]. Example item: " Overall, I think this platform is easy to use.". Items were measured on a 7-point Likert scale (1: strongly disagree; 7: strongly agree). The mean value of the items was used to calculate the scale's total score.

In addition, participants were invited to participate in an unstructured *in-depth interview* designed to deepen their experience with the platforms. The interviewer introduced the topic (e.g., "Can you describe your overall experience of two platforms?"). Participants could develop their responses freely. The interviewer tried to limit excessive digressions from the topics of interest without taking a coercive attitude.

2.3 Platforms

In this study, we used one VC platform and one VR social platform (see Figure 1).

- *Microsoft Teams* is a VC platform with features such as video calling and screen sharing that allow users to communicate and collaborate. This platform has been frequently used as an online learning solution.
- *Spatial* is a VR social platform that allows to organize meetings, presentations, courses, and events with several users simultaneously online and it can be used for educational purposes. Although Spatial can be accessed in immersive mode (using head-mounted displays), in this study, students accessed this platform through the computer, in desktop mode.

Participants were provided with instructions on how to access and use the platforms.

Figure 1. Screenshots taken during the lecture on the VC platform (left side) and on the VR social platform (right side).

2.4 Lectures

A lecture on computational thinking and coding was split into two learning modules: Module 1 and Module 2. Each module lasted approximately 30 minutes. Modules were delivered on two consecutive days at the same time. Lectures were delivered according to traditional teaching methods, with a lecturer speaking supported by a slides-based presentation. On both platforms, a tutor was online to help participants if they encountered any issues during the lecture.

2.5 Procedure

After obtaining participants' informed consent, a link was sent to them to provide their socio-demographic data. Participants were then randomly divided into two groups. Group A attended Module 1 on Teams and Module 2 on Spatial. Group B attended Module 1 on Spatial and Module 2 on Teams. For each module, and on both platforms, the session was opened 15 minutes before the lecture to guarantee a familiarization period and solve possible technical issues. After the familiarization period, a 30-minutes lecture was delivered. At the end of each lecture (Module 1 and Module 2), participants received a link to complete the *post-experience questionnaire battery*. Participants then came back online to ask any questions about the lecture content. At the end of Module 2, participants were further asked to discuss their overall experience with the two platforms in an unstructured *in-depth interview.*

3. Results

Analyses were performed using Jamovi statistical platform [12].

Social presence. The results of a paired-sample t-test showed no significant difference, $t(13) = 1.03$, $p = 0.32$, between the levels of social presence reported on the VC platform ($M = 5.06$, $SD = 1.07$) and VR social platform ($M = 4.50$, $SD = 1.45$).

Emotional experience. A series of paired sample t-tests were conducted separately for each emotion. Results are shown in Table 1 and revealed a significant difference between the VC platform and the VR social platform on enjoyment, boredom, awe, and interest, showing that the VR social platform elicited more enjoyment, awe and interest and less boredom.

Table 1. Paired sample t-tests (VC, VR) on self-reported emotions.

	VC M (SD)	VR M (SD)	t(13)	p
Enjoyment	3.64 (2.44)	6.71 (1.59)	-3.59	<0.01
Relaxation	4.93 (2.46)	4.57 (2.93)	0.41	n.s.
Anger	0.79 (2.67)	0.21 (0.58)	0.88	n.s.
Frustration	0.86 (2.66)	0.79 (1.05)	0.11	n.s.
Boredom	2.00 (1.84)	1.14 (1.29)	2.92	<0.05
Awe	1.50 (2.59)	4.79 (3.38)	-3.59	<0.01
Interest	5.43 (2.47)	7.57 (1.83)	-2.21	<0.05
Shame	1.64 (2.50)	0.93 (1.33)	1.20	n.s.
Anxiety	1.50 (2.98)	0.79 (1.12)	0.88	n.s.

Ease of use. A paired sample t-test conducted to measure students' perceived ease of use of the two platforms revealed that the VC platform (M=6.14; SD=0.66) was rated significantly easier to use, $t(13) = 3.90$, $p<0.01$, than the VR social platform (M=4.57, SD=1.22).

In-depth interview. Table 2 shows the main themes emerged and the partial transcriptions from participants' answers. Participant 7 from group 1 did not participate in the interview.

Table 2. Key themes emerged from the unstructured in-depth interview.

Theme 1: familiarity, ease of use, technical issues and need for training. The theme highlights participants' preference for platforms they are already familiar with (Teams), as it allows them to concentrate on the learning materials. However, they recognize that training and repeated exposure are necessary to overcome initial challenges and fully utilize platforms that are new to them (Spatial).
• Group 1, Participant 1: *"As regard to learning, I preferred Teams because I already knew how to use it... Spatial is more interesting, interactive and particular, but for learning I still prefer Teams."* • Group 1, Participant 2: *"But maybe, if you use Spatial more and more, sooner or later you learn how to use it and it becomes more interesting."* • Group 1, Participant 6: *"Since I wasn't familiar with Spatial it was hard to control the avatar and it was much more distracting."* • Group 2, Participant 1: *"Spatial was fun [but] it might be distracting […] Teams, I was already familiar with it, it is a very educational platform, very classic like many others."* • Group 2, Participant 4: *"[…] On Spatial there were more technical issues."* • Group 2, Participant 6: *"Furthermore, I was already familiar with Teams, it is easy […] and it's easy to follow the lecture."*
Theme 2: engagement, involvement, and interaction The theme highlights participants' perceptions of Spatial as a platform that offers a more interactive and involving experience compared to Teams. They feel more connected, part of a group, and appreciate the ability to move around and personalize avatars, leading to increased engagement.
• Group 1, Participant 3: *"Spatial is more interactive and you feel more involved and part of a group. Maybe after several uses it becomes more interesting and useful."* • Group 1, Participant 4: *"Spatial is more involving and it is more interesting than Teams. Teams does not engage you that much."* • Group 1, Participant 5: *"I agree [that Spatial is more engaging]. Even just being able to move around [...] it helps to concentrate."* • Group 1, Participant 6: *"Spatial engages you more and makes you feel more involved, but with Teams you can focus more on the learning materials."* • Group 2, Participant 6: *"On Spatial it was very nice to have an avatar that you could personalize without being seen. [...] it was impressive to see the head of the avatar moving according to my movements."* • Group 2, Participant 7: *"Spatial was fun [...]"*
Theme 3: cameras, real appearance and distractions The theme focuses on participants' perspectives regarding the use of cameras and their impact on distractions, as well as the preference for real appearance in online learning. Participants mention that avatars in Spatial can reduce distractions but acknowledge that seeing real appearances in Teams fosters a sense of closeness.
• Group 2, Participant 2: *"The avatar creation part distracted me a lot, but paradoxically it was easier to follow the lecture than on Teams as in Teams I get distracted by watching others' cameras."* • Group 2, Participant 3: *"[…] on Teams […] the camera favors it because you can see each other, and you feel more present."* • Group 2, Participant 5: *"I prefer Teams as I get distracted easily, and on Spatial it was easier to get distracted."*

- Group 2, Participant 6: *"With avatars you don't get distracted by looking at details, for example in the bedrooms, in Teams. However, for now, Teams is better, as I feel people closer if I can see how they really look like."*
- Group 2, Participant 7: *"On Spatial since I don't have the camera open, I get distracted, I get lost, and I stop listening. Teams forces me to listen, it's more like being in a face-to-face situation."*

4. Conclusion

This study compared the online learning experience with traditional VC and VR social platforms by analyzing social presence, emotional experience, and perceived ease of use. The results showed no significant differences in social presence between the two platforms. However, students' emotional experiences were significantly different, with the VR social platform eliciting more enjoyment, awe, and interest and less boredom than the VC platform. On the other hand, the VC platform was rated as more straightforward to use than the VR social platform, which could be due to students' familiarity with this type of platform.

The qualitative data from the unstructured in-depth interviews provide valuable insights into the factors affecting students' preferences and the perceived effectiveness of each platform. Most students found the VR social platform more interesting, engaging, and involving than the VC platform. However, most of them also found the VC platform more appropriate for learning, mainly because they were already familiar with it and knew how to use it.

So far, numerous studies have shown the effectiveness of both non-immersive [11] and immersive [13] VR for learning, but only a few studies have specifically analyzed the potential of VR social platforms in educational contexts. The present findings suggest that while VR social platforms hold promise for enhancing students' emotional experiences in online learning, there are still challenges to be addressed regarding ease of use and familiarity. Educators and researchers should continue to explore the potential of VR social platforms and develop strategies to overcome these challenges to optimize their effectiveness in online education. Additionally, future studies with larger sample sizes s are needed to validate these findings and provide a deeper understanding of the impact of VR social platforms in online learning by further analyzing other essential factors such as motivation and learning outcomes.

5. Limitations

It is important to note that this study is still ongoing, and the data presented here are based on a small sample size. This limited sample size restricts the generalizability of the findings, particularly in light of the use of multiple statistical tests. To validate and extend these preliminary results, a larger sample size would be necessary. Furthermore, it is worth mentioning that this study specifically focused on desktop VR systems. Future research should explore the effects of different VR setups, including head-mounted displays, to fully understand the impact of VR technology on the variables under investigation.

References

[1] D.T. Daigle, and A. Stuvland, Teaching political science research methods across delivery modalities: comparing outcomes between face-to-face and distance-hybrid courses, *J. Polit. Sci. Educ.* 17 (2021) 380–402.

[2] J. Short, E. Williams, and B. Christie, The social psychology of telecommunications, Wiley London, 1976.

[3] J.C. Richardson, Examining social presence in online courses in relation to students' perceived learning and satisfaction, State University of New York at Albany, 2001.

[4] M. Chessa, and F. Solari, The sense of being there during online classes: analysis of usability and presence in web-conferencing systems and virtual reality social platforms, *Behav. Inf. Technol.* 40 (2021) 1237–1249.

[5] S. Molinillo, R. Aguilar-Illescas, R. Anaya-Sánchez, and M. Vallespín-Arán, Exploring the impacts of interactions, social presence and emotional engagement on active collaborative learning in a social web-based environment, *Comput. Educ.* 123 (2018) 41–52.
[6] R. Pekrun, The control-value theory of achievement emotions: Assumptions, corollaries, and implications for educational research and practice, *Educ. Psychol. Rev.* 18 (2006) 315–341.
[7] R. Pekrun, Using self-report to assess emotions in education, *Methodol. Adv. Res. Emot. Educ.* (2016) 43–54.
[8] M. Gail Jones, J. Nieuwsma, K. Rende, S. Carrier, E. Refvem, C. Delgado, J. Grifenhagen, and P. Huff, Leveraging the epistemic emotion of awe as a pedagogical tool to teach science, *Int. J. Sci. Educ.* 44 (2022) 2485–2504.
[9] G. Makransky, L. Lilleholt, and A. Aaby, Development and validation of the Multimodal Presence Scale for virtual reality environments: A confirmatory factor analysis and item response theory approach, *Comput. Hum. Behav.* 72 (2017) 276–285.
[10] G.-J.Y. Peters, The alpha and the omega of scale reliability and validity: Why and how to abandon Cronbachâ€™s alpha and the route towards more comprehensive assessment of scale quality, *Eur. Health Psychol.* 16 (2014) 56–69.
[11] E.A.-L. Lee, K.W. Wong, and C.C. Fung, How does desktop virtual reality enhance learning outcomes? A structural equation modeling approach, *Comput. Educ.* 55 (2010) 1424–1442.
[12] The jamovi project, (2019). https://www.jamovi.org.
[13] A.F. Di Natale, C. Repetto, G. Riva, and D. Villani, Immersive virtual reality in K-12 and higher education: A 10-year systematic review of empirical research, *Br. J. Educ. Technol.* 51 (2020) 2006–2033.

Using 360° Video in Psychometric Assessment of Cognitive Functions: SemApp and its Usability data

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Abstract. The effectiveness of psychometric tests in assessing real-world abilities is increasingly emerging as an issue in the neuropsychological field. Researchers stress the importance of collecting information that is more comparable to what is observed in reality. In comparison to traditional paper-and-pencil tests, 360-degree technology appears as a promising tool for offering lifelike experiences in a controlled and safe manner, maintaining high levels of graphical realism and immersion. Moreover, it appears technical user-friendliness compared to traditional computer-based virtual reality. These characteristics seem to be essential components for resolving the validity problem. Thus, we aim to investigate the potential benefits of using 360-degree technology for memory assessment. Based on previous evidence, the present study aims to create a novel application focused on two crucial components of everyday memory: spatial and episodic memory. We present and test the usability of semApp, which is composed of an object recognition task and a spatial memory task. Both evaluate memory by simulating a real-life situation: a relocation and the exploration of a house. This cross-platform tool can be deployed on the patients' devices (e.g., tablets and smartphones) and guarantee an objective and standardized evaluation.
7 end-users judged the usability of the application. They were Mild Cognitive Impaired patients, who evaluate semApp as a promising tool for enhancing the ecological value of standard memory assessment tests.

Keywords. Memory, Assessment, Psychometric, 360° video, Virtual Reality

1. Introduction

Although cognitive changes in aging can be considered physiological, the incidence of neurodegenerative diseases drastically increases with age. While symptoms vary from person to person, memory problems are often the most common. Traditionally clinicians assess these deficits using paper-and-pencil tests. However, in recent years, there has been an ongoing debate regarding the use of traditional techniques, which is linked to their ecological validity [1,2]. As a result, researchers emphasize the necessity of observing cognitive and behavioral functioning in a life-like setting. In this scenario, Virtual Reality (VR) is a promising tool to improve the quality of the neuropsychological assessment process since it can provide realistic environments in a controlled and safe way [3]. Several authors have already employed VR to develop technological tools for the neuropsychological assessment of memory, creating virtual environments (e.g., office and supermarket) where patients could navigate the virtual space while learning and then recall some objects [4]. The results showed that these tasks are valid tools for measuring memory functioning in an ecological context. Among these technologies, 360° videos offer additional opportunities. They are spherical videos recorded by a

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special camera able to collect images from around the environment, where users can look around the scene as they would in real life: by moving the device, they can control the viewing direction and observe what is going on all around. The possibility to manipulate the position of the subject in space allows a considerable increase in the ecological validity of the tests and promotes an embodied experience [5]. Moreover, 360° videos have also a friendly design which makes them more suitable for older patients who may have some difficulties interacting with more sophisticated devices.

In this scenario, we propose an innovative tool to fit this promising panorama: semApp. Based on previous research [6,7], we implemented existing tools thanks to cutting-edge software to increase the ecological validity of the assessment and to improve the control of the environments, with standardized multimodal stimulation, precisely calibrated feedback about the performance, and automatic registration of outcomes. The present study aims to design and test the usability of this novel application to assess memory deficits, providing a tool based on two crucial components of memory: an object recognition task and a spatial memory task.

2. Method and Materials

2.1 Participants

Participants were enrolled among the patients and outpatients of the Department of Medical Rehabilitation of Istituto Auxologico Italiano in Milan. They were 7 volunteers with Mild Cognitive Impairment (MCI), aged 60 or over (without maximum age limitation), with normal or corrected-to-normal vision. Exclusion criteria were the presence of additional invalidating internist, psychiatric, and neurological conditions which could affect the app experience. The resulting sample included 3 females and 4 males, with a mean age of 79 (SD = 5.55) and a mean of 14.25 (SD = 5.01) years of education. Before the usability session, all participants signed the informant consent. The study received ethical approval from the Ethical Committee of the Istituto Auxologico Italiano. Participants were examined in two sessions. First, we administered neuropsychological tests to verify MCI. Then, users tested the app evaluating its usability.

2.2 semApp

SemApp (spatial and episodic memory assessment application) is a 360°-based tool aimed to assess memory by simulating a real-life situation. Ecological environments are shown to users, who are required to interact with the presented situations. The app includes two parts: an object recognition task and a spatial memory task. During the first task users are immersed in a living room, and they have to encode and then recall some target objects, simulating a relocation. In the second task, patients must freely navigate in an apartment, visit rooms, and then they must recognize the map of the house. We deployed this cross-platform tool on an iPad of 11.2in.

2.3 Measures

We evaluate the presence of MCI by performing a complete evaluation based on neuropsychological tests, reported difficulties, and Activities of Daily Life [8].

The usability has been assessed using quantitative measures such as the System Usability Scale (SUS) [9], the Senior Technology Acceptance Model (STAM) [10], and the subscale of cybersickness of the Independent Television Commission Sense of Presence Inventory (ITC-SOPI) [11]. Additionally, we used the thinking aloud protocol (TAP) [12], as a qualitative technique. It helps clinicians to describe users' difficulties during technological interaction and some possible solutions for those problems.

3. Results

Most users' responses fell along the scale midpoint of the SUS (response of 3) or more. The mean score of each item revealed that users judge the app as usable, for example, people would like to use the app frequently, the system was easy to use, and there was not too much inconsistency in this system; detailed SUS questions are listed in Table 1. The results of the STAM scale reveal that our sample has a positive attitude toward technology (M= 7.08/10; SD= 1.42), has a medium level of control/access to technological devices (M=5.83/10; SD= 2.38), presents anxiety-related technology (M= 6.14/10; SD= 2.39), and considers themselves in good health conditions (M= 6.00/10; SD= 0.75). No one reported dizziness and/or cybersickness, as shown by the ITC-SOPI sub-scale investigating negative effects (M= 1.55/5; SD= 0.42).

Table 1. The table presents the mean and standard deviation (SD) of each item of the SUS. Responses are measured on a 5-point scale from 1, strongly disagree to 5, strongly agree

Items	Means	SD
I think that I would like to use this system frequently	3,86	0,90
I found the system unnecessarily complex	2	0,82
I thought the system was easy to use	3,14	1,21
I think that I would need the support of a technical person to be	3,71	0,95
I found the various functions in this system were well integrated	4,43	0,53
I thought there was too much inconsistency in this system	1,57	0,79
I would imagine that most people would learn to use this system very quickly	4,14	1,07
I found the system very cumbersome to use	3,43	1,13
I felt very confident using the system	3,71	1,25
I needed to learn a lot of things before I could get going with this system	2,57	1,27

Qualitative results of the TAP revealed that patients did not encounter problems using the tablet. However, most patients reported difficulties in the exploration of the environments, limiting their experience. Many users reported unclear instructions in a familiarization part of the app or before the tasks. Four patients had difficulties during the selection of maps in the spatial memory task, reporting a complex selection mode.

4. Conclusion

Based on the need to solve the issues related to the ecological validity of neuropsychological assessment [13], we created a tool that used naturalistic and life-like situations to assess memory. Generally, patients reported a sense of inability to interact with technologies during their daily life without experts' aid; and some users experience problems relating to the design of the app. However, they judged semApp as usable, reporting interest in trying this new assessment methodology. Moreover, they also confirmed their propensity to accept and use of the proposed instrument.

Our findings are promising to encourage the use of 360°-based applications for memory evaluation, with the advantage to provide an objective and standardized evaluation retracing real-life-like abilities. However, further studies are needed to solve the problem revealed thanks to usability experience, test the efficacy, and validate the instrument.

References

[1] Serino S, Repetto C. New trends in episodic memory assessment: Immersive 360° ecological videos. Front Psychol. 2018;9(OCT):1–6.

[2] Sbordone RJ. Ecological validity: Some critical issues for the neuropsychologist. In: Ecological validity of neuropsychological testing. Delray Beach, FL, England: Gr Press/St Lucie Press, Inc; 1996. p. 15–41.

[3] Riva G, Mantovani F. Extending the Self through the Tools and the Others: a General Framework for Presence and Social Presence in Mediated Interactions. In: Interacting with Presence: HCI and the Sense of Presence in Computer-Mediated Environments. 2014. p. 9–31.
[4] Cavedoni S, Cipresso P, Mancuso V, Bruni F, Pedroli E. Virtual reality for the assessment and rehabilitation of neglect: where are we now? A 6-year review update [Internet]. Virtual Reality. Springer London; 2022. Available from: https://doi.org/10.1007/s10055-022-00648-0
[5] Riva G, Wiederhold BK, Mantovani F. Neuroscience of Virtual Reality: From Virtual Exposure to Embodied Medicine. Cyberpsychology, Behav Soc Netw. 2019;22(1):82–96.
[6] Bruni F, Mancuso V, Stramba-Badiale C, Greci L, Cavallo M, Borghesi F, et al. ObReco-2: Two-step validation of a tool to assess memory deficits using 360° videos. Front Aging Neurosci. 2022;14(July):1–10.
[7] Bruni F, Mancuso V, Stramba-Badiale C, Pieri L, Riva G, Cipresso P, et al. 360° immersive photos and videos, an ecological approach to memory assessment: the ObReco-2. In: Annual Review of Cybertherapy and Telemedicine (ARCTT). 2022.
[8] Albert MS, DeKosky ST, Dickson D, Dubois B, Feldman HH, Fox NC, et al. The diagnosis of mild cognitive impairment due to Alzheimer's disease: Recommendations from the National Institute on Aging-Alzheimer's Association workgroups on diagnostic guidelines for Alzheimer's disease. Alzheimer's Dement. 2011;7(3):270–9. Available from: http://dx.doi.org/10.1016/j.jalz.2011.03.008
[9] Brooke J. SUS-A quick and dirty usability scale. Usability Eval Ind. 1996;189(194):4–7.
[10] Chen K, Lou VWQ. Measuring senior technology acceptance: Development of a Brief, 14-Item Scale. Innov Aging. 2020;4(3):1–12.
[11] Lessiter J, Freeman J, Keogh E, Davidoff J. A cross-media presence questionnaire: The ITC-sense of presence inventory. Presence Teleoperators Virtual Environ. 2001;10(3):282–97.
[12] Lewis CH. Using the "Thinking Aloud" Method In Cognitive Interface Design (Technical report). Ibm. Rc-9265. 1982.
[13] Chaytor N, Schmitter-Edgecombe M. The ecological validity of neuropsychological tests: A review of the literature on everyday cognitive skills. Neuropsychol Rev. 2003;13(4):181–97.

Exploring the Effect of Different Hints on Flow State in Virtual Reality

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Abstract. Flow state is a state of intense focus and engagement, which is fulfilling for people experiencing it. Virtual Reality (VR) is known to be one of the most immersive technologies available today. As such, it has great potential to foster flow state in its users. This work tries to determine which design characteristics favour flow the most, with regard to providing guidance to the user. In particular, this research examines whether in a VR escape room, text hints or glowing cues are more effective to foster feelings of flow. 24 participants experienced the same VR escape room, guided by text hints or glowing cues. The intensity of the resulting flow state has been evaluated through the Activity Flow State Scale (AFSS) designed by Payne et al., and qualitative data has also been gathered, from direct observation and user comments. AFSS score, duration of the VR experience, and duration estimated by the participants, have been compared. This data has then been connected to findings resulting from the thematic analysis of direct observation and user comments. The results did not provide a clear indication that either of the hint versions distinctly produced more flow, but rather that they both acted in different ways on separate flow subcomponents. The qualitative data also gave rise to several insights into the complexities of designing Virtual Reality experiences to foster flow.

Keywords. Flow state, Virtual Reality, hints

1. Introduction

Flow state is an “optimal experience” wherein individuals are totally immersed in an activity and perceive it as positive and rewarding[1]. It is characterised by nine components that can be observed and measured[1][2] (see Section 2 for the list).

Virtual Reality (VR), as one of the most immersive technologies available today, has been recognised for its potential to induce flow[3]. In this study, an effort is made to understand which characteristics of a VR experience are more successful in favouring flow. In particular, this research focuses on the impact of different kinds of hints on the nine components of flow, and on flow overall.

In this research, a distinction is made between text hints and glowing cues. By text hints, we mean instances where the user is given a subtle hint on what to do next, by means of text. By glowing cues, we mean an object that is important for the next user task glowing. The research suggests that both text hints and glowing cues could hold potential benefits for fostering flow[4]. Text hints convey a message that engages users and encourages them to decipher it, providing a clear goal. So, it could be argued that it would be the most flow-inducing method. However, too straightforward text hints may make the task too easy, disrupting the balance between skills and challenges, potentially leading to feelings of boredom[1]. On the other hand, glowing cues may be more difficult to interpret initially but could offer indications while still allowing for exploratory and playful behaviour, which has been associated with increased flow experience[5]. So, both text hints and glowing cues have potential to promote flow. This study aims to investigate which hint design is more effective at fostering flow.

2. Methodology

For the purposes of this study, a VR escape room was designed and implemented (See Figure 1). In the VR experience, the goal is to leave the room by completing sequential tasks. Each step involves interacting with an object to obtain another useful object for the next step, ensuring the ability to always provide relevant hints. Examples of tasks are finding a key hidden in a vase, activating levers to open a safe, popping a balloon, and solving a jigsaw puzzle (See Figure 2). To eliminate the effects of learnability, the research was designed as a between-subjects study. The participants were randomly divided into two groups and assigned to two different versions of the same VR experience differing only for the type of hint: version A with text hints, and version B with glowing cues.

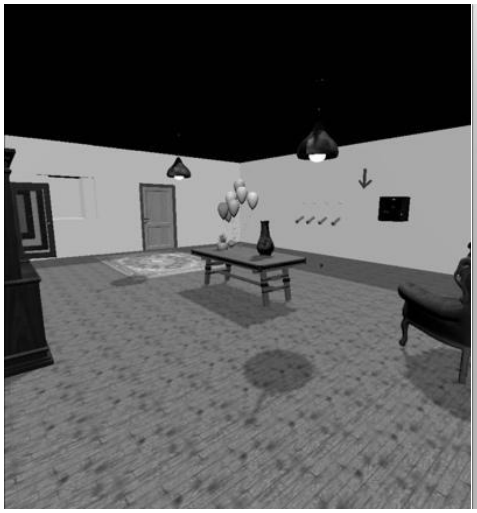

Figure 1. The VR escape room.

Figure 2. The jigsaw puzzle.

The independent variable in this research is whether the user receives guidance through text hints or glowing cues. The dependent variables are the following:

1. Flow experienced by the user. The subvariables are its nine components:
    1. Merging of actions and awareness;
    2. Clear goals;
    3. Concentration on the task at hand;
    4. Unambiguous feedback;
    5. Challenge-skill balance;
    6. Transformation of time;
    7. Sense of control;
    8. Loss of self-consciousness;
    9. Autotelic experience.
    10. Time that it takes the user to complete the escape room.
    11. Duration of the experience as perceived by the user.

The dependent variables are measured in the following ways:

1. Flow is measured through the Activity Flow State Scale (AFSS) developed and validated by Payne et al.[6]. The AFSS has 2 to 4 5-point Likert scale questions for each flow component. Each of the subvariables (**V1.1** to **V1.9**)'s score is the average of the scores of the Likert scales questions related to it. Overall flow score is the average of the scores of all components.

2. The actual experience duration is measured through a timer from the start of the VR experience to the end.
3. The duration perceived by the user is determined through a direct question at the end of the experience, such as "How much time do you think the VR experience took?".

The quantitative data collection took place along more qualitative research, which included direct observation of the participants with note-taking, as well as asking for general comments about the experience.

The study involved 24 participants, of which 7 female and 17 male. The average age of the participants is 25 years old. 15 of them had already tried VR before, and 9 had not. Participants were recruited from students and alumni at KTH Royal Institute of Technology, with the assumption that their age and technical university enrolment would result in sufficient affinity for technology to facilitate a smooth VR experience. Affinity for technology was measured using the ATI-S scale[7], with an average score of 4.69 out of 5, indicating a high inclination towards technology.

2.1 Ethical considerations

All participants were volunteers, informed of the study's purposes and provided with a consent form. The form outlined the study's objectives, researcher's contact information, experimental procedures, and data treatment. It ensured data anonymity and offered participants the options to request data deletion or withdraw consent at any time. The VR testing adhered to the health and safety guidelines of the Oculus Quest headset [8] to prevent harm to participants. Precautions were also taken to prevent the spread of Covid-19, including the provision of hand sanitizer, regular sanitization of the headset and controllers, and the use of participants' own devices for data collection.

3. Results and Discussion

The first data point is that the participants experienced a high level of flow. This is shown both in the quantitative results, where we can see a high overall average flow score (4.16 out of 5) and in the qualitative results: several participants made comments expressing concepts connected to flow (see Section 3.1). This shows that the intention to design the escape room in such a way to facilitate feelings of flow was mostly successful.

However, the average flow experienced by participants was similar between both versions, with version A averaging at 4.24 and version B at 4.08. Similarly, comparing average time spent in VR and the difference between actual and estimated experience duration yielded no notable results. The following results deal with differences in the flow components' scores.

The flow component "clear goals" was scored more highly in version A (4.57) than in version B (3.62). This suggests that participants in version A might have had a better understanding of the goals for each step of the experience, thanks to the hints being spelled out with text. However, there were not many indications of this in the qualitative data. It would be interesting to repeat the experiment with semi-structured user interviews and more specific questions in this regard.

Another notable data point regards the flow component "loss of self-consciousness". It had a relatively high score with respect to the other components, especially in version B (4.86). Mixed opinions were reported on self-consciousness by the participants (see point "Feelings of self-consciousness" in Section 3.1). However, the quantitative data shows that the "loss of self-consciousness" component, in version B, besides being scored higher on average, also had the lowest standard deviation across all flow components (0.35, when on average it was 0.96). So, the participants who experienced version B were overall more consistent in scoring this component highly. It seems that the glowing cues encouraged fewer feelings of self-consciousness in the participants. One hypothesis as to why is that the glowing cues might have made the escape room more difficult, because they were often not noticed by the participants, therefore the users

had virtually no guidance; since the room then required more effort to solve, the participants did not have cognitive resources to also think about people's perception of them. This hypothesis would be interesting to explore in further experiments, comparing feelings of self-consciousness in escape rooms with or without hints.

The difference in difficulty between the two versions is reflected by the quantitative data: the median score for the "challenge-skill balance" component was higher in version B (5, vs. 4.5 for version A). The participants characterized the room either as "easy" or "just right" with varying degrees, with some mentioning it would have been more rewarding if it had been harder.

3.1 Qualitative Data

Thematic analysis was performed on the qualitative data. The observations and statements of the participants expressing a similar theme have been grouped together; all the themes that emerged have been further grouped into three main areas. They are presented in the following.

Flow and related concepts. Many participants have remarked concepts that are closely connected to flow. Here are the most discussed ones.

- Enjoyment of the experience. Many of the participants described the escape room as fun and engaging, concepts closely related to flow experience.
- "Naturalness". Three of the participants specifically described the experience as "natural". One participant said: *"I was surprised at how fast it felt natural. Like in computer games, I just accepted 'this is now what's happening.'"* Other participants observed that they did not find a barrier in interacting with the virtual world, because it followed the same rules that they were used to in reality.
- Challenge-skill balance. Regarding the perceived difficulty of the room, two participants remarked that the experience was easy, and two others felt that having a higher difficulty could have improved the experience. It seems that the challenge-skill balance was not at the most flow-inducing level for everyone, and there could be more potential for flow if the difficulty was raised or made customizable.
- Time perception. Several participants noted some changes in their perception of time. Here are some quotes: *"Time was so different!"*; *"I don't know if my perception of time was right."*; *"I lost sense of time."*. These statements seem to reconfirm that the escape room, which was designed to bring about flow, succeeded in this regard, as time distortion is one of the most distinctive signs of flow.
- Feelings of self-consciousness. The participants were somewhat divided on this front, with one of them remarking that she felt self-conscious because in the beginning she did not know what to do, another one stating: *"The headset was a bit heavy, and once I thought about it, I was more self-conscious. Before, I did not realize I was in VR. I was aware of it, but I didn't think of it"*. So, the clunkiness of the hardware has the risk of making people self-conscious, which can interrupt the feelings of flow. Another participant remarked: *"I think I would do exactly the same actions in real life. I was not feeling what people were thinking about me."* This lack of self-consciousness is the best condition for flow.
- Another reality. One of the most interesting themes that emerged from people's statements was the deep immersion brought about by VR. Many people used the term "real" and "reality" when discussing this. Some examples: *"[during the experience] I can't believe it feels so real!"*; *"VR is a good experience, it always transports me to another reality [...] after some minutes there you really feel integrated in the game."* Some participants mentioned the moments in which they took the headset off, and they took some time to adapt to reality again: *"I still feel like I'm in the VR. I was afraid to come here because I didn't*

want to bump into something. [referring to the fact that when walking around in VR, they would often have to stop because of physical obstacles in their way]" The fact that many of them compare the VR experience with reality is also indicative of the "loss of self-consciousness" and "merging of actions and awareness" that they felt: in the escape room, the awareness that they were in VR slowly faded away; taking action and reaching specific goals became the main focus of their attention.

- Sense of purpose, and story. Some participants emphasized that it was important for them to know which steps to take next, and that initially not knowing what to do created feelings of frustration. This can be connected to the "clear goals" flow component. Also, some people remarked that having a story, a narrative, would have improved the experience. This indicates that having a clearer purpose, connected to a story, could benefit the sense of flow.

Hints. Most participants ignored or misunderstood glowing cues. Seven people were observed to openly ignore a glowing object. One participant later said: *"I did not notice anything glowing. Maybe I didn't pay attention to that."* Another said that he did notice things glowing, but he did not know that glowing meant that it was a cue.

Two different players expressed the concept that hints gave them feedback rather than a direction. They said: *"When I had it [the hint], I already had some idea of what I wanted, so it gave me kind of a feedback that I was right."*; *"The hints made me understand if I was going in the right direction, not so much as hints. Once I understood how it worked I progressed by myself."* This highlights the hints as game elements that are not only tied to one flow component, "clear goals", like it might be tempting to initially assume, but that can potentially have an effect on all of the components, and in this case they are related to the "clear feedback" flow component.

Individuality. One interesting area to explore is the impact that individual characteristics of each participant had on their experience, as well as the things in common that they all shared.

The most common observation that has been made on the participants' experience is their instinct to explore every corner of the room and to interact with many objects. While exploring, some participants thought creatively and did unexpected things. If the escape room were designed for the success of those alternate interactions, it could potentially create a bigger sense of flow, as it would reward participants for thinking creatively. In such a detailed experience, after the first few interactions the user's curiosity towards their environment would be stimulated and a more exploratory and playful behaviour might be favoured, which has been linked to flow state[5].

The impact of participants' individuality was quite evident when looking at the different ways in which they approached the challenges of the room. Those who had prior experience in video games and escape rooms expressed that their familiarity was advantageous in solving the room. Moreover, individual variations in behaviour and attitude were observed. For instance, one participant displayed high energy, swiftly interacting with objects throughout the room, while another adopted a methodical approach, thoroughly exploring at a slower pace.

In conclusion, hint design can impact different flow components in different ways. Designers looking to increase feelings of flow in VR experiences should consider their users' different experiences and playstyles to fine-tune challenge-skill balance, and use hints to make goals and feedback clear while still allowing for exploration and discovery.

References

[1] Csíkszentmihályi M. Beyond boredom and anxiety. Jossey-Bass; 1975.
[2] Jackson S, Marsh H. Development and Validation of a Scale to Measure Optimal Experience: The Flow State Scale. Journal of Sport & Exercise Psychology. 1996;18:17-35.
[3] Gaggioli A, Bassi M, Delle Fave A. Quality of Experience in Virtual Environments. In: Being there: Concepts, effects and measurements of user presence in synthetic environments; 2003. p. 122-32.

[4] He E, Lin J, Liu Z, Zhang Y. Research on Perceptual Cues of Interactive Narrative in Virtual Reality. In: Yamamoto S, Mori H, editors. Human Interface and the Management of Information. Information Presentation and Visualization. Lecture Notes in Computer Science. Cham: Springer International Publishing; 2021. p. 283-96. doi:10.1007/978-3-030-78321-1_22.

[5] Ghani JA, Deshpande SP. Task Characteristics and the Experience of Optimal Flow in Human-Computer Interaction. The Journal of Psychology. 1994;128(4):381-91. doi:10.1080/00223980.1994.9712742.

[6] Payne B, Jackson J, Noh S, Stine-Morrow E. In The Zone: Flow State and Cognition in Older Adults. Psychology and aging. 2011 Mar; 26:738-43. doi:10.1037/a0022359.

[7] Wessel D, Attig C, Franke T. ATI-S - An Ultra-Short Scale for Assessing Affinity for Technology Interaction in User Studies. In: Proceedings of Mensch und Computer 2019. MuC'19. New York, NY, USA: Association for Computing Machinery; 2019. p. 147-54. doi:10.1145/3340764.3340766.

[8] Facebook Technologies LLC. Oculus - Health and Safety Warnings. Available from: https://www.oculus.com/legal/health-and-safety-warnings/.

SECTION IV

ORIGINAL RESEARCH

Health care is one of the areas that could be most dramatically reshaped by these new technologies.

Distributed communication media could become a significant enabler of consumer health initiatives. In fact they provide an increasingly accessible communications channel for a growing segment of the population.

Moreover, in comparison to traditional communication technologies, shared media offer greater interactivity and better tailoring of information to individual needs.

Wiederhold & Riva, 2004

The Impact of Creative Virtual Reality on Decision-Making and Emotion Regulation

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Abstract. Digital tools have been increasingly applied in the field of psychology and well-being, such as Virtual Reality (VR), that provides vivid and realistic illusions of environments and stimuli to users' senses. Currently, one of the possible applications of VR in the field of psychology is the stimulation of creativity. Stimulating creativity might indeed enhance emotional regulation and promote positive feelings, which in turn might influence cognitive processes and past autobiographical memories. The present study aimed at evaluating the benefits and changes related to a creative VR experience on emotion regulation and the decision made during unpleasant past events. 25 healthy volunteers were enrolled and randomly assigned to one of two conditions: 1) painting VR, 2) neutral control condition. Before the experience, all participants were asked to think about an unpleasant past decision. Pre and post the exposure, participants evaluated the past decision and how much they felt the decision was based on System 1 or System 2. Results showed that participants in the creativity condition rated themselves as significantly more curious and felt that their creativity was stimulated compared to the control group. Furthermore, participants in the creative VR changed the perception of the how much they used System 1 in their choices, when controlling for emotional intelligence. Lastly, the creative experience led participants to feel less satisfied with their previous decision, possibly because it induced creative reasoning on possible alternatives. Results highlighted that VR for creativity can enhance creative feelings and shape emotions and individual relationship with decision-making.

Keywords. Virtual Reality, Creativity, Decision Making, Digital Tools, Emotion Regulation

1. Introduction

In recent years, digital tools for virtual content and experiences had a tremendous increase in number and spread among laypeople and in the research field. Virtual Reality (VR), in particular, has become increasingly utilized in mental health, psychology, and well-being [1]. These interventions usually target processes of distraction, relaxation and/or emotional regulation, and psychoeducational improvements [2-4].

Creativity received some attention among the possible psychological processes that might be targeted with VR [5]. Creativity is one intellectual ability to use personal knowledge to produce new ideas or valuable problem-solving solutions. Engaging people in creative activities might allow for the promotion of new solutions in response to challenging life events. A creative experience might also help in regulating negative

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emotions and internal states [6]. Painting and drawing experiences are also applied as therapeutic activities to improve psychological issues [7].

Using virtual environments to stimulate creativity might provide benefits in terms of increased realism and engagement, and it might create the possibility to experience a tailored exposure to creative stimuli, in a controlled virtual setting. Specifically, firstly VR might allow users to experience several ways of expressing their creativity in a virtual world (for example, experiencing different types of creative content and tools). Secondly, the use of immersive and realistic scenarios might induce a realistic illusion of 'being there' and let users feel and behave as if they really were in virtual environments. Furthermore, creating virtual creative content can be more easily corrected and deleted, lowering the risk of perceiving errors. Apart from emotional regulation, since creativity might help in producing new ideas, it might also help in re-elaborating previous past difficult or unpleasant autobiographical experiences.

Previous research already showed a positive relationship between immersive VR and individual creativity. Specifically, Yang and collaborators [8] showed that immersive VR can increase creativity and the generation of new ideas, helps maintain the attentional focus on creative tasks, and that designing new ideas in immersive environments is more effective than using paper-and pencils. The relationship between emotion, and autobiographical episodes has also already been tested [9]. However, it is still unclear if VR can help in this direction. Little is known about the possible relationship between virtual experiences, creativity, emotion regulation and the relationship with previous decisions and experiences.

On these bases, the present study aims at assessing:

1. the benefits and changes related to a VR experience (i.e., a painting experience) on self-perceived decision-making processes and emotions related to an unpleasant autobiographical episode of their life;
2. the differences between VR for creativity and a control group visualizing a natural landscape in the evaluation of decisions made during the recalled past unpleasant autobiographical episode and related emotions.

2. Method

Twenty-five healthy participants voluntarily took part in this research. After enrollment and the provision of informed consent, participants were randomly assigned to one of two groups: 1) *a painting group using VR* (*n*=13; Gender: Female *n*=7, Male *n*=6; M_{age} =33.92, SD_{age}=8.49; Age range: 23-52 years old) or 2) *a neutral control group using VR* (*n*=12; Gender: Female *n*=9, Male *n*=3; M_{age} =29.58, SD_{age}=4.62; Age range: 21-41 years old). The painting group was invited to use a VR program that allows participants to create immersive artwork with different color palettes and painting tools. The immersive experience was allowed through the use of an *Oculus Quest2 device*. Whereas, the second group was involved in a neutral condition, in which participants could see natural environments and scenarios with the VR headset. Both experiences lasted 15 minutes.

At the baseline, participants were invited to think about a past unpleasant autobiographical episode and rate the emotional experience related to it through *ad hoc* questions. Questions were related to their experienced negative emotions (*I felt anger in this situation;* with a 10-point Likert scale) and to the decision that they made in this situation. Specifically, participants were asked to rate the difficulty experienced during the decision made in this context (*How it was difficult to decide?;* with a 10-point Likert scale) and their use of System 1 and System 2 in the decision made in this episode. As in other studies [10], the use of System 1 was explored through the item "*To decide, I relied on intuition, inspiration*", while the use of System 2 was assessed with the item "*To decide, I relied on reasoning*" with a 10-point Likert scale. After the interventions, participants were also asked to rerate the same dimensions to assess any potential influences of the VR conditions on the explored variables.

Additionally, in order to check the influence of VR regarding the induction of personal creativity and personal sensations, after the VR stimulation, the following *ad*

hoc items (with a 10-point Likert scale) were administered: *"What I watched made me feel inspired"*, *"I felt that my creativity was stimulated"*, *"I felt free to express myself"*, and *"I felt curious"*.

Emotional intelligence (Brief Emotional Intelligence Scale; BEIS-10 [11]) and Self-Curiosity (Self-Curiosity Attitude-Interest Scale; SCAI [12-14]) were also explored to evaluate any possible influences of these variables on respondents' outcomes.

3. Results

Independent sample *t*-test were used to check the influence of VR stimulation regarding the induction of personal creativity and personal sensations in the painting and in the control group. Data showed that, compared to the control group, participants included in the painting group tended to perceive themselves significantly more curious ($t(23)=1.943$, $p < .05$, Cohen's $d = 0.77$; Painting group: $M=9.00$, $SD=1.08$; Control group: $M=8.00$, $SD=1.48$) and felt that their creativity was stimulated ($t(23)=3.340$, $p < .01$, Cohen's $d = 1.34$; Painting group: $M=8.08$, $SD=1.04$; Control group: $M=6.67$, $SD=1.07$). The effect sizes in both cases were relevant.

Furthermore, even if results highlighted a non-statistical significance, data suggested that participants exposed to painting activity tend to feel themselves more inspired (Painting group: $M=7.31$, $SD=1.89$; Control group: $M=6.42$, $SD=1.56$) and free to express themselves (Painting group: $M=7.85$, $SD=2.27$; Control group: $M=7.25$, $SD=2.42$) compared to the control condition.

Mixed-design analysis of variance was conducted with data collected at the baseline (before the VR stimulation) and after the VR conditions, in the painting and the control groups. Data highlighted a non-statistically significant change in the personal evaluation of their decisions made during the past autobiographical episode or in personal emotions related to it.

However, the repeated-measures analysis of variance (ANOVA) conducted on the experimental group only revealed that participants included in the painting group highlighted a tendency (even if not significant) to reduce the perception of using their *intuition, and inspiration* to manage the decisions made in their autobiographical episode after the exposure to the VR activity ($F=4.14$, $p=.065$; Painting group: *pre* $M=4.77$, $SD=2.55$, *post* $M=4.00$, $SD=2.55$). The investigation of the influence of emotion regulation abilities (i.e., emotional intelligence) suggested that the perception of using System 1 during this event significantly changed before and after the VR stimulation when controlling for emotional intelligence (ANCOVA; $p<.05$), but not for Self-Curiosity.

Finally, participants included in the painting group reported a significant change in their satisfaction with the choice that they made after the completion of the painting activity ($F=6.00$, $p<.05$, Hedges' g: .78; Painting group: *pre* $M=6.62$, $SD=2.26$, *post* $M=4.62$, $SD=2.79$).

4. Conclusion

Results from the present preliminary study give a first insight into how VR can stimulate creativity in healthy participants and which psychological features can be shaped and modified by this experience.

Overall, painting VR led to an increase in self-rated levels of curiosity, creativity, inspiration, and self-expression, meaning that the VR stimulation was effective in inducing a creative experience for users.

Furthermore, as regards the perception of past autobiographical episodes, participants in the creative VR changed their perception of how much they used System 1 in their choices when controlling for emotional intelligence. Thus, this result suggests that a painting and creative activity in VR can shape the self-perception of cognitive decision-making processes used in the past. In addition, after the VR experience, participants in the creative VR group were less satisfied with the choice they made. This

result might indicate that creativity helped participants to evaluate their past choices with a broader view and that they could think about possible alternative strategies that they could have applied. It is possible that participants in the VR painting conditions developed a more flexible and aware evaluation of their decision-making processes, generating new possibilities of actions.

The results of the present study should be interpreted in the light of some limitations: firstly, the sample size was quite limited, secondly the neutral VR condition may have shaped emotions as well, lastly, the present study employed a brief single session experience with a single category of individuals. Future studies with enlarged sample sizes, employing different control conditions, standardized self-assessment questionnaires and the possibility of training subjects or experiencing creative VR several times are needed.

Data from the present research will also allow for the construction of future digital interventions featuring innovative ways to enhance emotion regulation and stress management.

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References

[1] Freeman D, Reeve S, Robinson A, Ehlers A, Clark D, Spanlang B, Slater M. Virtual reality in the assessment, understanding, and treatment of mental health disorders. Psychol Med. 2017;47(14):2393–2400, doi:10.1017/S003329171700040X

[2] Glennon C, McElroy SF, Connelly LM, Mische Lawson L, Bretches AM, Gard AR, Newcomer LR. Use of Virtual Reality to Distract From Pain and Anxiety. Oncol Nurs Forum. 2018;45(4):545–552, doi:10.1188/18.ONF.545-552

[3] Anderson AP, Mayer MD, Fellows AM, Cowan DR, Hegel MT, Buckey JC. Relaxation with Immersive Natural Scenes Presented Using Virtual Reality. Aeros Med Hum Perf. 2017;88(6):520–526, doi:10.3357/AMHP.4747.2017

[4] Migoya-Borja M, Delgado-Gómez D, Carmona-Camacho R, Porras-Segovia A, López-Moriñigo JD, Sánchez-Alonso M, Albarracín García L, Guerra N, Barrigón ML, Alegría M, Baca-García E. Feasibility of a Virtual Reality-Based Psychoeducational Tool (VRight) for Depressive Patients. Cyberpsych Beh Soc N. 2020;23(4):246–252, doi:10.1089/cyber.2019.0497

[5] Graessler I, Taplick P. Supporting Creativity with Virtual Reality Technology. Proceedings of the Design Society: International Conference on Engineering Design. 2019;1(1):2011-2020, doi:10.1017/dsi.2019.207

[6] Ivcevic Z, Brackett MA. Predicting creativity: Interactive effects of openness to experience and emotion regulation ability. Psychol Aesthet Crea. 2015;9(4):480, doi:10.1037/a0039826.

[7] Deshmukh SR, Holmes J, Cardno A. Art therapy for people with dementia. Cochrane Database Syst Rev. 2018 Sep 13;9(9):CD011073, doi:10.1002/14651858.CD011073.pub2.

[8] Yang X, Lin L, Cheng PY, Yang X, Ren Y, Huang YM. Examining creativity through a virtual reality support system. Educational Technology Research and Development. 2018;66:1231-1254, doi:10.1007/s11423-018-9604-z

[9] Schulkind MD, Hennis LK, Rubin DC. Music, emotion, and autobiographical memory: They're playing your song. Mem Cogn. 1999;27:948–955, doi:10.3758/BF03201225

[10] Savioni L, Triberti S, Durosini I, Pravettoni G. How to make big decisions: A cross-sectional study on the decision making process in life choices. Curr Psychol. 2022;1-14, doi:10.1007/s12144-022-02792-x

[11] Durosini I, Triberti S, Ongaro G, Pravettoni G. Validation of the Italian Version of the Brief Emotional Intelligence Scale (BEIS-10). Psychol Rep. 2021;124(5):2356–2376, doi:10.1177/0033294120959776

[12] Aschieri F, Durosini I. Development of the Self-Curiosity Attitude-Interest scale. TPM-Testing, Psychometrics, Methodology in Applied Psychology. 2015;22(3):327–347, doi:10.4473/TPM22.3.2

[13] Aschieri F, Durosini I, Locatelli M, Gennari M, Smith JD. Factor structure invariance and discriminant validity of the Self-Curiosity Attitude-Interest scale. TPM-Testing, Psychometrics, Methodology in Applied Psychology. 2016;23(2):139–148, doi:10.4473/TPM23.2.1

[14] Aschieri F, Durosini I, Smith JD. Self-curiosity: Definition and measurement. Self Identity, 2020;19(1):105-115, doi:10.1080/15298868.2018.1543728

Body Dissatisfaction and Self-Disgust as Significant Predictors of Body-Related Attentional Bias. A Virtual Reality and Eye-Tracking Study

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Abstract. Body dissatisfaction, fear of gaining weight (FGW) and body anxiety have been extensively studied as some of the strongest risk and maintenance factors of anorexia nervosa (AN) symptomatology. Recently, a new theoretical model introduced self-disgust as a factor that can lead to avoidance behaviors when patients with AN face their body. This can make them vulnerable to relapse. In addition, body-related attentional bias (AB) (e.g., selective attention to weight-related body areas) can limit the efficacy of body exposure therapies. This study aims to investigate the possible predictors of AB, to better understand the underlying mechanisms that contribute to the maintenance of AN symptomatology. A total of 116 college students from the University of Barcelona participated in the study, using a combination of virtual reality and eye-tracking techniques to provide an objective and reliable assessment of AB in a highly realistic environment. Stepwise multiple linear regression analyses were performed to identify possible predictors of AB among body mass index, FGW, body anxiety, body dissatisfaction and self-disgust. The results shows that both body dissatisfaction and self-disgust are significant predictors of AB. While an increase in body dissatisfaction predicted a greater AB towards weight-related body areas (positive regression coefficients: $B_{Body\_dissatisfaction \rightarrow AB} > 0$, $p < .001$), the opposite occurred with self-disgust (negative regression coefficients: $B_{Self\_disgust \rightarrow AB} < 0$, $p < .02$). Such results provide initial evidence that self-disgust, which is a more intense negative feeling than body dissatisfaction, leads to gaze avoidance towards weight-related body areas, which are considered disgust elicitors.

Keywords: anorexia nervosa, attentional bias, body dissatisfaction, self-disgust, virtual reality, eye-tracking

1. Introduction

Anorexia nervosa (AN) is an eating disorder (ED) characterized by low weight (less than 85% of what is expected considering age and height), body image disturbances (BID; i.e., a dysfunctional way that individuals experience their body weight and shape) and an extreme fear of gaining weight (FGW). AN is considered one of the most serious ED and presents high comorbidity with other disorders, especially anxiety, depressive and

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personality disorders, and a multitude of medical complications derived from the state of malnutrition [1]. Previous studies showed that FGW and body anxiety towards specific own body areas (i.e., the body parts that the individuals may relate to weight) were some of the strongest risk and maintenance factors of AN symptomatology, which are also related to more severe ED symptoms [2]. Moreover, body dissatisfaction (i.e., the affective component of BID) causes a series of avoidance behaviors and negative checking strategies towards one's own body [3]. It has been shown to be a significant predictor of anorexia readiness syndrome (ARS) in women [4], and a predictor of a perceptual body distortion in the allocentric perspective (e.g., from third-person view), referring to external body benchmarks constructed by inter-individual comparison, influenced by abstract knowledge, beliefs, and attitudes related to a person's body in a given cultural context [5,6]. In addition, in a theoretical model recently proposed by Glashouwer & de Jong (2021) [7], self-disgust (i.e., intense negative feelings of revulsion and an overwhelming and irresistible urge to avoid potential disgust elicitors) could lead to avoidance behaviors when patients with AN face their body (e.g., hiding their body in wide clothing, not touching their body, or taking a shower with the lights turned off). This can make individuals vulnerable to relapse.

Body exposure therapies have been used to reduce the effects of these factors through habituation process [8] but can be limited due to body-related attentional bias (AB) (e.g., selective attention towards specific body areas). Previous studies described this AB as a tendency to focus more on self-reported unattractive body parts than other body parts in adult women with high body dissatisfaction (e.g., [9]) and patients with ED (e.g., [10]). In addition, body-related AB has been shown to be an important risk factor for maintaining BID and associated mental health concerns in healthy individuals and patients with EDs (see the full review in [11]). Previous studies have used virtual reality (VR), in combination with eye-tracking (ET) techniques, to assess the effects of body-related AB and enhance body exposure therapies for the treatment of ED (full reviews available in [12,13]). Indeed, the integrated ET feature in the VR head-mounted display (HMD) provides a direct, continuous, objective assessment of attentional patterns in real-time. It highlights avoidance and engagement with stimuli over time (e.g., with food cues or the participants' specific body parts) [14]. In addition, using VR technology, researchers and therapists can create highly realistic simulations of real-life settings and situations that individuals have associated with their body and weight concerns (e.g., a dressing room, a bathroom or a locker room), and design three-dimensional (3D) avatars that reproduce the patients' silhouettes based on their own body size, height, skin tone and clothes [15]. In addition, the full-body motion tracking feature of VR systems enables synchronization of movements of individuals and avatars, so that participants can perceive and feel their respective virtual bodies as if they were their real bodies by activating the feeling of ownership over a virtual avatar [16]. This paradigm is known as the full-body ownership illusion [17]. For these reasons, VR is considered a transformative technology that is now used in various fields of psychology, both in research and therapeutics (see full reviews in [18,19]).

This study aims to use a combination of VR and ET techniques to assess the body-related AB of participants, while looking at their avatars in a virtual mirror (e.g., from an allocentric perspective), to search for possible predictors of AB among variables related to AN (i.e., body mass index [BMI], FGW, body anxiety, body dissatisfaction and self-disgust) and thus better understand the underlying mechanisms that contribute to the maintenance of AN symptomatology.

2. Method

2.1 Participants

College students from the Faculty of Psychology of the University of Barcelona were recruited using social networks and flyers. Finally, 116 students (99 females, 17 males, M_{age} = 24.43 years, SD_{age} = 5.30 years; M_{BMI} = 22.52 kg/m^2, SD_{BMI} = 2.99 kg/m^2)

participated voluntarily in the study and went through the entire procedure. The exclusion criteria were self-reported diagnosis of ED or mental disorders with psychotic or manic symptoms (e.g., psychotic disorders or bipolar disorders), pregnancy (which could temporarily distort the body image), epilepsy and visual conditions (e.g., severe astigmatism that could distort eye-tracking measures).

2.2 Instruments

A VR environment was developed using Unity 3D 5.6.1. software. It consisted of a room without any furniture except for a large mirror located 1.54 m in front of the participant and two boxes placed on the floor beside him/her (see Figure 1). The participant was immersed in a VR-environment using a HMD HTC VIVE Pro Eye®, which integrates dual-OLED displays (combined resolution of 2880 x 1600 pixels and 615 PPI) and an ET feature powered by Tobii® with very high precision (binocular gaze data output frequency: 120 Hz, spatial accuracy between 0.5 and 1.1 degrees, 5-point calibration process). The virtual body reflected in the mirror was an avatar, designed using Blender® v2.78 and adjusted finely to each participant's height and silhouette through an initial photography procedure. The avatar wore standard clothes (including t-shirt, trousers and shoes), whose colors could be adjusted to that of the participant. In addition, the avatar wore a HMD and its head was covered by a grey cap, to reproduce the actual participant's condition during the task and reduce the influence of individual hairstyle.

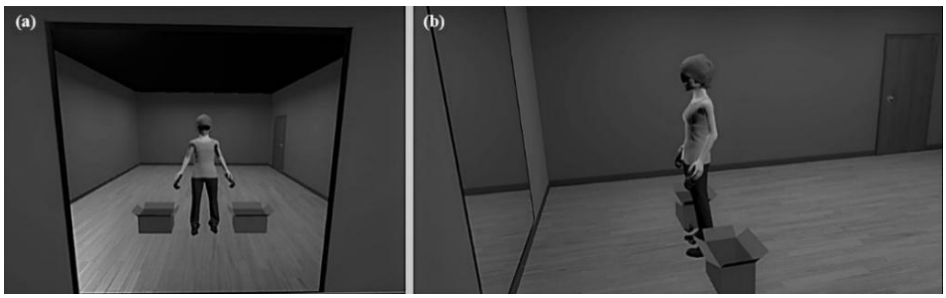

Figure 1. Front (a) and profile (b) views of female avatar in the VR immersive environment.

2.3 Measures

BMI was calculated after measuring the participant's weight and height on-site, using the formula BMI = weight (in kilograms)/ height (in m)^2. Body dissatisfaction was assessed through the Spanish version [20] of the 10-item EDI-BD subscale of EDI-3 inventory [21], which measures body dissatisfaction with the whole body and specific body parts. EDI-3 has robust validity indices, temporal stability and good internal consistency (Cronbach's alpha between .74 and .96) [20]. Self-disgust was assessed using the 12-item Self-Disgust Scale (SDS) [22], which shows good psychometric qualities in terms of internal consistency (Cronbach's alpha = .91), reliability (significant test-retest correlation of .94) and convergent validity [22]. In the current study, Cronbach's alphas were .85 for the EDI-BD scale and .88 for SDS. FGW and body anxiety were assessed through visual analog scales (VAS) from 0 to 100 with the following questions, respectively: "on a scale of 0 to 100, indicate to what extent you are afraid of gaining weight at this moment, where 0 is not at all and 100 is a lot", "on a scale of 0 to 100, indicate the level of anxiety toward your body that you are feeling at this moment, where 0 is not at all and 100 is a lot".

AB was assessed through a similar procedure to that used in a previous study (see the full description in [23]), based on the participants' visual fixations of more than 100 ms on specific body areas of interest (AOIs), recorded through the ET feature of the

HMD and then processed by OGAMA software (Freie Universität, Berlin, Germany). Such a specific gaze-behavioral measure has been shown to be a reliable measure of attention allocation towards specific body areas in previous studies using ET techniques (see full reviews in [12,24]).

Two groups of AOIs were defined based on the Physical Appearance State and Trait Anxiety Scale (PASTAS; [25]) and labelled as follows (see Figure 2a):

- Weight-related AOIs (W-AOIs): thighs, buttocks, hips, stomach, legs and waist.
- Non-weight-related AOIs (NW-AOIs): neck, chest, shoulders, arms and feet.

The head and hands of the participants were not considered in the calculation, since the avatars reflected in the mirror held VR devices (HMD and controllers) like the participants. In this case, fixations on these body parts had more to do with the attention towards these devices than with the participants' head and hands, and therefore could have biased the assessment of AB.

AB was assessed using complete fixation time (AB_CFT) and number of fixations (AB_NF), which were respectively defined as the difference between visual fixation duration (in ms) and number of fixations on W-AOIs minus those on NW-AOIs:

$$\text{AB\_CFT} = \text{Complete fixation time}_{\text{on W-AOIs}} - \text{Complete fixation time on}_{\text{NW-AOIs}} \quad (1)$$

$$\text{AB\_NF} = \text{Number of fixations}_{\text{on W-AOIs}} - \text{Number of fixations on}_{\text{NW-AOI}} \quad (2)$$

Both AB_CFT and AB_NF could thus adopt positive or negative values, depending on whether the participants' visual attention was predominantly focused on W-AOIs (positive values) or NW-AOIs (negative values) (see the examples of attentional patterns of both types in Figures 2b and 2c).

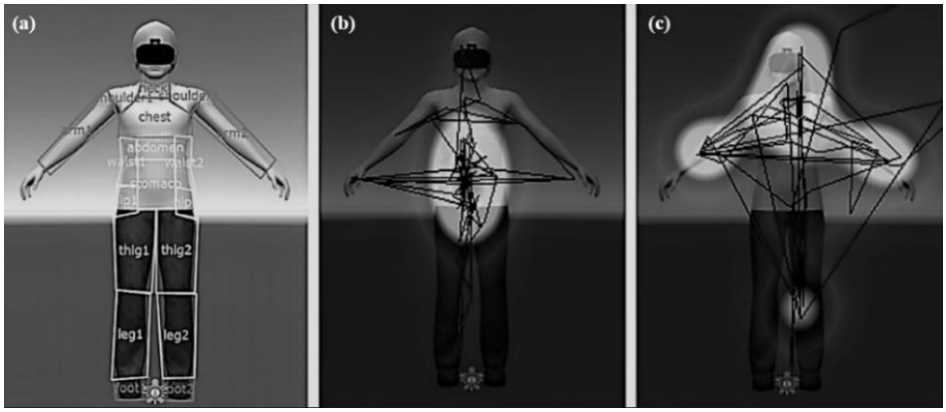

Figure 2. W-AOIs and NW-AOIs definition in OGAMA (a); examples of attentional patterns more focused on W-AOIs (AB_CFT > 0 and AB_NF > 0) (b), and on NW-AOIs (AB_CFT < 0 and AB_NF < 0) (c).

2.4 Procedure

This study was approved by the Bioethics Commission of the University of Barcelona (CBUB). At the beginning of the study, participants freely signed a consent form. Weight and height were then measured to calculate the BMI. Afterwards, while participants were answering the questionnaires and VAS to assess body dissatisfaction, self-disgust, FGW and body anxiety, the researcher created the avatars' silhouettes using a photography procedure. Participants were then immersed in the virtual environment using HTC VIVE Pro Eye ® HMD and equipped with body trackers to enable the avatars to move in the same way as their real body. A five-minute visuo-motor and visuo-tactile stimulation adapted from previous studies (e.g., see [26]) was then applied to elicit the Full Body Ownership Illusion (i.e., to perceive and regard a virtual body as one's own real body). Subsequently, the body-related AB was assessed during a 30-second free exposure task to participants' avatars reflected in a mirror in the virtual environment (i.e., from

allocentric perspective). HMD and body trackers were then removed, and the participants could rest for the necessary time, while the researcher answered any possible doubts.

2.5. Statistical analysis

Answers from EDI-BD and SDS questionnaires were processed using the Qualtrics® platform. In addition, ET data were imported into OGAMA software to process AB variables (AB_CFT and AB_NF). Then, stepwise multiple linear regression analyses were performed using IBM ® SPSS version 27 to identify possible predictors of AB (for both AB_CFT and AB_NF variables analyzed separately).

3. Results

Descriptive statistics for the entire sample are given in Table 1.

Table 1. Descriptive statistics for the entire sample. BMI = body mass index; AB_CFT and AB_NF = attentional bias (complete fixation time and number of fixations respectively); EDI-BD = body dissatisfaction scale; SDS = self-disgust scale; VAS_FGW = fear of gaining weight's VAS; VAS_BA = body anxiety's VAS.

	BMI	**AB_CFT (s)**	**AB_NF**	**EDI_BD**	**SDS**	**VAS_FGW**	**VAS_BA**
Mean	22.52	- 1.74	- 6.11	8.78	27.04	46.37	18.54
(SD)	(2.99)	(6.27)	(15.10)	(7.19)	(10.54)	(31.73)	(22.93)

All the linear regression's assumptions were satisfied. Linear relationships among the variables were apparent using scatter plots. There was homoscedasticity of the residuals (uniform variation of the residuals with predicted values as indicated by non-significant Pearson correlation; $p > .05$ for all variables) and normality of the residuals (as indicated by non-significant bilateral asymptotic significance in the Kolmogorov-Smirnof test; $p > .05$ for all variables). There was no multicollinearity between considered variables (tolerance > .1 and VIF < 10 for all variables). Finally, there was independence of the residuals, as assessed by Durbin–Watson statistics (1.78 and 1.72 respectively for AB_CFT and AB_NF regressions). No outliers were detected.

Analyses showed that both body dissatisfaction and self-disgust predicted AB_CFT with respectively $B_{EDI\text{-}BD \rightarrow AB\_CFT} = .360$ ($p < .001$) and $B_{SDS \rightarrow AB\_CFT} = -.176$ ($p = .011$), in a model that accounted for 14.1% of the explained variability (significant linear relation confirmed by ANOVA: $p = .001$). Similarly, body dissatisfaction and self-disgust predicted AB_NF with respectively $B_{EDI\text{-}BD \rightarrow AB\_NF} = .914$ ($p < .001$) and $B_{SDS \rightarrow AB\_NF} = -.397$ ($p = .016$), in a model that accounted for 15.1% of the explained variability (significant linear relation confirmed by ANOVA: $p < .001$). None of the other variables (BMI, FGW and body anxiety) explained a significant additional variance percentage of AB_CFT or AB_NF, so they were not included in the respective regression equations.

4. Discussion

Body dissatisfaction and self-disgust have been shown to be significant predictors of AB. An increase in body dissatisfaction predicted a greater AB towards weight-related body areas (an increase of 1 point on the EDI-BD subscale increased the AB_CFT by .360 seconds and the AB_NF by .914 fixations). However, the opposite occurred with self-disgust (an increase of 1 point on the SDS scale decreased the AB_CFT by .176 seconds and the AB_NF by .397 fixations). These results confirm a significant positive relationship between body dissatisfaction and body-related AB, which is defined as a tendency to focus more on some body parts (e.g., weight-related body parts) than other body parts (e.g., non-weight-related body parts), as shown in previous studies with non-clinical participants with high body dissatisfaction (e.g., [9]) and clinical patients with ED (e.g., [10]). These results provide the first evidence that self-disgust, defined as a more intense negative feeling than body dissatisfaction, has an opposite effect on the AB

and leads to gaze avoidance towards weight-related body parts considered as disgust elicitors, as predicted in the theoretical model [7]. However, such results still need to be confirmed with AN patients in future studies, to explore whether variables such as FWG, body anxiety and BMI also predict AB in patients, unlike in healthy participants. In addition, some improvements to the VR environment (to make it more relevant in everyday life situations), or to the avatars (e.g., using 3D body scanning to better design the avatars), should be considered to enhance the ecological validity with clinical patients.

As a conclusion, this study shows how the combined use of virtual reality and eye-tracking technology offers new opportunities to assess body-related AB, to better understand the underlying mechanisms that contribute to the maintenance of AN symptomatology, and to enhance body exposure therapies and AN treatment.

Acknowledgments

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References

[1] Mehler PS, Brown C. Anorexia nervosa – medical complications. J Eat Disord 2015 Mar;3(1):1–8, doi:10.1186/S40337-015-0040-8

[2] Calugi S, El Ghoch M, Conti M, Dalle Grave R. Preoccupation with shape or weight, fear of weight gain, feeling fat and treatment outcomes in patients with anorexia nervosa: A longitudinal study. Behav Res Ther 2018 Jun;105:63–8, doi: 10.1016/j.brat.2018.04.001

[3] Williamson DA, White MA, York-Crowe E, Stewart TM. Cognitive-Behavioral Theories of Eating Disorders. Behavior Modification 2016 Jul;28(6):711–38, doi: 10.1177/0145445503259853

[4] Rymarczyk K. The role of personality traits, sociocultural factors, and body dissatisfaction in ARS in women. J Eat Disord 2021 Apr;9(1):1–10, doi: 10.1186/s40337-021-00410-y

[5] Corno G, Serino S, Cipresso P, Banos RM, Riva G. Assessing the relationship between attitudinal and perceptual component of body image disturbance using virtual reality. Cyberpsychol Behav Soc Netw. 2018; 21(11). doi: 10.1089/cyber.2018.0340

[6] Monthuy-Blanc J, Bouchard S, et al. "eLoriCorps Immersive Body Rating Scale": Exploring the assessment of body image disturbances from allocentric and egocentric perspectives. J. Clin. Med. 2020; 9, 2926; doi:10.3390/jcm9092926

[7] Glashouwer KA, de Jong PJ. The revolting body: Self-disgust as a key factor in anorexia nervosa. Curr Opin Psychol 2021 Oct;41:78–83, doi: 10.1016/j.copsyc.2021.03.008

[8] Griffen TC, Naumann E, Hildebrandt T. Mirror exposure therapy for body image disturbances and eating disorders: A review. Clinical Psychology Review 2018;65:163–74, doi: 10.1016/j.cpr.2018.08.006

[9] Jansen A, Nederkoorn C, Mulkens S. Selective visual attention for ugly and beautiful body parts in eating disorders. Behav Res Ther 2005 Feb;43(2):183–96, doi: 10.1016/j.brat.2004.01.003

[10] Bauer A, Schneider S, et al. Selective Visual Attention Towards Oneself and Associated State Body Satisfaction: an Eye-Tracking Study in Adolescents with Different Types of Eating Disorders. J Abnorm Child Psychol 2017 Nov;45(8):1647–61, doi: 10.1007/s10802-017-0263-z

[11] Rodgers RF, DuBois RH. Cognitive biases to appearance-related stimuli in body dissatisfaction: A systematic review. Clin Psychol Rev 2016 Jun;46:1–11, doi: 10.1016/j.cpr.2016.04.006

[12] Jiang MYW, Vartanian LR. A review of existing measures of attentional biases in body image and eating disorders research. Aust J Psychol 2020 Mar;70(1):3–17, doi: 10.1111/ajpy.12161

[13] Stott N, Fox JRE, Williams MO. Attentional bias in eating disorders: A meta-review. Int J Eat Disord 2021 Aug;54(8):1377–99, doi: 10.1002/eat.23560

[14] Kerr-Gaffney J, Harrison A, Tchanturia K. Eye-tracking research in eating disorders: A systematic review. Int J Eat Disord 2019 Jan;52(1):3–27, doi: 10.1002/eat.22998

[15] Gutiérrez-Maldonado, J.; Ferrer-García, M.; Dakanalis, A.; Riva G. Virtual Reality: Applications to Eating Disorders. In: The Oxford Handbook of Eating Disorders. Oxford University Press: UK; 2018.

[16] Riva G, Gutiérrez-Maldonado J, Dakanalis A, Ferrer-García M. Virtual Reality in the Assessment and Treatment of Weight-Related Disorders. 2019;163–93, doi: 10.1007/978-1-4939-9482-3_7

[17] Maselli A, Slater M. The building blocks of the full body ownership illusion. Front Hum Neurosci 2013 Mar;7:83, doi: 10.3389/fnhum.2013.00083

[18] Magrini M, Curzio O, Tampucci M, Donzelli G, Cori L, Imiotti MC, et al. Anorexia Nervosa, Body Image Perception and Virtual Reality Therapeutic Applications: State of the Art and Operational Proposal. Int J Environ Res Public Heal 2022 Feb;19(5):2533, doi: 10.3390/ijerph19052533

[19] Riva G, Malighetti C, Serino S. Virtual reality in the treatment of eating disorders. Clin Psychol Psychother 2021;28(3):477–88, doi: 10.1002/cpp.2622

[20] Elosua P, López-Jaúregui A, Sánchez-Sánchez F. EDI-3, Inventario de Trastornos de la Conducta Alimentaria-3, Manual. Tea Ediciones: Madrid, Spain; 2010.

[21] Garner DM. Eating Disorder Inventory– 3 Professional manual. Odessa, Fl: Psychological Assessment Resources; 2004.
[22] Overton PG, Markland FE, et al. Self-disgust mediates the relationship between dysfunctional cognitions and depressive symptomatology. Emotion 2008 Jun;8(3):379–85, doi: 10.1037/1528-3542.8.3.379
[23] Meschberger-Annweiler F-A, Ascione M, Porras-Garcia B, et al. An Attentional Bias Modification Task, through Virtual Reality and Eye-Tracking Technologies, to Enhance the Treatment of Anorexia Nervosa. J Clin Med 2023 Mar;12(6):2185, doi: 10.3390/jcm12062185
[24] Kerr-Gaffney J, Harrison A, Tchanturia K. Eye-tracking research in eating disorders: A systematic review. Int J Eat Disord 2019;52(1):3–27, doi: 10.1002/eat.22998
[25] Reed DL, Thompson JK, et al. Development and validation of the Physical Appearance State and Trait Anxiety Scale (PASTAS). J Anxiety Disord 1991;5(4):323–32, doi: 10.1016/0887-6185(91)90032-O
[26] Porras-Garcia B, Ferrer-Garcia M, Serrano-Troncoso E, et al. Validity of Virtual Reality Body Exposure to Elicit Fear of Gaining Weight, Body Anxiety and Body-Related Attentional Bias in Patients with Anorexia Nervosa. J Clin Med 2020;9(10):3210, doi: 10.3390/jcm9103210

Allocentric Full Body Illusion extends Peripersonal Space

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Abstract. Body Self-Consciousness (BSC) is based on a multisensory integration (MSI) process, in which bodily signals and information entering the space immediately surrounding the body - the Peripersonal Space (PPS) - are integrated. The PPS contributes to the development of self-presentation and plays a critical role in shaping how people interact with the surrounding physical and social environment. Alterations in the PPS have been found to be associated with conditions characterised by abnormal anxiety responses or altered states of the BSC, suggesting a possible role in the maintenance of pathological behaviour. Thus, previous research has explored the possibility of manipulating PPS through body illusions. In the present study, we investigated whether a full-body illusion (FBI) presented from an allocentric spatial frame was able to extend the PPS boundary. Participants performed the first run of the PPS task and were then presented with the FBI, followed by a second run of the PPS task for both synchronous and asynchronous conditions. Results showed that PPS increased after the synchronous FBI compared to baseline. As the PPS reflects a change in the MSI, future studies should investigate whether PPS enhancement and allocentric FBI can positively influence body experience in conditions characterised by BSC alterations, such as eating disorders, as well as their effects on the way people interact with their physical and social environment.

Keywords. Full Body illusion, Multisensory Integration, Peripersonal Space

1. Introduction

The body is the basis of self-consciousness in what is defined as Body Self-Consciousness (BSC) [1]. BSC refers to the experience of owning a body (body ownership), being in a specific location within an environment (self-location), and having a body-centred perspective from which the world is perceived (egocentric perspective) [2]. This complex experience results from a multisensory integration (MSI) process in which information from different sensory modalities (e.g., visual and tactile) is encoded and fused into a unique and coherent percept [1]. In particular, bodily experience requires the integration of cross-modal body-related signals as well as information from stimuli entering the space immediately surrounding the body, the peripersonal space (PPS) [3].

PPS refers to the self-other boundary and is an essential component of self-consciousness as it shapes interactions with the physical environment (e.g., avoiding potential threats, interacting with objects) as well as social interactions [4]. MSI plays a crucial role in the PPS, allowing us to locate ourselves in space and helping us to localise external entities in close proximity to our body [4]. Indeed, multisensory facilitation occurs within PPS, meaning that crossmodal integration occurs much faster than in extrapersonal space (i.e., space far from the body) [5]. Indeed, a well-established task for

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assessing PPS requires participants to detect a tactile stimulus (e.g., vibration) on a specific body part while task-irrelevant visual stimuli approach them [5]. The distance at which reaction times (RTs) decrease due to the co-presentation of tactile and visual stimuli is considered an estimate of the PPS boundary [5,6].

Previous research has investigated PPS in psychopathological conditions characterised by abnormal fear responses and/or altered states of the BSC (e.g. phobias, trauma-related disorders) [4] and found an effect of stress and anxiety on PPS estimates. It has been proposed that this may play a role in the maintenance of pathological behaviours such as avoidance of certain stimuli and social isolation [4].

As a result, recent research has begun to investigate whether it is possible to manipulate PPS using the Full Body Illusion (FBI). It was found that promoting embodiment via a smaller or taller virtual body increased the PPS boundary [7], and that using virtual tools that extend the physical boundaries of the body affected PPS [8]. In addition, relatively recent research has found changes in PPS following FBI in both the anterior and posterior body space [9].

Despite promising results, there is still a lack of research in this area, and conflicting results have been found when Virtual Reality (VR) experiences are proposed [10].

In this pilot study, we wanted to investigate whether it is possible to extend PPS using the FBI. Specifically, we used a visual-tactile task to compare PPS boundary estimation before and after exposure to an allocentric (third-person) perspective FBI in VR. First paragraph.

2. Methods

2.1 Participants

For this pilot study, we recruited a total of 15 participants [9 females; mean age: 25.7 (SD=1.80); mean BMI: 21.7 (SD=3.14)]. None of them reported having a current and/or a history of neurological and/or psychiatric disorders.

2.2 Procedure

Participants completed a questionnaire to assess basic socio-demographic information. They then underwent the PPS task to measure baseline PPS limits. Subsequently, the FBI was presented from an allocentric (i.e., third-person) perspective and participants were instructed to stand behind the avatar and focus on its back for 5 minutes [9]. All participants received both synchronous and asynchronous visuotactile stimuli and were required to complete the Embodiment Questionnaire after each condition.

2.3 Peripersonal Space Task [6]

The visuotactile task to assess PPS required participants to respond as quickly as possible to a tactile stimulation on their face by pressing a button while observing a task-irrelevant, approaching ball in a virtual environment. The timing between the presentation of the visual and tactile stimuli was varied so that the tactile stimulation was delivered when the visual stimulus was at different distances from the subject (D1 ≈ 45 cm; D2 ≈ 80 cm; D3 ≈ 115 cm; D4 ≈ 150 cm; D5 ≈ 185 cm).

The task consisted of four types of trials: bimodal visuotactile, unimodal tactile, unimodal visual and attentive trials. In bimodal visuotactile trials (N=60), the tactile stimulation was delivered at five different time delays from the onset of the visual stimulation (D5=0.5s; D4=1s; D3=1.5s; D2=2s; D1=2.5s). Thus, the ball could be at five possible distances when the vibration was applied. In unimodal tactile trials (N=60), the vibrations were presented without a corresponding visual stimulus with a temporal delay as described above. In unisensory visual trials (N=60), the approaching ball approached the participant without a corresponding tactile stimulus. In addition, attention trials

(N=12) were proposed in which participants had to verbally report the presence of a red dot on the ball. The whole session lasted 15 minutes.

2.4 Full Body Illusion

The FBI used a standard size virtual body created using MakeHumans software and imported into Unity3D to create the immersive scenario. Participants wore a head-mounted display and were asked to stand behind the avatar (≈50 cm) and focus on its back. Participants received a visuotactile stimulation on the virtual and real body for 5 min. The same stimulation was offered both synchronously and asynchronously, varying the temporal synchrony between the felt and seen touch. After each condition, participants completed the Embodiment Questionnaire to assess the strength of the illusion [11].

3. Analysis

Performance in the PPS task was analyzed in terms of RTs to the tactile stimulation based on previous research [6]. RTs higher or lower than 2 standard deviations were excluded from the analyses. We computed mean RTs to tactile stimuli at different distances and subtracted it from the averaged RTs to bimodal trials for each participant. In this way, we obtained corrected RTs, where negative values indicated multisensory facilitation.

A 3 (Condition: Baseline, Synchronous, Asynchronous) x 5 (Distance: D1 to D5) repeated measures ANOVA was performed on corrected RTs to investigate the effect of the FBI stimulation and the different distances at which the tactile stimulation was provided. The Greenhouse-Geisser correction was applied when the sphericity assumption was violated as assessed by Mauchly's test.

We performed paired t-tests to compare the adjacent couples (e.g., D1 against D2, D2 against D3) within each condition to identify when multisensory facilitation stopped as a proxy of the PPS boundary [6].

Corrected RTs were fitted to a linear function and the relative slopes were extracted as indexes of segregation between the peripersonal and extrapersonal space(4,12). The function was described by the equation: $y(x) = y0 + k \cdot x$; where x represents the independent variable (i.e., the timing of tactile stimulation in ms), y the dependent variable (i.e., the reaction time), y0 represents the intercept at $x = 0$ and k is the slope of the function [6]. We ran a within-subjects ANOVA to compare the slopes in the different conditions to better characterize changes in PPS boundaries.

4. Results

Results from repeated measures ANOVA analysis showed a significant main effect for Condition ($F(2, 28) = 25.116$, $p < 0.001$, $\eta^2g = 0.112$) and Distance ($F(1.73, 24.31) = 38.62$, $p < 0.001$, $\eta^2g = 0.49$), as well as a significant interaction effect Distance*Condition ($F(2.08, 329.24) = 7.170$, $p < 0.001$, $\eta^2g = 0.158$; Figure 1). Thus, data highlighted significant differences among PPS boundaries between the conditions.

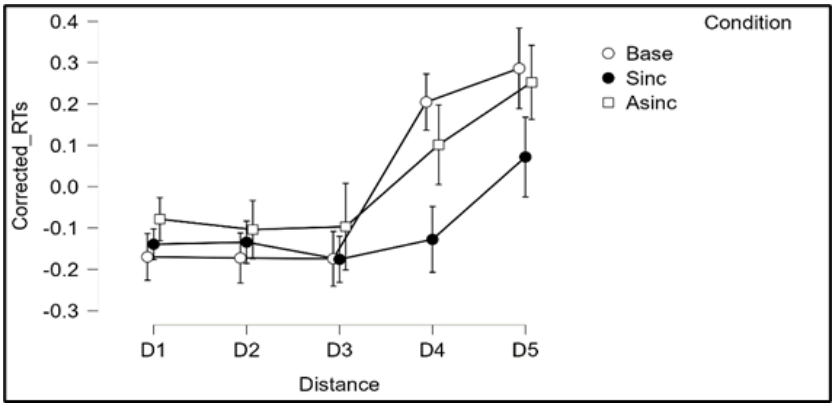

Figure 1. Repeated measures ANOVA considering Condition (baseline, asynchronous, synchronous) and Distance (from D1 to D5) as within factors.

The paired t-test revealed significant differences in reaction times (RTs; i.e., differences in multisensory facilitation effect) between D3 and D4 in the Baseline and Asynchronous conditions ($p = 0.001$, $p = 0.002$ respectively), whereas emerged between D4 and D5 in the Synchronous condition ($p = 0.019$). In the Asynchronous and Baseline conditions indeed multisensory facilitation dropped between D3 and D4 (i.e., corrected RTs were above zero, indexing the absence of facilitation), whereas it dropped between D4 and D5 in the Synchronous condition.

The within-subjects ANOVA including slopes in the different conditions as within factors showed a significant main effect of Condition ($F(2, 28) = 11.42$, $p < 0.001$, $\eta^2g = 0.32$) on slopes. Post hoc comparisons revealed that significant differences emerged when comparing the Baseline and Synchronous conditions ($p < 0.001$, Bonferroni-corrected) and the Synchronous and Asynchronous conditions ($p < 0.001$ Bonferroni-corrected), whereas no significant differences emerged between the Baseline and Asynchronous ones ($p = 0.474$, Bonferroni-corrected). Additionally, the slope was smaller in the Synchronous condition (Sync_mean = 0.094, SD = 0.035) compared to the other conditions (base_mean = 0.177, SD = 0.058, async_mean = 0.166, SD = 0.057), indexing an enlargement of the PPS boundary in the Synchronous condition [6].

5. Discussion and Conclusion

In this study, we investigated whether PPS boundaries could be altered by inducing embodiment over a virtual body using allocentric FBI in VR. We found that after synchronous stimulation during allocentric FBI, the PPS boundary expanded towards the location of the avatar, such that the PPS representation shifted from being centred on the location of the physical body to being centred on the embodied body [9]. Therefore, our data confirmed evidence that FBI can affect the BSC in all its components, namely body ownership, spatial perspective and self-location.

We suggest further research to evaluate allocentric FBI to investigate body experience and its underlying mechanisms. As PPS shift reflects a change in MSI [13], allocentric FBI may be effective in altering body experience by working on its underlying process. This is relevant to the study of pathological conditions characterised by altered BSC, such as eating disorders (EDs) [14]. Indeed, there is considerable evidence that patients affected by these conditions report altered body experience (e.g. body misperception), and recent work suggests that this may be related to MSI deficits [14]. Following this idea, previous research has used the egocentric (first-person) FBI to manipulate body perception in patients with EDs, with only short-term and marginally clinically significant results in terms of body misperception [10]. The use of the allocentric version of FBI and its ability to alter MSI may be more effective than the egocentric version in reshaping body experience.

We also recommend investigating the role of cognitive and affective body-related components on PPS and thus MSI processing. For example, body shame might influence PPS limits, with higher levels of negative affect associated with a limited PPS. This is

relevant for understanding the factors that influence a dysfunctional body-self relationship.

Finally, we suggest that the effects of expanding PPS boundaries should be better explored: as PPS expansion promotes social interactions [15], and restricted PPS appears to be associated with high levels of stress and anxiety [16], could expanding PPS boundaries influence how individuals interact with their physical and social environment? For example, it has been hypothesised that stress leads to a freezing response in which multisensory-motor resources are allocated only to the space immediately surrounding the body [16]: could manipulating PPS therefore help to cope with stress?

This line of research could improve our understanding of a complex phenomenon such as the BSC and provide insights into understanding pathological conditions characterised by alterations in bodily experience as well as disturbances in the way individuals interact with their environment.

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References

[1] Riva G, Dakanalis A. Altered processing and integration of multisensory bodily representations and signals in eating disorders: A possible path toward the understanding of their underlying causes. Front Hum Neurosci. 2018 Feb 1;12:49.
[2] Blanke O. Multisensory brain mechanisms of bodily self-consciousness. Nat Rev Neurosci. 2012 Aug 18;13(8):556–71.
[3] Blanke O, Slater M, Serino A. Behavioral, Neural, and Computational Principles of Bodily Self-Consciousness. Neuron. 2015 Oct;88(1):145–66.
[4] Rabellino D, Frewen PA, McKinnon MC, Lanius RA. Peripersonal Space and Bodily Self-Consciousness: Implications for Psychological Trauma-Related Disorders. Front Neurosci. 2020 Dec 10;14.
[5] Rossi Sebastiano A, Ronga I, Fossataro C, Galigani M, Poles K, Garbarini F. Multisensory-driven facilitation within the peripersonal space is modulated by the expectations about stimulus location on the body. Sci Rep. 2022 Nov 21;12(1):20061.
[6] Serino S, Trabanelli S, Jandus C, Fellrath J, Grivaz P, Paladino MP, et al. Sharpening of peripersonal space during the COVID-19 pandemic. Current Biology. 2021 Jul;31(14):R889–90.
[7] D'Angelo M, di Pellegrino G, Frassinetti F. The illusion of having a tall or short body differently modulates interpersonal and peripersonal space. Behavioural Brain Research. 2019 Dec;375:112146.
[8] Buck LE, Park S, Bodenheimer B. Determining Peripersonal Space Boundaries and Their Plasticity in Relation to Object and Agent Characteristics in an Immersive Virtual Environment. In: 2020 IEEE Conference on Virtual Reality and 3D User Interfaces (VR). IEEE; 2020. p. 332–42.
[9] Noel JP, Pfeiffer C, Blanke O, Serino A. Peripersonal space as the space of the bodily self. Cognition. 2015 Nov;144:49–57.
[10] Ferroni F, Gallese V, Soccini AM, Langiulli N, Rastelli F, Ferri D, et al. The Remapping of Peripersonal Space in a Real but Not in a Virtual Environment. Brain Sci. 2022 Aug 24;12(9):1125.
[11] Serino S, Polli N, Riva G. From avatars to body swapping: The use of virtual reality for assessing and treating body-size distortion in individuals with anorexia. J Clin Psychol. 2019 Feb 15;75(2):313–22.
[12] Nandrino JL, Ducro C, Iachini T, Coello Y. Perception of Peripersonal and Interpersonal Space in Patients with Restrictive-type Anorexia. European Eating Disorders Review. 2017 May;25(3):179–87.
[13] Serino A, Noel JP, Mange R, Canzoneri E, Pellencin E, Ruiz JB, et al. Peripersonal Space: An Index of Multisensory Body–Environment Interactions in Real, Virtual, and Mixed Realities. Frontiers in ICT. 2018 Jan 22;4.
[14] Brizzi G, Sansoni M, Di Lernia D, Tuena C, Riva G. Multisensory Integration Processing in Anorexia and Bulimia Nervosa: A Systematic Review. 2023;
[15] von Mohr M, Silva PC, Vagnoni E, Bracher A, Bertoni T, Serino A, et al. My social comfort zone: Attachment anxiety shapes peripersonal and interpersonal space. iScience. 2023 Feb;26(2):105955.

[16] Ellena G, Bertoni T, Durand-Ruel M, Thoresen J, Sandi C, Serino A. Acute stress affects peripersonal space representation in cortisol stress responders. Psychoneuroendocrinology. 2022 Aug;142:105790.

URBAN GAMERS LAB: Techniques and Tools to Develop Transversal Competences and Life Skills in Educational Context Using Technologies

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Abstract. Objectives. The URBAN GAMERS LAB project involves a multidisciplinary team (architects, engineers, and psychologists) to propose the activation of knowledge dissemination and digital transition of the younger generations in Emilia Romagna region, in Italy. Method and Study Phases. The project started in January 2022 and ends in January 2023. About 300 high school and university students, 50 teachers and municipal employees participated in the project. The study took place in three main phases: 1) from May to June the students attended lessons and workshops on how to use games in order to learn and develop skills such as problem solving, creativity, collaboration and negotiation using educational robots (Ozobot) and technologies (VR); 2) from September to November, students held lessons and workshops on gamification (how to build a video game) and functional use of technologies (e.g. online reputation), while municipal employees attended training courses on how to use gamification in order to develop skills useful for their duties; 3) monitoring and impact assessment phase: two questionnaires were administered to all those who participated in the project, one at the end of the first part of the June activities and one at the end of the November activities in order to verify the acquisition skills and project progress. Lastly, a final event was organized with the return of the results to all the project participants. Results and Conclusion. Results show an acquisition of problem-solving, negotiation and transversal competences in all participants with a high liking of the activities they had carried out during the planning phase.

Keywords. Digital Transformation, digital skills, problem-solving, creativity, educational robots.

1. Introduction

In response to the pandemic emergency, Information and Communication Technologies (ICT) have highlighted their potential in many fields, particularly in educational contexts. On the one hand, ICT-enabled distance learning and classes were carried on without interruption; on the other hand, the isolation of students was undoubtedly a negative aspect that influenced the ICT-enhanced educational context. The lack of social interaction and motivation leads to feelings of loneliness and dejection. Additionally, it strongly limited the ability to learn in a social context. This indicates a clear need to exploit novel technologies to promote a way of learning that is grounded in interactions and sociality. From Piaget's constructivist perspective, the process of understanding the world is the result of the relationship established between a thinking

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and acting subject and the object of his own experience. In addition, Papert underlined the importance of technological artifacts in learning, not as supporting this process but as in simulating reality. From Papert's point of view, knowledge cannot simply be transmitted as it is from one person to another, but each subject reconstructs information in a personal and original way. According to this, the use of technological devices (e.g., computers, tablets, and robots) represents an effective method for building knowledge, allowing students to apply the theoretical knowledge to practice. Even more, the use of a physical artifact (e.g., a robot, VR) determines an effective learning process as it makes students reflect about the knowledge they possess and how to apply it to the reality on which they are acting [1]. In [2,3] Papert highlights how the use of robotics kits, far from transmitting computer skills, generates curiosity and stimulates creativity and motivation to learn, allowing to build and enter in touch with powerful new ideas. Moreover, following the idea that learning is an active process based on experience and that social interactions can facilitate it, learners might make understanding more effective by working together. This means that technological innovation in education should be able to expand teachers/learners' opportunities for collaborative interaction and let them explore new strategies for teaching/learning [4]. Schools need to provide appropriate education in a ubiquitously digitalized world within complex and changing training needs and career landscapes. It has been highlighted that the citizens of the future are expected to develop critical thinking, problem solving, communication and teamwork, since these qualities have significant impact on the development of innovation. Communication, cooperation, and problem solving are, almost by definition, the future skills demanded. Together with ICT literacy, content creation abilities and safety constitute the so-called 21st century skills [5]. In this regard, URBAN GAMERS LAB project through its activities pointed to: 1) Promote awareness, especially among young people, regarding the importance of taking part in the digital transition, also defining the trajectories for the future of their city and region; 2) Allow students to recognize their talents through the creative and collaborative process; 3) Develop capacity building of municipality operators and librarians, through training workshops, for the dissemination of managerial skills with respect to gamification paths, thus promoting sustainability and autonomy in the proposition/participation of the projects; 4) Promote and support students in line with European Uninon DigComp programs, and with the digital agenda of the Emilia-Romagna Region, as well as in line with the guidelines of the Digital Agenda for Europe and with the objectives of the Italian Digital Agenda, in the development of transversal skills, life skills and competences such as critical thinking/problem solving, creativity, communication, collaboration, and ICT literacy; 5) Facilitate inclusion in digital transition processes on an urban scale through the game approach and adopting Game Thinking strategies. Participants were enabled to develop project ideas through a path of participation, knowledge growth and co-design of products and activities also using typical strategies of educational psychology (such as zone of proximal development and socio-cognitive conflict); and Game Thinking to solve specific challenges related to the territory (e.g., Emilia-Romagna region). The planned activities of the project, in addition to data collection for research purposes, were aimed at enhancing and integrating different realities (e.g., schools, university, library, etc.) of the municipality involved.

2. Method and Study Phases

Following the theoretical perspective described above, the general objectives of the project, and in line with the Digital Education Action Plan 2021-2027, the activities have been divided into two different moments: from May to June and from September to November 2022 and have been divided according to the areas of interest taken into consideration in this project.

2.1 Psychology based activities

Within the training module lasting about 2 hours a day for 5 days in the period of September and November, students had the opportunity to approach educational robotics. The activities have been designed to represent a constant challenge of increasing complexity to encourage involvement and interest: 1) Trial Test -> The first activity consists in analyzing the characteristics and functioning of the robot. Students are divided into groups of 4/5 and sheets; markers and 2/3 robots are provided for each group. In this activity, students draw on the sheet with markers and are encouraged to give free rein to their imagination and to search for information on how the robots work. After this first exploratory phase, information is shared, each group presents its findings, and the results are commented on together. 2) Code Test -> The second activity allows students to communicate with the robot using a sheet of codes, also in this case the activity is divided into an exploratory phase (in which they try to draw the codes and create paths) and a discovery sharing stage. 3) Robo-Rush -> The most complex activity is represented by a labyrinth in which students will have to identify the path (or paths) to get the robot to the central section of the labyrinth. The codes used and the time spent allow them to accumulate points, at the end of the activity compiled a ranking. The activity also provides for the identification of a "Team Leader" who guides the operations. 4) Debriefing -> Once the activity has been completed and the ranking has been drawn up, the Team Leader take the floor and comment the work done in the group, what worked and what didn't work. The speakers lead the students to reflect on communication methods, decision making and creativity, reporting concrete examples to introduce the topic of soft skills. Following the activities, theories and models of the main soft skills used during the day were presented. The focus was identified in getting students to reflect critically on the strategies and behaviors implemented during the activities, using a solid bibliographic base and an interactive presentation (facilitating questions and discussions on the topics presented).

2.2 Architecture based activities

Lessons were carried out in presence, with the help of the Discord digital platform as a private place, but easily accessible by students where they can interface with tutors and teachers in a less institutional form (unlike the systems already known and used by schools, such as Google Classroom). The platform also served as an exchange hub between different classes, thanks to the use of chat rooms reserved for individual student teams and others open to all teams from the various schools involved. The meetings were designed on "blocks" of a maximum of 3-4 hours in which theory and practice were mixed creating a unique experience. Brief explanation or introduction of a theme, followed by a connected activity played as much as possible by the participants and finally a reflection that often asked for a self-analysis or reflection on the part of the students. The leitmotif of the trainings was always based on three macro themes: 1) Design approach, following the Design Thinking methodologies, to provide participants with design tools; 2) Elements of psychology, to reflect on the more social and psychological aspects behind the game and playing; 3) Technological experimentation linked to the creation (concept and code) of video games. to learn the basics of programming and give a contemporary perspective of the world of work behind the gaming and video game market. Each meeting was thought of as a mix of theory and practice, thanks to varied activities and experiences useful for touching the concepts in question. The involvement of external guests, various professionals was also essential to give students perspectives from the academic and professional world. Each path began by giving the participants a contextualized design challenge on the city of Cesena, essential for creating engagement and an impact that was as visible as possible to male and female students. The idea of inserting small events within the itinerary integrated with the city of Cesena was an element that had the dual purpose of showing the city the projects in action, but also giving the students a concrete objective: a theater where they

could practice also the ability to tell one's ideas, to confront the city outside the classroom.

2.3 Engineering and Informatics based activities

Activities were divided as follows: in the morning the theoretical lessons were done (game design theory), while in the afternoon the practical activities (practical game design workshop) took place. The activities were based on the principles of: Collaborative design, Participatory design, educational game design. Then, for the game design lab, students were sorted into groups. The groups were mixed, creating heterogeneous groups that untangled the 'recurring' friendship groups. In this way we have tried to give birth to more unusual/original/heterogeneous ideas - as far as possible - from the meeting between students with different interests (compared to more consolidated groups of friends). Furthermore, forming groups in this way fostered the deepening of personal bonds between students. On a practical level, the activities saw the participation of 5 worktables (with 5-6 participants per group). The activity started with the choice of the type of game to develop videogame, serious game or boardgame. All groups opted for the board game. Next, we defined roles for each member of each group. Defining roles was necessary, given the large amount of work to be done. In this way, we have assigned each member a role (gameplay specialist, artist, lawyer, reviewer, IT specialist) a specific task. We therefore ensured that the projects could progress following specific objectives (from the definition of the game rules, the writing of the game manual, and even the graphic creation of the game board). Specifically, i) the gameplay specialist is responsible for defining the game rules and structuring the gameplay elements (scores, game progression, cards, rules, etc.). ii) The artist takes care of defining the aesthetic aspects of the game by taking care of the graphics of the boards, cards, pawns, etc. iii) The lawyer oversees writing the game manual, trying to make it as understandable as possible for new players. iv) the IT specialist has the task of creating the website, promoting the game by presenting it to an imaginary 'target' audience, furthermore the game creation process is also presented on the site. v) The reviewer is the most eclectic role, as he/she must work in close contact with the artist, lawyer, and IT specialist, checking their work and correcting the final products to guarantee their quality, while helping his fellow students or companions in the performance of their duties. The assignment of these roles has helped students in two ways: i) by dividing the complex project of creating a game into smaller and easier to manage tasks, ii) the choice of the role has been left to the individual members so that each could express their skills or interests, thus increasing their involvement in the activity, also through the sense of responsibility assigned. During workshops, the facilitators went around the tables helping the groups with their different requests and checked the progress of the individual projects. Furthermore, during the afternoon workshops, there were in-depth presentations on topics such as gameplay elements, board games, serious games - to suggest points of interest for the projects. On the last, single groups presented their games and in turn, each group tried the games of the other groups. In this way, changes and criticisms have been suggested based on the experience of external 'beta-testers'. Each group produced complete and playable board games in their entirety.

3. Results and Conclusion

The proposed questionnaire collects data relating to the students' perception of the activities carried out during the Urban Gamers Lab project. The items making up the questionnaire were created to highlight the expectations, expected utility, knowledge, and skills of the students in relation to technologies and their use in daily life. Within the project, two separate assessments were carried out at different times: "Questionnaire A" relating to the May design phase and "Questionnaire B" relating to the November phase. Both questionnaires were constructed using the logic of "forcing the answer", to proceed the respondent must necessarily answer all the previous questions. It is therefore not

possible to answer the Personal Data section, skip the Impact section and answer the questions relating to the Courses. However, it is possible to close the questionnaire at any time and not (permanently) answer the missing sections. This second eventuality explains why some participants did not complete the questionnaire; in each section we will report the number of participants who answered compared to the total. Here a summary of the principal results: 34 respondents to Questionnaire A, of which 19 answered all the sections, for Questionnaire B there were 64, of which 58 completed the questionnaire by answering all the sections. 1) Average age: Questionnaire A) 17 years (max 20; min 16), Questionnaire B) 16.39 years (max 17; min 15); 2) Gender: Questionnaire A) 28 Females, 6 Males, 1 Non-binary/third gender, Questionnaire B) 26 Females, 38 Males, 0 Non-binary/third gender. We then asked the participants about their perception of the project's usefulness and whether the activities carried out improved certain skills where 1 means "It has gotten much worse" and 5 means "It has improved a lot". 32 out of 34 (94%) answered these items for Questionnaire A and 63 out of 64 (98%) for Questionnaire B, in some items it is necessary to underline the difference between the general averages and the averages of those who compiled the questionnaire at 100% indicated in brackets: *Creativity* A) 3.69: Overall the activities were rated as useful in improving creativity (3.74) B) 3.63: 60% of respondents noticed an improvement in their creativity; *Problem Solving* A) 3.47: The ability to solve problems seems to be the skill least influenced by the proposed activities, although almost 25% of the respondents noticed an improvement. (3.52) B) 3.52: In the second questionnaire almost 54% of respondents noted an improvement in their ability to solve problems; *Communication*, As also expressed in the appropriate text boxes (which we will discuss later) the students appreciated the possibility of working in groups in all the proposed activities. A) 3.75: As can be seen from the average of the answers, the course had a positive impact on the communication skills of the participants. (3.84 in this case the average of the participants who completed the entire questionnaire increases by 0.9) B) 3.43: In the second evaluation, the average relative to the perception of improvement in one's own communication skills decreased, almost 43% of respondents answered positively. *Use of Technologies*, the competence perceived as most influenced by the project activities is related to the use of technologies. Within the project, programs and tools relating to the creation of video games were studied, as well as lessons on the functional use of technologies. A) 3.88: the only competence in which a decrease in the average is recorded by examining only the answers of those who filled out the questionnaire 100% (3.79) B) 3.83: Almost 78% perceived an improvement in their technical skills and in the functional use of technologies. *Decision Making*, this item was only included in the evaluation of the second part of the project, therefore it is not possible to report the averages of Questionnaire A. B) 3.35: 61% of respondents say they have not perceived any change in their ability to make decisions, while 33% say they have noticed an improvement in positive terms. *Leadership*, this item was only included in the evaluation of the second part of the project, therefore it is not possible to report the averages of Questionnaire A. B) 3.38: More than 36% noticed an improvement in their ability to lead a group of people, only 3 participants answered negatively to this item. In sum, these results show an acquisition of problem-solving, negotiation and transversal competences in all participants with a high liking of the activities they had carried out during the planning phase. This suggests an implementation of technologies and the dissemination of 21st century skills in educational contexts, fundamental for the preparation of students (and also teachers) for the future of education and job market.

References

[1] Mubin et al. (2013) A review of the applicability of robots in education. Journal of Technology in Education and Learning, 1(209-0015), 13
[2] Papert S. (1980) Mindstorms: Children, computers, and powerful ideas. Basic books
[3] Papert S. (1993) The children's machine: Rethinking school in the age of the computer. Basic Books, Inc.
[4] Braun et al (2020) Rethinking education in the digital age, Panel for the Future of Science and Technology EPRS Service Scientific Foresight Unit (STOA)

[5] Ferrari et al. (2012) Understanding digital competence in the 21st century: An analysis of current frameworks. In EC-TEL 2012: 21st Century Learning for 21st Century Skills (pp. 79–92)

The Iranian Adolescents' Increased Net Surfing and Sexual Behavior During Covid19 Pandemic: A Quantitative & Correlational Study

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Abstract. By December 2019, COVID-19 had spread worldwide, causing a pandemic and forcing counties to transition to mandatory social isolation and quarantine. The immediate mandated closure of schools was one such measure executed by the Iranian government (Rahmanzade, 2020), which led to a countrywide online educational system. Consequently, the Internet became a major source of information (Ferri et al., 2020), exposing Iranian adolescents to an unprecedented degree of unsupervised access to net surfing, increasing day by day (Khalajabadi Farahani, 2019). Using Ghavidel's (2012) adolescent sexual behavior inventory combined with Mojaradi's (2014) social media usage questionnaire[14], a sample population of 154 adolescents completed the questionnaire The researchers used a quantitative and correlation approach, the study investigated the multifactorial correlations between Iran's adolescents' sexual behavior and the increased Internet surfing during the COVID-19 pandemic.

Keywords. *Adolescents, Net Surfing, Sexual Behavior, Cultural Taboos*

1. Introduction

By late 2019, the Covid-19 virus had been recognized as a worldwide pandemic that soon proved devastatingly life-changing on levels previously never experienced [1-3]. COVID-19 led to a declaration of a state of emergency by countries worldwide, including Iran, which was rapidly and gravely being affected by this virus[4]. The COVID-19 outbreak and its subsequent mandatory quarantine resulted in the closure of schools, universities, museums, cultural places, and all public places where the risk of transmitting COVID-19 was higher [5-8]. Due to the lockdown of schools and the closure of face-to-face education, countries switched to online education leading to the adolescents' significant increase in netsurfing, which soon became a worldwide challenge [9,10]. Results from the self-report data collection showed that compared to pre-COVID-19 usage, adolescents spent more unsupervised time in cyberspace than any other age group [11-14]. Furthermore, a study on Iranian adolescents demonstrated that 55.6% of sexual risk-taking behavior takes place between the age of 16 to 21, which is considered a public health concern since it can lead to problematic sexual behavior in adulthood [15-18].

Based on various reports, Iranian adolescents' internet usage increased significantly (40%) during the COVID-19 pandemic as schooling, leisure time, and home life are

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happening via digital media [19,20]. A survey of 15-to 19-year-olds' attitudes about Internet usage in Iran showed that about 68.3% of adolescents were net surfing, 31.5% used the Internet daily, about 19.4% of them chatted with others, and 6% of this number made relationships with the opposite gender. More than 71% of 15- to 19-year-olds use VPN and have access to large amounts of information[21]. The usage of the Internet has had negative effects on the sexual patterns and behavior of the youth [21-23]. Uncontrolled Internet usage creates problems such as addiction, undesirable content rotation, exposure to private information, and overuse of entertainment [24].

2. Methods

This study used a quantitative, correlational, and deductive approach to examine the impact of the increased use of Iranian adolescents' net surfing on sexual behavior during the COVID-19 pandemic25. The Cross-cultural Research & Educational Institute's IRB committee approved the project, and written parental consent was obtained for all adolescent participants. Sample participant selection was based on convenient sampling and snowball recruitment25, using popular social media sites frequently visited by the sample population to invite qualifying individuals to participate. A total of 154 respondents, 93 females plus 61 males, completed the questionnaires. The sample population comprised 41/5% in the 15-16 age group, 35.7% in the 16-17 age group, and 79% in the 17-18 group showing the following internet habits. Overall, 24% of the participants reported net surfing 6 hours or more a day, 5.43% indicated net surfing 3 to 6 hours a day, and 31% showed less than 3 hours a day on the Internet.

Ghavidel's (2012) adolescent sexual behavior inventory and Mojaradi's (2014) social media usage questionnaire [26,27] were used as data collection instruments. Ghavidel's (2012) questionnaire has 90% reliability and 85% Cronbach's alpha based on the Likert fifth range of 'very low to very most' related to net surfing activity level, type of Internet usage, and consumer confidence level in Internet sources. Mojaradi's (2014) social media usage inventory is a three-dimensional instrument (Net surfing activity level, Type of Internet usage, and Consumer confidence level in Internet sources), which is constructed on the Likert fourth range of Never, Rarely, Sometimes, and Most of the time (Mojaradi, 2014). The correlation coefficient of the sexual behavior questionnaire was 80% Cronbach's alpha. Mojaradi's 17 questions relate to adolescents' sexual behavior, such as sexual behavior and sexual dreams [28].

3. Results

The result of the study showed a linear and direct correlation between adolescents' increased net surfing during COVID-19 and sexual behavior at the level of 0/0, which was validated by a two-tailed significance of 0.404 Pearson coefficient. Testing for gender differentiation in increased net surfing, the t-test showed no significant gap between male and female adolescents, which was confirmed by the mean variable of female participants of 56.9 in females and 59.2 in males. The t-test showed no difference between females' and males' increased sexual behavior. In this case, the mean variables were 31.1 in females and 33.6 in males indicating no significant difference between the two groups showed no significant difference in gender differences (see Tables 1 and 2).

Table 1. The research findings' statistical means and standard deviation

	1=F 2=M	N	Mean	Std. Deviation	Std. Error Mean
Net Surfing	1	93	56.9	11.28219	1.16991
	2	61	59.2	11.05157	1.41501
Sexual behavior	1	93	31.1	5.92824	0.61473
	2	61	33.6	6.68965	0.85652

Table 2. The statistical Analysis of the research findings

	Levene's Test for Equality of Var.		t-test for Equality of Means						
	F	Sig.	t	df	Sig. (2 tailed)	Mean Diff.	Std. Error Diff.	95% Confidence Interval of the Diff.	
								Lower	Upper
Net Surfing	0.054	0.816	-1.24	152	0.21	-2.2883	1.843	-5.9314	1.3547
Sexual Behav.	3.4	0.067	-2.44	152	0.01	-2.5164	1.028	-4.5476	-0.4852

3.1 Analysis of Variables (ANOVA)

Inclusion factors in this study were age, gender, the socio-economic status of parents, and the nature of the household structure. Exclusion factors exercised in this study were any demographic that did not fit into the middle socio-economic status since lower-income families may not have qualified to participate in the study due to the limited necessity for Internet access or the financial inability to purchase VPN or other necessary tools. The third variable was determined to be Covid-19 social isolation, which may be interpreted as a confounding variable influencing the independent and dependent variables. The extraneous variable may have been the restrictive sexual culture in Iran, combined with religious prohibitions, which is a factor in the adolescents' increased interest and curiosity toward sexuality.

3.2 Study Limitations and Recommendations

Due to restrictive religious laws, adolescents living in Iran are deprived of socializing and gender identity explorations[33]. This prohibited taboo needs further research into developmental discrepancies. The authors would like to make the following recommendations, a) The adolescents' shift in sexual behavior should be further researched to include a wider and more diverse sample group; b) The administrators to offer comprehensive sex education programs via elementary and secondary school curriculums, c) Researchers to investigate the implications of Covid19 pandemic on the adolescents' developmental shifts, such as increased interest in inappropriate net surfing, and other developmentally harmful practices, d) Health providers to offer educational materials regarding sexuality for parents and adolescents, and e) Educate and encourage parents on effective communication skills and remove cultural and intergenerational barriers.

4. Discussion

The increased accessibility to the Internet during the COVID-19 pandemic has led adolescents to new forms of interest, curiosity, and behavior in exploring topics related to sex. The results of this study conquered with the existing findings that increased Internet use during the pandemic positively correlates to increased sexual behavior[14,29] and how the Internet negatively affects the sexual pattern and behavior of adolescents[22]. More specifically, the results of this study showed a correlation between net surfing during the COVID-19 pandemic and sexual behavior at the level of 0/0 to be linear and direct. The overall result showed a direct correlation between increased net surfing usage and adolescents' sexuality confirming previous studies findings.

References

[1] Rahmanzade, Ra., Rahmanzadeh, Re., Hashemian, S., M, & Tabarsi, P. (2020). Iran's Approach to

[2] COVID-19: Evolving Treatment Protocols and Ongoing Clinical Trials. *Frontiers in Public Health, 8*.https://www.frontiersin.org/article/10.3389/fpubh.2020.551889
[3] Rassouli, M., Ashrafizadeh, H., Shirinabadi Farahani, A., and Akbari, M. E. (2020). COVID-19 Management in Iran as One of the Most Affected Countries in the World: Advantages and Weaknesses. *Public Health, 8*. https://doi.org/10.3389/fpubh.2020.00510
[4] Ahmady, S., Shahbazi, S., & Heidari, M. (2020). Transitioning to virtual learning in Iran Coronavirus disease–2019 crisis: Opportunity or challenge? *Disaster Medicine and Public Health Preparedness, 14*(3). https://doi.org/10.1017/dmp.2020.142
[5] Omidi, M., Maher, A., & Etesaminia, S. (2020). Lessons to be learned from the prevalence of Covid-19 in Iran. *Medical Journal of The Islamic Republic of Iran*. https://doi.org/10.47176/mjiri.34.54
[6] Lindberg, L.D., Bell, D. L., & Kantor, L. M. (2020). The Sexual and Reproductive Health of Adolescents And Young Adults During the COVID-19 Pandemic. *Perspectives on Sexual & Reproductive Health 52*(2), 75-79. https://doi.org/10.1363/psrh.12151
[7] Tajik, F, Vahedi, M. (2021). Quarantine and education: An assessment of Iranian formal education during the COVID-19 outbreak and school closures. *International Journal of Education and Development using*. *17* (1). http://ijedict.dec.uwi.edu/viewarticle.php?id=2864
[8] Wong, B. Y. M., Lam, T. H., Lai, A. Y. K., Wang, M. P., & Ho, S. Y. (2021). Perceived benefits andharms of the covid-19 pandemic on family well-being and their sociodemographic disparities in Hong Kong: A cross-sectional study. *International Journal of environmental research and public health, 18*(3), 1217. https://doi.org/10.3390/ijerph18031217
[9] Amran, M. S., & Jamaludin, K. A. (2021). The impact of unplanned school closures on Adolescent Behavioral Health during the COVID-19 pandemic in Malaysia. *Frontiers in Public Health, 9*. https://doi.org/10.3389/fpubh.2021.639041
[10] Education and covid-19: Focusing on the long-term impact of school closures. (2020). OECD Policy Responses to Coronavirus (COVID_19). https://doi.org/10.1787/2cea926e-en
[11] Ferri, F., Grifoni, P., & Guzzo, T. (2020). Online learning and emergency remote teaching: Opportunities and challenges in emergencies. *Societies, 10*(4), 86. https://doi.org/10.3390/soc10040086
[12] Ozturk, F. O., & Ayaz-Alkaya, S. (2021). A cross-sectional Study of Internet Addiction and psychosocial Problems among adolescents during the COVID-19 pandemic. *Archives of Psychiatric Nursing, 35* (6), 595-601. https://doi.org/10.1016/j.apnu.2021.08.007
[13] Siste, K., Hanafi, E., Sen, L. T., Murtani, B. J., Christian, H., Limawan, A. P., Siswidiani, L. P., & Adrian. (2021). Implications of covid-19 and lockdown on adolescent internet addiction: Data from a developing country. Frontiers in Psychiatry, 12. https://doi.org/10.3389/fpsyt.2021.665675
[14] Hatami, H., Abbasi-Kangevari, M., Malekpour, M.-R., & Kolahi, A.-A. (2021). Knowledge, Attitudes and safety practices about covid-19 among high school students in Iran during the first wave of the pandemic. *Frontiers in Public Health, 9*. https://doi.org/10.3389/fpubh.2021.680514
[15] Efrati, Y. (2019). Normal Versus Abnormal Sexual Behavior in Adolescents. *Psychiatric Times, 36* https://www.psychiatrictimes.com/view/normal-versus-abnormal-sexual-behavior-adolescents
[16] Mohammadizadeh, A., Ahmadabadi, Z., (2009). Co-occurrence of high-risk behaviors among high School adolescents in Tehran. *Family research, 4* (13), 87-100. https://www.sid.ir/fa/journal/ViewPaper.aspx?id=79084
[17] Banaei, M., Simbar, M., Ghasemi, V., & Nazem, H. (2019). Barriers to Adolescents' Access to Reproductive and sexual health Services in Iran: a systematic review. *International Journal of Pediatrics, 7*(12), 10505-10522. https://ijp.mums.ac.ir/article_13636.html
[18] Asrese, K., & Mekonnen, A. (2018). Social network correlates risky sexual behavior among Adolescents in Bahir Dar and Mecha Districts, North West Ethiopia: an institution-based study. *Reproductive Health, 15*(1), 61.
[19] Campos, J. R., Silva, A. T., Zanini, M. R., & Loureiro, S. R. (2019). Predictors of behavioral problems In adolescents: Family, personal and demographic variables. *Psico-USF, 24*(2), 273–285. https://doi.org/10.1590/1413-82712019240205
[20] Jahanbakhsh, M., Bagherian, H., Tavakoli, N., Ehteshami, A., Sattari, M., Isfahani, S., & Jangi, M. (2021). The role of virtual social networks in shaping people's attitudes toward COVID-19 in Iran. *Journal of Education and health promotion, 10*, 90. https://doi.org/10.4103/jehp.jehp_642_20
[21] Lobe, B., Velicu, A., Staksrud, E., Chaudron, S., & Di Gioia, R. (2020). How children (10-18) I experienced online Risks during the Covid-19 lockdown in - Spring of 2020. *EUR 30584 EN, Publication, Office of the European Union, Luxembourg*, 2021. https://doi.org/10.2760/066196,JRC124034
[22] Khalajabadi Farahani, F., (2019). Exposure to unconventional sexual content (pornography) on the Internet and cyberspace and its impact on sexual behavior and interpersonal relationships of adolescents in Tehran. *Family research, 15* (57), 127-153. https://www.sid.ir/fa/journal/ViewPaper.aspx?id=473409
[23] Asekun-Olarinmoye, O. S., Asekun-Olarinmoye, E. O., Adebimpe, W. O., & Omisore, A. G. (2014). Effect of mass media and Internet on Sexual Behavior of Osogbo metropolis, Southwestern Nigeria undergraduates. *Adolesc Health Med Ther, 28*(5), 15-23. DOI https://doi.org/10.2147/AHMT.S54339
[24] Werling, A. M., Walitza, S., Grünblatt, E., & Drechsler, R. (2021). Media use before, during, and after COVID-19 lockdown according to parents in a clinically referred sample in child and adolescent psychiatry: Results of an online survey in Switzerland. *Comprehensive Psychiatry*, 109:152260. https://doi.org/10.1016/j.comppsych.2021.152260

[25] Nainian, M.R., Adabdoost, F., Khatibi, S., & Qomian, F. (2021). Internet use and its relationship with Mental health and quality of life in high school students. *Clinical Psychology and Personality, 14* (2), 103-113. https://doi:10.22070/14.2.103-113
[26] Bryman, A. (2016). *Social research methods*. Oxford university press.
[27] Ghavidel Heidari, M., Kazemi, Y., Nikmanesh, Z and Azarkhordad, F. (2012). Relationship between Sexual Behaviors and Communication Media (Internet, Satellite and Mobile Phone) in Adolescents in the Border City of Zahedan. https://civilica.com/doc/179173
[28] Mojaradi, M. (2014). Social Media Inventory Questionnaire. Iran
[29] Ahmadpour, J., Asghari, S., Soltanian, A., Mohammadi, Y., & Poorolajal, J. (2018). Evaluation of Validity and Reliability of Persian Version of Problematic Internet Use (PIU) Questionnaire. large, *14* (1),53-62. http://irje.tums.ac.ir/article-1-5964-fa.htm
[30] Allen, M. (2017). *Research methods*, https://dx.doi.org/10.4135/9781483381411.n569
[31] Andrie, E. K., Sakou, I. I., Tzavela, E. C., Richardson, C., & Tsitsika, A. K. (2021). Adolescents' Online Pornography Exposure and Its Relationship to Sociodemographic and Psychopathological Correlates/ C*hildren*, *8*(10), 925. https://www.mdpi.com/about/proceedings

IAVRS – INTERNATIONAL AFFECTIVE VIRTUAL REALITY SYSTEM: Validating 360-Degree Images for Emotions Elicitation

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Abstract. All human experiences revolve around emotions. However, because emotions are characterized by quick changes and individual heterogeneity, eliciting, and measuring them has proven to be one of the most challenging tasks. Virtual reality has been suggested for this study thanks to its capability to evoke a sense of presence, sharing virtual content can result not only in a more reliable replication and representative sampling but also in a strongest emotional reaction. Among virtual reality technologies, 360-degree images allow interaction with the content and experience various emotions through head movements. Since 360-degree images offer a more realistic and immersive visual experience, the primary objective of this study was to examine how they might be used as an effective medium. The goal is to evaluate the efficiency of 360-degree images in eliciting basic emotions and to build an open-access database that can be used as a research tool. For 15 seconds, 51 participants will view a series of 360-degree images and move their mouse or finger to explore the surroundings. They will be required to rate the intensity of some emotions and self-report their level of valence, arousal, dominance, and sense of presence after each image. These data for every image are shown. The findings showed that the stimuli's valence and arousal dimensions varied reasonably. A standardized 360-degree database of videos that can elicit emotions would be very helpful for research on basic emotions, emotion recognition and regulation, and human-computer interaction and for studying emotional and cognitive processes under realistic conditions.

Keywords. Emotions, 360-degree images, Virtual reality, Emotion validation

1. Introduction

Emotions are portrayed as complex alterations that result in psychological and physiological changes that affect our cognition and behavior. They can be described as temporally induced states that are influenced by stimuli and influence a person's thoughts, feelings, behaviors, and physiological responses. Psychology studies that aim to elicit emotional states for research have a long history. Virtual reality (VR) has been used significantly more in psychological research in recent years [1], [2]. Since it can be used to create empathy machines and a variety of emotions, VR has been referred to as a strong and effective emotional induction mechanism as it has the potential to improve the ecological validity of psychological science. In addition, VR's success can be attributed to its ability to perform better than traditional non-immersive content and to maintain subjects' immersion in a social environment [3], [4], producing immersion and a sense of presence. Immersive 360-degree videos and images that display a scene in a

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photorealistic video that changes depending on head orientation are powerful and lifelike aspects of VR. A complete surround scene is created using multiple cameras, and the video is then digitally pieced together. On flat-screen devices, such as a phone or a computer, you can view them by dragging the viewpoint with a mouse or a finger. Because it's relatively easy to create content for immersive videos, there is a ton of content that is freely available on online platforms [5]. The ability of immersive technologies to arouse emotions has been employed by many authors. The interfaces used (desktop vs. head-mounted display), elements that can evoke emotions (such as sounds, music, light effects, etc.), and the type of immersive environment (computer generated vs real) vary between these studies, even though they all have a similar goal. Furthermore, the range of emotions covered by these studies—relaxation, joy, sadness, and anxiety—is rather limited. There is still no thorough investigation that considers all these affective states. By combining dimensional and discrete approaches, this study aims to validate a novel set of 360-degree emotional images. Although both the dimensional and discrete models are widely accepted in the scientific community as complementary frameworks for understanding emotions, studies frequently favor one approach over the other. By combining the two methods, it is possible to acknowledge the complexity and variety of emotional experiences.

2. Methods

2.1 Participants

Fifty-one participants, 40 females, and 11 males, with a mean of 37.4 years of age (SD=14.4, min=21 years; max=70 years) and a mean of 16.0 years of education (SD=2.22, min=8, max=21), were recruited. Without receiving payment, each participant voluntarily agreed to participate in the study. None of the participants mentioned any neurological or psychological disorders. According to the Helsinki Declaration, each participant provided written informed consent and received the same instructions.

2.2 Stimuli

To have images that could evoke a variety of emotions, we looked for pictures that were either qualitatively high or low in arousal and high or low in valence. To avoid cybersickness due to scene jumps, we collect 360-degree images taken with a stationary camera instead of videos. Personal contacts and internet searches on sites like Envato and Flickr are two sources for images. We chose urbanistic (such as views of squares, streets, and buildings) and naturalistic (such as views of lakes, mountains, seas, and parks) scenarios without semantic and verbal cues, allowing for international use. A total of 46 immersive images were selected for the study.

2.3 Questionnaires

The following state questionnaires were completed before the experiment began: Beck Depression Inventory (BDI) [6]; State and Trai Anxiety Inventory (STAI) [7]; Emotion Regulation Questionnaire (ERQ); Positive and Negative Affective Scale (PANAS) [8]. After each immersive image, participants reported their level of valence, arousal, and dominance using the Self-Assessment Manikin (SAM), their sense of presence “I had the feeling of being inside that environment” on a 7-point likert scale, and a rating on a Likert scale of each emotion of the Modified Differential Emotion Scale (mDES)[9].

2.4 Procedure

Participants took part remotely via a link, and after providing demographic data, consent forms, and questionnaire answers, they were asked to rate their valence, arousal, and dominance using the SAM as a baseline for their affective state. For a total of 30

minutes, each participant watched a different sequence of 23 360-degree images. Depending on the device being used (their mobile phone or pc), participants were instructed to freely explore the video using their fingers or mouse. After each image has been shown for 15 seconds, a 9-point rating scale for each SAM's dimension is shown on a white background inside the virtual environment. Then, using a 7-point Likert scale, participants had to rate their sense of presence and the intensity of emotions of mDES.

3. Results

At baseline, participants reported a positive tone (mean valence=6.43, sd=1.5) and moderate arousal (mean=4.88, sd=1.97). The mean values of state's questionnaire are shown in Table 1.

Table 1. Descriptive Measures of State Questionnaires

	BDI	STAI	PANAS_PA	PANAS_NA	ERQ_cr	ERQ_es
Mean	8.00	41.1	3.50	2.04	5.21	3.34
SD	6.11	12.0	0.727	0.579	0.839	1.04

Legend: PA=Positive Affect; NA=Negative Affect; CR= Cognitive Reappraisal; ES= Expressive Suppression

Mean values of Valence, Arousal, Dominance, Sop, and emotions are shown in Supplementary Material. Results of ITC-SOPI, that has been administered at the end of the study, reveal a good level of ecological validity of the 360°images (mean=3.71, SD=0.66) and sense of spatial presence (mean=2.84, SD=0.77), although the non-immersive modality.

4. Discussion

Standardized immersive images are required for emotional induction because, first, they elicit a stronger emotional response than 2d images; second, unlike previous studies that used movies, and video clips with semantic/dynamic aspects, this database allows for a basic induction of emotional states that can then be used and studied in conjunction with cognition worldwide. Furthermore, we used an ad hoc selection of images, selecting natural realistic environments devoid of semantic and verbal cues. IAVRS database can successfully elicit a wide range of emotional responses, including both positive and negative valence as well as different levels of arousal. The findings show a significant correspondence between the dimensional and discrete models of emotions. Additionally, in terms of arousal and valence values, the images that show convergence between the dimensional and discrete emotional models are particularly potent.

References

[1] P. Cipresso, I. A. C. Giglioli, M. A. Raya, and G. Riva, "The past, present, and future of virtual and augmented reality research: A network and cluster analysis of the literature," *Front Psychol*, vol. 9, p. 2086, 2018, doi: 10.3389/fpsyg.2018.02086.

[2] G. Riva, V. Mancuso, S. Cavedoni, and C. Stramba-Badiale, "Virtual reality in neurorehabilitation: a review of its effects on multiple cognitive domains," *Expert Rev Med Devices*, vol. 17, no. 10, pp. 1035–1061, 2020, doi: 10.1080/17434440.2020.1825939.

[3] A. Chirico, P. Cipresso, D. B. Yaden, F. Biassoni, G. Riva, and A. Gaggioli, "Effectiveness of Immersive Videos in Inducing Awe : An Experimental Study," *Sci Rep*, vol. 7, no. 1, pp. 1–11, 2017, doi: 10.1038/s41598-017-01242-0.

[4] J. Marín-Morales *et al.*, "Real vs. immersive-virtual emotional experience: Analysis of psycho-physiological patterns in a free exploration of an art museum," *PLoS One*, vol. 14, no. 10, 2019, doi: 10.1371/journal.pone.0223881.

[5] F. Borghesi, V. Mancuso, E. Pedroli, and P. Cipresso, “From Virtual Reality to 360° Videos,” 2022, pp. 549–572. doi: 10.4018/978-1-6684-4854-0.ch023.
[6] A. T. Beck, R. A. Steer, and G. K. Brown, *Beck depression inventory-II (BDI-II)*. Pearson, 1996.
[7] C. D. Spielberger, R. L. Gorsuch, and R. E. Lushene, “State-trait anxiety inventory,” *Stai Manual*, pp. 3–8, 1970.
[8] A. Terracciano, R. R. McCrae, and P. T. Costa, “Factorial and construct validity of the Italian Positive and Negative Affect Schedule (PANAS),” *Eur J Psychol Assess*, vol. 19, no. 2, p. 131, 2003, doi: 10.1027//1015-5759.19.2.131.
[9] C. E. Izard, F. E. Dougherty, B. M. Bloxom, and N. E. Kotsch, “The Differential Emotions Scale: A method of measuring the subjective experience of discrete emotions,” *Unpublished manuscript*, 1974.

Look at me, I am here! A Diary Study on Parental Phubbing and Children's Delay of Gratification

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Abstract: The last few years have witnessed a rapid development of new technologies, which has forced the use of new media in every aspect of life. In public places, it is not uncommon to see young people staring at their phone screens. Nor is it uncommon to see young mothers taking care of children and using a cell phone at the same time. Many studies show that being constantly online has negative effects on many spheres of life. The main aim of the diary study was to analyze the impact of mothers' use of smartphones in the presence of children on the children's ability to delay gratification. The sample size was N = 90. The participants were mothers of children aged 1–3 years. They were instructed to answer the questions that would be sent to their mobile phones every day, for 14 consecutive days. We used the Distraction in Social Relations and Use of Parent Technology Scale, the Modified Delayed Gratification Inventory, and the Daily Mood Measure, where mothers rated the items as describing their child and as referring to themselves (self-rating). We found that perceived children's and mother's positive emotions were mediators in the relationship between parental phubbing and children's ability to delay gratification. Parental phubbing was negatively related to mother's happiness, and since mother's happiness was positively correlated with perceived children's happiness, this translated into children's higher delay of gratification. The results may help understand the meaning of parental phubbing in a child's life.

Keywords: parental phubbing, happiness, sadness, delay of gratification, diary study, toddlers

1. Introduction

The past few years have witnessed a rapid development of new technologies, which has forced the use of new media in every aspect of life. In public places, it is not uncommon to see young people staring at their phone screens. Nor is it uncommon to see young mothers taking care of children and using a cell phone at the same time. This phenomenon is referred to as parental phubbing and is defined as disruptions caused by the parent using a mobile phone while playing with the child or during childcare [1] [2]. A considerable body of research has shown that mobile phone use in the presence of other persons that one is in a close relationship with causes a number of negative outcomes [3] [4] [5] [6]. Phubbing is often linked to depression and lower relationship satisfaction [7], anxiety [8], or the erosion of intimacy [9]. Studies have shown that adults feel frustrated when someone uses a mobile phone in their presence [10]. Research among adolescents showed that seeing their parents distracted by using their mobile phone was accompanied by negative emotions such as anxiety and aggression [11].

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Parental phubbing was found to be frequent also in the toddler–mother relationship [12] [13]. The main aim of our project was to analyze the impact of mothers' use of smartphones in the presence of children on the children's ability to delay gratification. What is more, we examined the role of children's and mother's daily emotional experience in this relationship.

A body of research indicates that parental distraction caused by these devices can translate into lower emotional well-being and weaken the relationship with the child [14]. When a parent uses a mobile phone during interaction with their child, this behavior has an impact because the child feels their parent's distraction. Research results suggest that in this kind of situation the child's performance deteriorates—for example, the child runs slower and more often falls while running [12]. The child feels anxious and frustrated when the parent is not with them because he or she is busy with their smartphone (talking, writing, viewing news, photos, etc.), the child perceives this as a lack of support [15]. The younger the child, the more difficult it is to cope with frustration because young children do not have an adequately developed self-regulation ability [16]. In the classic paradigm, self-regulation is understood as a delay of gratification, defined as a mechanism of choosing a distant reward when it is possible to obtain an immediate one [17]. Studies indicate that self-regulation ability develops in early childhood, between 3 and 5 years of age [19]. Thus, the delay of gratification in young children is in the process of developing. The sense of being important and the sense of being noticed by the mother are essential for its development.

When a parent uses a mobile phone in the presence of a child, the child's attention is focused on the phone, resulting in increased rather than decreased frustration, unlike in the case of other distracting stimuli [15]. The child's negative affect and frustration when a parent uses a phone in their presence become even stronger because the child expects support from the parent above all else, especially in difficult and challenging situations. This type of situation is comparable to that of an experiment where the child is faced with a challenging task cf. [12]. Research findings indicate positive relationships between negative affect such as frustration and problems with delaying gratification [17] [19]. Peake [20] emphasizes that the presence of a reward—the fact that it is within the child's sight—increases the child's level of frustration at gratification being withheld. Additionally, watching a parent immersed in their phone further intensifies the frustration felt by the child. Observations of children during an experiment involving delayed gratification revealed that what was very helpful in refraining from gratification was various strategies used by the children to divert attention away from the enticing stimulus [20]. When a parent used a mobile phone in the presence of a child, the child's attention was focused on the mobile phone, resulting in increased rather than decreased frustration, unlike in the case of other distracting stimuli [15]. We therefore formulated the following hypotheses: There is a negative relationship between mother's screen time in her child's presence and the child's ability to delay gratification (H1), and this relationship is mediated by the child's and mother's emotions (H2).

2. Method

2.1 Participants and Procedure

A sample of $N = 90$ participants took part in the study. They were mothers, aged 20 to 45 years ($M = 32.35$, $SD = 4.40$). The age of their children ranged from 1 to 3 years ($M = 1.96$, $SD = 0.81$); 37.1% of the children were boys and 62.9% were girls.

To test the hypotheses, we conducted a diary study using a mobile application for 14 consecutive days. That amount of time is recommended for diary studies and allows for minimizing the idiosyncratic week effect—in the other words, it reduces the risk of an untypical week distorting the results [21]. Mothers completed the questionnaires on their phones every day at a pre-selected time (before bedtime); they were not accompanied by their children when completing the measures. Participants were recruited through snowball sampling; announcements were sent out to kindergartens and posted on forums

for young mothers. All participants volunteered for the study and received a monetary reward of PLN 200 (equivalent to approximately USD 45). They met the criteria for participation: being a mother of a child aged 1–3 years, having a smartphone, and having high motivation to complete the survey every day. The mothers were informed about the purpose of the study and assured that their participation was anonymous. The study was conducted in compliance with the Declaration of Helsinki. It received approval from the Ethics Committee. We chose to use brief measures, which are recommended for diary studies, where subjects complete them each day for several days [21].

2.2 Measures

The Distraction in Social Relations and Use of Parent Technology **S**cale [10] was used to parental phubbing. The scale consists of four items (e.g., "During the time I spend with my child I find it difficult to stay away from checking my phone or mobile device"). The reliability indices for all measures are presented in Table 1; in all cases, their values are acceptable. To measure daily delayed gratification, we used the Modified Delayed Gratification Inventory [22], developed based on the questions about different aspects of delaying gratification, taken from the Delayed Gratification Inventory [23]. The scale included the following categories of delayed gratification: food, physical, social, and achievement. We performed a 2-level CFA to examine, based on the collected data, if the Modified Delayed Gratification Inventory was univariate at each level of measurement. The one-factor model was well fitted to the data at the within- and between-person levels: MLR χ^2 (10) = 41.76 ($p < .001$), CFI = .924, RMSEA = .051, SRMR-within = .047, SRMR-between = .051. The scale consists of 5 items (e.g., "When hungry, was the child able to wait for a meal or a snack?. To measure emotions, we used items from the measure developed by Maciejewski [24], assessing happiness (3 items) and sadness (3 items). Mothers rated the items as describing their child and as referring to themselves (self-rating). All scales achieved satisfactory internal consistency assessed using congeneric reliability at both within- and between-person levels (see Table 1).

2.3 Statistical Analyses

We conceptualized the data as a two-level structure in which daily measures were nested within individual respondent. To test the hypotheses, we used Mplus 7.3 software package to examine a within-person-level and between-person-level phenomenon [21]. At the person-level, general trends of differences between individuals can be identified. At the day-level, it is possible to determine the differences within a person regarding the variables measured. To test the model presented in Figure 1, we used 2-level path analysis. Because of the non-normal distribution, we used the MLR (robust maximum likelihood) estimator. We applied further criteria to evaluate the goodness of model fit: (1) comparative fit index (CFI) higher than .90; (2) root mean square error of approximation (RMSEA) and standardized root mean square residual (SRMR) lower than .07].

3. Results

Table 1 shows descriptive statistics (raw data), intraclass correlations, and within- and between-person-level correlations. ICC values ranged from .19 to .50.

Table 1. Descriptive statistics and within- and between-person-level correlations

	Descriptive statistics				Correlations				
Variable	*M*	*SD*	⌉	ICC	1	2	3	4	5
Within-person level									
1 mother's sadness (MS)	—	1.66	.88	—	—				
2 mother's happiness (MH)	—	1.66	.87	—	−.62	—			
3 children's sadness (CS)	—	1.40	.80	—	.46	−.42	—		
4 children's happiness (CH)	—	1.38	.82	—	−.38	.53	−.56	—	
5 children's delay of gratification (CDG)	—	0.73	.82	—	−.14	.21	−.23	.30	—
6 parental phubbing	—	0.94	.79	—	.16	−.18	.10	−.11	−.05
Between-person level									
1 mother's sadness (MS)	1.34	0.97	.99	.19	—				
2 mother's happiness (MH)	7.57	1.28	.98	.32	−.71	—			
3 children's sadness (CS)	1.13	0.83	.94	.20	.73	−.46	—		
4 children's happiness (CH)	8.18	1.09	.96	.34	−.48	.84	−.57	—	
5 children's delay of gratification (CDG)	3.60	0.79	.88	.50	−.11	.35	.10	.27	—
6 parental phubbing	2.19	0.84	.96	.40	.47	−.25	.38	−.16	.04

Note. N = 90; M = mean, SD = standard deviation; ⌉ = congeneric reliability; ICC = intraclass correlations. Correlations are statistically significant at $p < .05$ for within-person level $|r| > .06$ and for between-person level $|r| > .20$.

The two-level path analysis with MLR estimator showed an acceptable model fit for the collected data, presented in Fig. 1: $\chi^2(6) = 49.23$, $p < .001$; CFI = .960, RMSEA = .077, SRMR (within-person) = .047, SRMR (between-person) = .037. The path coefficients are shown in Fig. 1. The amounts of explained variance in the dependent variables in the model presented in Figure 1 at the within-person level were as follows: $R^2 = .025$ ($p < .05$) for MS, $R^2 = .031$ ($p < .05$) for MH, $R^2 = .180$ ($p < .001$) for CS, $R^2 = .225$ ($p < .001$) for CH, and $R^2 = .088$ ($p < .001$) for CDG. At the between-person level, the corresponding amounts of explained variance were: $R^2 = .231$ ($p < .05$) for MS, $R^2 = .062$ ($p = .263$) for MH, $R^2 = .597$ ($p < .001$) for CS, $R^2 = .747$ ($p < .001$) for CH, and $R^2 = .219$ ($p < .001$) for CDG. The hypotheses were supported at the between-person level.

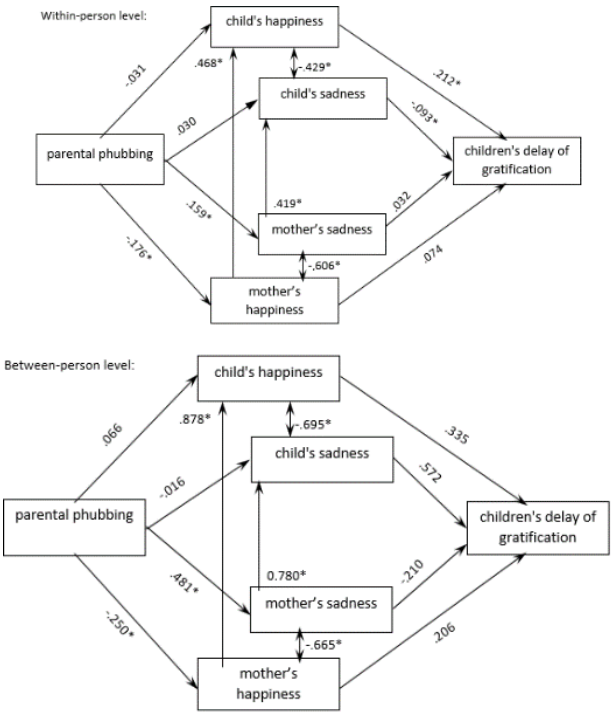

Figure 1. The model of parental phubbing

The model presented in Fig. 1 includes four mediators. Only one mediation path was statistically significant at the within-person level: Phubbing → MH → CH → CDG (within-person level: ® = −0.017, $p < .001$; between-person level: ® = −0.074, $p = .443$).

4. Discussion

The main aim of the investigation presented in this paper was to test the role of the children's and mothers' emotions in the relationship between mothers' use of smartphones in the presence of children on the children's ability to delay gratification. We found that perceived children's and mothers' emotions were mediators in the relationship between parental phubbing and children's ability to delay gratification. Parental phubbing was negatively related to mother's happiness, and because mother's happiness was positively correlated with perceived children's happiness, this translated into children's higher delay of gratification as reported by the mother. Similarly, a study by Pancani et al. [25] revealed a positive relationship between the level of parental phubbing and the level of perceived negative emotions in children. Conversely, low parental phubbing was related to higher mother's happiness, which was positively correlated with perceived children happiness, which in turn increased children's ability to delay gratification. Reference can be made to social learning theory, postulating that children's real-life experiences translate into their behavior—and for the youngest children the first source of experience is the parent–child relationship [26]. It can therefore be said that the mother's behavior shapes the child's behavior. Similarly, the mother's emotions can pass on to the child, as has been found, for example, in research on emotional contagion [2] and in studies showing that maternal behavior, but not paternal behavior, was related to the child's emotions [1].

What is more, we found a significant mediation effect at the within-person level. In other words, if on a particular day the mother uses the phone, it translates negatively into her own and her perceived child's positive emotions, which in turn translates into the delay of gratification on that day. The results indicate that the mother's focus on the phone instead of on the child leads to the mother feeling less joy; this translates into less joy experienced by the child, which, consequently, lowers the child's delay of

gratification. The child probably seeks immediate gratification in other ways (and looks for a different source of positive emotions), since he or she does not experience them from the mother. Smartphones can be used for family entertainment, social interactions, or access to educational materials for children. However, mobile devices can also distract parents from face-to-face interactions with their children, which are crucial for cognitive, language, and emotional development [14]. Conversely, if the mother does not use a mobile phone in her child's presence on a given day, this translates into her own and the child's positive emotions and, consequently, into the child's better ability to delay gratification. It should be noted that there is no direct relationship between maternal phubbing and the child's emotions. Everything depends on the mother's emotions—on whether the mother using the phone is at the same time able to show positive rather than negative emotions to the child. The child's negative affect, anger, and frustration when a parent is using a mobile phone in their presence become even stronger because the child expects support from the parent above all else, especially in difficult and challenging situations [6].

However, no significant mediation was found at the between-person level, indicating a general trend for each person. It should be noted that the children whose mothers took part in the study were 1–3 years of age, a time when their ability to delay gratification was still developing [19]. The sense of being important to and noticed by the mother is essential for its development. It can also be supposed that perhaps what is important is the length of the episodes of the mother using her phone in front of her child. It is possible that the child is more upset if these episodes are long and less upset if they are brief, even if there are many of them. However, because the phone usage times from all the days of the diary study were averaged, this possible pattern is not reflected in the results.

4.1 Limitations and Future Research

The possible limitation is the fact that the data we collected came from mothers' rating of children's emotions, which means the emotions experienced by mothers may have been projected onto the children. It would probably be better if an independent person observed the child for sorrows and joys, and even better if an independent observer or researcher did the same for the mother as well. The mother is not a good observer for several reasons, such as the lack of adequate preparation, cognitive ability issues such as selectivity of attention, memory effect (i.e., the mother relies on her memory of emotions and behaviors instead of reporting what she is observing), social approval bias, self-denial, or the inability to observe the child while phubbing. Future studies should be conducted among slightly older children, who have already developed the ability to defer gratification; perhaps more reliable correlations could be determined in that age group. Future studies would benefit from including an intervention to reduce parental phubbing, which could translate into emotions and delay of gratification. The next possible limitation is a lack of a control condition where a mother would be distracted by other activities (e.g., conversation).

References

[1] McDaniel BT, Sarah MC. Technoference: The interference of technology in couple relationships and implications for women's personal and relational well-being. Psychol. Pop. Media Cult. 2016: 5(1): 85–98. doi: 10.1037/ppm0000065

[2] Xie X. Julan X. Parental phubbing accelerates depression in late childhood and adolescence: A two-path model. J. Adolesc. 2020: 78: 43-52. doi: 10.1016/j.adolescence.2019.12.004

[3] Błachnio A, Przepiorka A. Be Aware! If You Start Using Facebook Problematically You Will Feel Lonely: Phubbing, Loneliness, Self-esteem, and Facebook Intrusion. A Cross-Sectional Study. Soc. Sci. Comput. Rev. 2018: 37(2): 270–278. doi:10.1177/0894439318754490

[4] Blanca MJ, Bendayan R. Spanish version of the Phubbing Scale: Internet addiction, Facebook intrusion, and fear of missing out as correlates. Psicothema. 2018: 30(4): 449-454. doi:10.7334/psicothema2018.153

[5] Roberts JA, David ME. Put down your phone and listen to me: How boss phubbing undermines the psychological conditions necessary for employee engagement. Comput. Hum. Behav. 2017: 75, 206-217. doi:10.1016/j.chb.2017.05.021

[6] Krasnova H, Abramova O, Notter I, Baumann A. Why phubbing is toxic for your relationship: Understanding the role of smartphone jealousy among "Generation Y" users. Twenty-Fourth European Conference on Information Systems (ECIS); 2016 Jun 6; İstanbul, Turkey, 109.
[7] Wang X, Gao L, Yang J, Zhao F, Wang P. Parental Phubbing and Adolescents' Depressive Symptoms: Self-Esteem and Perceived Social Support as Moderators. J Youth Adolesc. 2020: 49(2):427-437. doi:10.1007/s10964-019-01185-x
[8] Karadağ E, Tosuntaş ŞB, Erzen E, et al. Determinants of phubbing, which is the sum of many virtual addictions: a structural equation model. J Behav Addict. 2015;4(2):60-74. doi:10.1556/2006.4.2015.005
[9] Abeele MV. The social consequences of phubbing: A framework and a research agenda. In Handbook of mobile communication, culture, and information. New York: Oxford University Press: 2019.
[10] McDaniel BT, Radesky JS. Technoference: Parent Distraction With Technology and Associations With Child Behavior Problems. Child Dev. 2018: 89(1):100-109. doi:10.1111/cdev.12822
[11] Stockdale LA, Coyne SM, Padilla-Walker LM. Parent and child technoference and socioemotional behavioral outcomes: A nationally representative study of 10-to 20-year-old adolescents. Comput. Hum. Behav. 2018: 88: 219-226. doi:10.1016/j.chb.2018.06.034
[12] Kildare CA, Middlemiss W. Impact of parents mobile device use on parent-child interaction: A literature review. Comput. Hum. Behav. 2017: 75, 579–593. doi:10.1016/j.chb.2017.06.003
[13] Golen RP, Ventura AK. What are mothers doing while bottle-feeding their infants? Exploring the prevalence of maternal distraction during bottle-feeding interactions. Early Hum Dev. 2015;91(12):787-791. doi:10.1016/j.earlhumdev.2015.09.006
[14] Radesky JS, Kistin CJ, Zuckerman B, et al. Patterns of mobile device use by caregivers and children during meals in fast food restaurants. Pediatrics. 2014: 133(4): e843-e849. doi:10.1542/peds.2013-3703
[15] Elias N, Lemish D, Dalyot S, Floegel D. "Where are you?" An observational exploration of parental technoference in public places in the US and Israel. J. Child. Media. 2020: 15(1):1-13. doi: 10.1080/17482798.2020.1815228
[16] Reunamo J, Veijalainen J, Suhonen E, Sajaniemi N. Children's self-regulation and coping strategies in a frustrated context in early education. S. Afr. J. Child. Educ. 2019: 9(1): 1-8. doi:10.4102/sajce.v9i1.724
[17] Mischel W, Shoda Y, Rodriguez MI. Delay of gratification in children. Science. 1989: 244(4907): 933-938. doi:10.1126/science.2658056
[19] Carlson SM, Developmentally sensitive measures of executive function in preschool children. Dev. Neuropsychol. 2005: 28(2), 595-616. doi: 10.1207/s15326942dn2802_3
[19] Meindl P, Yu A, Galla BM, et al. A brief behavioral measure of frustration tolerance predicts academic achievement immediately and two years later. Emotion. 2019: 19(6): 1081-1092. doi:10.1037/emo0000492
[20] Peake PK. Delay of Gratification: Explorations of How and Why Children Wait and Its Linkages to Outcomes Over the Life Course. Nebr Symp Motiv. 2017: 64: 7-60.
[21] Nezlek J. Diary Methods for Social and Personality Psychology. New York: The Sage: 2012.
[22] Błachnio A, Chmielik MM. Till Phone Do Us Part: The Role of Phubbing in Relationship Satisfaction and Self-Esteem. J. Persp. Econ. Political. 2022: 2, 91-112. doi: 10.18290/pepsi-2021-0009
[23] Hoerger M, Quirk SW, Weed NC. Development and validation of the Delaying Gratification Inventory. Psychol Assess. 2011;23(3):725-738. doi:10.1037/a0023286
[24] Maciejewski DF, van Lier PA, Branje SJ, Meeus WH, Koot HM. A daily diary study on adolescent emotional experiences: Measurement invariance and developmental trajectories. Psychol Assess. 2017: 29(1): 35-49. doi:10.1037/pas0000312
[25] Pancani L, Gerosa T, Gui M, Riva P. "Mom, dad, look at me": The development of the Parental Phubbing Scale. J Soc Pers Relat. 2021: 38(2): 435–458. doi:10.1177/0265407520964866
[26] O'Connor TG, Matias C, Futh A, Tantam G, Scott S. Social learning theory parenting intervention promotes attachment-based caregiving in young children: randomized clinical trial. J Clin Child Adolesc Psychol. 2013: 42(3): 358-370. doi:10.1080/15374416.2012.723262

On the Importance of Social Touch for Senior Individuals and Ways to Ameliorate Social Isolation: Lessons Learned from the COVID-19 Pandemic

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Abstract: The need for touch exists below the horizon of consciousness. Interpersonal touch, or gentle physical contact between individuals, is an important aspect of human social interaction and has been shown to have numerous benefits for senior individuals. One of the main ways that interpersonal touch can benefit senior individuals is by reducing feelings of loneliness and social isolation. The outbreak of COVID-19 necessitated social distancing measures to mitigate the negative health consequences of the pandemic, which were particularly pronounced amongst vulnerable populations, especially those who live with dementia. At the same time, seniors' psychosocial wellbeing was compromised as opportunities for interpersonal touch became severely restricted. In this paper, we share what we have learned during the pandemic both on the critical importance of social touch for senior individuals, as well as on innovative ways to ameliorate the forced absence of social touch. Through a targeted literature review and an online survey study, our findings highlight the fact that social relationships and physical contact are key to personal wellbeing and underline the importance of social touch at an advanced age.

Keywords. Dementia, senior individuals, social touch, COVID-19, affective haptics, quality of life, nursing

1. Introduction

Social touch is a fundamental aspect of human interaction and communication, and it has been shown to have numerous positive effects on physical and mental well-being. As people age, social touch becomes even more crucial, particularly for seniors who often experience physical and emotional changes that can impact their quality of life. In recent years, there has been a growing interest in the role of social touch in the lives of seniors, and its potential benefits in improving their health and well-being. Studies have shown that touch can promote feelings of social connection and belonging. Subjective pleasantness ratings of slowly stroking touch even increase with age [15,19]. Additionally, touch has been shown to reduce stress and anxiety, which are common issues for seniors, particularly those living in long-term care facilities.

Interpersonal touch can help to lower blood pressure, to improve sleep quality, increase comfort levels and improve immune function [1,9]. In addition to the direct benefits of touch, it can also help seniors to maintain their emotional balance. Behavioral and psychological problems of older people with dementia are ameliorated after receiving massage or touch [14]. From the point of view of nurses in care settings, interpersonal touch enhances their own ability to comfort and to promote emotional attachment, making their work more personally satisfying, which has been shown to diminish the risk of burn-out [5,16].

The COVID-19 pandemic has had a significant impact on nearly every aspect of daily life, and social touch is no exception. For seniors, who are already at a higher risk of social isolation and loneliness, the pandemic created even greater barriers to physical touch and social connection. With social distancing measures in place, many seniors were unable to give and receive the social touch that they needed to maintain their physical and emotional well-being [6,27]. The effects of the pandemic on social touch amongst seniors are far-reaching and complex, and have especially impacted people with dementia living in intramural care settings. In this paper, we present the combined

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findings of a targeted literature review and an online survey study with the aim to explore the impact of the pandemic on social touch behaviors in senior care facilities. Through this exploration, we seek to uncover strategies and means – technological or otherwise - for promoting safe and meaningful social touch practices in senior care settings, and maintaining high levels of quality of life.

2. Methods

2.1 Design

We performed a short, targeted literature review focusing on the role and importance of social touch for elderly individuals. In particular, we focused on recent literature that presents or summarizes insights gained during the pandemic. To do this, we used a combination of the search terms "dementia", "touch", "COVID-19", "and wellbeing", using Google Scholar as search engine. In addition, we performed an online survey during the spring of 2021, at the height of the pandemic, probing a representative sample of care professionals on a broad range of issues, including social contact and touch, wellbeing, and the impact of social distancing measures. Below, we will provide further details of the online survey. The data of this online survey were also used to investigate the impact of physical care home design on people with dementia, see [24].

2.2 Participants

From a total of 1069 Dutch dementia care facilities listed on a Dutch website of dementia care facilities in the Netherlands, we randomly selected and approached 100 care facilities, which included 60 regular and 40 private dementia care facilities. These randomly selected facilities were each contacted by phone, after which the head nurse of each care facility was invited to participate in the online survey through email. The online survey was completed by a total of 46 dementia care professionals.

2.3 Setting & Materials

The online survey was administered through LimeSurvey with open and closed questions structured in several categories, including questions on social contact and touch, residents' well-being during the COVID pandemic, visits from family and friends, experiences of the care professional, the governmental restrictions regarding visits, touch and social distancing [24]. The online survey was approved by the ethical board of the HTI group at TU/e. Informed consent was provided by care professionals.

2.4 Data analysis

Thematic analyses were used for analyzing the open questions of the online survey, using a combination of Boeije's approach [2] and Braun and Clarke's approach [3]. The thematic analyses focused on touch and wellbeing were carried out by two researchers independently; insights were compared and differences resolved.

3. Results

3.1 Literature review

At the moment, one of the biggest threats to our society is found in the growing existence of loneliness, especially amongst senior citizens, while the human need for social proximity, attachment and belonging is crucial for survival. Threats to this need can be harmful to our feelings of wellbeing and safety, and may even cause physical pain [24,28]. In general, interpersonal affectionate touch (or social touch) plays an important role in promoting relatedness and feelings of happiness in communicating emotions and intensifying interpersonal communication between friends, couples and family members. Social touch promotes physical, emotional, social and spiritual wellbeing [9,20]. In nursing and care, massage and therapeutic touch are known to have beneficial effects and can increase feelings of well-being [1,5,14], as well as alleviate feelings of emptiness when other therapies are unsuccessful and words are not enough to bring comfort [23].

When we age, common hearing and vison loss have a significant impact on our ability to maintain social connections and feelings of belonging [22]. As we grow older and move into late adulthood our "tactile circumstances" change; this is already a

significant issue for healthy seniors, but increases in importance for seniors who live with memory disorders, personality changes, and impaired reasoning skills as a consequence of dementia. Despite a general decline of perceptual and cognitive abilities, the perception of light touch is comparatively preserved during normal aging. Subjective pleasantness ratings of slowly stroking touch even increases with age [15,17,19].

As a consequence of the social distancing measures associated with the COVID-19 pandemic, not being able to hug or touch had a significant impact on the quality of life of humans, especially the elderly and those who live with dementia. As Sachs [18] describes, people are able to adapt relatively well to a life without vision or hearing, but "an existence devoid of tactile sensation is another matter; sustained physical contact with other humans is a prerequisite for healthy relationships and successful engagement with the rest of one's environment". During COVID-19 we saw that a forced abstinence of social touch can lead to anxiety symptoms as a result of loneliness, causing a condition known as touch starvation or touch hunger [20]. For people with dementia the forced isolation and resulting loneliness could lead to a deterioration of the disease with increased negative psychological symptoms, due to reduced access to care and services and lack of mental and physical stimulation [13,23]. Also family caregivers of people with dementia who shared the same household experienced such challenges while taking care of a loved-one [12]. High rates of depression and anxiety in people with dementia were reported in care homes [7].

In most care homes we saw the daily struggle of trying to provide physical and mental care for the person with dementia while at the same time trying to follow the social distance restrictions. Despite these safety instructions and the use of Personal Protective Equipment (PPE) in rigid protocols, death tolls in care homes were high. Constantly reminding the person with dementia of the situation with restrictions – which they found hard to understand -, it became clear that you cannot live with and care for a person with dementia without touch [6,13,23].

Research by De Luca and colleagues [4,5] showed that interpersonal touch – not merely task-related instrumental touch (e.g., washing), but a more intentional, caring and comforting touch – can be of mutual benefit; a positive intervention for both the patient and the caregiver. Even more, the severe social distancing restrictions during the pandemic have led to an increased awareness amongst nursing staff of the importance of the use of touch in healthcare settings, including offering handholding and physical consolation to a person passing away without family allowed to be present. Despite all the restrictions, staff, family and informal caregivers demonstrated great resilience in trying to keep - quite literally - in touch. The main categories of affective touch interventions included (i) hugging or touching using physical barriers, including flexible plastic screens (e.g., hug screens or cuddle curtains), (ii) remote technology-mediated contact (e.g., video-calling), sometimes enriched through remote touch technologies (e.g., the Emerge Home platform using ultrasound tactile stimulation, or CuteCircuit's HugShirt based on haptic micro-actuators), (iii), active virtual touch devices, for example robotic animal companions [25], and (iv) passive affective haptic objects (e.g., soft, strokable plush toys or thermal objects, such as warm gloves),. Vasseur [26] performed a study to test the experiences with affective haptic stimuli (thermal, vibrotactile and force/pressure) during telecommunication to foster moments of remote contact using technology. The added value was particularly present in the provision of comfort by the use of soft fabrics [26]. Especially warmth was preferred to vibrations and touch-feedback during remote personal contact. In general, remote or mediated touch devices are typically challenging to deploy in care settings – the relevant technologies are still under development and can be rather fragile, expensive, and complicated in setup and usage. Moreover, the social touch signals tend to be ambiguous, and need to be contextualized to be meaningful. In contrast, robotic pets, or robotic companions, appear to have an intuitive appeal. The 'illusion of non-mediation' is rather high and the robotic animal pet is accepted as a feeling, sentient creature, and treated as a highly appreciated domestic animal. Relatively simple companion robots are preferred, with simple motoric actuation and an attractive soft skin to satisfy the need for positive tactile stimulation and social touch amongst people with dementia [25].

3.2 Online Survey

The thematic analysis of the responses of the dementia care professionals to the online survey in long-term care facilities yielded three main themes, regarding social touch and its specific entanglements in dementia care, the difficulties in navigating the tradeoffs between personal safety and psychosocial wellbeing in care settings, and the need to compensate for the restrictions imposed as a consequence of COVID-19.

Awareness of the Importance of Social Touch and Closeness to Loved Ones.
Having to be socially isolated to prevent infection with the COVID-19 virus, nursing staff, family, and residents have all realized, more than before, that social contact is necessary and that people should not be restricted from it. As nursing staff were advised against giving hugs or holding hands with residents, many of the residents were deprived of social touch and were reported to experience touch hunger. Respondents shared that social touch is a basic need especially in times of distress: *"Residents are touch starved. They miss receiving a hug". "A person with dementia should not be forced into a social distancing situation, they often live in a constant need of bodily contact"*.

It was not only burdensome for the person with dementia to cope with the no-touch situation, also the relatives missed the loving bodily contact. "*Although the family understood the difficult situation, they sometimes suffered more from the no-visit policy than the residents themselves".* Residents experienced feelings of loneliness, boredom, under-stimulation, alienation, and incomprehension in missing their loved ones and familiar, daily activities. Some experienced further deterioration of their dementia due to the changes that had been made for the sake of infection prevention; especially those with more advanced stages of dementia who no longer recognized their relatives. *"In dealing with a person with dementia non-verbal communication -to be able to see and to touch each other - is extremely important for bonding and trust".*

The nursing staff too became more aware of the significance of social touch during their work: *"I never thought I was so physically set, but not until now I realize myself how many touch opportunities are gone now I have to keep distance." "To be able to approach and touch the resident is so important in my work"*. It was especially harrowing to see older people pass away in isolation, not being able to touch or be touched by loved-ones; to bring comfort and consolation during their moments of need *"What hit me real hard was the process of the lonely passing away of the residents".*

Clashing Values in Caregiving: Safe Care versus Warm Care.
"You had to act against your gut instincts to fend off the residents who wanted to hug you." Inherent to many of the experiences that were reported was a fundamental tension between on the one hand wanting to keep residents safe and prevent infections with COVID-19, while on the other hand providing warm care, to show affection, and give warmth through social and physical touch, especially when relatives could not. *"For some residents a chat is not enough or not possible. They clearly have a need for physical touch in the form of holding hands, cuddling. This was discouraged as much as possible, so it felt like you were not doing right by the resident".*

The nurses had to work constantly in an atmosphere of being alert not to infect the residents, colleagues or their own loved ones at home. *"Social distancing was not always possible, our residents need a lot of physical care, you have to stand close. We tried to touch and hug less, but when the residents asked for it we couldn't resist to hold hands or offer a hug".*

Compensating for the Restrictive Measures and their Consequences
Nursing staff have tried hard to accommodate the absence of visits and arrange alternative contact moments. Respondents reportedly engaged in more social contact, giving extra individual attention. *"It was a tough period of time, but overall there was much understanding. Video calling, contact through the window, contact in a tent with a microphone, contact across a hedge in the garden. We have tried many things to still allow some contact. However, real, physical contact, a quick hug or a social touch, which is very important, was very much missed.*" Many residents did not understand the alternative visit and became more agitated and frustrated by the lack of intimacy and touch. Other residents, however, did enjoy the alternative means of social contact. *"We*

tried everything to establish warm contact, but real physical contact, like a hug, the inability to touch, was a great loss". The care professionals emphasize the need to learn from this situation, in order to be prepared for potential future lockdowns and to prevent the negative consequences of forced isolation and touch restrictions. *"After the lockdown our team is thinking of alternative ways to provide care; to use more domotics (like video-calling) or to buy a robotic cat to address touch needs".*

4. Discussion

People with dementia, individuals that emerge and exist through connection, are lost as a human without touch [6]. Indeed, the absence of social interactions has deeply affected this vulnerable group, whose opportunities to express these needs and take action to meet their unmet needs are limited. Both our literature review and survey highlight the fact that social relationships and physical contact are key to personal wellbeing and underline the importance of the entangled role of touch in dementia care [6,7,23]. To an extent, the tradeoff between safety and physical health versus psycho-social wellbeing is artifactual; both are key to an individual's health.

The outbreak of the COVID-19 pandemic has made us all acutely aware of the significance and meaning of social touch in our lives. Many efforts have been made to mitigate the negative effects of social isolation [8], including physical hug-screens, soft hugable or strokeable objects, and improvised handholding in the form of heated gloves. We also observed an increased use of digital touch technologies, including robotic pets, and various telepresence and virtual social touch devices.

As a consequence of the COVID pandemic, technology-mediated social contact (esp. video conferencing) has become more explicitly supported in care settings, and this has extended to an openness to experiment with remote or simulated social touch. Experiences over the last two years have been valuable in demonstrating what works, but also where it leaves us wanting, especially for a vulnerable group such as people living with dementia. Social touch mediated through technology, though potentially meaningful [11], is still in its infancy. For many people and contexts, it remains a poor proxy of interpersonal touch, demonstrating that social touch is so much more than the mere innervation of touch receptors in the skin. To date, it appears there are no satisfactory replacements for the closeness and warm physical interactions of a loved one. Affective haptic technology can, however, add value as an addition to existing warm contact.

Looking ahead, specific training on interpersonal touch in nursing education can change the perception of the richness and power of the use of compassionate touch in dementia care [5, 10]. Social restrictions in the future need to be reviewed and revised to allow and facilitate physical contact and touch for people living with dementia. They should be able to express and experience physical as well as social touch and closeness to loved ones at all times. We all have realized that, more than ever before, social contact is necessary and that people with dementia should not be restricted from it, jamais.

References

[1] Alp, F. Y., & Yucel, S. C. (2021). The effect of therapeutic touch on the comfort and anxiety of nursing home residents. *Journal of Religion and Health*, *60*, 2037-2050.

[2] Boeije, H. (2005). Bijlage: Stappenplan kwalitatief onderzoek. In H. Boeije (Ed.), *Analyseren in kwalitatief onderzoek* (pp. 1-15). Amsterdam, The Netherlands: Amsterdam Boom Onderwijs.

[3] Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77-101.

[4] De Luca, E., Fatigante, M., Zucchermaglio, C., & Alby, F. (2021). "Awareness to touch": A qualitative study of nurses' perceptions of interpersonal professional contact after an experiential training. *Nurse Education in Practice*, *56*, 103187.

[5] De Luca, E., Wilson, M., Shaw, M. R., & Landis, T. T. (2022). "Permission to touch": Nurses' perspectives of interpersonal contact during patient care. *Western Journal of Nursing Research*, *44*(5), 456-465.

[6] Douglas, C. (2021). A World of Touch in a No-Touch Pandemic: Living with Dementia in a Care Facility during COVID-19. *Anthropology in Action*, *28*(1), 8-15.

[7] El Haj, M., Altintas, E., Chapelet, G., Kapogiannis, D., & Gallouj, K. (2020). High depression and anxiety in people with Alzheimer's disease living in retirement homes during the COVID-19 crisis. *Psychiatry Research*, *291*, 113294.

[8] Faieta J, Faieta L, Leblond J, Routhier F and Best K (2022). Can technology abate the experience of social isolation for those affected by dementia? *Front. Aging Neurosci.* 13:779031.

[9] Field, T. (2001). *Touch*. Cambridge, Massachusetts: MIT Press.

[10] Gleeson, M., & Timmins, F. (2004). Touch: a fundamental aspect of communication with older people experiencing dementia. *Nursing Older People (through 2013)*, *16*(2), 18.
[11] Haans, A., de Bruijn, R., & IJsselsteijn, W. A. (2014). A virtual midas touch? Touch, compliance, and confederate bias in mediated communication. *Journal of Nonverbal Behavior*, *38*, 301-311.
[12] Harris, M. L., & Titler, M. G. (2022). Experiences of family caregivers of people with dementia during the COVID-19 pandemic. *Western Journal of Nursing Research*, *44*(3), 269-278.
[13] Herron, D. L., Runacres, J., Danton, I., & Beardmore, J. (2023). Carers' experiences of caring for a friend or family member with dementia during the COVID-19 pandemic. *Dementia*, *22*(3) 576–593
[14] Kopf, D. (2021). Massage and touch-based therapy: Clinical evidence, neurobiology and applications in older patients with psychiatric symptoms. *Zeitschrift fur Gerontologie und Geriatrie*, *54*(8), 753.
[15] McIntyre, S., Nagi, S. S., McGlone, F., & Olausson, H. (2021). The effects of ageing on tactile function in humans. *Neuroscience*, *464*, 53-58.
[16] Pedrazza, M., Berlanda, S., Trifiletti, E., & Minuzzo, S. (2018). Variables of individual difference and the experience of touch in nursing. *Western Journal of Nursing Research*, *40*(11), 1614-1637.
[17] Riva, F., Tschernegg, M., Chiesa, P. A., Wagner, I. C., Kronbichler, M., Lamm, C., & Silani, G. (2018). Age-related differences in the neural correlates of empathy for pleasant and unpleasant touch in a female sample. *Neurobiology of Aging*, *65*, 7-17.
[18] Sachs, F. (1988). The intimate sense. *The Sciences*, *28*(1), 28-34.
[19] Sehlstedt, I., Ignell, H., Backlund Wasling, H., Ackerley, R., Olausson, H., & Croy, I. (2016). Gentle touch perception across the lifespan. *Psychology and Aging*, *31*(2), 176.
[20] Schirmer, A., & McGlone, F. (2022). Editorial overview: Affective touch: neurobiology and function. *Current Opinion in Behavioral Sciences*, 101129.
[21] Thompson, E. H. (2016). The effects of touch. In: Olausson, H., Wessberg, J., Morrison, I., & McGlone, F. (Eds.) *Affective touch and the neurophysiology of CT afferents.* New York, NY: Springer.
[22] Tremblay, F., & Master, S. (2016). Touch in aging. *Scholarpedia of Touch*, 351-361.
[23] Tuijt, R., Frost, R., Wilcock, J., Robinson, L., Manthorpe, J., Rait, G., & Walters, K. (2021). Life under lockdown and social restrictions-the experiences of people living with dementia and their carers during the COVID-19 pandemic in England. *BMC Geriatrics*, *21*(1), 1-12.
[24] Tummers-Heemels, A., Coppelmans, A., de Kort, Y., & IJsselsteijn, W. (2022, September). Impact of Care Home Design on Wellbeing and Social Connections of People with Dementia During the COVID-19 Pandemic. In *Dementia Lab 2022: The Residue of Design: Proceedings of the 6th Dementia Lab Conference, D-Lab 2022, September 20–22, 2022, Leuven, Belgium* (pp. 27-37). Cham: Springer.
[25] Tummers-Heemels, A.I.M., Hillen, M. F., Kort, Y. A. D., & IJsselsteijn, W. A. (2020). Use of robotic animal companions in dementia care; a qualitative study of the immediate and long-term effects to enhance quality of life and feelings of wellbeing for individuals living with dementia. *Annual Review of Cybertherapy and Telemedicine, 2020*, 45-49.
[26] Vasseur, D. M. (2020) Warm Contact in Intramural Care: Exploring means to facilitate rich Telecommunication amid the COVID-19 pandemic. Master Thesis. Eindhoven University of Technology.
[27] Vente, T. (2021). A year without touch: a reflection on physician–patient interaction during COVID-19. *Pediatric Research*, *90*(6), 1115-1116.
[28] Von Mohr, M., Kirsch, L. P., & Fotopoulou, A. (2017). The soothing function of touch: Affective touch reduces feelings of social exclusion. *Scientific Reports*, *7*, 13516.

"Being Immersed in Aesthetic Emotions": Comparing immersive Vs. Non immersive VR in Aesthetic Emotions Elicitation

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Abstract. Virtual Reality (VR) changed the ways through which art is produced and also experienced by the audience. VR can convey effective emotional and aesthetic experiences thanks to the sense of presence. So far, previous studies have mostly focused on the cognitive implications of using virtual environments in aesthetic contexts. However, empirical studies testing whether and how immersion, sense of presence and engagement are able to emphasize emotional responses to artworks, compared to their simple 2D reproductions, are still scarce. In this study, we tested a new immersive aesthetic format of conventional 2D paintings consisting in a 360° spherical representation of the same paintings, enriched with narratives and music. This preliminary study aims at testing the role of immersion and sense of presence in promoting aesthetic emotions, in terms of aesthetic appreciation and emotional responses. To test this objective, in a within subject-design, each participant is exposed in a counterbalanced order to the new aesthetic format consisting of a set of virtual highly immersive paintings presented in a 360° environment (immersive condition) and to the same set of virtual paintings presented on a simple 2D virtual screen (non-immersive condition). Aesthetic emotions were measured through the AESTHEMOS scale containing 21 subscales covering prototypical aesthetic emotions, epistemic emotions and emotions indicative of amusement. Also, measures related to immersion, sense of presence, engagement and perceived novelty of the stimuli were assessed. Finally, self-report questionnaires measuring people's broader engagement with the arts and humanities, disposition to experience positive emotions and general aesthetic interest were administered to participants. For this preliminary study, we expected artworks to be judged more aesthetically pleasant and emotionally engaging compared to the same set of non-immersive stimuli, presented on a 2D screen. Moreover, we hypothesize immersion, sense of presence and engagement to positively correlate with higher aesthetic appreciation of those stimuli.

Keywords. Aesthetic emotions, Virtual Reality, Sense of presence, Immersion, Art, Aesthetic experiences

1. Introduction

The emergence of new digital media has had a significant impact on both the creation and perception of art. With the advancement of technology, artists have been able to create new forms of art that were previously impossible or difficult to achieve through traditional methods [1,2]. Digital media have also changed the way we perceive and experience art, since they have enabled new forms of audience engagement, such as participatory installations and interactive exhibitions, which allow viewers to become active participants in the creation and interpretation of art [3, 4].

Virtual Reality (VR) has become an increasingly popular tool for artists to create immersive and interactive art experiences since it allows creating virtual worlds and spaces that viewers can explore and interact with, providing a new level of engagement and interactivity with the artwork [5]. According to Kim and Lee, in a virtual environment, the observer becomes an active participant in the creation of the aesthetic experience, rather than a passive viewer [6].

VR is a powerful *affective* medium that is able to generate strong emotional responses, thanks to the experience of presence and immersion. This is achieved through a combination of sensory stimuli, including visual, auditory, and haptic feedback, as well as the ability to interact with and navigate within the virtual environment [7,8,9].

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1.1 Presence and aesthetic emotions

Presence is usually defined as the feeling of "being and acting there" [10,11,12]. Presence can be enhanced by realistic graphics and sounds, as well as by the ability to interact with objects and characters in the environment. Narrative content is also a chief actor in increasing the sense of presence [13,14,15,16].

Aesthetic emotions have been recently introduced and analyzed in the psychological literature [17]. These emotions arise from our engagement with art, music, literature, and other forms of creative expression. They can be differentiated from other types of emotions, such as basic emotions like anger or sadness, in that they are more complex and often have a longer duration. Aesthetic emotions can be both positive and negative [18]. Positive-valenced aesthetic emotion include emotions such as awe, wonder, and joy. These emotions are often associated with feelings of transcendence or a sense of being connected with something that is perceived as greater than ourselves [19]. Another important feature of aesthetic emotions is that they are highly subjective. Different people may have different emotional responses to the same piece of art, music, or literature, and these responses may change over time and with repeated exposure [20].

To sum up, immersion and sense of presence are crucial aspects of the VR experience, as they allow users to feel emotionally involved and fully engaged within the simulated environment. Lots of studies have been conducted to test the impact of immersion and sense of presence on emotional responses of participants induced by emotionally charged stimuli compared to neutral ones [21,22,23]. However, few studies have investigated the link between immersion, sense of presence and aesthetic emotions induced by artworks [24,25]. In this study, we tested a new immersive aesthetic format of conventional 2D paintings consisting of a 360° spherical representation of the same paintings, enriched with narratives and music.

Specifically, the main hypotheses are that i) *immersive paintings elicit more intense emotional responses than non-immersive ones in terms of aesthetic emotions*; ii) *aesthetic emotions are related to the levels of immersion, sense of presence, and engagement felt by participants*. By examining the interplay between immersion, sense of presence, engagement, and aesthetic emotions, the study seeks to contribute to the field of aesthetics and deepen our comprehension of how individuals interact with artistic stimuli.

2. Methods

2.1 Sample

The study involves twenty participants aged between 18 and 60 (mean age = 35.88 years; S.D = ± 11.01). Participants were volunteers and did not receive any payment or credit for their collaboration.

2.2. Stimuli

To verify the above hypotheses, stimuli for the immersive condition were chosen from an app, available on Meta Quest store, *Art Plunge*, which is a virtual gallery where the observer can get the feeling of being inside famous paintings. The gallery features 5 VR interpretations of the following artworks: *Mona Lisa* by Leonardo da Vinci (1503), *Starry Night* by Vincent Van Gogh (1889), *The Birth of Venus by* Sandro Botticelli (1863), *The Creation of Adam* by Michelangelo (1512), and *Girl Reading a Letter at an Open Window* by Johannes Vermeer (1659). These artworks have been designed to fully engage the viewer's senses and create a multi-sensory experience by incorporating sound, movement, and other sensory elements. Stimuli for the non-immersive condition include the five paintings (*Mona Lisa, Starry Night, The Birth of Venus, The Creation of Adam* and *Girl Reading a Letter at an Open Window)* in their 2D format, displayed on a virtual screen.

2.3 Experimental design and materials

The experiment involved a *within-subjects* design. Each subject experienced both the immersive condition consisting in the five virtual paintings from *Art Plunge* app and non-immersive condition, consisting of the five paintings displayed in their 2D format. The 10 virtual stimuli - immersive and non-immersive paintings - were run on a standalone Head Mounted Display (HDM) (MetaQuest 2) and their order of presentation was randomized. Navigation and movement within the environment were possible through the use of a wireless joystick. Narratives and music during the exploration were played by headphones incorporated into the HMD.

2.4 Measures and Instruments

Aesthetic disposition

Participants' disposition to live positive emotions (Disposition Positive Emotions Scale)– DPES [26]– and their general aesthetic interest for literature, art, cinema, design, food and nature (Desire for Aesthetics Scale-DFAS) [27] was assessed before the experimental session.

Aesthetic emotions

After each experimental condition aesthetic emotions were assessed through AESTHEMOS scale [28]. The scale contains 21 subscales with two items each, that are designed to assess the emotional signature of responses to stimuli's perceived aesthetic appeal in a highly differentiated manner. Also, before the experimental session and after each experimental condition, the Italian PANAS [29] version was used to capture the two main clusters of the affective experience.

Perceived connectedness with the artist

After each experimental condition, participants rated how much they felt connected to the artist through the Inclusion of Other in the Self Scale [30]. Respondents see seven pairs of circles that range from just touching to almost completely overlapping. One circle in each pair is labeled "self," and the second circle is labeled "other," that is, the artist. Respondents choose one of the seven pairs to answer the question, "Which picture best describes your relationship with the artist?".

Immersion, sense of presence, engagement and familiarity

After viewing each painting, participants are asked by the experimenter to rate their perception of the painting using four rating scales, ranging from 0 to 100, that included items measuring immersion, sense of presence, engagement and perceived novelty of the stimulus ("Quanto ti sei sentito presente all'interno dello scenario che hai appena osservato?", *"How present did you feel within the scenario you just observed?"*; "Quanto ti sei sentito immerso all'interno dello scenario che hai appena osservato?", *"How immersed did you feel within the scenario you just observed?"*; "Quanto lo stimolo ti ha coinvolto?", *"How involved did the stimulus make you feel?"* ; "Quanto avevi familiarità con lo stimolo appena visto?", *"How familiar were you with the stimulus you just saw?"*).

2.5 Procedure

The day of the experiment, participants were welcomed and instructed to sit comfortably in a quiet room and completed the online questionnaires before the experimental session took place. They were then instructed on how to wear the virtual reality headset and manipulate the two controllers. Participants were exposed both to the virtual gallery from *Art Plunge* app, containing the highly immersive virtual paintings and to the same set of virtual 2D paintings, in a counterbalanced, with a break in between. After viewing each painting, participants rated their perception of the painting using four rating scales, ranging from 0 to 100, that included items measuring immersion, sense of presence, engagement and perceived novelty of the stimulus. After each set of paintings, participants were required to complete post-questionnaires, aimed at measuring the overall experience. Participants were also given the opportunity to provide open-ended feedback at the end of their experience.

3. Results

3.1 Aesthetic disposition

We computed total scores related to each dimension of DPES scale (Happiness, Compassion, Amusement, Love, Pride, Awe) and overall score of DFAS scale obtained by participants.

Table 1. Descriptive statistics related to each dimension of DPES scale and DFAS scale

	Mean	**Std. Deviation**
DFAS	134.11	15.52
Happiness	4.33	.47
Compassion	5.40	.55
Amusement	4.80	.93
Love	4.28	1.12
Pride	4.80	.55
Awe	5.11	.59

N=20

3.2 Aesthetic emotions in Virtual Reality

Paired-samples t-tests were conducted on each separate subscale of AESTHEMOS scale. Results showed a significant difference for all the subscales apart from Humor, Relaxation, Feeling of Ugliness, Anger, Uneasiness and Sadness.

Table 2. Descriptive statistics of each dimension of AESTHEMOS scale for both immersive and non-immersive condition.

	Mean		***St d. Deviation***		***Paired t-test (Equal Variances assumed)***		
	Immersive	*Non-immersive*	*Immersive*	*Non-immersive*	*T (df =19)*	*p*	*D(Cohen)*
Beauty	*6.50*	*5.27*	*.79*	*1.06*	*5.93*	***.00***	*.61*
Fascination	*6.33*	*3.72*	*.66*	*1.58*	*5.55*	***.01***	*1.40*
Being Moved	*5.38*	*3.33*	*1.86*	*1.45*	*3.92*	***.04***	*1.57*
Awe	*5.66*	*3.50*	*1.00*	*1.00*	*6.50*	***.00***	*1.00*
Enchantment	*6.27*	*3.83*	*1.50*	*1.39*	*6.05*	***.00***	*1.21*
Nostalgia	*4.33*	*3.11*	*1.62*	*1.57*	*2.76*	***.024***	*1.32*
Joy	*5.83*	*4.87*	*1.11*	*1.40*	*3.74*	***.01***	*.75*
Humor	*4.88*	*4.16*	*1.45*	*1.22*	*1.88*	*.09*	*1.14*
Vitality	*5.72*	*3.61*	*1.32*	*1.24*	*4.99*	***01***	*1.26*
Energy	*5.05*	*3.50*	*1.68*	*1.25*	*4.60*	***.00***	*1.01*
Relaxation	*5.16*	*4.38*	*1.34*	*.89*	*1.86*	*.10*	*1.25*
Surprise	*4.27*	*2.66*	*1.27*	*1.08*	*3.96*	***.00***	*1.21*
Interest	*6.27*	*5.05*	*1.00*	*1.18*	*3.27*	***.01***	*1.12*
Intellectual Change	*5.72*	*4.55*	*.93*	*1.15*	*6.26*	***.00***	*.55*
Insight	*5.05*	*3.33*	*1.37*	*1.29*	*3.53*	***.00***	*1.46*
Feeling of ugliness	*1.55*	*1.50*	*.16*	*.00*	*1.00*	*.34*	*.16*
Boredom	*1.88*	*2.44*	*.76*	*.41*	*2.85*	***.02***	*.58*
Confusion	*2.11*	*1.77*	*.68*	*.50*	*2.82*	***.02***	*.70*
Anger	*1.61*	*1.61*	*.33*	*.33*	*.00*	*1.00*	*.50*
Uneasiness	*2.00*	*1.50*	*.90*	*.00*	*1.66*	*.13*	*.90*
Sadness	*2.44*	*2.22*	*1.28*	*.56*	*.59*	*.56*	*1.12*

A Wilcoxon Signed-Ranks Test indicated that the perception of connectedness to the artist rated by participants in the immersive condition was significantly higher than the perception of connectedness to the artist rated by participants in the non-immersive condition ($Z = -2.56$, $p = .010$).

3.3 The link between immersion, sense of presence, engagement and aesthetic emotions

A paired-samples t-test was conducted on total scores related to immersion, presence, engagement and familiarity computed on the mean ratings participants gave for each painting from the immersive and non-immersive condition. A first analysis showed a significant difference between the two conditions for all dimensions but familiarity [t(immersion) = 10.65, p <.001, d= 10.90; t(presence) =6.34, p <.001, d= 16.36; t(engagement) =5.66, p <.001, d= 15.04]. Specifically, participants gave higher rates related to immersion, presence and engagement after viewing immersive paintings compared to non-immersive paintings.

Table 3. Descriptive statistics of ad-hoc items related to immersion, presence, engagement, familiarity for both immersive and non-immersive conditions.

	Mean		***Std. Deviation***	
	Immersive	***Non-immersive***	***Immersive***	***Non-immersive***
Immersion	*94.80*	*56.06*	*5.34*	*13.58*
Presence	*93.06*	*58.44*	*4.37*	*17.13*
Engagement	*93.82*	*65.40*	*5.10*	*15.62*
Familiarity	*93.42*	*89.62*	*6.70*	*5.97*

N= 20

To better explore the possible link between emotion and presence, we analyzed in both conditions the correlations between the level of immersion, presence, engagement and the emotional level experienced after each experience.

In the immersive condition, a positive correlation emerged between presence and insight dimension of AESTHEMOS scale [r(19)= .782, p= .05] and between immersion and both fascination and beauty dimensions of AESTHEMOS scale [r(19)= .688, p= .05; r(19)= .784, p= .05] while in the non-immersive condition, negative correlations emerged between sense of presence and humor and relaxation dimension of AESTHEMOS scale [r(19)= -.744, p= .05, r(19)= -.836, p= .01].

4. Discussion and Conclusion

In this study we compare the aesthetic emotions felt by observers in response to immersive and non-immersive paintings. The study used a quantitative approach to gather data from participants who were shown both types of paintings and asked to report their emotional responses.

The results of the study showed that participants reported a higher level of aesthetic emotions when viewing immersive paintings compared to non-immersive paintings. Immersive paintings were found to elicit stronger feelings of awe, fascination, inspiration, enchantment, joy, surprise and relaxation and were found to be more intellectually challenging. On the other hand, non-immersive paintings were associated with boredom. Moreover, results from the IOSS scale showed that participants felt a deeper connection with the artist in the immersive condition compared to the non-immersive one. Also, correlations between immersion and sense of presence scores and AESTHEMOS dimensions showed that immersive paintings engage the viewer's attention more fully and create a greater sense of presence and involvement, leading to stronger aesthetic emotional responses. Our findings suggest the importance of immersion and the sense of presence as mediating variables between the media experience and the aesthetic emotions induced by it.

Overall, the study provides insight into the potential of immersive art to elicit strong emotional responses from viewers. It highlights the importance of considering the immersive qualities of artworks in the evaluation of their aesthetic impact. These results, even if preliminary, could have interesting implications for artists, curators, and art enthusiasts, as well as for the development of immersive technologies in the art world. Immersive technologies offer the potential to create highly immersive and interactive art experiences that can evoke strong emotional responses in viewers, and potentially transform their aesthetic perceptions and experiences.

This study has some caveats. First, as a pilot study, the size of the experimental sample was limited. So, for some analyses the statistical power was low. Second, we measured emotional states using self-report questionnaires only. Even if the assessment tools used were validated and effectively tested in different contexts, the use of physiological indexes may help in obtaining a more complete picture of the emotional response of the user.

Further research is needed to explore the mechanisms underlying the emotional impact of immersive art and to investigate the role of individual differences in the perception of immersive and non-immersive paintings.

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References

[1] Allen, M. (2002). The impact of digital technologies on film aesthetics.
[2] Guo, Y., Wang, D., & Cui, W. (2014, May). The Study of New Media Art Aesthetic. In *International Conference on Education, Language, Art and Intercultural Communication (ICELAIC-14)* (pp. 455-457). Atlantis Press.
[3] Cavazza, M., Lugrin, J. L., Hartley, S., Le Renard, M., Nandi, A., Jacobson, J., & Crooks, S. (2005). Intelligent virtual environments for virtual reality art. *Computers & Graphics*, *29*(6), 852-861.
[4] Kwastek, K. (2013). *Aesthetics of interaction in digital art*. Mit Press.
[5] Bates, J. (1992). Virtual reality, art, and entertainment. *Presence: Teleoperators & Virtual Environments*, *1*(1), 133-138.
[6] Kim, Y., & Lee, H. (2022). Falling in love with virtual reality art: A new perspective on 3D immersive virtual reality for future sustaining art consumption. *International Journal of Human–Computer Interaction*, *38*(4), 371-382.
[7] Steuer, J.S. (1992). Defining virtual reality: dimensions determining telepresence. Journal of Communication 42:73–93. 8- Riva, G., Davide, F., & IJsselsteijn, W.A. (eds.). (2003). Being there: concepts, effects and measurements of user presence in synthetic environments. Amsterdam: IOS Press. Available at: www.emergingcommunication. com/volume5.html. Accessed November 1, 2006.
[8] Riva, G., & Waterworth, J.A. (2003). Presence and the self: a cognitive neuroscience approach. PresenceConnect. Available at: http://presence.cs.ucl. ac.uk/ presenceconnect/articles/Apr2003/jwworthApr 72003114532/jwworthApr72003114532.html. Accessed November 1, 2006.
[9] Riva, G., Waterworth, J.A., & Waterworth, E.L. (2004). The layers of presence: a bio-cultural approach to understanding presence in natural and mediated environments. CyberPsychology & Behavior 7:405–419.
[10] IJsselsteijn, W.A., & Riva, G. (2003). Being there: the experience of presence in mediated environments. In: Riva, G., Davide, F., & IJsselsteijn, W.A. (eds.), Being there: concepts, effects and measurements of user presence in synthetic environments. Amsterdam: IOS Press, pp. 3–16. Available at: www.emergingcommunication.com/volume5.html. Accessed November 1, 2006.
[11] Riva, G., Mantovani, F., Capideville, C. S., Preziosa, A., Morganti, F., Villani, D., … Alcañiz, M. (2007). *Affective Interactions Using Virtual Reality: The Link between Presence and Emotions. CyberPsychology & Behavior, 10(1), 45–56.* doi:10.1089/cpb.2006.9993.
[12] Slater, Mel. "Immersion and the illusion of presence in virtual reality." *British journal of psychology* 109.3 (2018): 431-433.
[13] Biocca, Frank, and Ben Delaney. "Immersive virtual reality technology." *Communication in the age of virtual reality* 15.32 (1995): 10-5555
[14] Baños, R. M., Botella, C., Alcañiz, M., Liaño, V., Guerrero, B., & Rey, B. (2004). Immersion and emotion: their impact on the sense of presence. *Cyberpsychology & behavior*, *7*(6), 734-741.
[15] Pinchbeck, D. M., & Stevens, B. (2005, August). Presence, narrative and schemata. In *Proceedings of Presence 2005: The 8th International Workshop on Presence* (pp. 221-26).
[16] Menninghaus, Winfried, et al. "What are aesthetic emotions?." *Psychological review* 126.2 (2019): 171.
[17] Silvia, Paul J., and Elizabeth M. Brown. "Anger, disgust, and the negative aesthetic emotions: Expanding an appraisal model of aesthetic experience." *Psychology of Aesthetics, Creativity, and the Arts* 1.2 (2007): 100.
[18] Perlovsky, Leonid. "Aesthetic emotions, what are their cognitive functions?." *Frontiers in Psychology* 5 (2014): 98.
[19] Marković, Slobodan. "Components of aesthetic experience: aesthetic fascination, aesthetic appraisal, and aesthetic emotion." *i-Perception* 3.1 (2012): 1-17.
[20] Xue, Tong, et al. "CEAP-360VR: A Continuous Physiological and Behavioral Emotion Annotation Dataset for 360 VR Videos." *IEEE Transactions on Multimedia* (2021).
[21] Voigt-Antons, Jan-Niklas, et al. "Comparing emotional states induced by 360 videos via head-mounted display and computer screen." *2020 twelfth international conference on quality of multimedia experience (QoMEX)*. IEEE, 2020.
[22] Somarathna, Rukshani, Tomasz Bednarz, and Gelareh Mohammadi. "Virtual reality for emotion elicitation–a review." *IEEE Transactions on Affective Computing* (2022).
[23] Kwastek, K. (2016). Immersed in Reflection? The Aesthetic Experience of Interactive Media Art. In *Immersion in the Visual Arts and Media* (pp. 66-85). Brill.
[24] Dogramaci, Burcu, and Fabienne Liptay. "Immersion in the visual arts and media." *Immersion in the Visual Arts and Media*. Brill, 2016. 1-17.
[25] Shiota, M. N., Keltner, D., & John, O. P. (2006). Positive emotion dispositions differentially associated with Big Five personality and attachment style. The Journal of Positive Psychology, 1(2), 61-71.

[26] Lundy, D. E., Schenkel, M. B., Akrie, T. N., & Walker, A. M. (2010). How Important is Beauty to You? The Development of the Desire for Aesthetics Scale. *Empirical Studies of the Arts*, *28*(1), 73–92. https://doi.org/10.2190/EM.28.1.e

[27] Schindler, I., Hosoya, G., Menninghaus, W., Beermann, U., Wagner, V., Eid, M., & Scherer, K. R. (2017). Measuring aesthetic emotions: A review of the literature and a new assessment tool. Plos One, 12(6), e0178899.

[28] Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: the PANAS scales. Journal of personality and social psychology, 54(6), 1063.

[29] Aron, A., Aron, E. N., & Smollan, D. (1992). Inclusion of other in the self scale and the structure of interpersonal closeness. Journal of Personality and Social Psychology, 63(4), 596-612.

Digital Self-Harm: Examining Emotionally Unstable Personality Traits and Non-Suicidal Self-Injury as Predictors

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Abstract. Digital self-harm (DSH) is an area within non-suicidal self-injury (NSSI) and self-harm that has not been extensively studied. An individual who engages in digital self-harm makes an anonymous account to create the impression that they are a victim of cyberbullying or cyberharassment. Research shows that there are several risk factors for NSSI, one of which includes borderline personality disorder (BPD), so the current study examined whether emotionally unstable personality traits and NSSI predicted digital self-harm. 112 freshmen at a large midwestern university completed an anonymous internet-based survey measuring: engagement in NSSI, engagement in DSH, and emotionally unstable personality traits. 61 (54%) students self-reported engaging in NSSI, and 17 (15%) students self-reported engaging in DSH. The results indicated that individuals who engaged in NSSI were significantly more likely to engage in DSH; females were more likely to engage in both NSSI and DSH compared to males. However, the study did not find that all BPD personality traits correlated with individuals who engaged in DSH. Individuals who engaged in more types of DSH scored significantly higher on Dysregulated Anger, Despondence, Behavioral Dysregulation, Affective Dysregulation, Fragility, Dissociative Tendencies, Manipulativeness, Oppositional, and Rashness. Personality facets were similar among DSH and NSSI. These results suggested a relationship between DSH, NSSI, and BPD features. The higher percentage of reported DSH and NSSI in the current study (as compared to past studies) may be related to the increased stress experienced during the COVID-19 pandemic. Future considerations should include DSH behavior for a more holistic approach when assessing self-harm amongst at-risk adolescents and young adults.

Keywords. digital self-harm, self-cyberbullying, non-suicidal self-injury, borderline personality disorder, emotionally unstable personality traits

1. Introduction

On August 2, 2013, 14-year-old English teenager Hannah Smith committed suicide[1]. Her parents found online a trail of hurtful messages directed at their daughter via the social media site Ask.fm. They approached the police and used these online messages as proof that their daughter had been the victim of cyberbullying. However, after further digging, a detective connected IP addresses from Hannah's laptop and the hurtful posts, strongly suggesting that Hannah herself had been authoring the hurtful messages. These posts were made just a few weeks before she took her own life. Hannah's death was a fatal consequence of the phenomenon known as digital self-harm, a form of self-injury where individuals will intentionally make hurtful comments about oneself through online networks. Limited research exists on digital self-harm (DSH), specifically as DSH relates to traditional forms of self-harm, such as non-suicidal self-injury (NSSI).

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1.1 Background

1.1.1 Digital Self-Harm

A few years before Hannah's suicide, a Microsoft researcher first used the term "digital self-harm" to describe a self-harassing behavior that she had observed among a social media platform called Formspring[2]. Users created an anonymous account to write themselves mean questions, then used their personal account to answer those mean questions[2]. Little was known about digital self-harm at this time. In a sample of 600 college students, 9% self-reported engaging in digital self-harm during their high school years[3]. A survey[4] of US adolescents aged 12-17 found that 6% of students admitted to digital self-harm – defined as either 1) "anonymously posting something online about myself that was mean," or 2) "anonymously cyberbullied myself online." More recently, an updated survey[5] of US adolescents found 8.6% engaged in digital self-harm; there was no difference between males and females. Thus, digital self-harm has also been conceptualized as self-cyberbullying.

Digital self-harm has also been defined as online activity that supports NSSI, particularly of an individual's physical wellbeing[6]. Online communities have facilitated the discussion of eating disorders as a reasonable lifestyle alternative. These communities, also known as pro-eating disorder communities (pro-ED), view eating disorder behaviors as acceptable rather than threatening to one's personal health[7]. Attempts to monitor and restrict pro-ED content, such as "thighgap" or "thinspiration," has contributed to the creation of tags that circumvent such restrictions, such as "thyghgap" or "thynspiration." These variant communities encourage pro-ED lifestyles and other forms of self-harm[8]. A hashtag analysis across Tumblr, Instagram, and Twitter of ED-related social media content showed 33.4% of content was specifically related with Anorexia, Bulimia, or General Eating Disorders, while 7.1% of content was associated with self-injury or self-harm[9].

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1.1.2 Non-suicidal self-injury

The fifth edition of the APA's Diagnostic and Statistical Manual of Mental Disorders (DSM-5) uses the phrase non-suicidal self-injury (NSSI) with regards to self-harm. NSSI refers to the intentional injuring of oneself without intention to die [10]. Traditional forms of self-harm include intentionally cutting parts of the body such as one's arms or wrists without suicidal intention. Other forms include burning of the skin with a cigarette, cigarette lighter or match; causing bruising on the head due to repeated banging; or preventing a wound from healing [11].

NSSI behavior typically originates during an individual's adolescent years, between the time when one is 12 and 16 years old [12]. Factors such as the tendency for adolescents to be more impulsive and emotionally reactive are likely to make an individual's adolescent years particularly vulnerable to NSSI [13]. A European study [14] reported 27.6% of adolescents admitted to having committed an act of self-harm at least once in their lives. In Canada [15], youths aged 13-17 who visited Emergency Departments in Ontario revealed two contrasting trends over time; from 2003-2009, youths who presented with self-harm related complaints fell 32%, but from 2009-2017, these same complaints rose 135%.

Research also indicates that NSSI continues into one's college years. In the US[16], 17% of university students sampled between 18-24 admitted to having committed an act of self-harm at least once in their lives. Of these, 75% reported having committed self-harm recurrently. These results were supported by a review [17] of NSSI engagement across ages; individuals 18-25 fell into the highest risk group for individuals who could engage in NSSI. Among university students, lifetime engagement in NSSI was high, ranging from 36%[18] to 45% [19]. In addition, 20% of the freshman university students surveyed [19] reported current engagement in NSSI. These high prevalence rates suggest a heightened need to address NSSI among populations of college-aged students.

1.1.3 Borderline Personality Disorder

Cluster B personality disorders consist of antisocial personality disorder, borderline personality disorder, histrionic personality disorder, and narcissistic personality disorder[10]. Borderline personality disorder (BPD) consists of volatile mood, self-image, and impulsivity. A study [20] of Australian youth (15-25 years of age) with BPD revealed that over three-quarters reported a lifetime engagement with NSSI, and over the past year, nearly two-thirds reported attempting suicide. While self-mutilating behavior is one criterion for diagnosing BPD [10], a proportion of individuals with BPD —nearly 10%— die by suicide [21-22].

There are consistent findings that suggest a dimensional understanding of BPD may better conceptualize the personality disorder categorically. Research [23] identified the following facets of the five-factor personality model that consistently comprise BPD individuals: six neuroticism facets (high anxiousness, high depressiveness, high angry hostility, high impulsiveness, high vulnerability, and high self-consciousness), one openness to experience facet (high fantasy), and three agreeableness facets (low compliance, low trust, and low straightforwardness), and one conscientiousness facet (low deliberation). These profile elements correspond closely with the results of a study [24] on NSSI among undergraduate freshmen, specifically one facet of extroversion (low assertiveness) and two facets of conscientiousness (low dutifulness and low self-discipline).

1.2 Current Study

The current study examined whether emotionally unstable personality traits and NSSI predicted digital self-harm. Since NSSI typically originates during an individual's adolescent years and continues into their college years, the current study focused specifically on first-year college freshmen. The authors expected to find that individuals who engaged in traditional forms of NSSI were more likely to engage in digital self-harm. In addition, the authors hypothesized a significant relationship between digital self-harm and emotionally unstable personality traits. Specifically, individuals who engage in digital self-harm will score higher on all facets of Neuroticism, and lower on certain facets of Agreeableness (i.e., low compliance, low trust, and low straightforwardness) and Conscientiousness (i.e., low deliberation).

2. Method

2.1 Participants

All participants were treated in accordance with the ethical guidelines established by the IRB (Protocol Number: IRB-2020-158). Initially, the raw data included 223 participants; however, 111 participants started the survey but did not complete it. Thus, the final data set for statistical analysis included 112 freshmen at a large midwestern university. The participants' average age was 18.74 years (*SD* = 1.19), with 59 male participants, 51 female participants, and 2 participants who self-reported as non-binary. In the anonymous survey, participants self-reported their number of NSSI and DSH behaviors *in the past 12 months*. 61 (54%) participants self-reported engaging in at least one form of NSSI. The average number of NSSI behaviors engaged in was 2.84 (*SD* = 1.87). In total, 17 (15%) participants self-reported engaging in at least one type of DSH. The average number of DSH behaviors engaged in was 2.24 (*SD* = 1.25). Females were more likely to engage in *both behaviors* (i.e., NSSI+DSH) compared to males (Fisher's Exact Test $p = .06$, $\varphi = .30$).

2.2 Materials

The first section of the survey consisted of qualification questions (age, current college classification). The next three sections measured emotionally unstable personality traits (i.e., short form of the Five-Factor Borderline Inventory; FFBI-SF),

self-harm (i.e., adapted version of the Functional Assessment of Self-Mutilation; FASM); and digital self-harm (i.e., adapted version of the Cyberbullying Deviancy Scale; CDS). Cronbach's alpha was greater than .75 for all measures in this study.

FFBI-SF. The long form, FFBI, is a 120-question scale that uses the Five-Factor Model to assess BPD traits. The FFBI-SF is a shortened 48 item version of the FFBI [25].

FASM. A modified version of the Functional Assessment of Self-Mutilation (FASM) [26] examined the incidence and motivations behind self-injurious behavior over the past 12 months. Participants answered 11 yes or no questions to assess different forms of self-injurious behaviors.

Cyberbullying Deviance Scale. Finally, an adapted version of the Cyberbullying Deviancy Scale (CDS) [27] was used to assess digital self-harm (i.e., self-cyberbullying) behaviors in the past 12 months. The original scale assesses perpetrators of cyberbullying. To adapt for the current study, we converted the subject of the scale to oneself and specified "have you ever used a real or fake account and...." A sample modified question would be: "Created an Internet 'bashing' poll, either over IM or on a website, about someone that you know without their consent?" was changed to "Created an Internet 'bashing' poll about *yourself*, either in a group chat or public forum?" The seven questions were scaled from 1 (never) to 5 (6+ times).

2.3 Design & Procedures

Freshmen (first-year) undergraduate students were recruited from a large midwestern university (USA) during the Spring 2020 semester while campus was closed, and classes moved to a virtual/online format, due to the COVID-19 pandemic. Students were virtually recruited from: a large introductory psychology course where they were required to complete 15 units of research (one unit of research credit per one-half hour) and 19 additional introductory level courses from a variety of disciplines. The total number of students across these lectures was 11,081, and the total number of professors/instructors contacted was 35. Of these professors, 20 (57%) responded; of those who responded, 7 (35%) agreed to distribute the study to their students, 11 (55%) declined to distribute the study, and 2 (10%) deferred to another professor. As a result, 1,645 students were possible recipients of the study link although not all the students were guaranteed to be freshmen.

As part of the recruitment material, a PowerPoint slide was created with a hyperlink and a QR code for the survey, and this slide was included in the email to professors. The anonymous internet-based survey was hosted on Qualtrics©, and participants were assigned random ID numbers. After agreeing to the consent form, the participants were directed to a page with qualification questions: 1) must be 18 years of age or older, and 2) currently a freshman at the large midwestern university.

3. Results

Results indicated a statistically significant positive correlation between individuals who engaged in more types of NSSI and individuals who engaged in more types of DSH, $r(112) = .35$, $p < .001$, 95% CIs [1.17, 1.92] and [.16, .51], respectively. This hypothesis was supported.

As shown in Table 1, there was a statistically significant positive correlation between individuals who engaged in more types of DSH and the following personality facets: Dysregulated Anger, Despondence, Behavioral Dysregulation, Affective Dysregulation, Fragility, Dissociative Tendencies, Manipulativeness, Oppositional, and Rashness. In comparison, there was a statistically significant positive correlation between individuals who engaged in more types of NSSI and Anxious Uncertainty, Despondence, Self-Disturbance, Affective Dysregulation, Fragility, Dissociative Tendencies, Manipulativeness, and Oppositional.

Table 1. Correlations between DSH, NSSI, and BPD Facets

	DSH [1]	DSH vs. Non [2]	NSSI [3]	NSSI vs. Non [4]	N1	N2	N3	N4	N5	N6	N7	O1	A1	A2	A3	C1
DSH [1]	1	.861 ***	.347 ***	.218 *	.049	.197 *	.241 **	.155	.324 ***	.259 **	.313 ***	.286 **	.045	.190 *	.195 *	.271 **
DSH vs. Non [2]		1	.363 ***	.187 *	.087	.147	.235 **	.083	.201 *	.177 *	.239 **	.228 **	.019	.068	.133	.108
NSSI [3]			1	.718 ***	.175 *	.067	.334 ***	.291 **	.125	.199 *	.249 **	.371 ***	.115	.198 *	.169 *	.134
NSSI vs. Non [4]				1	.129	.080	.304 **	.318 ***	.136	.141	.158 *	.295 **	.099	.181 *	.089	.113
N1					1	.344 **	.580 ***	.487 ***	.257 **	.497 ***	.450 ***	.343 ***	.465 ***	.212 *	.285 **	.081
N2						1	.349 ***	.383 ***	.597 ***	.661 ***	.448 ***	.199 **	.393 ***	.369 ***	.675 ***	.437 ***
N3							1	.583 ***	.375 ***	.510 ***	.754 ***	.588 ***	.424 ***	.237 **	.368 ***	.218 **
N4								1	.514 ***	.609 ***	.529 ***	.619 ***	.631 ***	.621 ***	.523 ***	.359 ***
N5									1	.699 ***	.504 ***	.473 ***	.498 ***	.537 ***	.620 ***	.717 ***
N6										1	.652 ***	.429 ***	.492 ***	.481 ***	.602 ***	.528 ***
N7											1	.603 ***	.359 ***	.317 ***	.474 ***	.324 ***
O1												1	.448 ***	.371 ***	.302 **	.281 **
A1													1	.582 ***	.460 ***	375 ***
A2														1	.565 ***	.578 ***
A3															1	.515 ***
C1																1

* $p < .05$, one-tailed. ** $p < .01$, one-tailed. *** $p < .001$, one-tailed.

1 = This variable represents the total number of DSH behaviors that participants self-reported engaging in
2 = This variable indicates if an individual engaged in DSH behavior (1) vs. did not engage in DSH behavior (0)
3 = This variable represents the total number of NSSI behaviors that participants self-reported engaging in
4 = This variable indicates if an individual engaged in NSSI behavior (1) vs. did not engage in NSSI behavior (0)

N1 = Anxious Uncertainty; N2 = Dysregulated Anger; N3 = Despondence; N4 = Self-Disturbance; N5 = Behavioral Dysregulation; N6 = Affective Dysregulation; N7 = Fragility; O1 = Dissociative Tendencies; A1 = Distrustfulness; A2 = Manipulativeness; A3 = Oppositional; C1 = Rashness

A *t*-test (independent samples) was conducted to compare engagement in DSH and the significantly correlated facets of neuroticism, openness, agreeableness, and consciousness. There was a significant difference in the Despondence ($t(110) = -2.53$, $p = .013$; $d = .67$), Behavioral Dysregulation ($t(110) = -2.15$, $p = .034$; $d = .57$), and Dissociative Tendencies ($t(110) = -2.46$, $p = .015$; $d = .65$) scores between DSH engagement and no DSH engagement. There was a marginal significant difference in the Affective Dysregulation ($t(110) = -1.89$, $p = .062$; $d = .50$) and Fragility ($t(18) = -1.88$, $p = .076$; $d = .68$) scores between DSH engagement and no DSH engagement. All means and standard deviations are shown in Table 2. This hypothesis was partially supported.

Table 2. Means and Standard Deviants for NSSI, DSH, and Personality Facets

TABLE 4.2

Means and Standard Deviations for NSSI and DSH Engagement by Personality Facet

Personality Facet	DSH (+) [1]	DSH (-) [2]	NSSI (+) [3]	NSSI (-) [4]
Anxious Uncertainty	3.88 (1.12)	3.63 (1.04)	3.79 (.96)	3.52 (1.14)
Dysregulated Anger	2.75 (1.30)	2.27 (1.16)	2.43 (1.20)	2.24 (1.18)
Despondence	3.37 (1.07) **	2.63 (1.11) **	3.06 (1.14) ***	2.37 (1.00) ***
Self-Disturbance	3.04 (1.04)	2.79 (1.11)	3.15 (1.00) ***	2.45 (1.09) ***
Behavioral Dysregulation	2.77 (1.19) **	2.20 (.97) **	2.41 (1.07)	2.13 (.94)
Affective Dysregulation	2.97 (1.21) *	2.46 (1.00) *	2.67 (1.09)	2.37 (.99)
Fragility	2.16 (1.02) *	1.68 (.64) *	1.86 (.77) *	1.63 (.66) *
Dissociative Tendencies	3.07 (1.36) **	2.27 (1.21) **	2.73 (1.28) ***	1.99 (1.13) ***
Distrustfulness	2.78 (.92)	2.73 (.98)	2.82 (1.01)	2.63 (.93)
Manipulativeness	2.10 (1.00)	1.94 (.83)	2.11 (.95) *	1.80 (.69) *
Oppositional	2.26 (.86)	1.97 (.79)	2.08 (.86)	1.93 (.73)
Rashness	2.28 (1.19)	1.98 (.96)	2.13 (1.00)	1.90 (.99)

*** $p < .01$ ** $p < .05$ * $p < .10$
1 = This indicates that the participant engaged in DSH
2 = This indicates that the participant did not report engaging in DSH
3 = This indicates that the participant engaged in NSSI
4 = This indicates that the participant did not report engaging in NSSI

4. Discussion

The main goal of this research was to offer new insights on digital self-harm (DSH) and its relationship to non-suicidal self-injury (NSSI) and emotionally unstable personality traits. In particular, the incidence of DSH among college undergraduate freshmen was at the forefront of this study; 15% of individuals who completed this study admitted to engaging in some type of DSH in the past year. This is higher than what has been reported from previous studies of DSH [3-5]. In addition, there was a significant positive correlation NSSI and DSH. Based on these results, we recommend that clinicians and counselors who work closely with at-risk youth and college-age individuals include digital self-harm questions when assessing traditional forms of NSSI.

Regarding BPD, the results suggested that individuals who engage in DSH had similar emotionally unstable personality traits as those who self-reported engaging in NSSI. Four facets of neuroticism (Despondence, Behavioral Dysregulation, Affective, and Fragility), one facet of openness (Dissociative Tendencies), two facets of agreeableness (Manipulativeness and Oppositional), and one facet of conscientiousness (Rashness) showed significant positive correlation with DSH engagement. This personality scoring fits with a five-factor personality model for BPD, with the facets from this study corresponding to high depressiveness, high impulsiveness, high vulnerability for neuroticism; high fantasy for openness; both low compliance and straightforwardness for agreeableness; and low deliberation for conscientiousness[23]. However, among the neuroticism facets, Self-Disturbance significantly correlated with NSSI behavior, but did not correlate significantly with DSH behavior. On the other hand, Behavioral Dysregulation significantly correlated with DSH behavior, but did not correlate significantly with NSSI behavior. Overall, the NSSI correlations were consistent with previous research [24].

In future research, methods to detect digital self-harmers should be prioritized. Recent technology has made pattern detection across different online content more viable. Natural language processing models that utilize differences in stylometry and other linguistic characteristics have been used to sift through online chats to identify the user. One study developed a system using multiple machine learning methods to identify cyberbullying perpetrators on Twitter to a 93% accuracy [28]. Another study found 70-75% accuracy across four different machine learning models: gradient boost, random forest, logistic regression, and support vector machines [29]. By using artificial intelligence models, such as these, users could be identified across accounts, increasing the likelihood of connecting anonymous digital self-harm accounts with their primary accounts.

4.1 Limitations

The data collection for this current study was impacted by the COVID-19 pandemic. This history effect presented several limitations for recruitment and participation. With regards to recruitment, several professors who were invited to distribute recruitment material were unwilling to distribute as they cited the increased stress experienced from the ongoing COVID-19 pandemic (specifically the number of emails being sent during this time frame). Data collection also took place during a time when residential students were forced to move-off campus, which may have inhibited the completion of the survey given poor Internet connectivity. As a result, the overall sample size was not as large as the researchers desired. In addition, the higher percentage of reported DSH and NSSI in the current study (as compared to past studies) may be related to the increased stress experienced during the COVID-19 pandemic. Finally, comorbidity rates [30. 31] are high for NSSI and other mental disorders which were not assessed in the current study (e.g., anxiety and mood disorders, PTSD, and substance use disorder).

4.2 Conclusion

Despite these limitations, we argue that the strong effect sizes in this study support the findings of a significant relationship between NSSI, DSH, and emotionally unstable personality traits. We encourage future studies with diverse research designs (e.g., sampling methodologies, cross-culture studies, variables of interest) to improve external validity. These findings have larger implications when examining self-harm behavior by clinical practitioners, teachers, educators, and parents. It is possible that DSH behavior may help identify individuals who are vulnerable to future NSSI behavior and vice versa. Both possibilities emphasize the importance of understanding the relationship between physical (real-world) and digital behaviors that cause self-harm. In the DSM-5, NSSI behavior is already a part of the criteria that clinicians use to diagnose borderline personality disorder[10]. Currently, NSSI is part of the "Conditions for Further Study" section in the DSM. We suggest future considerations should include DSH behavior for a more holistic approach when assessing self-harm. This approach could result in a better understanding of the relationship between physical and digital self-harm amongst at-risk adolescents and young adults.

References

[1] BBC.com (May 6, 2014). *Hannah Smith inquest: Teenager posted 'online messages'*. Retrieved from https://www.bbc.com/news/uk-england-leicestershire-27298627

[2] Boyd, D. (December 7, 2010). *Digital Self-Harm and Other Acts of Self-Harassment*. Retrieved from: http://www.zephoria.org/thoughts/archives/2010/12/07/digital-self-harm-and-other-acts-of-self-harassment.html

[3] Englander, E. (2012). Digital self-harm: Frequency, type, motivations, and outcomes. Retrieved from http://webhost.bridgew.edu/marc/DIGITAL%20SELF%20HARM%20report.pdf

[4] Patchin, J. W., & Hinduja, S. (2017). Digital self-harm among adolescents. *Journal of Adolescent Health*, *61*(6), 761-766

[5] Patchin, J.W., & Hinduja, S. (2022). Digital self-harm and suicidality among adolescents. *Child and Adolescent Mental Health*, 28(1), 52-59.

[6] Pater, J., & Mynatt, E. (2017, February). Defining Digital Self-Harm. In Proceedings of the 2017 ACM Conference on Computer Supported Cooperative Work and Social Computing (pp. 1501-1513). ACM.

[7] Borzekowski, D. L., Schenk, S., Wilson, J. L., & Peebles, R. (2010). e-Ana and e-Mia: A content analysis of pro–eating disorder web sites. *American journal of public health*, *100*(8), 1526-1534.

[8] Chancellor, S., Pater, J. A., Clear, T., Gilbert, E., & De Choudhury, M. (2016, February). #thyghgapp: Instagram content moderation and lexical variation in pro-eating disorder communities. In *Proceedings of the 19th ACM Conference on Computer-Supported Cooperative Work & Social Computing* (pp. 1201-1213). ACM.

[9] Pater, J. A., Haimson, O. L., Andalibi, N., & Mynatt, E. D. (2016, February). "Hunger Hurts but Starving Works": Characterizing the presentation of eating disorders online. In *Proceedings of the 19th ACM Conference on Computer-Supported Cooperative Work & Social Computing* (pp. 1185-1200). ACM.

[10] American Psychiatric Association. (2013). Diagnostic and statistical manual of mental disorders (5th ed.).

[11] Gratz, K. L. (2001). Measurement of deliberate self-harm: Preliminary data on the Deliberate Self-Harm Inventory. *Journal of psychopathology and behavioral assessment*, *23*(4), 253-263.

[12] Skegg, K. (2005). Self-harm. *The Lancet*, 366(9495), 1471-1483.

[13] Ladouceur, C. D. (2012). Neural systems supporting cognitive-affective interactions in adolescence: the role of puberty and implications for affective disorders. *Frontiers in integrative neuroscience*, *6*(65) 1-11.

[14] Brunner, R., Kaess, M., Parzer, P., Fischer, G., Carli, V., Hoven, C. W., ... & Balazs, J. (2014). Life-time prevalence and psychosocial correlates of adolescent direct self-injurious behavior: A comparative study of findings in 11 European countries. *Journal of Child Psychology and Psychiatry*, *55*(4), 337-348.

[15] Gardner, W., Pajer, K., Cloutier, P., Zemek, R., Currie, L., Hatcher, S., ... & Duque, D. R. (2019). Changing rates of self-harm and mental disorders by sex in youths presenting to Ontario emergency departments: repeated cross-sectional study. *The Canadian Journal of Psychiatry*, 0706743719854070.

[16] Whitlock, J., Eckenrode, J., & Silverman, D. (2006). Self-injurious behaviors in a college population. *Pediatrics*, *117*(6), 1939-1948.

[17] Rodham, K. & Hawton, K. (2009). Epidemiology and phenomenology of nonsuicidal self-injury. In M. K. Nock (Ed.), *Understanding nonsuicidal self-injury* (pp. 37-62). Washington, DC: American Psychological Association.

[18] Harrison, K. D. (2009). Self injury among a college population: The role of attachment, self esteem, and emotional expression as risk factors (Doctoral dissertation, Roosevelt University).

[19] Wester, K., Trepal, H., & King, K. (2018). Nonsuicidal Self-Injury: Increased Prevalence in Engagement. *Suicide and Life-Threatening Behavior, 48*(6), 690-698.

[20] Andrewes, H. E., Hulbert, C., Cotton, S. M., Betts, J., & Chanen, A. M. (2019). Relationships between the frequency and severity of non-suicidal self-injury and suicide attempts in youth with borderline personality disorder. *Early intervention in psychiatry*, *13*(2), 194-201.

[21] Gunderson, J. G. (2011). Borderline personality disorder. *New England Journal of Medicine*, *364*(21), 2037-2042.

[22] Björkenstam, E., Björkenstam, C., Holm, H., Gerdin, B., & Ekselius, L. (2015). Excess cause-specific mortality in in-patient-treated individuals with personality disorder: 25-year nationwide population-based study. *The British Journal of Psychiatry*, *207*(4), 339-345.

[23] DeShong, H. L., Mullins-Sweatt, S. N., Miller, J. D., Widiger, T. A., & Lynam, D. R. (2016). Development of a short form of the five-factor borderline inventory. *Assessment*, *23*(3), 342-352.

[24] MacLaren, V. V., & Best, L. A. (2010). Nonsuicidal self-injury, potentially addictive behaviors, and the Five Factor Model in undergraduates. *Personality and Individual Differences*, *49*(5), 521-525.

[25] DeShong, H. L., Grant, D. M., & Mullins-Sweatt, S. N. (2019). Precursors of the emotional cascade model of borderline personality disorder: The role of neuroticism, childhood emotional vulnerability, and parental invalidation. *Personality Disorders: Theory, Research, and Treatment*

[26] Lloyd, E. E., Kelley, M. L., & Hope, T. (1997, April). Self-mutilation in a community sample of adolescents: Descriptive characteristics and provisional prevalence rates. In *annual meeting of the Society for Behavioral Medicine, New Orleans, LA.*

[27] Zezulka, L. A., & Seigfried-Spellar, K. C. (2016). Differentiating Cyberbullies and Internet Trolls by Personality Characteristics and Self-Esteem. *Journal of Digital Forensics, Security and Law: Special Issue on Cyberharassment*, *11*(3), 7-26.

[28] León-Paredes, G. A., Palomeque-León, W. F., Gallegos-Segovia, P. L., Vintimilla-Tapia, P. E., Bravo-Torres, J. F., Barbosa-Santillán, L. I., & Paredes-Pinos, M. M. (2019, November). Presumptive Detection of Cyberbullying on Twitter through Natural Language Processing and Machine Learning in the Spanish Language. In *2019 IEEE CHILEAN Conference on Electrical, Electronics Engineering, Information and Communication Technologies (CHILECON)* (pp. 1-7). IEEE.

[29] Sahay, K., Khaira, H. S., Kukreja, P., & Shukla, N. (2018). Detecting cyberbullying and aggression in social commentary using nlp and machine learning. *International Journal of Engineering Technology Science and Research*, *5*(1).

[30] Cipriano A, Cella S, & Cotrufo P. (2017). Nonsuicidal self-injury: a systematic review. *Frontiers in Psychology*, *8*, 1–14.

[31] Møhl B. (2019). *Assessment and Treatment of Non-Suicidal Self-Injury*. New York, NY: Routledge.

DUAL-Rehab: Dual-task meets 360° Technology in an Innovative Instrument

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Abstract. The global population is aging, leading to an increase in cognitive problems such as Alzheimer's Disease. To address this issue, innovative interventions are required that target the preclinical stages of pathologies, such as Mild Cognitive Impairment and Subjective Memory Complaints. One promising non-pharmacological intervention, in neurological patients, is dual-task training, which involves performing two exercises concurrently (i.e., physical and cognitive activity). However, most of this training has been carried out in sterile laboratories, limiting the transfer of the ability to real life. To address this, innovative technology such as 360° videos is being utilized to create lifelike experiences that offer promising outcomes. The current study aims to present a prototype of a novel and ecological dual-task training program using 360° technology to enhance the cognitive functioning of individuals with a preclinical stage of dementia. The 360° dual-task training will consist of different exercises taking place in daily environments, such as houses, hospitals, offices, etc., and each exercise will reproduce different ordinary activities, requiring participants to perform motor tasks while interacting with the environment. The program will cover 10 bi-weekly sessions and will be available in two different modalities: immersive and non-immersive. The immersive modality requires the use of a head-mounted display, to train cognitive functions and a cycle ergometer for motor activity. The non-immersive one consists of the use of a table and a portable cycle ergometer. This technology-based intervention will provide older individuals with an innovative and personalized instrument to improve their quality of life by being cognitively engaged.

Keywords. Virtual Reality, 360-degree video, Dual-Task, Aging, Neuroscience

1. Introduction

The aging of the population is one of the key challenges that social and health systems are currently facing. As a result of this tendency, the number of people experiencing cognitive loss due to aging is fast increasing. Indeed, global life expectancy increased from 66.8 years in 2000 to 73.3 years in 2019, and healthy life expectancy increased from 58.3 years to 63.7 years. It is evident that life expectancy has increased faster than healthy life expectancy, leading to a larger proportion of years lived with a disability [1]. Thus, together with life expectancy also increase a call for innovative interventions targeting the early preclinical stages of illness, to prevent disability. An example is the preclinical stages of Alzheimer's Disease (AD), i.e., Mild Cognitive Impairment (MCI), and Subjective Memory Complaints (SMC). The preclinical phase offers a possible window for preventing deterioration, underlining the importance of treating modest alterations in cognition throughout this period [2,3].

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MCI is defined as a transitional state between normal and pathological aging, marked by a modest deterioration of cognitive abilities, particularly involving memory. However, people with MCI preserve most of their functional and daily activities [4,5]. Recently, SMC has been included in research on the preclinical phases of AD. This condition refers to a subjective experience of cognitive decline and changes in memory compared to previous functioning [6]. Therefore, current research on AD has progressively shifted towards understanding preclinical conditions in the field of non-pharmacological interventions. Among the non-pharmacological interventions, the most used technique to prevent a decline in cognitive abilities is cognitive training. In particular, these interventions appear to be most effective when combined with motor training and many authors documented their beneficial effects on balance, mobility, overall functional status as well as general cognition, memory, and attention [4,7,8].

Nevertheless, many practical aspects of the treatments remain ambiguous, such as the optimal dose, in terms of frequency length, and duration of the sessions, a great number of authors agree with the use of dual-task (DT) interventions. The DT consists of either two motor tasks or one motor and one cognitive performance [7–9]. In particular, interventions including cognitive-motor dual-task training (DTT), seem to be the best solution to generate positive results in motor difficulties, global functions, activities of daily life, and mood in healthy aging and patients [10–13].

Most of the DTT employs non-ecological environments and tasks, with limited generalizability to daily life situations [14,15]. The use of 360° videos could overcome this limitation. 360° videos can be described as an extension of virtual reality technology. They are spherical videos or photos, captured by an omnidirectional camera, that allows immersing the subject in authentic natural environments, being viewed via an ordinary web browser in that users can pan around by clicking and dragging, or by moving their head depending on the used device. This technology seems to offer a valid alternative to traditional computer-generated VR and mixed-reality interfaces (16). 360° videos could solve and overcome the problems related to virtual reality, such as cybersickness, high-cost software, and psychometric issues [17]. Moreover, they offer a more ecological alternative, capturing real environments and providing a high level of visual realism. These features could increase participant engagement. User-friendly design also makes 360° technologies more suitable for patients with mild to severe impairments [18,19] who may have some difficulties interacting with more sophisticated devices. Thus, immersive technologies may have a crucial role in delivering cognitive training, as highlighted by some preliminary results [4]. Thanks to the flexibility of 360° technology, dual-task exercises could be embedded into realistic, but safe and controlled contexts. This increases motivation, which can positively impact on treatment adherence and to the possibility to transfer the results in real life.

Therefore, the work aims to present a preliminary overview of a DTT exploiting the potentiality of the 360° technology in terms of interactivity and ecological validity addressed to two different populations: SMC and MCI. Specifically, we would create an integrated training including two phases: 1) in-hospital rehabilitation, where subjects will be provided sessions of the training in immersive modality; 2) at-home rehabilitation, where older adults will be asked to perform at home the non-immersive version of the training. The main objective is to propose training to improve cognitive functions, thus advancing literature about non-pharmacological interventions in the preclinical stages of dementia along with innovative technical instruments.

2. Method and Materials

The aim is to create an intervention to train cognitive functions and motor concurrently in situations as realistic as possible, simulating a real-life circumstance in a daily setting. Moreover, the added value is to design a tool to be provided through two phases: in-hospital and at-home rehabilitation. In the first case, the rehabilitation targeted sessions of the 360° dual-task training will be delivered in an immersive modality; at home, patients will be asked to perform the non-immersive version of the training. The

in-hospital rehabilitation will be provided with the use of a Head Mounted Display (HMD) and a cycle ergometer; thanks to these instruments users could train their motor ability (cycling) and do cognitive exercises which reflect the context encountered outside the hospital. A tablet with a portable cycle ergometer will be used to deploy the training at home. In both stages, 10 biweekly sections are provided, i.e., 5 weeks with 2 training sessions per week in the hospital, followed by 5 weeks at home. As well as in the hospital patients are trained two times a week, and at home, they are instructed to perform 2 activities each week, for 5 weeks.

2.1 DUAL-Rehab

Previous experiences showed that users encountered interest and satisfaction in using 360°-based tool, and they are fascinated by the exploration, reporting enjoyment during the experience (20–22). Based on the evidence of the positive opinion expressed by users in using these instruments, we develop DUAL-Rehab. DUAL-Rehab (cognitive-motor dual-task rehabilitation) is a training designed thanks to the 360° technology and deployed for use on both immersive devices and Android or iOS tablets. DUAL-Rehab consists of 20 different exercises divided into 10 days of activities with increasing difficulty. Each day is composed of a mix of 7 exercises, requiring about 30 minutes. Exercises aim to train memory, executive functions, attention skills, and motor ability enhancing users' independence and autonomy in performing daily activities. During the dual-task exercises, subjects will have to perform motor tasks while interacting with the environments. All exercises occur in an everyday environment in which patients will practice routine actions. Particularly, activities involve watching a 360° video while cycling. Users could look around themself while performing the tasks, moving their heads, or clicking on the tablet (depending on the phases of the rehabilitation). Although the motor activities remain constant, cognitive training varies day by day and among activities. Day one contains basic activities such as watching the video and identifying, saying it aloud, the words starting with a predefined letter among distractors. Another one requires finding the letters, moving the tablet/head, to create a word. Going on with days, another task requires to remember where the drugs are, after seeing a video, or if some objects were at their right or left. A more difficult task requires patients to recognize the map of a home after having explored it moving through the rooms by clicking on each door (Figure 1).

Figure 1. The upper figure shows a panoramic photo of a room that is part of the house that patients had to explore. At the bottom, the maps of the house

Another exercise requires patients to explore the house through the different rooms and count as many target objects as possible they encounter. The activities vary from

inside to outside scenarios. For example, we created a park with different target objects; while people cycle to proceed forward, they name objects with different colors at the side of the pathway. The instructions are to select only the images that are colored with the target color. The target color changed depending on the day (Figure 2).

Figure 2. A screenshot showing the park with different objects that patients had to name based on their color

Whenever needed, the interaction is provided either through buttons superimposed on the video, in the case of the tablet, or via a specific User Interface, in the case of HMD.

The user receives textual and audio instructions before starting the training and before each activity. To deliver the message as clearly as possible, we recorded audio of a therapist who read the instructions to also consider the appropriate vocal inflections and tones. The user has the option to listen to the instructions again before proceeding to the task.

The 360° videos were created thanks to some actors who reproduce different daily activities (i.e., cooking, using the telephone, managing medications). All the 360° videos were recorded using specific instrumentations (insta360 TITAN).

The videos will be managed to create the final application. The application will be developed using specific software, such as Unity. The application will begin with a screen where ten buttons representing the training days, allowing the users to select only the right training day. Once the daily training session has started, the user is only permitted to click on the buttons to advance to the subsequent screens, pause or resume a video, and respond to the questions; going backward is not permitted. Every daily training session will start with a welcome screen that provides details about the session (the day's number) and reminds the user to perform each job according to the instructions. When the user clicks the button at the bottom of the welcome screen, the training starts. When all the exercises have been performed, the training day is complete, the application directly avoids its repetition, and the daily training session information will be saved on the device. The performance data for each scene, such as time and accuracy, will be recorded and stored.

3. Conclusion

The ongoing scientific debate about the ecological validity of classical tools encourages the implementation of new technology in the neuropsychological field [23–25]. Based on this rationale, we aimed to propose a training instrument focused on naturalistic and life-like situations. Moreover, we added the potential of the simultaneous performance of motor and cognitive tasks, methods that authors suggest as the new frontiers of rehabilitation. Indeed, most daily situations require the ability to perform more than one task at the same time: more often a cognitive and a motor task. For example, while walking we need to adapt our gait to the obstacles of the environment or

just participate in a conversation [26]. Indeed, the cognitive demand to remodulate the available information and pay attention to the component involved in the walk could provide an alteration in motors [27] or cognitive patterns, or even both [26,28].

Thus, we will develop a dual-task 360°-based application that allows a more ecological performance covering the everyday issue of final users. Based on the literature, this instrument seems to be promising in training patients. However, further studies will be conducted to refine the app and test its usability and clinical efficacy.

References

[1] Rutkowski TM, Abe MS, Koculak M, Otake-Matsuura M. Classifying Mild Cognitive Impairment from Behavioral Responses in Emotional Arousal and Valence Evaluation Task - AI Approach for Early Dementia Biomarker in Aging Societies. Annu Int Conf IEEE Eng Med Biol Soc IEEE Eng Med Biol Soc Annu Int Conf. 2020 Jul;2020:5537–43.

[2] Weintraub S, Carrillo MC, Farias ST, Goldberg TE, Hendrix JA, Jaeger J, et al. Measuring cognition and function in the preclinical stage of Alzheimer's disease. Alzheimer's Dement (New York, N Y). 2018;4:64–75.

[3] Park J-H. Effects of Cognitive-Physical Dual-Task Training on Executive Function and Activity in the Prefrontal Cortex of Older Adults with Mild Cognitive Impairment. Brain & NeuroRehabilitation. 2021 Nov;14(3):e23.

[4] Gallou-Guyot M, Mandigout S, Combourieu-Donnezan L, Bherer L, Perrochon A. Cognitive and physical impact of cognitive-motor dual-task training in cognitively impaired older adults: An overview. Neurophysiol Clin. 2020 Nov;50(6):441–53.

[5] Cheng Y-W, Chen T-F, Chiu M-J. From mild cognitive impairment to subjective cognitive decline: conceptual and methodological evolution. Neuropsychiatr Dis Treat. 2017;13:491–8.

[6] Warren SL, Reid E, Whitfield P, Moustafa AA. Subjective memory complaints as a predictor of mild cognitive impairment and Alzheimer's disease. Discov Psychol [Internet]. 2022;2(1):13. Available from: https://doi.org/10.1007/s44202-022-00031-9

[7] Norouzi E, Vaezmosavi M, Gerber M, Pühse U, Brand S. Dual-task training on cognition and resistance training improved both balance and working memory in older people. Phys Sportsmed. 2019 Nov;47(4):471–8.

[8] Pereira Oliva HN, Mansur Machado FS, Rodrigues VD, Leão LL, Monteiro-Júnior RS. The effect of dual-task training on cognition of people with different clinical conditions: An overview of systematic reviews. IBRO reports. 2020 Dec;9:24–31.

[9] Fritz NE, Cheek FM, Nichols-Larsen DS. Motor-Cognitive Dual-Task Training in Persons With Neurologic Disorders: A Systematic Review. J Neurol Phys Ther. 2015 Jul;39(3):142–53.

[10] Wajda DA, Mirelman A, Hausdorff JM, Sosnoff JJ. Intervention modalities for targeting cognitive-motor interference in individuals with neurodegenerative disease: a systematic review. Expert Rev Neurother. 2017;17(3):251–61.

[11] Morris M, Iansek R, Smithson F, Huxham F. Postural instability in Parkinson's disease: a comparison with and without a concurrent task. Gait Posture. 2000;12(3):205–16.

[12] Dorfman M, Herman T, Brozgol M, Shema S, Weiss A. Dual-Task Training on a Treadmill to Improve Gait and Cognitive Function in Elderly Idiopathic Fallers. 2014;246–53.

[13] Lauenroth A, Ioannidis AE, Teichmann B. Influence of combined physical and cognitive training on cognition : a systematic review. BMC Geriatr [Internet]. 2016;21–3. Available from: http://dx.doi.org/10.1186/s12877-016-0315-1

[14] Mellinger CD, Hanson TA. Considerations of ecological validity in cognitive translation and interpreting studies. Transl Cogn & Behav [Internet]. 2022;5(1):1–26. Available from: https://www.jbe-platform.com/content/journals/10.1075/tcb.00061.mel

[15] Burgess PW, Alderman N, Forbes C, Costello A, Coates LM-A, Dawson DR, et al. The case for the development and use of "ecologically valid" measures of executive function in experimental and clinical neuropsychology. J Int Neuropsychol Soc. 2006 Mar;12(2):194–209.

[16] Nenna F, Zorzi M, Gamberini L. Augmented Reality as a research tool: investigating cognitive-motor dual-task during outdoor navigation. Int J Hum Comput Stud [Internet]. 2021;152(September 2020):102644. Available from: https://doi.org/10.1016/j.ijhcs.2021.102644

[17] Borghesi Francesca, Mancuso Valentina, Pedroli Elisa C Pietro. From Virtual Reality to 360° Videos: Upgrade or Downgrade? The Multidimensional Healthcare VR Technology. In: Hershey, editor. Handbook of Research on Implementing Digital Reality and Interactive Technologies to Achieve Society 50. Pennsylvania, USA; 2022.

[18] Sbordone RJ. Ecological validity: Some critical issues for the neuropsychologist. In: Ecological validity of neuropsychological testing. Delray Beach, FL, England: Gr Press/St Lucie Press, Inc; 1996. p. 15–41.

[19] Realdon O, Serino S, Savazzi F, Rossetto F, Cipresso P, Parsons TD, et al. An ecological measure to screen executive functioning in MS: the Picture Interpretation Test (PIT) 360°. Sci Rep [Internet]. 2019;9(1):1–8. Available from: http://dx.doi.org/10.1038/s41598-019-42201-1

[20] Bruni F, Mancuso V, Stramba-Badiale C, Greci L, Cavallo M, Borghesi F, et al. ObReco-2: Two-step validation of a tool to assess memory deficits using 360° videos. Front Aging Neurosci. 2022;14(July):1–10.

[21] Pedroli E, Mancuso V, Stramba-Badiale C, Cipresso P, Tuena C, Greci L, Goulene K, Stramba-Badiale M RG and GA. Brain M-App's Structure and Usability: A New Application for Cognitive Rehabilitation at Home. Front Hum Neurosci. 2022;16.

[22] Pedroli E, Cipresso P, Greci L, Arlati S, Mahroo A, Mancuso V, et al. A New Application for the Motor Rehabilitation at Home: Structure and Usability of Bal-App. IEEE Trans Emerg Top Comput. 2020;9(3):1290–300.
[23] Chaytor N, Schmitter-Edgecombe M. The ecological validity of neuropsychological tests: A review of the literature on everyday cognitive skills. Neuropsychol Rev. 2003;13(4):181–97.
[24] Parsons TD, Carlew AR, Magtoto J, Stonecipher K. The potential of function-led virtual environments for ecologically valid measures of executive function in experimental and clinical neuropsychology. Neuropsychol Rehabil. 2017;27(5):777–807.
[25] Neguț A, Matu S, Sava FA, David D. Virtual reality measures in neuropsychological assessment : a meta-analytic review. 2016;4046(March).
[26] Al-yahya E, Dawes H, Smith L, Dennis A, Howells K, Cockburn J. Neuroscience and Biobehavioral Reviews Cognitive motor interference while walking : A systematic review and. Neurosci Biobehav Rev [Internet]. 2011;35(3):715–28. Available from: http://dx.doi.org/10.1016/j.neubiorev.2010.08.008
[27] Prupetkaew P, Lugade V, Kamnardsiri T, Silsupadol P. Cognitive and visual demands, but not gross motor demand, of concurrent smartphone use affect laboratory and free-living gait among young and older adults. Gait Posture [Internet]. 2019;68:30–6. Available from: https://www.sciencedirect.com/science/article/pii/S0966636218307227
[28] Yogev-Seligmann G, Hausdorff JM, Giladi N. The role of executive function and attention in gait. Mov Disord Off J Mov Disord Soc. 2008;23(3):329–42.

The Brain at Play: Investigating Motivational Factors and Perceived Effects of High-level Problem-solving in Video Games

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Abstract. The research has often explored personality and motivational factors as well as cognitive improvement related to action video games. However, less attention has been devoted to games and video games that require high-level problem-solving abilities (e.g., investigation and deduction, strategic thinking, and complex logic). In the present study, 147 participants rated their interest in high-level problem-solving games and filled in the Big Five Inventory for personality, the Gaming Motivation Scale (GAMS), and an ad-hoc measure for perceived cognitive benefits in terms of literacy, numeracy, and adaptive problem solving based on the OECD-PIAAC model (Programme for the International Assessment of Adult Competencies). While significant results regarding personality did not emerge, regression analysis showed that the interest in high-level problem-solving games is predicted by identified regulation, highlighting that the participants feel that playing such games is important for their cognitive improvement. Consistently, further analyses revealed that the participants believe that high-level problem-solving games playing foster cognitive abilities in all three areas of literacy, numeracy, and adaptive problem-solving. These results call for further investigation of high-level problem-solving in games and its possible benefits for educational aims and the training of complex cognitive processing.

Keywords. *video games, investigative, problem solving, personality, motivation*

1. Introduction

Psychological research on video games has thrived in the last decades. However, researchers have neglected some aspects of these complex media in favor of others. For example, because of the huge interest in the possible effects of violent content on behavior, action video games have been studied consistently more than other genres [1,2]. The same happened with massively multiplayer games because of the rise of the Metaverse and eSports [3].

Many studies have explored the potential of video game play for the empowerment of cognitive abilities. Research has emphasized that action video games improve cognitive abilities such as divided attention, visual sensitivity, speed of processing, and others [4-6]. Despite some studies having partially downsized these effects due to methodological limitations [7], today it is mostly accepted that video game playing could train and improve some cognitive abilities, especially in terms of low-level cognitive processing such as divided attention [4]. Also, board games are commonly considered

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able to improve cognitive abilities, although recent research results are controversial regarding the identification of specific abilities [8].

Indeed, the gaming scene is currently seeing a renewed interest in single-player games requiring high problem-solving abilities, e.g. context awareness and analysis, investigation and deduction, logical puzzles and decryption, strategical thinking ("high problem-solving" games, HPS games for short from now on) [9]. This rise in interest towards complex problem-solving in ludic activities appears connected to similar contents across other media, such as investigative board games and the re-flourishing of gamebooks, the "return of the whodunit" in cinema [9,10].

The psychological research on video games has explored the motivational factors related to game playing, finding that personality relates to preferences for game genres and specific actions/activities in video games [11,12]. For example, conscientious people appreciate the possibility to collect tools within the virtual worlds, while extroverted gamers make use of the social opportunities inherent to multiplayer games [13,14]. Another area of interest, which is often studied both concerning personality and cognitive outcomes, is motivation. The reasons why people play games could be associated with Self Determination theory, namely important drives for video game playing regarding the possibility to feel autonomous and competent and also cultivating and maintaining social relationships [15,16]. In the case of HPS games, passionate gamers may be motivated to play those games due to the value they attribute to HPS games' ability to improve their intellect and cognitive capabilities (a concept known in Self Determination theory as identified regulation) [17]. Consistently, HPS game players may perceive that their gaming activities result in notable benefits in their everyday problem-solving challenges (a concept known as "transferability" of skills) [18]. It is interesting to explore both the motivational factors involved in players' selection of HPS games and the perceived benefits in terms of cognitive empowerment and influence on everyday activities (e.g., whether they affect players' perceived abilities in work or study tasks).

The research tackles two main open research questions:

- What personality and motivational factors are involved in the preference towards HPS games and video games?
- What perceived benefits do players find in HPS games and video games, and are they transferred to everyday work or study tasks?

We propose three main hypotheses for the current study:

- Hp1: preference for HPS games is related to gamers' personality, specifically in terms of a positive relationship with introversion, since these games are mostly played alone;
- Hp2: preference for HPS games is positively predicted by gamers' motivation, specifically in terms of competence and autonomy (i.e., identified regulation);
- Hp3: preference for HPS games will predict gamers' perceived benefits in terms of specific skills involved in everyday problem-solving, namely literacy, numeracy, and adaptive problem-solving.

2. Methods

167 people were originally surveyed by an online questionnaire; data from 147 of them were deemed complete and adequate for the analysis. The final participants were mostly male (90) and highly educated (73 with a master's degree, 29 with a PhD or postgraduate title, 39 high school, and 6 middle school). Mean age was 33,37, SD=8.57. They participated by filling in an online questionnaire sent by snowball sampling [19] starting from the researchers' contacts.

2.1 Instruments

HPS games

An ad-hoc measure was employed to assess respondents' preference towards HPS games. Based on previous research that assessed gamers' preferences [20, 21], participants responded to the question: "how much do you like to play this genre of game/video game"? The participants rated their preference towards any game genre on a 0-100 Likert scale. The list featured game genres typically investigated in similar literature (e.g., action games, first-person shooters, MMORPGs, etc.) but also other game genres that could be associated with HPS games, namely Point and click graphical adventures, Investigative games, Gamebooks, Escape Rooms, RPGs, Logic Puzzles, Textual adventures, Survival horror games.

Gaming Motivation Scale

It is a questionnaire to assess motivations leading individuals to play games [22,23]. It contains 18 items on a 7-point scale ranging from 1 ("do not agree at all") to 7 ("very strongly agree"). It measures intrinsic motivation, integrated regulation (i.e., self-assimilation with an activity), identified regulation (i.e., engagement in an activity because congruent with an individual's values and needs), introjected regulation (i.e., engaging in an activity to avoid bad emotions and feelings), external regulation (i.e., engaging in an activity to receive rewards or avoid punishments) and amotivation (lack of motivation).

Big Five Inventory

The big five inventory [24,25] is a self-report measure designed to assess the big five personality traits: extraversion, agreeableness, conscientiousness, neuroticism, and openness. It consists of 44 items which are rated on a 5-point Likert scale from 1 (disagree a lot) to 5 (agree a lot).

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The scale developed to detect the perception of cognitive skills was built starting from the constructs of literacy, numeracy, and problem-solving of the OECD-PIAAC international survey [26]. 25 items were derived from the components that make up the three constructs. They are rated on a 4-point scale (from 1 = not at all, to 4 = a lot). In general, literacy (9 items) indicates accessing, understanding, evaluating, and reflecting on written texts to achieve one's goals, develop knowledge and potential, and participate in society. Numeracy (7 items) is understood as access, use, and critical reasoning with mathematical content, to manage situations in adult life. Adaptive problem solving (9 items) indicates the ability to achieve one's goals in a dynamic situation, where the solution is not immediately evident; it requires defining the problem, seeking information, and applying a solution in a variety of environments and contexts.

3. Results

First, we created a mean variable related to the preference for HPS games. An exploratory factorial analysis showed that Point and click graphical adventures (.628), Investigative games (.775), Gamebooks (.748), Escape Rooms (.588), Logic Puzzles (.738), and Textual adventures (.695) all related to one single factor. Instead, RPGs and Survival Horror games were less clearly related to this factor, probably because they could contain action elements. The average variable was created with the games listed above. To assess Hp1, we performed a correlation between preference for HPS games and Big Five Inventory personality traits: no significant correlations emerged.

To assess Hp2, we performed regression analysis with a preference for HPS games as the outcome variable and the subscales of GAMS (motivation) as the predictors. The model was significant (ANOVA: $F=6.932$; $p<.001$) with an explained variance of 24%. Consistently with Hp2, GAMS-Identified regulation emerged as a positive predictor for

the preference towards HPS games (B=3.510 ; SE=1.195 ; Beta=.331 ; t = 2.936 ; p=.004).

To assess Hp3, we performed three separate regression analyses with a preference for HPS games as the only predictor and each domain of the perceived benefits (literacy, numeracy, adaptive problem solving) as the outcome variable. All the regression analyses were significant and consistent with Hp3. The first model (literacy) was significant (ANOVA: F=20.650 ; p<.001) with an explained variance of 13%. Preference for HPS games emerged as a positive predictor for Literacy perceived benefits (B=.016 ; SE=.004 ; Beta=.365 ; t = 4.544 ; p<.001).

The second model (numeracy) was significant (ANOVA: F=14.476 ; p<.001) with an explained variance of 9%. Preference for HPS games emerged as a positive predictor for Numeracy perceived benefits (B=.015 ; SE=.004 ; Beta=.312 ; t = 3.805 ; p<.001).

The third model (adaptive problem solving) was significant (ANOVA: F=15.412 ; p<.001) with an explained variance of 10%. Preference for HPS games emerged as a positive predictor for Adaptive problem-solving perceived benefits (B=.013 ; SE=.003 ; Beta=.321 ; t = 3.926 ; p<.001).

We also checked the main variables of the study for differences between males and females: no significant differences emerged.

4. Discussion and Conclusion

The present study assessed personality and motivational factors involved in the preference towards games and video games requiring high-level problem solving (e.g., investigation and deduction, complex reasoning). In addition, the research investigated the perceived benefits of these games in terms of literacy, numeracy, and adaptive problem-solving.

Correlations between the preference for HPS games and the Big Five personality traits did not yield significant results. It is possible that personality traits are not particularly relevant for what regards the preference for HPS games: while HPS games are often played alone, they can still be played as a shared experience (e.g., escape rooms), so possibly Hp1 on introversion did not accurately describe the complexity of HPS games experience. Future research may explore the role of personality characteristics more closely related to predilection for intellectual challenges, such as the need for cognition [27], which is tendency to engage in and enjoy effortful cognitive endeavors.

As a confirmation for Hp2, identified regulation emerged as an efficient predictor for preference towards HPS games. Since identified regulation is defined as the motivation to participate in an activity because it is perceived as important for one's personal growth [28], this result highlights that gamers are driven to HPS games not only by mere enjoinment or fun but also by the intention to positively challenge and possibly improve their intellectual abilities. Consistently, further regression analyses confirmed that gamers tend to believe that playing HPS games has concrete benefits in terms of the improvement of all the cognitive abilities used in everyday complex tasks, namely literacy, numeracy, and adaptive problem-solving.

With caution considered the relatively small sample and explained variance indexes, these results could be considered encouraging for what regards the recognition of HPS games and the possibility to employ games and video games not only to empower "basic" cognitive abilities (e.g., divided attention) but also high-level reasoning that could be transferred to everyday complex problem-solving tasks. One limitation of the present study is that the research assessed perceived benefits while it did not measure actual outcomes in problem-solving tasks, which would be an interesting aim for future research (e.g., comparing passionate HPS gamers with controls in various problem-solving performances). Furthermore, the fact that gamers feel that HPS games hold an important value for improvement, along with the belief in their positive benefits, may foster the effort put into problem-solving activities via self-efficacy, which is often associated with identified regulation [29,30]. Another limitation is the average variable

created to investigate HPS games which was developed ad-hoc for this study. Further research on this topic would benefit from validated tools to analyze preference towards HPS games.

Another limitation of the present study regards the lack of data about other gaming habits, gaming style, hours of game playing per week, etc. Future research may consider these aspects and also employ different research designs to include a control group with different game preferences in order to assess differences related to perceived or actual outcomes of gaming.

Although preliminary, the results of the present study highlight the importance of psychological and pedagogical research on the cognitive effects of games and video games beyond the action genre. HPS games may represent opportunities for education and cognitive empowerment that are still to be fully understood. This could provide interesting indications to educators who plan to use games, video games, or gamified interactive technologies in general to promote learning or social change, in that it will shed light on the usage of media to train high-level cognitive processing.

References

[1] Ferguson CJ. Action game experimental evidence for effects on aggression and visuospatial cognition: similarities, differences, and one rather foolish question. Front Psychol. 2014 Feb 7;5:88.

[2] Rebetez C, Betrancourt M. Video game research in cognitive and educational sciences. Cogn Brain Behav. 2007 Mar 1;11(1):131-42.

[3] Fritsch T, Ritter H, Schiller J. The effect of latency and network limitations on mmorpgs: a field study of everquest2. InProceedings of 4th ACM SIGCOMM workshop on Network and system support for games 2005 Oct 10 (pp. 1-9).

[4] Green CS, Bavelier D. Action video game training for cognitive enhancement. Curr Opin Behav Sci. 2015 Aug 1;4:103-8.

[5] Anderson, A. F., & Bavelier, D. (2011). Action game play as a tool to enhance perception, attention and cognition. In S. Tobias & J. D. Fletcher (Eds.), Comp Games Instruct (pp. 307–329). IAP Information Age Publishing.

[6] Silva GM, Sales HF, Fernandes TP, Gomes ME, Rodrigues SJ, Bonifacio TA, Leite LH, Santos NA. Relationship between long-term recreational video gaming and visual processing. Entert Comp. 2022 Aug 1;43:100501.

[7] Redick TS, Unsworth N, Kane MJ, Hambrick DZ. Don't shoot the messenger: Still no evidence that video-game experience is related to cognitive abilities—A reply to Green et al.(2017). Psychol Sci. 2017 May;28(5):683-6.

[8] Noda, S., Shirotsuki, K., & Nakao, M. (2019). The effectiveness of intervention with board games: a systematic review. BioPsychoSocial Med, 13(1), 1-21.

[9] Triberti S, Carruba MC Giocando a cambiare: alla ricerca delle proprietà educative di giochi e videogiochi. Quaderni di Agenda Digitale. 2023 (in press)

[10] Giove C. Prefazione. In AA. VV., Creature, Gate on Games - Zerosem S.R.L., Guamo (Lucca), 2022

[11] Chory RM, Goodboy AK. Is basic personality related to violent and non-violent video game play and preferences? Cyberpsychol Behav Soc Netw. 2011 14(4): 191-198

[12] Ventura M, Shute V, Kim YJ. Video game play, personality and academic performance. Comput Edu. 2012 58(4), 1260-1266

[13] De Hesselle LC, Rozgonjiuk D, Sindermann C, Pontes H, Montag C. The associations between Big Five personality traits, gaming motives, and self-reported time spent gaming. Pers Indiv Differ. 2021 171, 110483

[14] Reer F, Krämer NC. The connection between introversion/extraversion and social capital outcomes of playing World of warcraft. Cyberpsych, Beh Soc N. 2017;20(2):97–103.

[15] Ryan RM, Rigby CS, Przybylski A. The motivational pull of video games: A self-determination theory approach. Motiv Emotion. 2006;30(4):344–60.

[16] Rogers R. The motivational pull of video game feedback, rules, and social interaction: Another self-determination theory approach. Comput Hum Behav. 2017;73:446–50.

[17] Zhang J, Zhang Y, Song Y, Gong Z. The different relations of extrinsic, introjected, identified regulation and intrinsic motivation on employees' performance. Manage Decis. 2016;54(10):2393–412.

[18] Sebri V, Savioni L, Triberti S, Durosini I, Mazzocco K, Pravettoni G. Do you transfer your skills? from sports to health management in cancer patients. Front Psychol. 2020;11.

[19] Sedgwick P. Snowball sampling. BMJ. 2013;347(dec20 2).

[20] Dale G, Kattner F, Bavelier D, Green CS. Cognitive abilities of action video game and role-playing video game players: Data from a massive open online course. Psychol Pop Media. 2020, 9(3), 347.

[21] Sevin R, DeCamp W. Video game genres and advancing quantitative video game research with the genre diversity score. Comput Games J. 2020. 9(4), 401-420.

[22] Lafrenière M-AK, Verner-Filion J, Vallerand RJ. Development and validation of the Gaming Motivation Scale (GAMS). Pers Indiv Differ. 2012;53(7):827–31.

[23] Peracchia S, Presaghi F, Curcio G. Pathologic use of video games and motivation: Can the gaming motivation scale (GAMS) predict depression and trait anxiety? Int J Env Res Pub He. 2019;16(6):1008.

[24] John OP, Donahue EM, Kentle RL. Big five inventory. PsycTESTS Dataset. 1991;

[25] Ubbiali A, Chiorri C, Hampton P. Italian big five inventory. Psychometric properties of the Italian adaptation of the big five inventory (BFI). BPA (Bollettino di Psicologia Applicata). 2013 Jan 1;59(266).
[26] The assessment frameworks for cycle 2 of the programme for the International Assessment of Adult Competencies. OECD Skills Studies. 2021;
[27] Cacioppo, J. T., & Petty, R. E. (1982). The need for cognition. J Pers Soc Psychol, 42(1), 116.
[28] Vlachopoulos, S. P., & Karageorghis, C. I. (2005). Interaction of external, introjected, and identified regulation with intrinsic motivation in exercise: relationships with exercise enjoyment. J Appl Biobehav Res, 10(2), 113-132.
[29] Tamari, G. (2022). Teacher self-efficacy and its role in increasing motivation. Educ Sci Psychol, 61(1).
[30] Guay, F., Bureau, J. S., Litalien, D., Ratelle, C. F., & Bradet, R. (2020). A self-determination theory perspective on RIASEC occupational themes: Motivation types as predictors of self-efficacy and college program domain. Motiv Sci, 6(2), 164.

SECTION V

CLINICAL OBSERVATIONS

Cybertherapy is a field that is growing rapidly due to today's technology and information boom.

Virtual reality and advanced technologies have been used successfully to in a variety of healthcare issues, including treatment of anxiety disorders and phobias, treatment of eating and body dysmorphic disorders, neuropsychological assessment and rehabilitation and distraction during painful or unpleasant medical procedures.

The novel applications of these technologies yield many advantages over traditional treatment modalities, and the disadvantages that accompanied the first trials of virtual reality are quickly being addressed and eliminated.

Virtual reality peripherals such as data gloves, physiological monitoring and Internet worlds are swiftly demonstrating their usefulness in cybertherapy applications.

Wiederhold & Wiederhold, 2004

App-Based Intervention for Female Orgasmic Disorder in Emjoy: A Randomized Controlled Trial

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Abstract. It is estimated that 40-45% of adults worldwide have had or will have a sexual problem. Psychosexual treatments are considered effective and yet female untreated rates are high. E-mental health, specifically apps, might be a solution. Therefore, it becomes interesting to design and test the efficacy of an app-based intervention for female orgasm disorder (FOD) adapted to be administered in Emjoy (i.e., an app focused on female sexual health). To achieve this goal, 16 women diagnosed with FOD followed and finished an 8-week app-based intervention program: 8 women were part of the app intervention group, and 8 were part of a minimum therapeutic contact control group. The intervention consisted in a total of 275 minutes of audio-guided exercises planned to treat every item relevant to their disorder, and included different techniques, such as psychosexual education, cognitive restructuring, and sexual stimulation. The means between groups were compared with an ANOVA, and significant between-group differences were found in Sexual Satisfaction, Function, and Anxiety, favoring intervention. Participants declared to be very satisfied with both the outcomes of the intervention and the treatment itself. Even if research is still needed, this app-based intervention using Emjoy seems to be effective in improving some of the variables which may be related to the maintenance of FOD. To our knowledge, this is the first app-based intervention that focus solely on female sexual health, and even though it cannot replace therapy, it appears as an interesting way to help women in reaching for help that, otherwise, they would not seek.

Keywords. App-based intervention, Sexual disorder, Mobile application, Trial, Randomized

1. Introduction

Female Orgasmic Disorder (FOD) is characterized by the absence, delay, infrequency, and/or reduced intensity of orgasms, even after the person has been stimulated and is aroused [1]. FOD affects many women: epidemiological data indicates that 20-50% of the female population suffers from it [2-3]. Psychological factors such as religiosity, guilt, or low educational level interfere with women's ability to achieve orgasm [4], leading patients to experience difficulties with interpersonal relationships, stress, and an increased likelihood of reporting symptoms of depression or anxiety [5]. Specifically, sexual anxiety can block the possibility of having an orgasm through the inhibition of sexual arousal and the suppression of the ability to relax [6]. The treatment with the strongest empirical evidence for FOD is based on Cognitive-behavioral Therapy (CBT) and consists of maximizing stimulation (i.e., any physical or psychological activity that arouses a person's sexual desire or triggers a sexual response) and minimizing inhibition (i.e., psychological or emotional factors that can prevent a person from experiencing or expressing their sexual desires or engaging in sexual activities) [7]. Even if CBT seems to be effective in treating FOD [8-9], the majority of women who suffer from this condition do not seek help due to negative expectations (e.g., thinking no one can help

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them), sexual repression [5], or shame [10], among others. Considering this ratio of untreated individuals, traditional psychological approaches to sexual problems are insufficient to cover such a large number of people in need. Online interventions appear therefore an optimal solution thanks to their characteristic (e.g., increased privacy and comfort, increased engagement, or the possibility of being delivered remotely and without the need for expensive equipment or facilities). E-mental health interventions are a set of treatments based on interventions that have already been proven to be effective in person and that, for this reason, are adapted to be distributed via the Internet or related technologies [11]. This broad category of therapies also includes application-based interventions. Among apps that have the goal of improving women's sexuality, only a few of them, such as Emjoy, are designed by mental health professionals (e.g., psychologists). Emjoy (letsemjoy.com) targets communication and pleasure, as well as other variables related to sexual well-being, such as self-esteem, mindfulness in the present moment, and the couple's relationship. By virtue of these features, together with the possibility to customize the user experience, Emjoy represents a promising candidate for intervening in the variables involved in maintaining FOD. Overall, applications have already been used to improve sexuality, mostly with the objective to reduce risky sexual behaviors of specific groups (i.e., young people [12-13] and mothers [14]). As far as we know, indeed, no interventions have been carried out with apps whose goal is to improve the variables that intervene in the maintenance of clinical conditions (e.g., FOD). Given the high rates of women with untreated sexual problems, new technologies in general, and apps in particular, have a good therapeutic potential: they provide greater security and privacy than in-person therapies the possibility of exploring the person’s own body as a form of exposure and psychoeducation and are more flexible than standard interventions in that the treatment, is always available to users [12;14]. The objective of this study is to extend the content of the app Emjoy, tailoring the intervention for FOD, as well as to test the effectiveness of this intervention in improving this clinical condition.

2. Method

2.1. Participants and Procedure

As shown in Figure 1, after the sample recruitment process, which reached 1300 potential participants by advertising through social media, and the Emjoy app itself (where a banner was added for inviting the user to join the treatment group to the main tab in the app), a total of 797 women showed interest in the study by completing a screening questionnaire; 170 were invited to join a call with the research team, and 57 of them participated in an initial evaluation to check if they matched the DSM-5 (Diagnostic and Statistical Manual of Mental Disorders-5th edition) diagnostic criteria for FOD. Among these 57 women, 36 met the criteria and were thus enrolled in the study. A total of 21 individuals completed the intervention: 11 women took part in an intervention group (IG), which consisted of the app Emjoy, while 10 were part of a control group (CG) based on minimum therapeutic contact. Inclusion criteria to be part of the study were (a) presenting a diagnosis of FOD, according to the DSM-5 diagnostic criteria, (b) being at least 18 years old, (c) not having participated in a previous psychological intervention in the last year, (d) having access to a mobile phone with the characteristics to run Emjoy, and an internet connection, and (e) not having used the Emjoy app before.

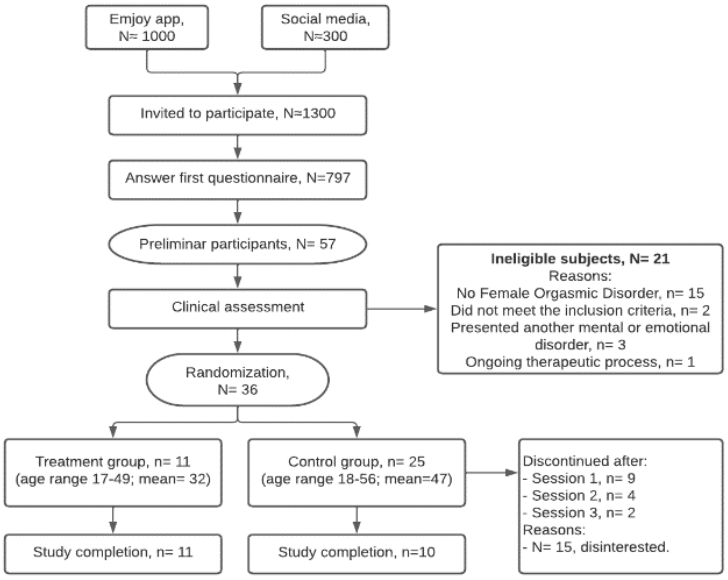


Figure 1. The flowchart of participants.

Prior to starting treatment, the aim of the study was explained to the participants, and the informed consent was signed. The assessed variables were measured before and after the intervention, and a follow-up was conducted 1 month after the intervention ended. During the 8-week treatment program, the users received three emails from the Emjoy team, asking if they had any doubts or queries about the app. Among the sample of participants that completed the post-intervention evaluation (N= 21), only 18 participants were included in the final sample because two of them, according to the app, did not adequately follow the treatment journey. For this reason, they had to be removed from the IG. To keep the samples balanced, three participants were then aleatorily removed from the CG. Thus, the total number of women included in the post-assessment as well as in the follow-up was 16: 8 women (age range 26-49; M= 37; SD=7.96) were part of the IG, while 8 (age range 20-56; M= 44; SD=12.99) of the CG. The reasons for drop-outs are specified in Figure 1. The study was approved by the Ethics Committee of Rey Juan Carlos University (registration number: 0710202221522).

2.2. Measures

Sexual Satisfaction. The Golombok Rust Inventory of Sexual Satisfaction scale (GRISS) [15] consists of a 28-item that assesses desire, pleasure, and sexual gratification within sex acts; higher scores indicate the presence of sexual problems. Answers are provided through a Likert-type response format ranging from 0= "never" to 4= "always".

Sexual Function. The Female Sexual Function Index (FSFI) [16] provides scores on 6 domains: sexual arousal, vaginal lubrication, orgasm, pleasure/desire, satisfaction, and pain. The sum of these domains provides a total score on Sexual Function, where higher scores indicate better sexual functioning. The FSFI consists of 19 items with 5-point Likert-type responses about frequency (from 1= "never" to 5= "always"), intensity (from 1= "really hard or almost impossible" to 5= "no difficulties") and satisfaction (from 1= "not at all satisfied" to 5= "really satisfied") of each domain.

Initiative and Sexual Communication. The Female Sexual Function Questionnaire (FSFQ) [17] assesses sexual response cycle, initiative, and sexual communication through 14 items that employ a 5-point Likert-type scale ranging from 1= "never" to 5= "always".

Sex-Guilt. The Brief Mosher Sex-Guilt Scale (BMSGS) [18-19] assesses cognitions, affects, and behaviors associated with a generalized expectancy for self-mediated

punishment related to sex, through 10 items raging on a 6-points Likert scale from 1= "not at all true" to 6= "extremely true".

Sexual Anxiety. The Sexual Anxiety scale of the Expanded Sexual Arousability Inventory (SAI-E) [20] assesses levels of nervousness, worry, restlessness, concern, or fear about sexual behaviors through 28 items based on 4-points Likert-type responses from 1= "relaxing" to 4= "extremely anxiety-provoking".

3. App-based treatment: Intervention Group - IG

The intervention lasted 8 weeks, during which participants practiced every day what was presented in the app, and included different techniques, such as psychosexual education, cognitive restructuring through audios, guided practices, and sexual stimulation. A specific therapeutic journey for FOD was created inside the Emjoy app, and a total of 275 minutes of audio-guided exercises were created to extend the basic intervention provided by the app so that it targeted the disorder. The 8-week plan was scheduled as follows:

-Week 1: four sessions around the topic "all about orgasms", and four sessions around the topic "love your vulva". The first four sessions lasted 16 minutes each and included information about why orgasms are important, how they work, and how someone can have them. In the first session, scientific contents related to orgasms were explained (i.e., how the nervous system rules our ability to have them). In the second and third ones, information was given on the working mechanism of orgasms, how the body reacts to them from a scientific point of view, or the situations or items to use for achieving an orgasm. Finally, session number four focused on the misinformation surrounding female orgasms, exploring what is real, and what is fake. Concerning the sessions centered on loving the vulva, they lasted 17 minutes each and had the purpose of understanding and appreciating the vulva, as well as breaking mental barriers that may be holding back the participants' orgasms. The different sessions included drawing a vulva, discovering and understanding all parts of it, exploring the person's own vulva, working with the associated negative thoughts, and learning how to keep good hygiene.

-Week 2 (29 minutes per session; four sessions in total) was directed at discovering what the participant enjoys, including clarifying sexual preferences or understanding what produces sexual arousal. The sessions included guided visualizations and body scan practices aimed at exploring both the body and pleasure areas. Additionally, there was one session devoted to boundaries as they are important for having a safe and healthy sex life. In this session participants could learn more about their needs, and how to communicate them.

-Week 3 was about discovering one's own body, and had a duration of 25 minutes per session. During the course of the sessions, the participants focused on finding out why self-pleasure is essential to discover their own preferences. The goal was to provide them with tools to start a self-exploration journey. In order to do so, the first step was to learn what erogenous zones are, and how to find them; the second step was then to find their preferred ones through guided practice in imagination. Additionally, there were two sessions of masturbation: the first one focused on breaking the stigma around it, working with dysfunctional beliefs that may arise when thinking about self-pleasure; and the second one was a guided practice on how to masturbate.

-Week 4, participants faced orgasm anxiety through four sessions of 37 minutes each and went further into the issue of anorgasmia with five sessions of 26 minutes each. First, during the course of the week, individuals explored different techniques for reducing the anxiety associated with sexual pleasure and climax, including psychoeducation on how anxiety limits orgasms, cognitive restructuring to let the limiting beliefs go, and systematic desensitization in which participants faced their fears to allow pleasure during

masturbation. After this, the same steps were followed to help the participant to enjoy masturbation with a partner. The sessions about anorgasmia included information about the issue (e.g., definition of the phenomenon, types, common causes), the importance of the brain-body connection when referring to climaxing, and techniques to improve the ability to orgasm, including practical tips, information on things the participant might be doing which do not actually help, how mindfulness can help to experience better orgasms, and how arousal and sexual stimulation are linked to orgasm. Additionally, participants were guided to elaborate an action plan for the week.

- Week 5 included five sessions of 44 minutes each and was focused on how to orgasm (i.e., first steps, tips, tricks, and guides to orgasm with and without a partner). In these sessions, participants explored what an orgasm is, learned how to discern the signs of having one, and discovered more about their pleasure, including physical, mental, and emotional techniques to relax. Additionally, mental blocks were explored and worked out (i.e., through cognitive restructuring), and information about partner climaxing was given along with insight into what toys are best for our bodies.

- Week 6 resumed the work done in week 3 and continued in week 7. It was about discovering one's own body (vol. II). It consisted of three sessions that lasted 24 minutes each: when participants began to know their bodies, it is possible for them to level up and learn new techniques and erogenous zones, with the objective to find new ways to pleasure themselves and improve sexual well-being. The first and third sessions were focused on clitoris sensitivity (including learning techniques to stimulate it), and the second one was on vulva sensitivity.

- Week 7 also consisted in three sessions that lasted 24 minutes each and included exploring the best ways to stimulate breasts and nipples and to have an orgasm in the shower. Additionally, information was given on ergonomic masturbation positions.

- Week 8 included five sessions, with a duration of 33 minutes each, in which participants learned a range of masturbation and associated techniques, like conscious breathing (i.e., affects pleasure during sex), timing (e.g., taking a musical approach), pressure, or intensity.

4. Minimum therapeutic contact control group (CG)

Control group sessions consisted of individual online informative talks delivered via videoconference, during which participants were provided with information about female orgasm (e.g., what is an orgasm, neuronal orgasm, factors that may influence consecution, sexual response), masturbatory techniques (e.g., key elements to achieve pleasure, anatomy of the female genitalia, pleasure areas) and techniques to focus attention on one's body (i.e., an important factor to pleasure). These individual sessions took part once a month and had a duration of one hour.

5. Data analysis

Descriptive analyses were performed in order to appropriately present the characteristics of the sample. Univariate and multivariate outliers and normality were determined using Tabachnick and Fidell's [21] criteria. Differences prior to the intervention were assessed through analyses of variance and independence tests. A significance level of 5% was adopted. Two-way repeated-measures analysis of variance (between-within ANOVA) was used to investigate the time-by-group interactions, controlling for the effect of age, severity of the condition, profession, and education. To

achieve this, the IBM SPSS Version 22 [22] was used. Post-hoc analyses were carried out in order to determine whether (between and/or within) levels are equal to zero or different from it by providing one post-hoc p-value and an estimate of the difference between the levels of interest. Additionally, qualitative data was retrieved by asking the participants about their experience (e.g., what do you think about the treatment?; from 0 to 10, how would you rate it?).

6. Results

The sociodemographic characteristics of the sample are presented in Table 1: no significant differences were found in the assessed variables at pre-intervention.

Table 1. Sociodemographic characteristics of the two groups of the sample at the beginning of the study

Variables	Condition	IG (n=8)	CG (n=8)
Age		M= 37 ± 7.96	M= 44 ± 12.99
Gender	Female	100%	100%
Education	Low educational level	2 (28.57%)	2 (28.57%)
	Mean educational level	4 (57.14%)	3 (42.86%)
	High educational level	1 (14.29%)	2 (28.57%)
Profession	Employed	6 (86.71%)	5 (71.43%)
	Unemployed	1 (14.29%)	2 (28.57%)

Significant between-group differences were found in sexual satisfaction, function, and anxiety, with the IG reporting a significantly greater improvement in the variables of interest than the CG ($p<0.01$). The detailed results can be found in Table 2. In particular, concerning the levels of sexual satisfaction evaluated before the beginning of the intervention, the results showed a score of 51.45 for the IG and 56.02 for the CG, revealing no statistically significant differences between the two groups in such dimensions before treatment ($p>0.01$). In the post-intervention phase, the score reported was 34.57 in the IG and 54.43 in the CG, showing a significant difference between the two groups of treatment ($p<0.01$). Regarding sexual function, the pre-treatment assessment results pointed out no statistically significant group differences, with the IG scoring 54.09 and the CG 49.28 ($p>0.01$). A significant group difference was instead found post-treatment, with a score of 69.14 and 47.80 in the IG and CG respectively ($p<0.01$). Finally, with regards to sexual anxiety, results showed that the IG reported a score of 55 before the intervention, while the CG of 53.4. Following the treatment, the IG scored 27.43, while the CG 54.1 ($p<0.01$). There were no significant between-group differences in sex guilt, initiative, and sexual communication ($p>0.01$) instead.

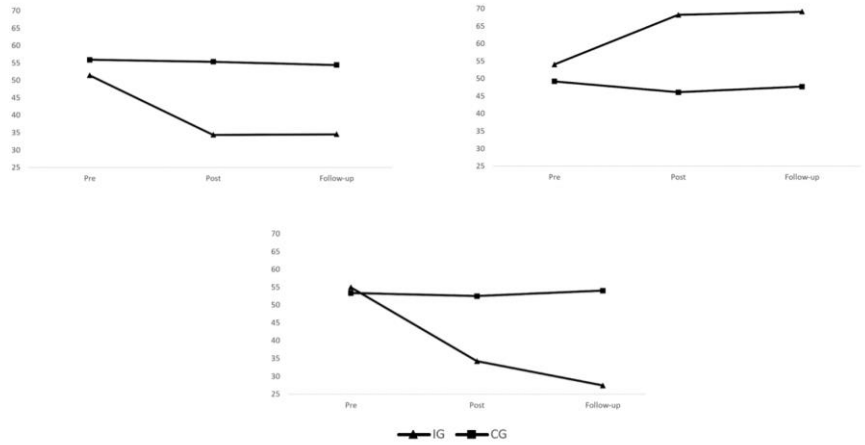
Table 2. Participants' scores in outcome variables from pre- to post-intervention, and follow-up

Variables	Condition	Time			Between-group difference
		Baseline	Post-treatment	Follow-up	
Sexual satisfaction	**IG**	51.45	34.38	34.57	16.88*
	CG	56.02	55.4	54.43	1.59
Sexual function	**IG**	54.09	68.25	69.14[a]	15.05*
	CG	49.28	46.2	47.80	1.48
Sexual anxiety	**IG**	55	34.25	27.43	27.57*
	CG	53.4	52.6	54.1	-0.7

a= scores under the cut-off point; *=statistically significant ($p\leq0.01$).

All these results were maintained in the follow-up: the IG levels of sexual satisfaction went from 34.38 to 34.57 ($p>0.01$), the IG levels of sexual function went from 68.25 to 69.14 ($p>0.01$), and IG levels of sexual anxiety went from 34.25 to 27.43

($p>0.01$). No significant differences were found between both measures, pointing to a maintenance of the results. Figures 2-4 show the groups' measures over time.



Figures 2-4. Intervention Group (IG) and Control Group (CG) measures over time.

Finally, the modality of the IG treatment was rated as very convenient and flexible (M=9.71 SD=0.49, where "10" means "very convenient and flexible). In addition to this, participants reported that they could access the app at any time that fitted their timetables, finding this characteristic as particularly beneficial (M=10, SD=0, where "10" means it completely fitted their timetables). Lastly, they felt comfortable as they avoided the embarrassment of going to a clinic (M=9.20, SD=0.76, where "10" means they completely avoided the embarrassment). Overall, participants declared to be very satisfied with both the treatment outcomes and the intervention itself (M=10, SD=0, where "10" means it completely fitted their timetables).

7. Discussion and Conclusion

This app-based intervention using Emjoy seems to be effective in improving some of the variables which may be related to the maintenance of FOD. To our knowledge, this is the first app-based intervention that focuses solely on female sexual health, and that aims at treating those maintenance variables. Even though it cannot replace therapy, Emjoy appears as an interesting way to support women in reaching for help that, otherwise, they would not seek. App-based intervention may indeed be able to overcome many of the barriers associated with face-to-face interventions for sexual disorders (e.g., feeling ashamed to go to the clinic). Studies focused on other health conditions associated with social stigma, and shame in discussing such contents (e.g., Human Immunodeficiency Virus [HIV]) gave users a sense of privacy and comfort when exploring these issues on their smartphones or other personal electronic devices [23]. Another promising line of research that facilitates patients with sexual disorders in seeking help is the use of Metaverse [24]. Such as app-based intervention, this type of therapy does not involve direct contact with the therapist and allows the implementation of standard interventions for sexual disorders (e.g., CBT) through avatars, while receiving the therapy from a location perceived as safe (i.e., their home). Future work is, however, necessary to explore more in-depth facilitators and barriers to both in-person and app-based interventions as well as to assess which of them is more effective. In addition to this, since one of the possible barriers to treatment adherence is the difficulty that individuals may have in reaching the clinic (e.g., the impossibility of taking time off from work, problems with child-care or transportation, etc.) [25], Emjoy defeats this

complication by guaranteeing to the patient the flexibility of receiving the intervention wherever and whenever they want.

References

[1] American Psychiatric Association, Kupfer, D.J., Regier, D.A., Arango López, C., Ayuso-Mateos, J. L., Vieta Pascual, E., & Bagney Lifante, A. (2014). DSM-5: Manual diagnóstico y estadístico de los trastornos mentales (5th ed. ed.). Editorial Médica Panamericana.

[2] West SL, Vinikoor LC, Zolnoun D. A systematic review of the literature on female sexual dysfunction prevalence and predictors. Annu Rev Sex Res. 2004;15(1):40-172.

[3] Graham CA. The DSM diagnostic criteria for female orgasmic disorder. Arch Sex Behav. 2010 Apr;39(2):256-70. doi: 10.1007/s10508-009-9542-2.

[4] Meston, C.M., Hull, E., Levin, R.J., & Sipski, M. (2004). Disorders of orgasm in women. The Journal of Sexual Medicine, 1, 66-68.

[5] Alcoba Valls, S.L., García-Giralda Ruiz, L., & San Martín Blanco, C. (2004). Guía de Buena Práctica en Disfunciones Sexuales (1st ed. ed.). IM&C, S.A.

[6] Shifren, J.L., Monz, B.U., Russo, P.A., Segreti, A., & Johannes, C.B. (2008). Sexual problems and distress in United States women: prevalence and correlates. Obstet Gynecol., 112, 970-978.

[7] Rosen RC, Leiblum SR. Treatment of sexual disorders in the 1990s: an integrated approach. J Consult Clin Psychol. 1995;63(6):877-890. doi: 10.1037//0022-006x.63.6.877.

[8] Carvalheira AA. Intervención terapéutica en las disfunciones sexuales femeninas: perspectiva psicosexológica. Revista Internacional de Andrología. 2007;5(1):88-91.

[9] Lue TF, Basson R, Rosen RC, Giuliano F, Khoury S, Montorsi F. Sexual medicine: sexual dysfunctions in men and women. 2004th ed. Health Publications.

[10] Vila, A., Ardoy-Cuadros, J., Romero-Moreno, R., & Nogales-Gonzalez, C. Novel therapeutic approaches: a qualitative study to explore attitudes toward an avatar-based therapy [oral presentation]. In: 15th International Congress of Clinical Psychology; 16-18 November 2022; Virtual.

[11] Ritterband LM, Thorndike F. Internet interventions or patient education web sites? J Med Internet Res. 2006;8(3):e580.

[12] Jackson DD, Annang Ingram L, Boyer CB, Robillard A, Huhns MN. Can Technology Decrease Sexual Risk Behaviors among Young People? Results of a Pilot Study Examining the Effectiveness of a Mobile Application Intervention. Am J Sex Educ. 2016;11(1):41-60. doi: 10.1080/15546128.2015.1123129

[13] Ignacio M, Garofalo R, Pearson C, Kuhns LM, Bruce J, Scott Batey D, et al. Pilot feasibility trial of the MyPEEPS mobile app to reduce sexual risk among young men in 4 cities. JAMIA Open. 2019;2(2):272-279.

[14] Oldham EI. The "Accepting Pleasure Program"(APP)–Turning Moms on to the Pleasures of Maternal Sexuality [Doctoral dissertation]. Capella University; 2021.

[15] Rust, J., & Golombok, S. (1986). The GRISS: A psychometric instrument for the assessment of sexual dysfunction. Archives of Sexual Behavior, 15(2), 157-165. doi: 10.1007/BF01542452.

[16] Rosen, R., Brown, C., Heiman, J., Leiblum, S., Meston, C., Shabsigh, R., Ferguson, D., & D'agostino, R. (2000). The Female Sexual Function Index (FSFI): A multidimensional self-report instrument for the assessment of female sexual function. Journal of Sex & Marital Therapy, 26, 191-208. doi: 10.1080/009262300278597

[17] Borrás Valls, J.J., Gómez Llorens, O., Aznar Vicente, J., Caballero Martín, A., Pérez Conchillo, M., & Sánchez, F. (2004). Diseño y validación del cuestionario de Función Sexual de la Mujer (FSM). Atención Primaria, 34(6), 286-292. doi: 10.1016/S0212-6567(04)78649-6

[18] Janda, L.H., & Bazemore, S.D. (2011). The revised mosher Sex-Guilt Scale: Its psychometric properties and a proposed ten-item version. The Journal of Sex Research, 48(4), 392-396. doi: 10.1080/00224499.2010.482216

[19] Mosher DL. Interaction of fear and guilt in inhibiting unacceptable behavior. J Consult Psychol. 1965;29:161-167.

[20] Chambless, D.L., & Lifshitz, J.L. (1984). Self-reported sexual anxiety and arousal: The expanded sexual arousability inventory. The Journal of Sex Research, 20(3), 241-254. doi: 10.1080/00224498409551223.

[21] Tabachnick, B.G., & Fidell, L.S. (2001). Using multivariate statistics (4th ed.). Allyn & Bacon.

[22] IBM Corp. (2013). IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: Author.

[23] Cordoba, E., Idnay, B., Garofalo, R., Kuhns, L. M., Pearson, C., Bruce, J., ... & Schnall, R. (2021). Examining the Information Systems Success (ISS) of a mobile sexual health app (MyPEEPS Mobile) from the perspective of very young men who have sex with men (YMSM). *International journal of medical informatics*, *153*, 104529.

[24] Vila, A., & Riva, G. (2022). SexTreatverse: Avatar-Based Virtual Reality for the Treatment of Female Sexual Disorders. *Cyberpsychology, behavior and social networking*, *25*(6), 404-415.

[25] Sansoni, M., Tagai, E. K., Lapitan, E., Wen, K. Y., Xu, J., Belfiglio, A., ... & Miller, S. M. (2022). Development of a text message-based intervention for follow-up colposcopy among predominately underserved Black and Hispanic/Latinx women. *Cancer Causes & Control*, *33*(6), 861-873.

The Electrodermal Activity of Children with ASD in Virtual Reality Tasks Resembling Regular Actions

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Abstract. The diagnosis of autism spectrum disorder (ASD) is made through qualitative procedures addressed to children and their caregivers. On the one hand, these procedures are administered in anonymous settings with reduced ecological validity. On the other, they measure the child's behaviours qualitatively, without using objective and implicit measurements that tap into the biological basis of the disorder. It is necessary to overcome these limitations by introducing ecological settings and objective measures related to the nuclear symptoms of the disorder. In this context, the present study wanted to test the feasibility of a virtual reality (VR) procedure to investigate different patterns in the electrodermal activity (EDA) between children with ASD and their peers with typical development (TD). Fifteen children with ASD and 15 with TD measured their EDA during baseline recording. Then, they performed three interactive virtual tasks resembling regular actions. They were to take game-based and non-game-based goal-directed actions. The results reinforced previous evidence on EDA differences in children with ASD during baseline recording compared to their peers with TD. They also suggested a potential relation between EDA at baseline and the diagnostic score indexes in the ASD group. Finally, this study reported the presence of different EDA patterns in children with ASD when they are asked to perform non-game-based virtual activities in which the upper limb movement is required to take goal-directed actions. This evidence might be relevant for implementing VR systems for the early and quantitative detection of ASD.

Keywords. autism spectrum disorder, virtual reality, sensory dysfunction, children, electrodermal activity

1. Introduction

The assessment of autism spectrum disorder (ASD) is based on observational procedures limited in their objectivity. First, they are administered in settings with reduced ecological validity; second, they measure child's behaviors qualitatively rather than using objective and implicit measurements that tap into the biological basis of the disorder. Novel technology-based procedures involving objective measures are being developed and tested to fulfill these needs. Specifically, virtual reality (VR) is a promising technology for the ASD population enabling the controlled simulation of everyday situations wherein realistic psychophysiological reactions can be measured [1]. In addition, the recent inclusion of sensory dysfunction into ASD diagnostic criteria has fostered research on this objective biomarker [2], which represents hyper/hypo-sensitivity to a wide range of stimuli due to atypical sensory processing and integration.

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In ASD, electrodermal activity (EDA) represents a reliable marker of the physiological reactions to sensory stimulations [3]. In particular, children with ASD present atypical EDA patterns during baseline recording and in response to sensory stimulations [4]. There is also a relationship between the psychophysiological reactions in ASD and the score indexes in several procedures used to assess the disorder, the social or communicative abilities, and the presence of repetitive or challenging behaviors [4,5].

There are effective instances of using VR in the automatic identification of ASD based on EDA measurement [6]. However, it is still necessary to investigate the effectiveness of the EDA-based ASD identification involving immersive virtual environments in which users can interact and play.

In this framework, the present study tested the feasibility of an immersive VR interactive procedure for detecting atypical patterns in EDA between children with ASD and children with typical development (TD). The virtual procedure consisted in performing three tasks requiring game-based and non-game-based goal-directed actions. The goal of the study was to detect possible atypical EDA patterns in children with ASD compared to their peers with TD regardless of the virtual action required to perform. The relationship between EDA in children with ASD and their diagnostic score indexes was also tested.

2. Method

2.1. Participants

The study included 30 children belonging to two different groups: 15 children with ASD and 15 children with TD between 3 and 7 years old. Participants in the autistic group were 12 males and 3 females, which is in line with the prevalence ratio of the disorder (4 males for every 1 diagnosed female). The mean age in the group with ASD was 54.00 (13.75) months. The TD group included 9 males and 6 females with a mean age of 60.33 (13.75) months. All participants were Spanish, right-handed and did not take any medication as reported by their caregivers. In addition, caregivers of autistic participants provided the assessment reports of the Autism Diagnostic Observation Schedule 2 (ADOS-2) [7] to confirm the ASD diagnosis previously made. Further clinical documentation of the child regarding the absence of comorbidities was also provided by caregivers. The mean indexes of the ADOS-2 in the ASD group were 12.75(3.68) in social affect, 2.50(1.32) in repetitive behaviors, and 15.12(4.05) as the total score. TD participants' caregivers answered a short questionnaire designed ad hoc to exclude the presence of symptoms related to cognitive impairments, neurodevelopmental, and personality disorders. Participants with ASD were recruited through the Development Neurocognitive Centre Red Cenit (Valencia, Spain), whereas participants belonging to the TD group were recruited through a social media promotion of the study. Adherence to the study was voluntary. Before children participated in the study, caregivers gave their written consent. The study has been approved by the Ethical Committee of the Polytechnic University of Valencia (ID: P_06_04_06_20).

2.2. Procedure

A three-surface CAVE-Automatic Virtual Environment (CAVE) of 4 m x 4 m x 3 m was implemented as VR system. 100° images at 55 cm of distance were projected on each surface by three ultra-short lens projectors. The virtual environment was projected onto the central surface of the CAVE, while the two side surfaces were left black and thus devoid of animation. The Azure Kinect DK (Microsoft Corporation, 2019) ensured the virtual interaction and it was placed on a 40 cm high tripod in front of the central surface of CAVE. This strategic location permitted participants to visualize the virtual environment in its entirety without any interference with their view. Moreover, the resolution mode of the Azure Kinect DK depth camera was 640 x 576 at 30 frames per second, allowing the tracking of the participant's body throughout the CAVE.

After a familiarization phase between the child and the experimenter, the study started asking participants to wear the Empatica E4 wristband which recorded EDA. Afterward, the EDA baseline was recorded for 60 seconds while participants were invited to seat and to relax, to do not move their limbs, and focus on their breathe. At this stage of the study, no virtual stimulation was presented and care was taken to ensure same conditions across participants. Next, participants were able to spot a virtual human shape in the virtual environment in a transparent mode that mirrored their head, trunk, and limb movements. Participants chose between the male and female virtual human shape (see Figure 1). In this way, the meta-self-recognition with the avatar was facilitated and the sense of immersion and virtual presence were enhanced. After a familiarization phase with the virtual human shape in which the experimenter asked participants to raise their hands and move their legs, both ASD and TD groups performed three virtual tasks while their EDA was recorded. These tasks asked to perform game-based and non-game-based goal-directed actions with different limbs. The selected tasks and their usability were suitable for children [8]. The task order was randomized and counterbalanced across participants. At the beginning of each task, the experimenter informed participants about task objectives using predetermined sentences. Whether any participant did not understand task objectives, more in-depth instructions and/or examples of how to perform were provided using a top-down strategy. The EDA recording in each task covered from the beginning of participant's performance to its end.

In the kick task (KT), participants were asked to perform playful virtual actions. They had to kick five virtual balls with one of their lower limbs (see Figure 1a). The virtual ball appeared in a red shadow and after three seconds, turned green for indicating it was time to kick. The trajectory of the ball after kicking was predetermined and random. After each kick, the ball appeared again for the next kick and participants always found it in front of the virtual human shape. In the bubble task (BT), participants had to blow up thirty bubbles in a fall by touching them (see Figure 1b). As for the KT, the BT required to perform game-based actions. The virtual bubbles were of different colors and fell two by two in front of the virtual human shape in the area reachable by the upper limbs. Different falling speeds of the bubbles were implemented to avoid floor and ceiling effects: the first ten bubbles fell at a slow speed (0.20 m/s), the next ten bubbles according to a moderate speed (0.30 m/s), and the last ten bubbles fell at a fast speed (0.45 m/s). Finally, in the flower task (FT), participants were asked to perform non-game-based actions. They had to pick a virtual flower and leave it on a bench placed on the opposite side of the bunch of flowers (see Figure 1c). This action was repeated 5 times and required the movement of the upper limb to move the flower, as well as the movement of the lower limbs to reach the picking up and leaving locations. The FT execution differed from the further tasks because it was not based on conventional games and required to follow predetermined instructions.

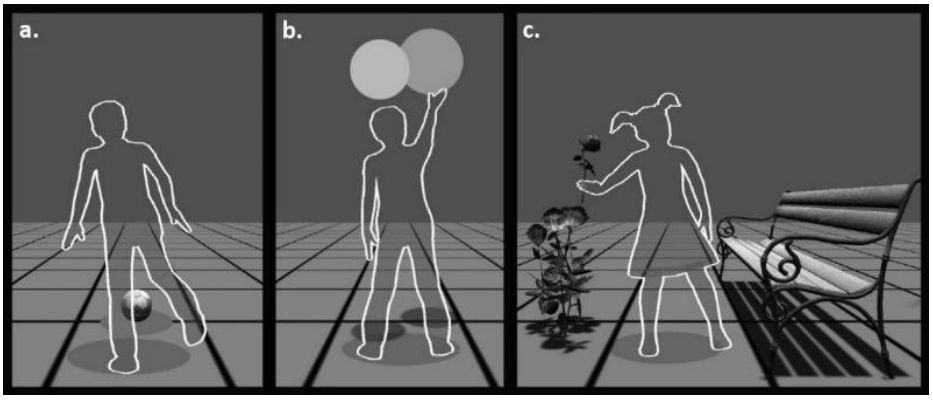

Figure 1. Screen captures of the interactive virtual tasks with instances of the male and female virtual human shapes: a. KT; b. BT; c. FT.

3. Electrodermal activity recording and processing

EDA recording was conducted under carefully controlled conditions to ensure consistency among all participants. In particular, the experimenter was the same for all subjects, the room temperature was set at 21°C and the room light was the same. EDA raw signals recorded at 4 Hz were pre-processed using Ledalab v.3.4.8 (www.ledalab.de) via Matlab R2020a (The MathWorks, Inc.). Pre-processing involved expert evaluators visually inspecting and selecting the artifact start and end, followed by automatic artifact correction through interpolation using a spline. The skin conductance level (SCL) and skin conductance response (SCR) were then obtained from the signal by applying continuous decomposition analysis. The SCL represents the basal activity and relates to slow changes in the skin conductance likely elicited by internal thoughts and situational demands. The SCR represents the subjective response to external stimuli which provoke rapid changes in skin conductance. Finally, SCL and SCR were processed using Python to obtain different metrics. For EDA recorded at baseline, the mean and SD of SCL and SCR were calculated. The SCR number of peaks per minute was computed by identifying local maxima through comparison of adjacent values, considering a minimum amplitude of 0.05μS and a minimum width of 1s at half the prominence height. Furthermore, when signal peaks were detected, mean and maximum peak amplitude were also measured. For EDA in each task, the SCL and SCR were rescaled dividing by the mean of their corresponding in the EDA baseline signal. Then, the metrics described for the baseline were also calculated for these normalized signals.

3.1 Data analysis

The statistical analyses were conducted using SciPy and Pingouin Python libraries. Shapiro–Wilk test was applied to determine whether the metrics were normally distributed, and Levene's test was applied to check the homogeneity of variance. The level of significance was set at $\alpha = 0.05$. Independent sample t-test was run to check potential differences in age between groups. Spearman correlations were used to assess the relationship between the ADOS-2 indexes in the ASD group and their EDA metrics during baseline recording and task performances. Finally, differences between groups in their EDA metrics at baseline and during task performances were tested. The group differences were analyzed using independent sample t-test for normal and homogeneous distributions, Welch's t-test for normal and non-homogeneous distributions, and Mann-Whitney Wilcoxon test for non-normal distributions. The effect size was calculated using Cohen's D for normal distribution and matched pairs rank-biserial correlation for non-normal distributions.

4. Results

Age did not differ significantly between groups ($t(28) = -6.33$; $p = .218$). Regarding correlations between EDA metrics of children with ASD and their ADOS-2 indexes, significant positive correlations were found in the baseline recording, while no significant correlations were found during task performance (see Table 1).

Table 1. Correlations between EDA metrics at baseline recording and ADOS-2 indexes

EDA metrics at baseline recording	**ADOS-2**					
	Social affect		Repetitive behaviors		Total score	
	r	*p*-value	r	*p*-value	r	*p*-value
Mean SCL	.47	.144	.75	.007**	.65	.030*
SD SCL	.61	.045*	.52	.105	.72	.013*
Mean SCR	.40	.221	.72	.013*	.57	.067

SD SCR	.53	.094	.62	.044**	.67	.024*
SCR peaks per min	-.01	.960	.43	.013*	.12	.495
SCR amplitude peak mean	.38	.037*	.69	<.001***	.58	<.001***
SCR amplitude peak max	.43	.017*	.59	<.001***	.63	<.001***

* $p < .05$, ** $p < .01$, *** $p < .001$.

Regarding group differences in EDA metrics at baseline recording, Table 2 showed the EDA metrics presenting statistical differences between groups.

Table 2. EDA variables in children with ASD and TD that were statistically significant in the baseline recording

Metric	**Description (µS)**	**Statistic**	***p*-value**	**Effect size**
SCL SD †	ASD: .128 (.29) TD: .351 (.54)	U = 72.0	.048*	.360
SCR Mean †	ASD: .116 (.20) TD: .291 (.46)	U = 72.0	.048*	.360
SCR peak amplitude mean †	ASD: .197 (.31) TD: .350 (.87)	U = 47.0	.017*	.484
SCR peak amplitude max †	ASD: .511 (.61) TD: .828 (1.49)	U = 56.0	.047*	.385

† This variable was not normally distributed. The median (interquartile range) is detailed in the description. * $p < .05$, ** $p < .01$, *** $p < .001$

Finally, in the KT and BT, the EDA metrics did not differ between groups. On the contrary, in the FT there was a statistically significant difference between groups in the SCL SD ($t(28) = 62.0$: $p = .019$*; $r = 0.449$). During the performance in the FT, the children with ASD presented greater SCL SD than their peers with TD (ASD: .136 (.19); TD: .053 (.13)).

5. Discussion

Findings showed that in the ASD group some metrics of EDA recorded at baseline positively correlated with the ADOS-2 score indexes. This finding is in accordance with previous evidence and reinforces the idea that there is an association between the sensory dysfunction measured by EDA, and ASD indexes related to behavioral, cognitive, social and motor abilities [4,5]. On the contrary, across tasks, there was no a relationship between the ADOS-2 indexes of the autistic children and their EDA. Despite many studies reported this kind of association in several tasks [4], a few studies used EDA rescaled by baseline signal as in this case [e.g., 9]. The EDA normalization by baseline provides the actual proportion in the physiological reaction that is directly linked to task stimulation. The current absence of associations between symptom severity and physiological changes aligns with findings involving a similar approach [9]. Regarding EDA comparisons between groups at baseline, findings described an atypical physiological hypoactivation in children with ASD, which is in line with previous evidence [e.g., 4].

Findings during the virtual interaction showed that in tasks asking for game-based actions (the KT and BT), the two groups did not present significant differences in their physiological reactions. Likely, autistic individuals may present typical physiological reactions (at least in EDA) while they are experiencing virtual tasks resembling regular and engaging activities. It could be of interest studying whether different physiological measures, such as respiration and heart rate, would differ in the autistic population during the performance in this type of tasks. Finally, in the FT, children with ASD reported different physiological reactions, as reflected by the more significant variability in the SCL. The different nature of the FT compared to the other two tasks may have had a role

in this atypical manifestation in the ASD group [10]. Indeed, following predetermined instructions and performing non-game-based actions may have increased the levels of stress and anxiety in the autistic children during task execution, likely due to the lack of previous experience on how to perform. On the contrary, the children with TD might have been able to manage better the novelty and the different requirement in the FT. Despite the current findings do not follow a unique direction (i.e., physiological hyperactivation or hypoactivation in ASD during challenging situations), they favor the hypothesis that challenging tasks based on non-game-based actions may foster the manifestation of atypical EDA reactions compared to other types of tasks characterized by a reduced level of challenge.

This study presented some limitations worth to be mentioned. First, sample size was reduced and only children who accepted to wear the Empatica E4 wristband and accomplished the tasks were included. Second, the sample groups were not matched for IQ and future studies should consider cognitive ability as potential factor that may affect the physiological reaction during task performance.

6. Conclusion

The present study assessed EDA differences between autistic children and their peers with TD while playing different interactive and immersive virtual tasks. The findings confirmed previous evidence on EDA differences recorded at baseline, and on the relation between EDA of children with ASD recorded at baseline and their diagnostics score indexes. Regarding task performance, only the virtual task asking for non-game-based actions fostered the manifestation of atypical EDA in the children with ASD. Likely, challenging and stressful tasks are more discriminant than non-challenging tasks in arising EDA untypicalities in ASD. Studies such as the present one may address the development of virtual interactive procedures for the early assessment of ASD involving objective measures and ecological settings.

References

[1] Clemente M, Rey B, Rodríguez-Pujadas A, Barros-Loscertales A, Baños RM, Botella C, …, Ávila C. An fMRI study to analyze neural correlates of presence during virtual reality experiences. Interacting with Computers 2014; (3): 269-284.

[2] American Psychiatric Association. Diagnostic and statistical manual of mental disorders (5th ed.) 2013.

[3] Schupak BM, Parasher RK, Zipp GP. Reliability of electrodermal activity: quantifying sensory processing in children with autism. American Journal of Occupational Therapy 2016; 70(6): 7006220030p1-7006220030p6.

[4] Lydon S, Healy O, Reed P, Mulhern T, Hughes B, Goodwin MS. A systematic review of physiological reactivity to stimuli in autism. Developmental neurorehabilitation 2016; 19(6): 335-355.

[5] Fenning RM, Baker JK, Baucom BR, Erath SA, Howland MA, Moffitt J. Electrodermal variability and symptom severity in children with autism spectrum disorder. Journal of autism and developmental disorders 2017; 47(4): 1062-1072.

[6] Alcañiz Raya M, Chicchi Giglioli IA, Marín-Morales J, Higuera-Trujillo JL, Olmos E, Minissi ME, Teruel Garcia G, Sirera M, Abad L. Application of supervised machine learning for behavioral biomarkers of autism spectrum disorder based on electrodermal activity and virtual reality. Frontiers in human neuroscience 2020; 90.

[7] Lord C, Rutter M, DiLavore PC, Risi SA. Diagnostic Observation Schedule-WPS (ADOS-WPS). Los Angeles, CA: Western Psychological Services; 1999.

[8] Minissi ME, Giglioli IAC, Mantovani F, Sirera M, Abad L, Alcañiz M. A qualitative and quantitative virtual reality usability study for the early assessment of ASD children. In: ANNUAL REVIEW OF CYBERTHERAPY AND TELEMEDICINE; 2021.

[9] Vernetti A, Shic F, Boccanfuso L, Macari S, Kane-Grade F, Milgramm A, ..., Chawarska K. Atypical emotional electrodermal activity in toddlers with autism spectrum disorder. Autism Research 2020; 13(9): 1476-1488.

[10] Minissi ME, Gómez-Zaragozá L, Marín-Morales J, Mantovani F, Sirera M, Abad L, Cervera-Torres S, Gómez-García S, Chicchi Giglioli IA, Alcañiz M. The whole-body motor skills of children with autism spectrum disorder taking goal-directed actions in virtual reality, *Front. Psychol.* 2023; 14: 1140731.

Prediction of the Dosage of the Electric Stimulus Needed for Electroconvulsive Therapy (ECT) based on Patient's Pre-ictal EEG using Artificial Intelligence

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Abstract. One of the most effective and rapid treatments for Major Depressive Disorder (MDD) is Electroconvulsive Therapy (ECT). However, cognitive adverse effects remain a great risk among patients undergoing ECT. These side effects are robustly tied to the dosage of the electric stimulus given to the patient. Two methods are currently used to determine an accurate dosage: the age-based method and the titration method. Furthermore, electroencephalograms (EEG) are done during an ECT session, to assess the adequacy of the treatment. Therefore, Artificial Intelligence (AI) could offer a third way, by analyzing the EEG before the shock is administered (called the pre-ictal EEG), using deep learning algorithms, to determine the adequate dosage of the electric stimulus needed. Once the EEG signals were decomposed using Fast Fourier Transform (FFT), we fed them into the Fuzzy Causal Effect Variational Auto Encoder (FCEVAE) deep learning algorithm. We implemented an FCEVAE model to identify patterns in patients' pre-ictal EEGs that lead to positive or negative outcomes of the ECT session. These outcomes were determined by the clinician in charge of the ECT session, based on the EEG assessment. A total of 470 EEGs were collected. The FCEVAE seems able to predict individualized ECT dosages based on the patient's pre-ictal EEG. The FCEVAE model had an overall accuracy of 90.33%, as measured by the root mean square measure. The use of FCEVAE seems promising in the field of EEG analysis and ECT, although further research is needed to optimize the model and its clinical applications.

Keywords. Artificial Intelligence, Electroconvulsive therapy, ECT, Causal transformers, Electroencephalogram, EEG

1. Introduction

Major Depressive Disorder (MDD) became the leading cause of disability worldwide in 2012 [1]. Even if a good share of patients will respond adequately to an antidepressant medication, about one third will be considered treatment-resistant [2]. Moreover, MDD can lead to some life-threatening situations, like catatonic syndrome or active suicidal ideations that need rapid-acting treatments. Electroconvulsive therapy (ECT), one of the oldest therapies in the field of psychiatry, remains the most effective treatment for severe depressive disorder, especially in the case of treatment-resistant or life-threatening depression [3].

The principle of this therapy is to induce a generalized seizure with the administration of an electric current that passes into the brain, using electrodes that are placed on the scalp. The generalized seizure induced and the dose of electricity used have various and lasting effects on the central nervous system [4]. However, a seizure alone is not sufficient to produce a therapeutic effect, and generalized seizures can be induced without generating any antidepressant effects [5]. The seizure threshold is defined as the

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minimum charge that will induce an unambiguous generalized seizure. This threshold depends on the patient and several factors: age, sex, current medications, electrode placement, pulse width and recent ECT treatments [6]. A therapeutic seizure will be obtained when the delivered electric charge is above the seizure threshold, using a multiplier that depends on the various sites on the scalp where the stimulus is delivered. Additionally, one of the major drawbacks of this treatment is the possibility of the occurrence of cognitive adverse effects that can result in cognitive impairment and memory loss [7]. These cognitive side-effects are proportional to how much the stimulus dose is above a patient's threshold [8]. Hence, there is a constant need to assess the adequacy of the charge delivered, with a trade-off between efficacy and cognitive side-effects.

Presently there are two main techniques to assess the amount of charge to deliver: the age-based method and the titration method. In the age-based method, the electric charge is simply determined according to the patient's age, depending on the site of the stimulus (e.g., 2.5 times the age for bitemporal stimulation). The amount of the charge is supposed to be around the adequate suprathreshold ratio. In the titration method, the seizure threshold is determined using increasing charges, starting with the lowest, so as to find the minimal charge that induces a seizure. Then a multiplier is applied, depending on the site of the stimulus, to get the adequate suprathreshold ratio (e.g. 2 times for bitemporal stimulation). Each method has advantages and drawbacks, and there is still some debate about the best method to use [9].

Finally, ECTs are performed under anesthesia. Electroencephalograms (EEGs) are recorded during the ECT session, to assess the quality of the seizure, from the beginning of the anesthesia until the end of the seizure. Recently, mental healthcare professionals, in collaboration with Artificial Intelligence (AI) researchers, started using machine learning algorithms to predict successful and unsuccessful ECT sessions [10]. Hence the aim of the present study is to assess if AI is able to predict the adequate dose to deliver to the patient, analyzing the pre-shock EEG (called the pre-ictal EEG).

2. Method

Ethics approval was first obtained from the ethics committee of the Centre intégré universitaire de santé et de services sociaux de la Mauricie-et-du-Centre-du-Québec. We first anonymized data gathered from ECT sessions at the Ste-Marie Hospital in Trois-Rivière, Quebec, Canada. EEGs that were recorded during the ECT sessions were used to train AI. To extract the underlying elements in EEGs causing successful and unsuccessful ECT sessions, we performed data pre-processing, and applied causal deep learning algorithms to the pre-ictal data.

To prevent obtaining dense- and low-dimensional latent space, which would negatively influence the Deep Learning (DL)'s performance [11], we used Convolutional Neural Network and Long-Short Term Memory (CNN-LSTM) architecture [12]. Next, to remove the noise from the EEGs, which occurs when an electric charge is applied to the patient's skull, we used Moving Average Technique (MAT) [10]. We then divided the EEGs into pre-ictal EEGs and after-shock parts. EEGs contain some hidden patterns that DLs cannot process [10]. In our case, Fast Fourier Transformation (FFT) was the best technique that revealed the frequency and amplitude of the components hidden in EEGs to DLs. Then we fed the FFT's output to an autoencoder variational-based DL called Fuzzy Causal Effect Variational autoencoders (FCEVAE) [11].

FCEVAE is a fuzzy version of Causal Effect Variational autoencoders (CEVAE) [13]. We added causal fuzzy rules to CEVAE to create Fuzzy CEVAE or FCEVAE [14]. We first used FCEVAE to detect good and bad EEGs. These outcomes were determined by the clinician in charge of the ECT session, based on the EEG assessment. In our next step, we used FCEVAE to predict the amount of charge to be applied to the patients' skulls.

3. Results

A total of 470 EEGs were collected. Out of these, 350 were used to train the FCEVAE model, while 120 were reserved for testing. The FCEVAE model had an overall accuracy of 90.33%, as measured by the root mean square measure (Table 1). However, it takes about 30 minutes for FCEVAE to predict the charge to be applied to the patient's skull. This is a big flaw as mental healthcare professionals cannot wait 30 minutes before applying the shock to the patient's skull. One reason for FCEVAE being slow is that it is small compared to bigger DLs such as Transformers which have billions of neurons.

The use of FCEVAE seems promising in the field of EEG analysis and ECT, although further research is needed to optimize the model and its clinical applications. In our future work, we will be using Transformerbased DLs such as GPTchat architecture. The objective is to reach a computing speed around one minute, in order to get the use of the AI compatible with the clinical practice.

Table 1. Outcomes related to training/test statistics for FCEVAE

	N		Age mean (SD)	EEG (nb)	Charge Administrated Mean (%)	Predicted Charge Mean (%)	RMSE	Network Accuracy	p
	Female	Male							
Training	19	19	61.21 (4.94)	350	51.44	48.77	0.04	94.25%	0.0293
Testing	6	5	59.91 (3.82)	120	50.61	49.33	0.06	90.33%	0.0366

Note. SD : standard deviation; nb : number; RMSE : Root Mean Square Error.

References

[1] World Health Organization, 2017.
[2] Rush AJ, Warden D, Wisniewski SR, et al. STAR*D: revising conventional wisdom. CNS Drugs. 2009; 23:627-47.
[3] UK ECT Review Group, 2003.
[4] Merkl A, Schubert F, Bajbouj M. Antidepressant electroconvulsive therapy: mechanism of action, recent advances and limitations. Experimental Neurology. 2009; 219: 20-6.
[5] Lambourn J, Gill D. A controlled comparison of simulated and real ECT. British Journal of Psychiatry. 1978; 133:514-519.
[6] Dunne RA, McLoughlin DM. ECT prescribing and practice. In: Waite J, Easton A, editors. The ECT handbook third edition. Glasgow (UK): Bell and Bain Limited; 2013. P 33.
[7] Semkovska M, McLoughlin DM. Objective cognitive performance associated with electroconvulsive therapy for depression: a systematic review and meta-analysis. Biological Psychiatry. 2010; 68: 568-77.
[8] McCall WV, Reboussin DM, Weiner RD, et al. Titrated moderately suprathreshold fix high-dose right unilateral electroconvulsive therapy: acute antidepressant and cognitive effects. Archive of General Psychiatry. 2000; 57:438-44.
[9] Lemasson M, Rochette L, Galvao F, et al. Pertinence of Titration and Age-Based Dosing Methods for Electroconvulsive Therapy. Journal of ECT. 2018; 34:220-6.
[10] Kalantarpour C, Faghihi U, Roucaut FX. Using Deep Learning algorithms to detect the success or failure of the Electroconvulsive Therapy (ECT) sessions. The Thirty-Fourth AAAI Conference on Artificial Intelligence (AAAI-19). 2021.
[11] Faghihi U, Kalantarpour C, Saki A. Causal Probabilistic Based Variational Autoencoders Capable of Handling Noisy Inputs Using Fuzzy Logic Rule. Science and Information Conference. 2022; 190-202.
[12] Sainath TN, Vinyals O, Senior A, et al. Convolutional, long short-term memory, fully connected deep neural networks. IEEE international conference on acoustics, speech and signal processing (ICASSP). 2015; 4580-84.
[13] Louizos C, Shalit U, Mooij JM, et al. Causal effect inference with deep latent-variable models. Advances in Neural Information Processing Systems. 2017.
[14] Faghihi U, Robert S, Poirier P, et al. Association to Reasoning, an Alternative to Pearl's Causal Reasoning. Proceedings of AAAI-FLAIRS. North-Miami-Beach (Florida). 2020.

Virtual Standardized Patients for Cognitive Behavioral Therapy Training: Description of Platform Architecture

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Abstract. There is a significant need for novel technologies that allow clinicians-in-training to practice with an interactive virtual standardized patient (VSP; based on real-life patients). Building on previous successes, virtual reality, artificial intelligence (AI), and natural language processing (NLP) technologies are used to develop and test a robust web-based Virtual Insomnia Patients™ (VIPs) platform. The AI-VIP responds strategically to input by utilizing a combination of expert VSP systems and deep learning techniques. The expert system uses the content collected from the Structured Clinical Interview for Sleep Disorders. Our VIPs involve a hybrid design process that mixes Agile and User-Centered iterative approaches with 3 main components: 1) realistic and artificially intelligent avatars for interacting with training clinicians; 2) a front-end system that implements multiple virtual avatars of varying race, ethnicity, and genders built using the Unity game engine; 3) back-end system that handles data storage, automates diagnostic accuracy and therapist fidelity measures to provide real-time comparison and feedback. The real-time feedback system employs natural language processing of a trainee's textual interactions with the VIP using computational models from the language used by real-life trained therapists. The VIP platform involves a universal storage language for the VIP dialog and symptoms that is updatable by trained clinicians, as well as a standardized 3D model system for the avatars allowing the selection of animations to match symptoms. VIPs will increase the availability of treatment, improving service members' psychosocial functioning, psychological and physical health, and overall fitness and decreasing accidents and military expenses.

Keywords. Virtual standardized patients, artificial intelligence, psychology, learning technologies

1. Introduction

Sleep is a biological requirement that is crucial for maintaining physical and psychological health and resiliency [1]. Impaired sleep in the form of insomnia is characterized as a deficiency in the amount or quality of sleep that negatively impacts waking activities for more than one month. [2] Insomnia is a significant risk factor for psychological health conditions (e.g., depression, anxiety, PTSD, substance use disorders and suicide) and psychosocial problems (e.g., irritability, fatigue, reduced

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quality of life, and concentration problems) [3]. While insomnia is often treated with medication, side effects and dependency represent significant risks.

An alternative to pharmacotherapeutic approaches to treating insomnia, cognitive behavioral therapy for insomnia (CBT-I) promises substantial benefits with minimal risks. As a treatment approach, CBT-I focuses on inducing cognitions and behaviors related to sleep. [4]. It is important to note that CBT-I has been found to be efficacious for intervening with clinically diagnosed insomnia and is considered the gold standard therapeutic intervention recommended by both the American College of Physicians [5] and the American Academy of Sleep Medicine [6]. Moreover, CBT-I has been found to be the preferred treatment over medication for individuals with insomnia [7]. Further, CBT-I offers more long-lasting benefits than medication [8].

While cognitive behavioral therapy for insomnia (CBT-I) has considerably more long-term effectiveness than medications, there are two important limitations: 1) CBT-I is frequently unattainable for many persons experiencing insomnia who may well receive substantial assistance from it [9]; and 2) there are not enough providers trained to deliver CBT-I, partially because there are too few training opportunities.

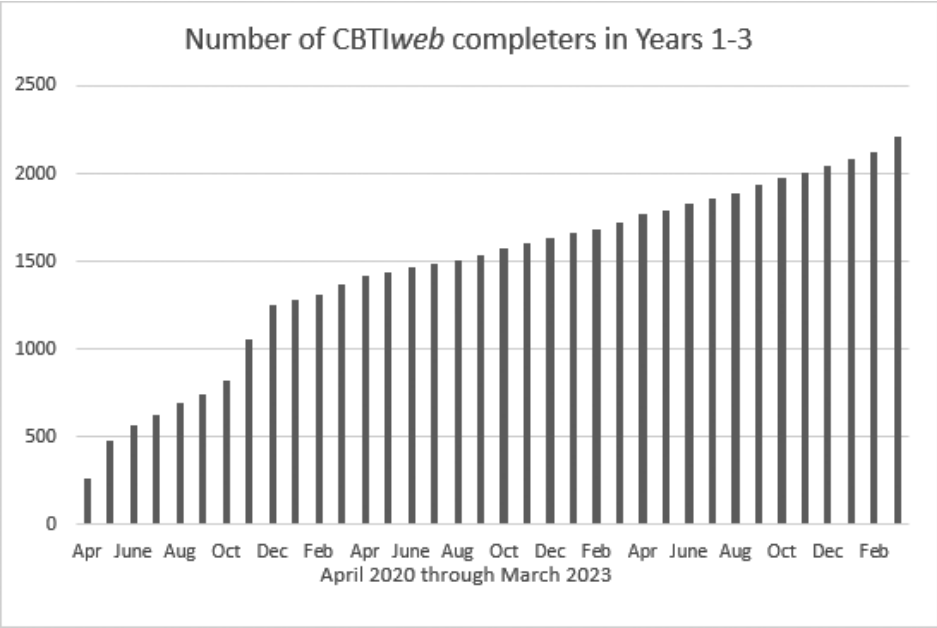

Figure 1. Number of CBT-I Web completers.

Digital approaches to CBT-I are emerging as technology advance. These digital CBT-I approaches use computational technologies like personal computers, the Internet, tablets, smartphone applications, and other devices in telehealth. Moreover, these digital health applications are actively being developed and researched [10, 11 see 12 for a recent meta-analysis]. These CBT-I platforms are not only designed with the chief mechanisms of CBT-I but also deliver added levels of personalized care to improve user engagement, together with the usage of email cues, signals, alarms, etc. Moreover, digital interventions using CBT-I allows users to assess their sleep condition through online sleep diaries, surveys, and/or syncing with other algorithmic devices such as wrist-worn actigraph applications that track various sleep patterns and gather ecological momentary assessment data. Results from a recent quantitative meta-analysis revealed that internet-based CBT-I had significantly greater impacts on limiting insomnia severity and comorbid factors (e.g., depression and anxiety). Further, these improvement effects were maintaining at a 6-month follow-up. These results suggest support for digital approaches that implement CBT-I. It also suggests that digital approaches to CBT-I are effective treatment alternatives for insomnia interventions in terms of clinical effectiveness and positive user satisfaction. All this is couched in a demonstration that the digital CBT-I intervention was successful in its impact on comorbid anxiety and depression [13].

We developed and tested CBTIweb as a user-friendly and engaging training platform to increase provider access to CBT-I training [14, 15]. Since its launch (April 1, 2020), CBTIweb has provided an entire course of didactic training (equivalent to a typical 8-hour workshop provided by leaders in the field) to more than 1400 providers. Thus, CBTIweb is clearly addressing the shortage of providers trained in CBT-I. In comparison to CBTIweb, only 1050 Veterans Administration (VA) providers have completed the in-person didactics in the past 10 years as part of a national dissemination of CBT-I (see Figure 1). An important limitation for both CBT-I in-person and CBTIWeb is that after didactic training CBT-I, clinicians require supervised clinical training to achieve competence with human standardized patients (HSPs). Given that it is not always feasible for clinicians in training to interact with patients with the full range of psychiatric disorders during training, HSPs (actors hired to portray patients) are nearly ubiquitous in current clinical education [16], and have been used to evaluate the skills of clinicians in training with objective structured clinical examinations (OSCE).

Unfortunately, HSPs are limited by high costs, training efforts, and inconsistencies in their ability to accurately depict patients. In addition, new standardized patients often need to be trained every year, requiring more costs, variance, and trainer time. Thus, there is a serious need for technology that allows clinicians in training to practice CBT-I first with interactive Virtual Standardized Patients that are based on real-life patients before their supervised clinical training. The use of computer-generated Virtual Standardized Patients is progressively appealing as technological enhancements are allowing for the production of Virtual Standardized Patients that are consistent and realistic [17-20]. Virtual Standardized Patients can be developed to reflect a wide variety of clinical symptoms and behaviors useful in teaching clinical trainees critical thinking and diagnostic acuity. Virtual Standardized Patients can also be used in the evaluation of clinical management strategies.

2. Virtual Insomnia Patient™ Platform and Architecture

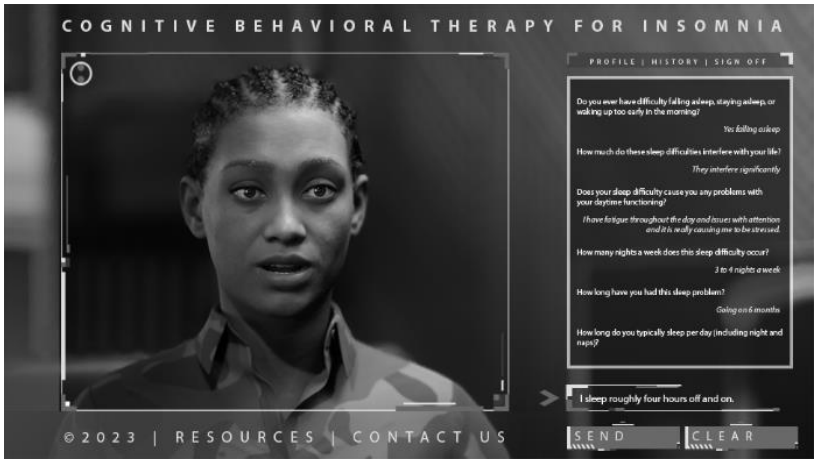

Figure 2. Virtual Insomnia Patient™.

Building on our previous successes, we utilize state-of-the-science virtual reality, artificial intelligence (AI), and natural language processing (NLP) technologies to develop and test a robust web-based Virtual Insomnia Patients™ (VIPs) platform (see Figure 2). The VIP AI responds strategically to provider input by utilizing a combination of expert systems and deep learning techniques such as the transformer architecture. The expert system uses the content collected from the Structured Clinical Interview for Sleep Disorders (SCISD) and military CBT-I studies, stored in the VIP content storage system, as its knowledge base.

Our VSPs involve a hybrid design process that mixes Agile and User-Centered iterative approaches with 3 main components: 1) realistic and artificially intelligent

avatars for interacting with training clinicians; 2) a front-end system that implements multiple virtual avatars of varying race, ethnicity, and genders built using the Unity game engine; 3) back-end system that handles data storage, automates diagnostic accuracy and therapist fidelity measures to provide real-time comparison and feedback. The real-time feedback system employs natural language processing of a trainee's textual interactions with the VIP using computational models from the language used by real-life trained therapists (See Figure 3).

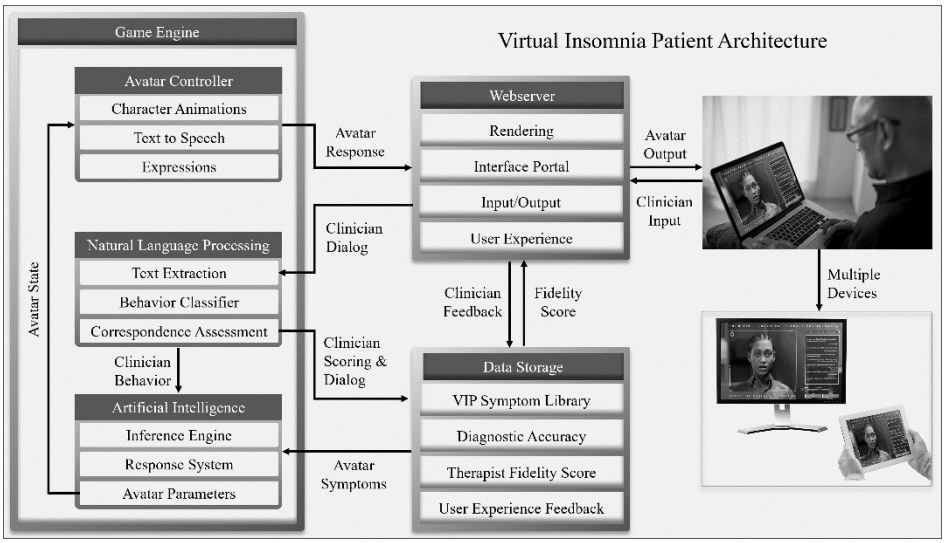

Figure 3. Virtual Insomnia Patient™ Platform Architecture.

The VIP platform involves a universal storage language for the VIP dialog and symptoms that is updatable by trained clinicians, as well as a standardized 3D model system for the avatars allowing the selection of animations to match symptoms. This design relies on rapid internal and external testing to get user experience data throughout all iterations of development which is possible due to the idea that each of the sub-components of the platform can be built and tested independently and then merged with minimal effort.

3. Conclusion

Good sleep is crucial for sustaining physical and psychological health and resiliency. Insomnia is a significant risk factor for mental (depression, anxiety, PTSD, substance use, suicide) and psychosocial (e.g., irritability, fatigue, reduced quality of life, and concentration problems) problems: accidents, disability, work problems (e.g., absenteeism), and attrition. Military Healthcare costs for insomnia are unknown, but civilian healthcare costs are estimated to be $107 billion per year.

Medications are the most commonly used treatments for insomnia in military populations but have significant side effects (e.g., slowed cognitive processing and reaction time) that are dangerous in a military environment. Cognitive behavioral therapy for insomnia (CBT-I) is the first line recommended treatment for insomnia, resulting in similar short-term and considerably better long-term outcomes than medications.

However, there is a critical lack of providers competently trained to provide CBT-I, due in part to the limitations of available training options. Our group is addressing one barrier to the dissemination of CBT-I, via our development of the web-based provider training program (CBTIweb), which offers low-cost didactic training to interested providers. In the 16 months since CBTIweb was made available online, 1488 (93/mo) providers per month have completed all training and passed a comprehensive post-test. Thus, CBTIweb is clearly capable of addressing the shortage of providers trained in CBT-I.

Newly trained therapists require supervised practical clinical training to achieve competence to deliver the intervention (e.g., CBT-I). Thus, the next major hurdle for CBT-I dissemination, as well as other interventions, is how to obtain adequate, cost-effective realistic practice and supervision in the diagnosis and treatment of insomnia after didactic training (in-person or otherwise). Traditionally, new/student psychological and medical health trainees gain practical experience through a stepwise combination of 1) role-playing with other students or human standardized patients (HSPs, i.e., persons recruited and trained to exhibit the characteristics of a Real patient) followed by 2) treatment of Real volunteer patients (often at low/no-cost training clinics), both under close supervision and consultation by an expert. HSPs also have drawbacks, such as high costs and training efforts and inconsistencies in their ability to accurately depict patients and high turnover from year to year. When multiplied across years and training facilities (i.e., DoD, VA, and civilian), the additive cost of HSPs can be substantial. Moreover, while practicing with HSPs is the ideal training model, the reality is that most training that occurs in practicing professionals typically is not associated with any additional supervised experience.

We can now develop realistic Virtual Standardized Patients that can reduce cost, ensure standardization, faithfully model physical symptoms, and provide real-time feedback to providers-in-training. Herein, we describe the first Web-based Virtual Insomnia Patient™ program that aims to disseminate CBT-I training. The Virtual Insomnia Patients™ proffer the comprehensive, standardized, engaging elements of an in-person standardized patient while eliminating the most substantial barriers to providers: high cost, time constraints, and inconsistency. The Virtual Insomnia Patient™ platform provides therapists-in-training with the practical assessment and therapy practice needed for readying themselves to efficaciously provide CBT-I interventions with “real” patients.

The latest iteration of our Virtual Standardized Patients project is the development of Virtual Insomnia Patients™ for automating and accelerating dissemination of first-line CBT-I for providers-in-training that complete in-person or online (CBTIweb) didactic training. The short-term impact will be massive dissemination of CBT-I across the military, veteran, and civilian providers-in-training via a highly efficient Web-based training program and competency development tool (accessible for minimal cost to the learner). We expect this training program will result in knowledge gains similar to, or better than, those of an in-person standardized patient practical training with respect to learning and behavior. Virtual Insomnia Patients™ should be more efficient and cost-effective. The Virtual Insomnia Patients™ project aims to have a long-term impact on the overall health of the 20% of service members suffering from chronic insomnia by drastically improving access to quality, evidence-based, non-pharmacological treatment. In addition, once fully developed and validated, this platform can be easily modified to have the same paradigm-shifting increase in training efficiency for other important evidence-based interventions like posttraumatic stress disorder (PTSD), depression, suicide, etc. The ultimate goal is to rapidly train providers to a level of competence that will allow them to provide the most effective treatments to service members with insomnia as well as other disorders such as PTSD, anxiety, and depression.

References

[1] Parrino L, Vaudano AE. The resilient brain and the guardians of sleep: new perspectives on old assumptions. Sleep Medicine Reviews. 2018 Jun 1;39:98-107.

[2] American Academy of Sleep Medicine. The International Classification of Sleep Disorders: Diagnostic and Coding Manual. 2nd ed. Westchester, IL: American Academy of Sleep Medicine; 2005

[3] Fernandez-Mendoza J, Vgontzas AN. Insomnia and its impact on physical and mental health. Current psychiatry reports. 2013 Dec;15:1-8.

[4] Morin CM, Vallieres A, Guay B, et al. Cognitive behavioral therapy, singly and combined with medication, for persistent insomnia: a randomized controlled trial. JAMA. 2009;301(19):2005–2015.

[5] Qaseem A, Kansagara D, Forciea MA, Cooke M, Denberg TD Clinical Guidelines Committee of the American College of Physicians. Management of chronic insomnia disorder in adults: a clinical practice guideline from the American College of Physicians. Ann Intern Med. 2016;165(2):125–133.

[6] Schutte-Rodin S, Broch L, Buysse D, Dorsey C, Sateia M. Clinical guideline for the evaluation and management of chronic insomnia in adults. J Clin Sleep Med. 2008;4(5):487–504.
[7] Vincent N, Lionberg C. Treatment preference and patient satisfaction in chronic insomnia. Sleep. 2001;24(4):411–417.
[8] Riemann D, Perlis ML. The treatments of chronic insomnia: a review of benzodiazepine receptor agonists and psychological and behavioral therapies. Sleep Med Rev. 2009;13(3):205–214.
[9] Smith MT, Neubauer DN. Cognitive behavior therapy for chronic insomnia. Clin Cornerstone. 2003;5(3):28–40.
[10] Soh HL, Ho RC, Ho CS, Tam WW. Efficacy of digital cognitive behavioural therapy for insomnia: a meta-analysis of randomised controlled trials. Sleep medicine. 2020 Nov 1;75:315-25.
[11] Tsai HJ, Yang AC, Zhu JD, Hsu YY, Hsu TF, Tsai SJ. Effectiveness of digital cognitive behavioral therapy for insomnia in young people: Preliminary findings from systematic review and meta-analysis. Journal of Personalized Medicine. 2022 Mar 16;12(3):481.
[12] Lee S, Oh JW, Park KM, Lee S, Lee E. Digital cognitive behavioral therapy for insomnia on depression and anxiety: a systematic review and meta-analysis. NPJ Digital Medicine. 2023 Mar 25;6(1):52.
[13] Ye YY, Zhang YF, Chen J, Liu J, Li XJ, Liu YZ, Lang Y, Lin L, Yang XJ, Jiang XJ. Internet-based cognitive behavioral therapy for insomnia (ICBT-i) improves comorbid anxiety and depression—a meta-analysis of randomized controlled trials. PLoS One. 2015 Nov 18;10(11):e0142258.
[14] Wilkerson AK, Wardle-Pinkston S, Dietch JR, Pruiksma KE, Simmons RO, Bunnell BE, Taylor DJ. Web-based provider training of cognitive behavioral therapy of insomnia: engagement rates, knowledge acquisition, and provider acceptability. Cognitive Behaviour Therapy. 2022 Jul 4;51(4):343-52.
[15] Taylor DJ, Dietch JR, Pruiksma K, Calhoun CD, Milanak ME, Wardle-Pinkston S, Rheingold AA, Ruggiero KJ, Bunnell BE, Wilkerson AK. Developing and testing a web-based provider training for cognitive behavioral therapy of insomnia. Military medicine. 2021 Jan;186(Supplement_1):230-8.
[16] May W, Park JH, Lee JP: A ten-year review of the literature on the use of standardized patients in teaching and learning: 1996-2005. Med Teach 2009; 31:487–492.
[17] Parsons TD, Kenny P, Ntuen CA, Pataki CS, Pato MT, Rizzo AA, St-George C, Sugar J. Objective structured clinical interview training using a virtual human patient. Studies in health technology and informatics. 2008 Jan 1;132:357-362.
[18] Kenny PG, Parsons TD. Embodied conversational virtual patients. In Conversational agents and natural language interaction: Techniques and effective practices 2011 (pp. 254-281). IGI Global.
[19] Parsons TD. Virtual standardized patients for assessing the competencies of psychologists. In Encyclopedia of Information Science and Technology, Third Edition 2015 (pp. 6484-6492). IGI Global.
[20] Pataki C, Pato MT, Sugar J, Rizzo AS, Parsons TD, St George C, Kenny P. Virtual patients as novel teaching tools in psychiatry. Acad Psychiatry. 2012 Sep 1;36(5):398-400.

An Online Psychological Intervention focused on Body Compassion in Breast Cancer Survivors: A Pilot Study

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Abstract. Breast cancer diagnosis and related treatments lead to relevant physical and psychological consequences for patients and survivors. Online psychological intervention can be used to emotionally support women who received this diagnosis, helping them in the management of their emotions and in the elaboration of bodily issues. The present study explored the benefits related to an online home-based psychological intervention focused on Body Compassion and emotional issues after cancer. Eighteen women who received a breast cancer diagnosis in the past participated in four online psychological sessions weekly. Findings highlighted that participants showed a statistically significant decrease in their anxiety symptoms after the psychological intervention. Non-significant improvement emerged in depressive symptoms and Body Image perception. This study highlighted the possible benefits related to an online group psychological intervention focused on Body Compassion, and given suggestions for future research.

Keywords. Breast cancer, online psychological intervention, Body Compassion, emotions, anxiety, cancer survivors

1. Introduction

A breast cancer diagnosis and related treatments seriously impact women's physical and emotional well-being, even years after treatments [1]. Cancer journey could lead to relevant changes in breast cancer patients' and survivors' emotions, cognitions, and behaviors, impairing social relationships and their abilities in daily tasks [2]. For example, scientific literature shows that women could change the image and perception of their body after breast cancer [3]. The body is often perceived as an explicit remind of the diagnosis and a source of danger because of the fear of cancer recurrences. Thus, interoceptive sensations are usually assessed as a source of worry, leading to anxiety and depression [3-4]. Women may also tend to perform checking behaviors, searching for some nodules in their breasts in an obsessive way [4].

Promoting individuals' psychological resources to deal with bodily issues is indeed fundamental [3]. Studies demonstrated that an efficacy approach to coping with bodily issues could be self-compassion interventions, which specifically focus on the own body and its related emotion [5]. As a general definition, self-compassion is characterized by the tendency to treat themselves with kindness and support [6]. More specifically, Body Compassion (BC) aims to promote inner sensations' awareness and

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kindness towards the body [7]. People who show high BC generally tend to accept their bodies and physical vulnerabilities with a low level of anxious and depressive symptoms [8]. Accordingly, studies showed that psychological intervention could address a positive body image in breast cancer survivors, enhancing a compassion approach towards their body [3,9]. However, inequities (e.g., costs of transport, geographical distance, and difficulties in scheduling other appointments during everyday life) can limit access to psychological interventions, reducing individuals' participation in mental health programs [10]. In order to engage a broader sample of participants, telemedicine and new technologies offer innovative opportunities for psychological treatments, especially in terms of accessibility thanks to provide connections also in remote areas [11]. Moreover, online interventions are a cost-effective way that give the possibility to cope with psychological issues by staying connecting each other's and providing psychological interventions in groups [12]. In general, they are widely employed in the healthcare field to increase the accessibility to psychological interventions in a group and patient engagement [1,12]. This way, online psychological interventions are promising for the promotion of positive well-being in the overall population.

Despite the positive impact of BC programs and online interventions, specific online and tailored psychological interventions to promote Body Compassion in breast cancer survivors are still lacking [1]. Therefore, the present study assessed a one-month psychological intervention in a group focused on BC to promote positive emotions and Body Image in breast cancer survivors through an online psychological program.

2. Methods

This study was performed in line with the principles of the Declaration of Helsinki. Eighteen women voluntarily agreed to participate in the present study and signed an informed consent before enrollment. They were required to be over 18 years of age and with a history of breast cancer. People who showed cognitive impairments and/or psychiatric symptoms that did not allow participation in the group intervention were excluded. Regarding socio-demographical data, participants had an average age of 50.66 years (Age range: 34 – 69 years old; SD_{age} = 8.97). The majority of them obtained a University degree (61.1%), were married (66.7%), and had one or more children (55.6%). Moreover, 72.4% of participants lived in the northern regions of Italy, and the 55.6% of them have never been involved in psychological intervention.

All participants were invited to participate in a one-month online psychological intervention conducted by a psychotherapist with expertise in the psycho-oncological field. The intervention took place in March 2022 and was structured in four different sessions (one session a week). The sessions used a BC approach and were focused on the emotional consequences experienced by women after breast cancer. Specifically:

1. in the first session, the psychotherapist provided a theoretical background on BC to all women included in the intervention. Then, participants filled a table in which they evidenced maladaptive cognitive, emotional, and behavioral features associated with their body before and after diagnosis and oncological treatments. Results were shared in the online group;
2. in the second session, participants discussed coping behaviors (e.g., avoidance and checking) that worsen Body Image distress in the longer term. The psychotherapist also provided specific behavioral strategies to improve positive behaviors towards their body. For example, the psychotherapist invited women to a graduated exposure to their stressful sources;
3. in the third session, the psychologist proposed a relaxation technique to identify inner sensations and modify cognitive distortions about body perception. Particularly, women were instructed to stay in contact with their inner sensations, discovering their positive and negative emotions. Then, the psychotherapist provided some cognitive restructuring strategies to promote positive behavioral changes by managing dysfunctional Body Image-related schema (e.g., cognitive errors) and replacing faulty self-talk with a new positive one;

4. in the last session, participants reflected on their usual physical vulnerabilities and possible changes after the psychological intervention, assessing the unfolded day-to-day thoughts, emotions, and behaviors. At the same time, the psychotherapist provided them specific suggestions to stop self-perpetuating negative attitudes towards the own body.

Before and after the intervention, participants completed some questionnaires:

- the *Hospital Anxiety and Depression Scale* (HADS) [13]; this scale, composed of 14 items, assess symptoms related to anxiety and depression.
- The *Body Image Scale* (BIS) [14]; this scale consists of 9 items and assesses how people feel about their appearance and evaluates women's self-perception of their appearance, attractiveness, and body satisfaction.

3. Results

A within-subject analysis of variance (ANOVA) was conducted to compare the negative emotions of anxiety and depression and the Body Image scores reported by participants before and after the online psychological intervention. Data revealed a statistically significant reduction in the level of anxiety reported by breast cancer survivors after the intervention. No statistically significant differences emerged in the symptoms related to depression and Body Image perception before and after the intervention (Table 1).

Table 1. Descriptive statistics and ANOVA results of the explored variables

	Before psychological intervention (M, SD)	**After psychological intervention (M, SD)**	***F***	***p***	η^2
Anxiety	10.61(4.07)	8.38(4.18)	9.264	.007*	.353
Depression	7.11(3.70)	7.22(3.59)	.020	.888	.001
Body Image	31.05(8.59)	24.33(12.76)	3.692	.072	.078

4. Conclusion

The present psychological intervention promoted through four online sessions conducted by an expert psychologist in psycho-oncological issues evidenced the possible benefits of a BC program on breast cancer survivors' well-being. As a pilot study, findings highlight the possibility to decrease anxiety symptoms, which are some of the main emotional issues for breast cancer survivors [15]. Similarly, an online psychological intervention focused on BC might improve individual's awareness of interoception, reducing the fear of unknown inners sensations and, as a consequence, the fear of cancer recurrence. This way, women who had experienced breast cancer diagnosis and treatments might be more able to manage their bodily sensations and their related negative emotions after the psychological intervention, replacing a faulty self-talk on the own perception of frailty and vulnerability with a new positive one. However, no significant results emerged in reference to depression and Body Image. The relatively small and self-selected sample size as well as the absence of a control condition are limitations that must be taken into account. This way, future research should explore women's motivation to participate in an intervention focused on their needs to promote their physical and psychological well-being [16, 17,18]. Accordingly, literature highlight the relevance of support cancer patients 'commitment in

psychological intervention to promote well-being and share emotions [17]. Moreover, the adoption of online psychological interventions increasing engagement and managing bodily issues should be promoted in breast cancer survivors [19].

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References

[1] V. Sebri, I. Durosini, and G. Pravettoni, "The Body after Cancer: A Qualitative Study on Breast Cancer Survivors' Body Representation", International Journal of Environmental Research and Public Health 19.19 (2022): 12515. 15.

[2] F. Andreis, F. Meriggi, C. Codignola, I. Frigoli, T. Prochilo, S. Mutti, ... & A. Zaniboni, A. "Impact of a psycho-educational team in early breast cancer patients' coping strategies: the Venere project", Reviews on Recent Clinical Trials 13.4 (2018): 274-280.

[3] V. Sebri, I. Durosini, and G. Pravettoni, "How to address the body after breast cancer? A proposal for a psychological intervention focused on body compassion." Frontiers in Psychology 13 (2023): 8458.

[4] R. E. Harris, E. Ichesco, C. Cummiford, J. P. Hampson, T. L. Chenevert, N. Basu, S. M. Zick, "Brain connectivity patterns dissociate action of specific acupressure treatments in fatigued breast cancer survivors." Frontiers in Neurology 8 (2017): 298.

[5] Z. Latifi, S. Mozhgan, M. Shokoufe, "Evaluation of the effectiveness of self-healing training on self-compassion, body image concern, and recovery process in patients with skin cancer." Complementary therapies in clinical practice 40 (2020): 101180.

[6] E. González-Hernández, D. Campos, R. Diego-Pedro, R. Romero, R., R. Baños, R., L. T. Negi, and A. J. Cebolla, "Changes in the semantic construction of compassion after the cognitively-based compassion training (CBCT®) in women breast cancer survivors", The Spanish Journal of Psychology, (2021), 24

[7] S. Denu, "Impact of Acceptance and Body Compassion in Endometrial Cancer Patients." Diss. Xavier University, 2018.

[8] J. K. Altman, "Cross-validation of the body compassion scale in a sample of women in perimenopause." (2018).

[9] J. N. Kirby, "Compassion interventions: The programmes, the evidence, and implications for research and practice." Psychology and Psychotherapy: Theory, Research and Practice 90.3 (2017): 432-455.

[10] A. Packness, S. Wehberg, L. H. Hastrup, E. Simonsen, J. Søndergaard, J., F. B. Waldorff, "Socioeconomic position and mental health care use before and after first redeemed antidepressant and time until subsequent contact to psychologist or psychiatrists: a nationwide Danish follow-up study." Social Psychiatry and Psychiatric Epidemiology 56 (2021): 449-462.

[11] R. Elkaddoum, F. G. Haddad, R. Eid, & H.R. Kourie. Telemedicine for cancer patients during COVID-19 pandemic: between threats and opportunities. Future oncology, 16(18), (2020): 1225-1227.

[12] N. Naik, B. M. Hameed, S.G. Nayak, A. Gera, S. R. Nandyal, D.K., Shetty, ... & B. K. Somani, B. K. Telemedicine and Telehealth in Urology—What Do the 'Patients' Think About It?. Frontiers in Surgery, 9, (2022): 385.

[13] A. S. Zigmond, P. Snaith P, "The hospital anxiety and depression scale." Acta Psychiatr Scand. 1983, 67: 361-370. 10.1111/j.1600-0447.1983.tb09716.x.

[14] P. Hopwood, I. Fletcher, A. Lee, S. Al Ghazal, "A body image scale for use with cancer patients." European journal of cancer 37.2 (2001): 189-197.

[15] I. Durosini, S. Triberti, L. Savioni, V. Sebri, G. Pravettoni, "The Role of Emotion-Related Abilities in the Quality of Life of Breast Cancer Survivors: A Systematic Review." International Journal of Environmental Research and Public Health 19.19 (2022): 12704.

[16] V. Sebri, I. Durosini, D. Mazzoni, G. Pravettoni, "Breast Cancer Survivors' Motivation to Participate in a Tailored Physical and Psychological Intervention: A Qualitative Thematic Analysis." Behavioral Sciences 12.8 (2022): 271.

[17] L. Savioni, S. Triberti, I. Durosini, V. Sebri, & G. Pravettoni, Cancer patients' participation and commitment to psychological interventions: a scoping review. Psychology & Health, (2021) 1-34.

[18] I. Durosini, L. Savioni, S. Triberti, P. Guiddi, P., Pravettoni, G. "The motivation journey: a grounded theory study on female cancer survivors' experience of a psychological intervention for quality of life." International Journal of Environmental Research and Public Health 18.3 (2021): 950.

[19] M. J. Esplen, L. Trachtenberg, "Online interventions to address body image distress in cancer", Current opinion in supportive and palliative care (2020), 14(1), 74-79.

Therapists are Makers: Virtual Reality and Virtual Environments Creation Capability for the Treatment of Rare Cases of Phobia and Obsessive-Compulsive Disorders

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Abstract. Virtual Reality Exposure Therapy (VRET) a form of exposure treatment that leverages the technology and immersive properties of virtual reality has been used in mental health for several decades with clinical efficacy. Nowadays, several companies propose ready to use virtual environments (VE) for clinicians. However, in practice, therapists or researchers may face rare demands such as patients exhibiting unusual phobias or OCD that require specific therapeutic VEs not available on the market. Therefore, empowering therapist with the tools of a "maker" to create therapeutic VEs themselves for rare cases may be a potential solution. Consequently, this trial involving 8 rare single cases was designed to test this assumption and has three objectives: to assess if a therapist with no coding skills can construct multiple specific therapeutic VEs with a free game engine, to measure the potential therapeutic efficacy of VRET and the VEs for rare cases of phobias and OCD, and to ensure these VEs yielded presence. Psychometric scales were used to assess the effects of the treatment. There was a discernible reduction of the distinct phobia and OCD for each case and a statistically significant improvement on anxiety, mood and mental quality of life scores. The presence level was satisfactory. Despite these promising results, these were single cases and further research on the game engine accessibility for clinicians and trials with a large sample of rare phobias or OCD are encouraged.

Keywords. Virtual reality, phobia, obsessive-compulsive disorders, presence, game engine, virtual environments

1. Introduction

Since 2016 onward, Virtual reality (VR), a postmodern immersive media, has been gaining momentum with the mass production of VR equipment and pushing its boundaries with the emerging notion of metaverses. VR allows users to interact in real time with computer-generated environments and is increasingly being used by mental healthcare professionals for psychotherapy. Consequently, a growing number of companies have released numerous virtual environments (VE) ready for use by researchers and therapists in the context of virtual reality exposure therapy (VRET) sometimes also called VR assisted cognitive behavioral therapy. This type of psychotherapy enables patients to be exposed to anxiogenic situation for obtaining fear extinction in the framework of cognitive behavioral therapy (CBT) [1]. During the exposure component, reality is replaced by artificially created stimuli inside a computerized world [1]. Past clinical studies demonstrated the effectiveness of VRET in treating participants suffering from many common anxiety disorders (phobias etc.) or obsessive compulsive disorders (OCD) [2]. However, in practice, therapists or researchers may face rare demands such as patients exhibiting unusual phobias or OCD that required specific therapeutic VEs. Indeed, while various anxiety disorders and phobias (aviophobia, agoraphobia, etc.) have been treated successfully with VRET, other

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rarer ones have yet to be tested with this method. Another aspect of this problem is that the virtual environments required are usually not available on the market or not build by private companies as the inherent rarity is not of financial or commercial interest. It is in this context that empowering therapists with the tools of a "maker" able to create themselves therapeutic VEs for rare cases may be a potential solution. Consequently and for facilitating VE creation, Riva et al. proposed NeuroVR, a virtual reality platform that provides clinical professionals with a cost-free VE editor in 2007 [3]. Nowadays, therapists with minimal training can utilize powerful and free 3D game engines with user-friendly editors, making Riva et al.'s first initiative a possible response for treating rare cases in VR. To assess these hypotheses, a trial involving 8 rare single cases was designed with three objectives. Firstly, to evaluate if a therapist with no coding skills can construct multiple specific therapeutic VEs. Secondly, to measure the potential therapeutic effect of VRET and the VEs for rare cases of phobias and OCD. Lastly, this trial aims to ensure these VEs yielded presence with limited cybersickness.

2. Methodology

Prior to the inclusion, each participant signed individually an informed consent form listing the content of the experimental protocol in accordance with the declaration of Helsinki [4].

2.1. Sample

The sample is comprised of a compilation of 8 single case participants (5 women, 3 men) each respectively diagnosed with asbestophobia (fear of asbestos), brontophobia (fear of thunder), coulrophobia (fear of clowns), frigophobia (fear of cold), globophobia (fear of balloons), submechanophobia (fear of submerged human-made objects), harm OCD (fear of harming others) and OCD related to error responsibility. Diagnoses were established by the authors based on a semi-structured interview, the Anxiety Disorders Interview Schedule for DSM-5 (ADIS-5) [5].

The mean age of the sample was 34.0 years (SD 14.30), ranging from 18 to 53 years. The mean duration of the phobia or OCD was 11.25 years (SD 5.65) and the mean age of onset was 22.75 years (SD 12.56).

2.2. Assessments

Pre- and post-treatment measures were assessed using self-rated fear, obsessions, anxiety, mood and quality of life questionnaires with the following self-report scales:
Rare Phobia Related Cues Questionnaires (RCQ). As no validated questionnaire related to fear of thunder, asbestos, clowns, cold, balloons and submerged objects existed at the time of this study, questionnaires based on the same format than squalophobia [6] were constructed. Each scale is a 20-item questionnaire and hinges on the description of 20 phobia related situations that provoke anxiety. The items are rated from one to ten points. These instruments have yet to be validated on a large scale of subjects but was utilized nonetheless as there were no alternative solutions.

Yale-Brown obsessive-compulsive scale YBOCS is a 10-item scale administered by therapist in the form of a semi-structured interview to measure the severity of obsessions and compulsions [7]. This scale was registered with the two cases of OCD.

State Trait Anxiety Inventory (STAI Y-A and Y-B) [8]. Form A specifically assesses state-anxiety at the time of the test, and form B assesses trait-anxiety in general.

*Beck's Depression Inventory version II (*BDI-II) [9]. This 13-item scale allows for a quick self-evaluation of depression symptoms.

SF-12 quality of life questionnaire [10]. Quality of life was assessed with this 12-item scale assessing well-being on two composite scores: physical and mental.

Aside from pre/post measures, the *Subjective Units of Discomfort* (SUD) [11] was recorded at three regular intervals throughout each VR exposure session. It is a 10 or 100 points scale test which measures the perceived level of anxiety at a given time.

Presence level and cybersickness were registered after each session using the *Presence Questionnaire PQ v3.0* [12] and the *Simulation Sickness Questionnaire (SSQ)* [13]. The PQ consists of 32 items rated on a 7-point scale, assessing the participant's perception of presence. The SSQ is a 16-item instrument on a 4-point scale assesses motion sickness related symptoms exhibited in a simulation or virtual environment.

2.3. Procedure

Following the intake assessment and the diagnostic interview, all cases were invited to undergo a standardized treatment protocol consisting of 10 weekly sessions of 30 to 40 minutes for phobia cases and 11 sessions for OCD cases. The first four sessions were devoted to cognitive component of VRET and the methods were identical and executed as outlined by several authors [14, 15]. During these sessions, all participants were taught psychoeducation, anxiety management, cognitive restructuring, positive self-statements, and mental imagery. The two cases suffering from OCD were offered an additional fifth session to cover prevention response, a behavioral component especially aimed at OCD [15].

The procedures in the remaining six sessions comprised VR exposure to different VEs related to each of the rare phobias or OCD. The VR exposure was gradually anxiogenic, as the fear-provoking stimuli varied in difficulty inside a same VE. Participants were instructed, but never coerced, to enter the VE, remain close to the anxiogenic cues until the anxiety level had diminished and were regularly encouraged to review and apply the aforementioned cognitive and behavioral methods acquired during the four/five first sessions, as recommended for the delivery of therapeutic exposure and desensitization [15, 16].

2.4. Apparatus and Virtual Environments

The VR system included a Sony PSVR Head-Mounted Display or HMD coupled with a three degrees of freedom head tracker (latency < 18ms) exploited by the software Trinus.

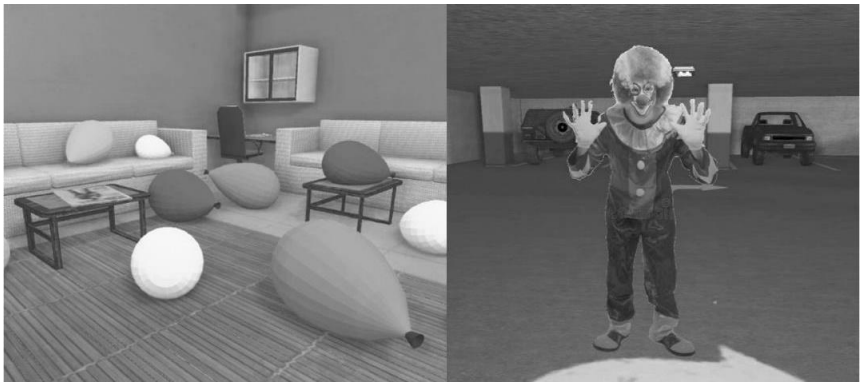

Figure 1,2,3 & 4. Screenshots of 4 out of 9 VEs created for the present study of single cases: several submerged human-made objects (up left), a cloudy sky with lightning (up right), colorful balloons in a living room (down left) and a clown in downtown (down right).

The latter enabled the subject to visually explore the environment in first-person view with the corresponding head movements performed in real time. A wireless remote control with a directional pad was also used, allowing various actions, from walking to swimming, to interacting with different 3D objects (such as grabbing balloons).

All virtual environments were constructed by the first author, a psychiatrist with no coding skills, who was trained in using the free game engine Unreal Engine 4 (Epic Games) specifically to address these disorders. This software was selected because of its accessibility, creation capability, VR compatibility, vast tutorial library, and the power of its visual scripting system [17]. Visual scripting allowed users with no coding skills to program events occurring in VEs. Training in exploiting this game engine for VE creation was carried out in a self-taught manner and for a total duration of 60 hours, using freely available video tutorial on YouTube as well as dedicated forum. VEs construction was based on the account of the situation and cues dreaded by each of the cases of this study. Consequently, the VEs comprised a series of houses with accessible roofs covered with asbestos materials, an accessible house and a coastline with cloudy sky and lightning, a downtown with multiple different clowns, a living room with switchable air conditioning system and refrigerator, a living room full of colorful movable balloons, a beach and a sea with various human-made submerged or floating objects, avatars that can be pushed and placed on a ridge, and a dining room with movable tables and breakable place settings. All VEs were constructed as open worlds where the participants were free to walk, swim or dive about.

3. Results

Seven participants completed the protocol (the participant with frigophobia opted out due to a high level of anxiety during initial VR exposures). Means and standard deviations of pre-post measures are reported in table 1. Concerning RCQ and YBOCS, pre-post comparison indicated that the treatment was associated with a discernible mitigation of all distinct phobias (42.90%) and obsessions/compulsions (30.87%). For all other measures, the Wilcoxon Signed Rank Test and effect sizes indicated a significant improvement in state-anxiety $Z=-2.37$ ($r=.63$), mood $Z=-2.38$ ($r=.64$) and the mental factor of quality of life $Z=-2.37$ ($r=.63$) following participation in the treatment program (all $p<0.025$). Repetitive SUD measurements for point anxiety (mean and maximum) throughout the 6 VR sessions are shown in table 2. A significant reduction in the mean and maximum level of anxiety was detected over time $Z=-2.36$ ($r=.63$) and $Z=-2.41$ ($r=.64$) respectively ($p<0.025$). Regarding immersion, presence rates were satisfactory (PQ = 116.14, SD = 12.63) and cybersickness was low (SSQ = 3.83, SD = 1.57).

Table 1. Means, standard deviations of the dependent variables and Wilcoxon Signed Rank Test of the results between Pre-and Post-test period (Time)

n	RCQ Pre-Post	YBOCS Pre-Post	BDI Pre-Post	STAI A Pre-Post	STAI B Pre-Post	SF12 Ph Pre-Post	SF12 Me Pre-Post
1	143 - 102		21 - 15	46 - 41	45 - 39	36 - 37	34 - 37
2	132 - 71		22 - 13	38 - 30	29 - 28	50 - 50	44 - 53
3	117 - 54		16 - 15	51 - 35	46 - 44	57 - 57	38 - 50
4*	151 - -		18 - -	62 - -	56 - -	38 - -	35 - -
5	126 - 59		14 - 13	45 - 31	29 - 28	51 - 52	41 - 47
6	137 - 88		21 - 16	49 - 39	19 - 19	42 - 40	40 - 43
7		24 - 15	22 - 19	43 - 38	46 - 47	52 - 53	31 - 35
8		28 - 21	23 - 22	46 - 43	51 - 50	50 - 50	28 - 30

n: participants' number, * drop out. RCQ: Rare Phobia Related Cues Questionnaires; YBOCS: Yale-Brown obsessive-compulsive scale, BDI-II: Beck Depression Inventory version 2, STAI-YA and -YB: State Trait Anxiety Inventory; SF-12 mental and physical quality of life questionnaire.

Table 2. Means and maximum scores of SUD Subjective Unit of Discomfort for the 6 VR exposure sessions.

VR session (n=7)	VR S1	VR S2	VR S3	VR S4	VR S5	VR S6
SUDmean (SD)	33.76 (15.01)	29.86 (13.20)	27,42 (8,98)	23,90 (9,38)	22,19 (8,48)	18.67 (9.87)
SUDmax (SD)	60,71 (12.05)	43,57 (15,73)	39,28 (14,56)	35,71 (15,39)	27,14 (12,20)	22,86 (10,74)

4. Conclusion

This research provides some evidence of the potential therapeutic effect of VRET for rare cases of phobias and OCD. Moreover, the therapist's self-taught construction of open-world virtual environments (VEs) using a 3D game engine elicited sufficient presence and yielded discernible clinical effects. The outcomes revealed a significant reduction in anxiety, worry, and depression, as well as an increase in the mental factor of quality of life. However, this is a compilation of rare and distinct cases, which limits the generalizability of the conclusions. Therefore, these results should be interpreted with caution until they are replicated in a large sample and with a control condition. Regarding the VE creation capability, the 60 hours needed to become proficient in constructing VEs may be a daunting duration for a therapist. However, with the emergence of Artificial Intelligence (AI) assisted creation of 3D objects using text prompts, such as Point-E from OpenAI also known for ChatGPT, the required training time could be dramatically reduced in the future. Lastly, evaluating the motivation and training time necessary for multiple therapists to acquire the skills to create VEs and the implication of AI would be a relevant initiative for addressing these unusual predicaments and, in doing so, enabling therapists to become makers in this fascinating century.

References

[1] Rothbaum BO, Hodges L, Ready D. Virtual reality exposure therapy for Vietnam veterans with post-traumatic stress disorder. Journal of clinical psychiatry 2001;62(8):617-22.

[2] Meyerbröker K, Morina N. The use of virtual reality in assessment and treatment of anxiety and related disorders. Clinical Psychology & Psychotherapy. 2021;28(3):466-76.

[3] Riva G, Gaggiolo A, Villani D, Preziosa A, Morganti F, Corsi R, et al. NeuroVR: an open source virtual reality platform for clinical psychology and behavioral neurosciences. studies in Health Technologies and Informatics. 2007;125:394-9.

[4] World Health Organisation WHO. World Medical Association Declaration of Helsinki. Bulletin of the WHO. 2001;79(4):373-4.

[5] Brown TH, Barlow D. Anxiety Disorders Interview Schedule for DSM-5 (ADIS-5 Adult Version). Oxford: Oxford University Press; 2014.

[6] Malbos E, Burgess GH, Lançon C. Virtual Reality and Fear of Shark Attack: A Case Study for the Treatment of Squalophobia. Clinical Case Studies. 2020;19(5):339-54

[7] Goodman WK, Price LH, Rasmussen SA, Mazure C, Fleishmann RL, Hill CL. The Yale-Brown obsessive-compulsive scale I. Development, use, and reliability. Archives Of General Psychiatry. 1989;46:1006-11.

[8] Spielberger CD. Manual for the STAI. Consulting psychologist press ed. Palo Alto CA1983.

[9] Beck AT, Steer RA, Brown TA. Beck Depression Inventory manual (2nd ed.). San Antonio: TX: Psychological Corporation. ; 1996.

[10] Gandek B, Ware JE, Aaronson NK. Crossvalidation of item selection and scoring for the SF-12 Health Survey in nine countries: results from the IQOLA Project International Quality of Life Assessment. Journal of Clinical Epidemiology. 1998;51(11):1171-78.
[11] Wolpe J. The Practice of Behavior Therapy. New York,USA: Pergamon Press; 1969.
[12] Witmer BG, Singer MJ. Measuring Presence in Virtual Environments: A presence Questionnaire. Presence: Teleoperators and Virtual Environments. 1998;7(3):225-40.
[13] Kennedy RS, Lane NE, Berbaum KS, Lilienthal MG. Simulator Sickness Questionnaire: An Enhanced Method for Quantifying Simulator Sickness. International Journal of Aviation Psychology. 1993;3(3):203-20.
[14] Beck AT, Emery G. Anxiety disorders and phobias : a cognitive perspective: Ed basic Books; 1985.
[15] Barlow DH. Clinical Handbook of Psychological Disorders. New York: The Guilford Press; 2007.
[16] Vincelli F, Choi YH, Molinari E. A VR-based multicomponent treatment for panic disorders with agoraphobia. Ios Press ed2001.
[17] Malbos E, Rapee RM, Kavakli M. Creation of Interactive Virtual Environments for Exposure Therapy through Game Level Editors: Comparison and Tests on Presence and Anxiety International Journal of Human-Computer Interaction. 2013;29(12):827-37.

Healthcare Professionals' Attitudes towards Virtual Reality for Cancer Patients

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Abstract. Virtual Reality is nowadays used in many contexts related to patient care and treatment, such as Parkinson's Disease, Alzheimer, Post-Traumatic Stress Disorder, and many other psychological symptoms (e.g., anxiety, depression) and pain. Virtual Reality is also largely used in oncological contexts, focusing on physical and psychological symptoms. Despite the benefits related to this technology in the healthcare setting - and particularly in the oncology area - it is not yet widely deployed. The aim of this study was to investigate oncologists' attitude towards Virtual Reality to deeper understand their thoughts in accordance with personality traits and individuals' characteristics. Results showed that oncologists perceived Virtual Reality as an *effective* and *reliable* tool to address *Education* and *Rehabilitation* medical purposes. Virtual Reality used for *Education*, *Relaxation*, and *Rehabilitation* were also considered by oncologists as significantly *easier to use and implement with their cancer patients* than Virtual Reality used for the *Reduction of Physical Pain*. Future studies may deeper explore oncologists' attitudes towards new technologies used in the clinical practice and the possible role of personal aspects influencing the acceptance of these technologies in healthcare context.

Keywords. Virtual Reality, Cancer, Oncology, Attitudes, Healthcare

1. Introduction

In recent years, Virtual Reality (VR) based solutions are increasingly being used in the healthcare world. VR is generally used to enhance patients' experience by effectively engaging them in health-related activities. Alongside the traditional medical procedures, this technology can bring benefits in a wide variety of areas related to patient care and treatment, such as Parkinson's Disease [1], Alzheimer [2], Post-Traumatic Stress Disorder (PTSD) [3], and many other psychological symptoms (e.g., anxiety, depression) [4] and pain [5]. VR can also be used in the oncological field, with a focus on physical and psychological aspects. After receiving a diagnosis of cancer, people may experience intense negative feelings, such as anxiety, stress, fear, and body-related symptoms, such physical performance limitation [6-7]. All these aspects bring among issues that negatively affect patients' well-being. Mitigating the negative-related symptoms of cancer diagnosis and promoting a better quality of life is a crucial part of the cancer journey [7-10]. Some studies have found encouraging results regarding the use of VR to increase satisfaction in oncological care, reduce cancer-related

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psychological symptoms and pain, and improve treatment adherence [11,12,13]. For example, studies showed that VR could support patients during different phases of cancer treatments by reducing their distress (e.g., during chemotherapy) [14,15]. Additionally, VR is a tool easy to use and without risk for participants. Moreover, it could be considered very inexpensive for health institutions [e.g., 16] and its use is still uncommon in the context of care [17]. For example, Tennant and colleagues [18] analyzed healthcare workers' acceptability of VR interventions in Australian oncological setting and found low levels of self-confidence towards VR. Healthcare professionals were also concerned about the absence of technical support and the time they would have to invest in using VR [18]. Exploring the healthcare professionals' attitudes towards new technology represent an important issue to better improve the introduction of technological entities in the context of care [19-21]. On these bases, the present study aims to understand oncologists' attitudes about the use of VR with cancer patients. Different scenarios were used to deeper understand professionals' thoughts about VR. Since attitudes can be influenced by personality traits [22] we tested the oncologists' personality using the Big Five Inventory (BFI) [23]. Lastly, we assessed the possible influence of self-confidence or belief in their ability to make decisions, including participation in shared decision making through the Decision Self Efficacy Scale (adapted for VR) [24] and the Brief Emotional Intelligence Scale (BEIS-10) [25] on professionals' attitudes.

2. Method

This study aimed to investigate oncologists' attitudes towards potential use of VR in the oncological setting. Twenty-nine professionals who work in an Italian hospital participated in this research (11 of them were oncologists, whereas 18 were oncology residents). Participants included in the study have an age range between 25 and 60 years old (M_{age}=32.97, SD_{age}=9.76; Gender: 19 Male, 10 Female) with a mean of 6.45 years of professional practice (*SD*=9.20; range: 0-34 years of professional practice). Each participant was invited to observe exemplifier images related to four specific types of Virtual Reality applications in the oncological field and read a brief description of the scenarious. The selected applications were related to the use of Virtual Reality for:

- *relaxation*: VR is used to promote relaxation in cancer patients during treatments' administration (e.g., chemotherapy). Soothing and calm scenarios and guided physical exercises (e.g., breathing exercises) were used to promote a greater awareness of patients' body sensations, helping them to reduce their level of arousal;
- *rehabilitation:* VR is used to improve physical rehabilitation through physical activities. The use of a viewer with an immersive scenario and joysticks may help patients to perform some typical physical movements related to some gaming activity from which they can benefit for the purposes of physical rehabilitation;
- *reduce physical pain:* VR is used to help patients to reduce their physical pain related to treatments and cancer journey. For example, the immersion in a virtual environment in which they perform actions and interact with objects may help them to shift their focus away from physical pain;
- *education:* VR is used to educate cancer patients about the procedures connected to oncological treatments. For example, simulated immersive environments of hospital rooms and treatment procedures may help patients to adequately understand the phases foreseen during the intervention.

Afterwards, in order to explore the attitudes of oncologists and oncology residents towards VR, participants were invited to rate on a 7-point Likert scale of agreement how much they perceive any application of VR as *Useful*, *Easy to Use and Implement with cancer patients*, *Effective, Reliable,* and *Innovative*. Other psychological variables

will also be assessed to explore any possible influence of these aspects on healthcare professionals' attitudes towards VR. Specifically, personality traits, decisional self-efficacy, and emotional intelligence were explored through the Big Five Inventory (BFI) [23], the Decision Self-Efficacy Scale (adapted for Virtual Reality) [24], and the Brief Emotional Intelligence Scale (BEIS-10) [25].

3. Results

Preliminary analyses showed that all the professionals included in this study did not personally use VR in their clinical practice with cancer patients and that this technology was not actually implemented in their hospital.

Repeated-measures Analysis of Variance (ANOVA) was used to investigate differences among healthcare professionals' attitudes towards different applications of VR in the oncological field (within-subject variable). Results showed that oncologist professionals perceived VR for *Education* and *Rehabilitation* as significantly more *effective* and *reliable* than VR used for *Relaxation* and *Reduction of Physical Pain*. VR used for *Education, Relaxation,* and *Rehabilitation* were also considered by oncologists as significantly *easier to use and implement with their cancer patients* than VR used for the *Reduction of Physical Pain*. No statistical differences emerged in the perception of *usefulness* and *innovativeness* of VR in the explored scenarios. Repeated-measures Analysis of Covariance (ANCOVA) was also conducted to explore if psychological traits influenced participants' attitudes towards VR used in the oncological field. Data showed that VR for *Education* and *Rehabilitation* were perceived as significantly more *reliable,* also when controlling for personality traits, especially neuroticism. Additionally, VR used for *Education, Relaxation,* and *Rehabilitation* were also considered significantly *easier to use and implement with cancer patients* than VR used for the *Reduction of Physical Pain,* also when controlling for neuroticism personality trait. No statistically significant results emerged for decision self-efficacy and emotional intelligence.

Table 1. ANOVA results and descriptive statistics of the professionals' attitudes towards VR used in the oncological context

	Reduce physical pain **M(SD)**	**Relaxation** **M(SD)**	**Rehabilitation** **M(SD)**	**Education** **M(SD)**	***F(df)***	***p***
Useful	4.79(1.37)	5.11(1.55)	5.07(1.63)	5.25(1.55)	.811	.491
Easy to use and implement with cancer patients	4.04(1.17)	4.86(1.41)	4.64(1.77)	4.86(1.24)	5.510	<.01
Effective	4.31(1.54)	4.55(1.64)	4.93(1.67)	5.03(1.52)	2.803	<.05
Reliable	4.32(1.39)	4.46(1.55)	4.71(1.61)	5.04(1.45)	2.781	<.05
Innovative	6.48(.78)	6.28(.92)	6.21(1.08)	6.52(.69)	1.634	.188

4. Conclusion

In this study, we assessed the attitudes towards VR of twenty-nine oncology or oncology residents who work in an Italian hospital. Participants were invited to observe images and read four scenarios of applications of this technology in the oncological field. Then, they were asked to rate their perceptions about the possible use of VR with specific purposes. Data showed that oncologists tend to perceive VR for *Education* and *Rehabilitation* as significantly more *effective* and *reliable* than VR used for *Relaxation* and *Reduction of Physical Pain*. In addition, VR used for *Education, Relaxation,* and *Rehabilitation* were considered by oncologists as significantly *easier to use and implement with their cancer patients* than VR used for the *Reduction of Physical Pain.*

It is possible that healthcare professionals who work in an oncological setting tend to perceive the use of virtual technologies as less effective and reliable for the treatment of physical symptoms related to the diagnosis and oncological treatments, such as treatment of pain. In these cases, oncologists may prefer to use other tools and treatments for the direct management of symptoms. On the contrary, the creation of situations closer to reality through VR may allow cancer patients to experience situations similar to real life due to the immersive environments and the high resolution. This could be useful especially for rehabilitation exercises and education purposes.

It is possible that the fact that none of the oncologists were not familiar with the use of VR may have impacted their attitudes towards it. According to the literature, familiarity with technology generally enhances the perception of its ease of use. Healthcare professionals who have prior experience or exposure to VR could find it easier to understand, thus increasing the likelihood of its adoption [26].

Future studies need to further assess oncologists' attitudes towards new technologies used in their clinical practice and in their teamwork, considering previous experience with VR for cancer patients on technology acceptance [19,20,27]. Additionally, it would be interesting to investigate the impact of socio-demographic characteristics (e.g., age and gender) on the VR implementation. The efficacy of VR within the oncological field also needs to be explored deeper with scientific studies.

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References

[1] Canning CG, Allen NE, Nackaerts E, Paul SS, NieuwboerA, Gilat M. Virtual reality in research and rehabilitation of gait and balance in Parkinson disease. Nat Rev Neurol 2020; 16(8), 409–425, doi:0.1038/s41582-020-0370-2

[2] White PJ, Moussavi Z. Neurocognitive Treatment for a Patient with Alzheimer's Disease Using a Virtual Reality Navigational Environment. Journal of experimental neuroscience 2016; 10, 129–135, doi:10.4137/JEN.S40827

[3] Kothgassner OD, Goreis A, Kafka JX, Van Eickels, RL, Plener PL, Felnhofer A. Virtual reality exposure therapy for posttraumatic stress disorder (PTSD): a meta-analysis. Eur J Psychotraumato 2019 10(1), 1654782. doi: 10.1080/20008198.2019.1654782

[4] Li H, Dong W, Wang Z, Chen N, Wu J, Wang G, Jiang T. Effect of a Virtual Reality-Based Restorative Environment on the Emotional and Cognitive Recovery of Individuals with Mild-to-Moderate Anxiety and Depression. International journal of environmental research and public health 2021 18(17), 9053. doi: 10.3390/ijerph18179053

[5] Pourmand A, Davis S, Marchak A, Whiteside T, Sikka N. Virtual Reality as a Clinical Tool for Pain Management. Curr Pain Headache R. 2018;22(8):53, doi: 10.1007/s11916-018-0708-2

[6] Ness KK, Wall MM, Oakes JM, Robison LL, Gurney JG. Physical performance limitations and participation restrictions among cancer survivors: a population-based study. Ann Epidemiol. 2006;16(3):197-205, doi: 10.1016/j.annepidem.2005.01.009

[7] Durosini I, Triberti S, Savioni L, Sebri V, Pravettoni G. The Role of Emotion-Related Abilities in the Quality of Life of Breast Cancer Survivors: A Systematic Review. Int J Env Res Pub He. 2022;19(19):12704, doi:10.3390/ijerph191912704

[8] Savioni L, Triberti S, Durosini I, Sebri V, Pravettoni G. Cancer patients' participation and commitment to psychological interventions: A scoping review. Psychology & Health. 2022;37(8):1022-1055, doi: 10.1080/08870446.2021.1916494

[9] Durosini I, Savioni L, Triberti S, Guiddi P, Pravettoni G. The motivation journey: a grounded theory study on female cancer survivors' experience of a psychological intervention for quality of life. Int J Env Res Pub He. 2021;18(3):950, doi: 10.3390/ijerph18030950
[10] Durosini I, Triberti S, Sebri V, Giudice AV, Guiddi P, & Pravettoni, G. (2021). Psychological benefits of a sport-based program for female cancer survivors: The role of social connections. Front Psychol. 5516, doi:10.3389/fpsyg.2021.751077
[11] Reynolds LM, Cavadino A, Chin S, Little Z, Akroyd A, Tennant G, Dobson R, Broom R, Gautier A. The benefits and acceptability of virtual reality interventions for women with metastatic breast cancer in their homes; a pilot randomised trial. BMC cancer 2022; *22*(1), 360, doi: 10.1186/s12885-021-09081-z
[12] Zasadzka E, Pieczyńska A, Trzmiel T, Hojan K. Virtual Reality as a Promising Tool Supporting Oncological Treatment in Breast Cancer. Int J Env Res Pub 2021; *18*(16), 8768, doi: 10.3390/ijerph18168768
[13] Desselle M, Holland L, McKittrick A, Kennedy G, Yates P, Brown J. "A Wanderer's Tale": The development of a virtual reality application for pain and quality of life in Australian burns and oncology patients. Palliat Support Care 2022; 1-7, doi:10.1017/S1478951522000530
[14] Schneider SM, Prince-Paul M, Allen MJ, Silverman P, Talaba D. Virtual reality as a distraction intervention for women receiving chemotherapy. *Oncology nursing forum*, 2004 *31*(1), 81–88, doi:10.1188/04.ONF.81-88
[15] Chirico A, Maiorano P, Indovina P, Milanese C, Giordano GG, Alivernini F, Iodice G, Gallo L, De Pietro G, Lucidi F, Botti G, De Laurentiis M, Giordano A. Virtual reality and music therapy as distraction interventions to alleviate anxiety and improve mood states in breast cancer patients during chemotherapy. Journal of cellular physiology, 2020 235(6), 5353–5362, doi:10.1002/jcp.29422.
[16] Palanica A, Docktor MJ, Lee A, Fossat Y. Using mobile virtual reality to enhance medical comprehension and satisfaction in patients and their families. Perspectives on medical education. 2019;8(2):123–127, doi: 10.1007/s40037-019-0504-7

Looking Through Your Eyes: Using Immersive Virtual Reality to Promote Well-Being among Cancer Survivors and Their Partners

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Abstract. The growing success of cancer therapy has increased the survival rates of many oncological diseases, posing the challenge of how to sustain survivors' well-being. Since partners are the most important source of support for patients, and their role is essential to successfully cope with the challenges associated with the disease, the current study aims to enhance the survivors' adjustment to the post-treatment life changes by focusing on the couple's well-being. An Embodied Perspective-Taking (EPT) paradigm will be implemented by using Virtual Reality (VR) to propose a VR Patient-Journey (VR-PJ) that guides the partner in feeling on their skin what their significant other is suffering and the problems they are facing. EPT will create in the participant the perceptual illusion of taking the perspective of the partner, allowing the caregiver to see through their eyes, from a first-person perspective, all the steps of the partner's oncological journey, from the diagnosis to the current daily life. Our hypothesis is that the VR-PJ will work as a transformative experience able to promote empathic communication and greater couple well-being.

Keywords. Virtual Reality, Cancer, Survivor, Well-Being, Partner, Transformative Experience, Perspective-Taking, Empathy, Communication

1. Introduction

The growing success of cancer therapy and detection has increased the survival rates of many oncological diseases. Consequently, the number of survivors is increasing over time, presenting the challenge of appropriately sustaining survivors [1]. Relationships represent a primary starting point for promoting their well-being. Partners are indeed the most important source of support for patients, and their role is essential to successfully cope with the challenges associated with the disease [2; 3]. Nevertheless, the complications that follow oncological treatments put a strain on the relationship, negatively affecting coping success throughout the survivorship [2]. Among the areas of interventions for improving the couple's well-being, communication is one of the most important [4]. Feeling understood is a key characteristic of emotional support, able to promote couple satisfaction [5] and functional dyadic coping [6]. In educational contexts,

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assuming the patient's perspective, and experiencing the steps of the medical journey through their eyes, showed a positive impact on empathy levels [7]: feeling what the Other is feeling creates a bridge between the experiences of the two people, promoting an emotional awareness of what is happening [8, 9, 10]. The use of a Patient-Journey (PJ) paradigm [11] provides certainly a framework for understanding the complex phases and numerous stages in the lives of individuals who have experienced different types of clinical conditions. To achieve this objective, the use of Virtual Reality (VR) represents an advantageous approach [12]. The embodiment of bodily experiences through VR offers a universal language capable of transcending individual variance, thereby facilitating the challenges associated with comprehending other people's emotions. Psychological experiences often have, in fact, an abstract nature, making them difficult to grasp universally due to individual differences in imagery and perspective-taking. VR circumvents these challenges by visually presenting participants with the necessary information, providing an immersive experience comparable to real-life situations [13], and inducing a sense of presence within the given scenario [14]. These distinctive attributes, combined with the ability to adopt the visual perspective of another individual fully embodying their experiences [15], have given VR the label of "*ultimate empathy machine*" [16]. The aim of our VR-PJ is thus to introduce a groundbreaking approach designed to empower partners in communicating with their significant others more empathically. By accomplishing this goal, we also expect to amplify the perceived support bestowed upon the cancer survivor, ultimately fostering closeness between the two individuals. We hypothesize that the VR-PJ will be more effective than theoretical VR training in boosting empathic communication and that its characteristic of being immersive and able to make up for possible difficulties in imagery (thus visually showing what is described as opposed to simply telling the steps of care) will play a role in promoting this change.

2. VR Patient-Journey and Its Potential as a Transformative Experience

2.1. Design

The VR-PJ has been structured according to the three-stage model proposed by Lamprell and Braithwaite [11]. Specifically, in the first stage (i.e., interruption of the Ordinary World and crossing the threshold into the Special World), the PJ describes entering the patient's condition: the new setting of the story becomes the health care system. During the second stage (i.e., Road of Trials and Obstacles), the patient describes the events and treatments, sharing perceptions and the personal impact of such experiences. Lastly, in the third stage (i.e., Road Back to New Normal), the patient's story concludes with the completion of the medical process: the patient contemplates a new conception of normalcy, incorporating lifestyle changes. In our VR-PJ, this model is narrated using an Embodied Perspective-Taking (EPT) paradigm. EPT creates in the participant the perceptual illusion of taking the perspective of the survivor, allowing the caregiver to see through their eyes [17]. Once the partner assumes the egocentric view, they will experience the oncological journey, from the diagnosis to the current daily life. Different avatars will be created depending on the type of oncological disease of the survivor (e.g., breast, gynecological, colon, or head and neck cancer, etc.). This experience will include multimodal stimulation (i.e., auditory - the storytelling of what the patient is thinking, feeling, or saying, and visual stimuli - all the steps of the journey seen from the perspective of the survivor) to create greater involvement in the task and a deeper perception of being in their significant other's body. Excerpts of the scenario can be found in Figures 1 to 4. The protocol will be carried out as a single-blind randomized controlled trial and will include both within (i.e., evaluation pre, and post-VR experience, and at 1-month follow-up) and between components. Regarding this latter characteristic, participants will be randomly allocated to one of the following experimental conditions:

Condition 1: *VR Patient-Journey (VR-PJ)*, characterized by visual and auditory stimulations along with immersiveness;

Condition 2: PC Patient-Journey (PC-PJ), represented by the same experience as the VR-PJ, but participants will use a pc (i.e., non-immersive);

Condition 3: AUDIO Patient-Journey (A-PJ), distinguished by the presence of the VR-JP storytelling alone. Partners will thus rely solely on auditory stimuli and imagery;

Condition 4: VR Theoretical Training on Empathic Communication (VR-TTEC), depicted by an avatar who will explain the importance of empathic communication, using an immersive scenario of the same length as the VR-PJ with no first-person perspective of the cancer journey steps.

2.2. Participants

The targets of the study are partners of female cancer survivors. We specifically chose to focus on male partners in light of gender differences observed in empathy, where male individuals more often compared to women encounter difficulties in adopting another person's perspective or "standing in their shoes" [18]. Couples will be considered eligible for recruitment if survivors underwent surgery (alone or in addition to other treatments), are in a relationship, are not in active treatment, and do not present comorbidities that are incompatible with the use of VR.

2.3. Procedure

Following the completion of self-reported questionnaires at the baseline, both the partner and the cancer survivor will engage in a role-playing exercise centered around a communication task. During this phase, physiological measures will be recorded. Subsequently, the partner will partake in the VR-PJ session, lasting approximately 30 minutes. After the VR-PJ experience, a post-VR-PJ assessment involving the same baseline measures will be administered, alongside the repetition of the initial communication task. To assess the potentially lasting effects over time, a follow-up evaluation will be conducted one month after the VR-PJ experience, involving only the completion of questionnaires by the participating couple. This follow-up will enable us to ascertain the persistence and durability of the observed effects following the VR intervention.

2.4. Measures

The study will employ self-reported questionnaires, physiological measures (e.g., heart rate), and a behavioral task to collect data concerning the emotional and cognitive states of participants before, during, and after the VR experience. Self-reports will collect information about psychological variables such as empathy, couple's satisfaction, well-being, perceived support, emotional closeness, and communication, as well as VR-related variables like sense of presence, embodiment, and cybersickness. Physiological measures will complete such evaluation helping to understand whether the VR experience increases the autonomic synchronization between the two partners [19]. To analyze if the partner is more empathic in communicating with their significant other, the dyad will also undergo a structured communication task, evaluated by the partner (i.e., perceived self-efficacy in communicating empathically), the survivor (i.e., perceived empathy in the partner's words), and external evaluators (trained *ad hoc* to identify verbal and non-verbal cues of empathic communication).

Figure 1

Figure 2

Figure 3

Figure 4

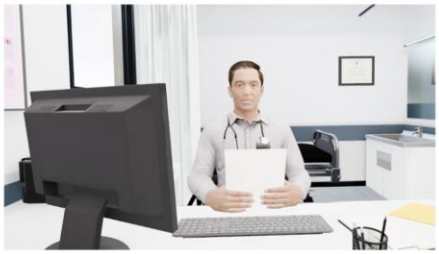

Figure 1. The person receives the screening results. **Figure 2.** After receiving the screening results, she tells her partner that she must go to the hospital for a medical visit. **Figure 3.** The person is in the hospital, looking for the waiting room. **Figure 4.** The person meets the physician for the medical visit.

3. Discussion

The current VR experience aims to improve couples' well-being by using a VR-PJ that gives the possibility to the partner of a cancer survivor to stand in their significant other's shoes, fostering empathy. Given that experiencing conditions inherent to illness is part of the so-called "transformative experiences" [20], in that they transform the individual epistemically and existentially, we believe that carrying out the VR-PJ can enhance the variables involved, functioning for the partner precisely as a potentially transformative experience. The VR-PJ may thus work as an out-of-the-ordinary life moment that allows the partner to reflect on deeper dimensions of his existence and enhance feelings of connectedness towards the Other [20]. Looking through the partner's eyes and feeling what she is feeling involves emotional and epistemic affordances [21]. Emotional affordances are visual clues designed to provoke a strong emotional response from the user. Epistemic affordances are, on the other hand, cognitive signals mostly shaped into scripted narratives designed to elicit introspection and life-changing realizations which provide participants the chance to incorporate and construct new knowledge systems. According to this viewpoint, epistemic affordances are created to provide open-ended "*experiments of the self*". Such situations, place the participants in confusion or perplexity and serve as turning points from which change may emerge. Visually seeing the different steps of the oncological journey (i.e., scenario) while listening to what their significant other is thinking, saying, and feeling (i.e., the storytelling told from an egocentric perspective) will provide the emotional and cognitive richness that is necessary to promote a transformation in the way the partner looks at their own and at their significant other's experience: it will be possible to make accessible and understandable what is epistemically inaccessible (i.e., vicariously undergoing the experience lived by another person), with the sensory wholeness of real-life experiences [22]. Thanks to this, the partner will deeply connect with the survivor, building closeness and communicating in a more empathic way.

Changing the body changes, indeed, also our mind. Numerous studies have established that the embodiment in different body forms exerts diverse influences on individuals' cognition. This phenomenon relies on the integration of multisensory signals that provide the person with perceptual evidence regarding their body. Consequently, such embodiment experiences can lead to modifications in body ownership,

subsequently influencing attitudes and behaviors [23]. White participants in a dark-skinned avatar, for example, exhibit a reduction in racial prejudice against Black persons; adults embodied in a kid avatar overestimate item sizes as compared to an adult-shaped body of the same height as the child; white individuals embodied in a dark skin casually dressed avatar play the drums more aggressively than white people embodied in a light skin formally dressed body [23]. Likewise, within the context of our VR-PJ, manipulating the partner's virtual body has the potential to induce bodily resonance and alterations in their cognitive processes, resulting in heightened empathetic responses. Embodiment in a scenario experienced from a different perspective may thus be seen as a powerful, implicit, learning technique [24].

In conclusion, recognizing VR-PJ as a technique capable of initiating changes from the body upwards presents a promising avenue for unexplored applications. This approach offers a rapid and effective means of enhancing empathic communication, in stark contrast to conventional training methods that are often time-consuming and resource-intensive. Classical empathy and empathic communication enhancement training frequently encounter limitations, leading to participants' dropouts and substantial costs for sponsoring institutions. The lengthy and intricate protocols, often requiring numerous prolonged sessions, can pose significant challenges. For instance, previous studies have required participants to undergo eight sessions lasting one hour and thirty minutes each [25] or five sessions of two hours each [26], impacting the feasibility of large-scale implementation. Embracing the VR-PJ as a transformative tool offers a pragmatic solution to overcome these limitations. By considerably reducing the intervention time frame while still achieving the desired outcomes, this approach paves the way for widespread adoption and utilization. Its potential to rapidly cultivate empathic communication skills holds immense promise for promoting meaningful connections, empathy, and support among individuals, providing novel opportunities to enhance well-being and relationships in various contexts. As further research delves into the full spectrum of applications, the integration of VR-PJ can revolutionize empathy-based interventions and empower individuals to understand others.

References

[1] Shapiro CL. Cancer survivorship. N Engl J Med [Internet]. 2018;379(25):2438–50. Available from: http://dx.doi.org/10.1056/nejmra1712502.

[2] Borstelmann, N. A., Rosenberg, S. M., Ruddy, K. J., Tamimi, R. M., Gelber, S., Schapira, L., ... & Partridge, A. H. Partner support and anxiety in young women with breast cancer. Psycho-Oncology. 2015; 24(12), 1679-1685. doi.org/10.1002/pon.3780.

[3] Cerea, S., Sansoni, M., Scarzello, G. *et al*. Psychological variables associated with quality of life in patients with head and neck cancer: the role of body image distress. *Support Care Cancer* . 2022; **30**, 9127–9139. https://doi.org/10.1007/s00520-022-07334-6.

[4] Jonsdottir, J. I., Jonsdottir, H., & Klinke, M. E. A systematic review of characteristics of couple-based intervention studies addressing sexuality following cancer. Journal of Advanced Nursing. 2018; 74(4), 760-773. doi.org/10.1111/jan.13470.

[5] Cramer, D., & Jowett, S. Perceived empathy, accurate empathy, and relationship satisfaction in heterosexual couples. *Journal of Social and Personal Relationships*., 2010 *27*(3), 327-349.

[6] Falconier, M. K., & Kuhn, R. Dyadic coping in couples: A conceptual integration and a review of the empirical literature. *Frontiers in Psychology*. 2019;*10*, 571. doi: 10.3389/fpsyg.2019.00571.

[7] Yu, J., Parsons, G. S., Lancastle, D., Tonkin, E. T., & Ganesh, S. "Walking in Their Shoes": The effects of an ‚immersive digital story intervention on empathy in nursing students. *Nursing Open*- 2021; *8*(5), 2813-2823.

[8] Sansoni, M., & Riva, G.. 360-VIRTOncology: Virtual Reality to Improve Cancer Patients' Well-Being. *Cyberpsychol. Behav. Soc. Netw. 2022; 25*, 620–622. https://doi.org/10.1089/cyber.2022.29255.ceu

[9] Sansoni, M., Bartolotta, S., Gaggioli, A., and Riva, G.. "Can you Empathize with Me? Development of a 360° Video-Training to Enhance Residents' Empathic Abilities," *2022 IEEE International Conference on Metrology for Extended Reality, Artificial Intelligence and Neural Engineering (MetroXRAINE)*. 2022; Rome, Italy, 2022, pp. 211-216, doi: 10.1109/MetroXRAINE54828.2022.9967557.

[10] Sansoni, M., Scarzello, G., Serino, S., Groff, E., & Riva, G. Mitigating negative emotions through virtual reality and embodiment. *Frontiers in Human Neuroscience*, 2022; *16*, 916227. doi.org/10.3389/fnhum.2022.916227.

[11] Lamprell, K., & Braithwaite. Patients as story-tellers of healthcare journeys. *Medical Humanities*, 2016; *42*(3), 207-209.

[12] Sansoni, M., Malighetti, C., Riva, G. Psychological and Educational Interventions Among Cancer Patients: A Systematic Review to Analyze the Role of Immersive Virtual Reality for Improving Patients' Well-Being.

In: De Paolis, L.T., Arpaia, P., Sacco, M. (eds) Extended Reality. XR Salento 2022. Lecture Notes in Computer Science, vol 13446. 2022. Springer, Cham. https://doi.org/10.1007/978-3-031-15553-6_30.

[13] Botella, C., Quero, S., Baños, R. M., Perpiñá, C., García Palacios, A., & Riva, G. Virtual reality and psychotherapy. In *Cybertherapy*. 2004; pp. 37-54. IOS Press.

[14] Riva, G., Davide, F., & IJsselsteijn, W. A.. *Being there: Concepts, effects and measurements of user presence in synthetic environments*. Ios Press. 2003.

[15] Serino, S., Sansoni, M., Di Lernia, D. *et al*. 360-degree video-based body-ownership illusion for inducing embodiment: development and feasibility results. *Virtual Reality*. 2023. https://doi.org/10.1007/s10055-023-00836-6.

[16] Bollmer, G. Empathy machines. *Media International Australi. 2017; 165*(1), 63-76.

[17] Petkova, V. I., & Ehrsson, H. If I were you: perceptual illusion of body swapping. PloS one. 2008; 3(12), e3832.

[18] Rochat, M. J. Sex and gender differences in the development of empathy. *Journal of neuroscience research*. 2023; *101*(5), 718-729.

[19] Pérez, P., Madsen, J., Banellis, L., Türker, B., Raimondo, F., Perlbarg, V., ... & Sitt, J. D. Conscious processing of narrative stimuli synchronizes heart rate between individuals. Cell Reports. 2021; 36(11), 109692.

[20] Carel, H., Kidd, I. J., & Pettigrew, R.. Illness as transformative experience. *The Lancet*. 2016;*388*(10050), 1152-1153.

[21] Chirico, A., Pizzolante, M., Kitson, A., Gianotti, E., Riecke, B. E., & Gaggioli, A. Defining transformative experiences: a conceptual analysis. Frontiers in Psychology.2022; 2862.

[22] Gaggioli, A., Chirico, A., Triberti, S., & Riva, G. Transformative interactions: designing positive technologies to foster self-transcendence and meaning. Annual Review of Cybertherapy and Telemedicine. 2016; 14, 169-175.

[23] Slater, M., & Banakou, . The Golden Rule as a Paradigm for Fostering Prosocial Behavior With Virtual Reality. *Current Directions in Psychological Science*. 2021; *30*(6), 503–509. https://doi.org/10.1177/09637214211046954.

[24] Maister, L., Slater, M., Sanchez-Vives, M. V. & Tsakiris, M. Changing bodies changes minds: owning another body affects social cognition. *Trends in Cognitive Sciences*. 2015; **19**, 6–12, https://doi.org/10.1016/j.tics.2014.11.001.

[25] Ramezani, A., Ghamari, M., Jafari, A., & Aghdam, G. F. The effectiveness of a ToM training program in promoting empathy between married couples. *Journal of Couple & Relationship Therapy*. 2020; *19*(1), 1-25.

[26] Angera, J. J., & Long, E. C. Qualitative and quantitative evaluations of an empathy training program for couples in marriage and romantic relationships. *Journal of Couple & Relationship Therapy*. 2006; *5*(1), 1-26.

SECTION VI

WORK IN PROGRESS

It is important to emphasize the importance of developing technological strategies (such as artificial intelligence or augmented reality) that can provide either new enhanced experiences or technological systems also nurtured by artificial intelligence techniques developed by humans.

These new mixed ICT tools might evolve into experts in "helping others," with the objective of making our net-shared experience increasingly more competitive, creative, and capable in the task of helping others. Of course, this has significant ethical implications, which will also need to be explored at greater depth.

Botella, Riva, Gaggioli, Wiederhold,Alcaniz, and Banos, 2012

New Horizons for Neuropsychological Assessment: a Novel Platform for Building Cognitive Tasks with 360-degree Videos and Images

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Abstract. Neuropsychological testing aims to evaluate cognitive abilities on a behavioral task. Most neuropsychological tests are conducted using paper-and-pencil modality or computerized protocols. Recent concerns about the effectiveness of these procedures have focused on their ecological validity, i.e., the relationship between test results seen in a laboratory setting and actual daily cognitive functioning. The emergence of virtual reality presents new clinical and experimental opportunities since it is focused on exposing people to simulated but realistic stimuli and environments while simultaneously maintaining a controlled laboratory environment and gathering cutting-edge measures of cognitive functioning. An additional opportunity for neuropsychological assessment in the field of VR are 360° immersive images and videos. Although recent studies have provided encouraging results for memory and executive function testing, their use in neuropsychological assessment is not yet so widespread. One issue might be the challenge of creating tools or modifying 360-degree videos in accordance with clinical requirements. This study aims to present a platform to develop ecologically valid and controlled environments, with standardized multimodal stimulation, precisely calibrated feedback about the performance, and automatic registration of outcomes. Two memory tests will be presented: an object recognition task and a spatial memory task. Implementing 360° media does not require the knowledge and understanding of advanced technical skills, and the equipment needed to record and visualize them is more affordable than a standard VR setup. By evaluating behaviors in real-world situations, this platform could make it possible to develop ecological testing or enhance existing ones with higher rate of ecological validity.

Keywords. Neuropsychological assessment, 360-degree images and videos, memory, virtual reality

1. Introduction

A behavioral task is used in neuropsychological testing to assess cognitive abilities. Most neuropsychological tests are performed via computerized or paper-and-pencil protocols. The ecological validity of these procedures, or the correlation between test results

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obtained in a laboratory setting and actual daily cognitive functioning, has recently been highlighted as a concern regarding the effectiveness of these procedures. Furthermore, due to the subjects' self-judgment and self-consciousness in front of the researcher, self-reported measures are subject to a variety of biases. Numerous psychometric techniques have been employed to pinpoint and eliminate potential instances of deception and lying to deal with these problems and remove any deceiving biases. One way to address these problems is by developing tests with higher ecological validity rates. In a perfect world, you would be able to assess how people behave in routine situations when performing particular tasks. Unfortunately, several problems make this impossible for researchers. It is preferable to create prototypical situations under the guidance of a researcher because for beginners, conducting an invasive experiment in participants' real-life situations would give rise to numerous ethical concerns. Thus, scientists have been working to develop even more cutting-edge methods.

Virtual reality (VR) is a new technology that has emerged that offers new clinical and experimental opportunities in psychology because it is concentrated on exposing people to simulated but realistic stimuli and environments while simultaneously maintaining a controlled laboratory environment and gathering cutting-edge measures of cognitive functioning. In the past ten years, VR has grown significantly [1], [2]. Additionally, there have been several significant advancements in computer gaming hardware and software over the past few years. It's interesting to note that many gaming devices have found applications in medicine, thanks to the collaborative efforts of engineers and clinicians. A device that is frequently used in clinical settings, such as post-stroke rehabilitation and gesture-driven cognitive tasks, is Microsoft Kinect. The difficulty of developing effective clinical prototypes and experimental designs without the aid of engineers, however, is this method's biggest drawback [3], [4].

An additional opportunity for neuropsychological assessment can be offered by 360° immersive images and videos, a recent VR innovation. A fisheye view of the surroundings can be captured using 360° cameras and then displayed on a head-mounted display or by simply dragging the viewpoint with a mouse or finger. You can choose where to look, but you can't directly interact with the stories because of how they are realized. Users now have the agency to customize their own interpretation of the narrative, which is referred to as personalization. It is possible for a director to plan an experience for the audience with the intention of penning specific directions for their attention, but in the end, it is up to the audience to choose where they will look and how they will spend their time. Therefore, agency, which contributes to the creation of presence, which is what gives you the impression of being in the environment, is one of the most notable differences between 360 and 2D video. Consistent with VR, 360-degree videos can evoke strong emotional reactions by giving the user the impression that they are physically present and that they are interacting and reacting as if they were in the real world. A sense of presence is the illusion of "being there" created by a virtual environment[5]–[7]. In any 360° video, users can choose their point of view, but there are two options: first-person and third-person. When a character is seen through the audience's eyes as if they were the character themselves, this is referred to as a "first person point of view." Instead of the reader participating in the story, the phrase "third-person point of view" describes how the reader observes the narrative. This method has advantages over the first-person perspective because it is less likely to completely lose presence.

All these features make 360° videos and images an ideal tool for building novel cognitive tasks. In fact, patients can experience photorealistic environments in a first-person perspective with immersive 360° scenarios: this quality can increase the procedure's accuracy and is crucial for the evaluation of a variety of memory-related factors. Additionally, the photorealistic style that distinguishes 360° technologies can increase their ecological value: in fact, the level of immersion and realism has an impact on memory coding procedures. Although 360° videos, compared to VR, seem to be non-interactive, by placing a link or hotspot on a door, it is possible to change the environment and give the impression that one is moving between rooms, even though they are not designed to allow for proper interaction. In this way, 360-degree videos can give viewers

a stronger sense of presence by giving them the impression that navigating and touching objects is possible. Furthermore, since these technologies don't require any manual control, a larger target audience, including those with motor impairments, can be reached. Even more, it is possible to explore the surroundings or select items by focusing on the hotspots with the look.

While memory and executive function testing has recently shown encouraging results, their use in neuropsychological assessment is still not as common. One problem could be the difficulty of developing tools or editing 360-degree videos to meet clinical requirements.

In fact, today, as opposed to earlier, the cost of the software, not the hardware, is the primary issue with virtual reality. In fact, for less than $1,500 USD, you can buy the necessary hardware, which consists of a computer with a good graphics card, a head-mounted display (HMD), and a Kinect. However, programming a customized protocol or developing an experimental design costs thousands of dollars per experiment because a team of engineers and user specialists collaborates with a psychologist to design new technologies[8]–[12]. Customization is the main issue with using new technology and VR. Researchers who want to use VR must be flexible and adaptive. The more flexibility they require, the more complex they must be, which calls for more complex programming, computer graphics expertise, user design specialization, usability, ergonomic concerns, software developer kit integrators, engineering, 3D architectural knowledge, and so forth.

This study aims to present a cutting-edge platform, MindScape, created by clinicians for clinicians to develop ecologically valid and controlled environments, with standardized multimodal stimulation, precisely calibrated feedback about the performance, and automatic registration of outcomes. This software gives everyone the chance to use completely customizable virtual environments for whatever purpose they choose. The effectiveness of the created scenarios can be increased by using photographs of things and people the patient interacts with daily. Two memory tests will be presented: an object recognition task and a spatial memory task. The first aims to evaluate visual memory by simulating an actual situation that might occur in daily life. Users must encode and then recall some target objects that have been moved while they are immersed in a virtual living room. In the second, patients have to navigate in apartment rooms and have to recognize the map of the house between four maps.

The implementation of 360° immersive photos and videos does not require the knowledge and understanding of advanced technical skills, and the equipment needed to record and then visualize 360° materials is also more affordable than standard VR set-up. Additionally, 360° environments offer a higher level of visual realism because they are visual representations of actual situations, which can further boost participant engagement.

Specifically, (a) the ability to experience the 360° environments from an immersive egocentric perspective, and (b) the high visual fidelity offered, which is associated with improved visual memory encoding, make 360°-VR a suitable tool to study memory functioning. Then, these new VEs seem promising for creating more ecological tools for the evaluation of memory processes given their capacity to elicit visual exploration mechanisms similar to those adopted in real environments.

2. MindScape

The newly developed platform incorporates existing software that plays 360° media with JavaScript and HTML extensions with the aim to revolutionize neuropsychological assessment. The platform offers researchers a special virtual environment builder that makes it simple for complete beginner users to make a virtual scene that best satisfies the requirements of experimental design and clinical protocols.

MindScape can in fact combine 360-degree images and videos with questionnaires to produce original tasks and tests that can be used to test and learn more about people's

cognitive processes. Both researchers and clinicians can use the platform because it is made to be user-friendly and available. It offers a distinctive and interesting way to administer neuropsychological assessments with its user-friendly interface and seamless integration of 360° media. The platform enables a more immersive experience and a more accurate representation of real-world scenarios by utilizing 360° media. Additionally, it offers a variety of questionnaire options that enable researchers and clinicians to customize assessments for particular needs or populations. Due to its adaptability, the platform can be used in a variety of contexts, such as research studies, clinical evaluations, and educational settings.

Hotspots, Animated Panorama, Hosting, Live Panorama, 3D Transition Effect, Social Sharing, Maps, Floor Plans, Virtual Reality Hotspots, and 360-Site Streams are a few of the platform's key features. Users can also design their own virtual tasks, and the program is compatible with a variety of platforms. Researchers can create protocols very easily in the editor module. They can import, move, rotate, and scale a variety of 2D and 3D objects, images, and videos using a drag-and-drop method to set them off for a time- or space-specific events. Overall, the use of 360-degree photos and videos in neuropsychological testing could result in more precise and ecologically sound evaluations of cognitive processes. It allows for a more thorough understanding of a person's cognitive abilities and can ultimately result in more effective interventions and treatments by creating a more engaging and realistic environment.

These features give healthcare professionals and researchers the freedom to use, duplicate, distribute, research, alter, and enhance any content (objects and environments) for the good of the VR community. The ability to navigate and interact with the environments while creating hotspots that connect various panoramas is the platform's other feature. The system provides several standard features when running simulations that can improve the realism of the simulated scene. These include 3D audio, realistic walk-like motion, advanced lighting techniques for improved image quality, and collision detection to regulate movement in the environment. Immersive and non-immersive visualization modalities are the two basic configuration options for the player. Using an HMD and the immersive modality, the scene can be visualized either in mono or stereoscopic mode. There is also support for head-tracking sensors. The virtual environment can be shown using a desktop monitor or a wall projector in the non-immersive mode. Depending on the hardware configuration selected, the user can interact with the virtual environment using keyboard, mouse, or joy-pad commands. When the experiment starts, the researcher can position the camera in the editor to establish the users' initial views. Moreover, once an object has been added to a 360-degree panorama, it is possible to trigger it and give it a command to perform an action in response to a specific trigger-set event. For instance, a sound may be played when a user navigating a virtual environment approaches an object (e.g., a car). A straightforward visual menu is used to set the trigger and action. To effectively expose users to virtual reality using real video within virtual environments, it is also possible to create an interactive video section based on pre-recorded narratives.

2.1. Two novel memory tasks from MindScape

Two new memory tasks have been created using 360-degree media thanks to MindScape. In the first one, which is intended to test episodic memory, patients are instructed to assist in relocating a person. Then they are instructed to open boxes, label the items inside them (encoding), then recall each item using free recall and identify it among other objects (see Figure 1).

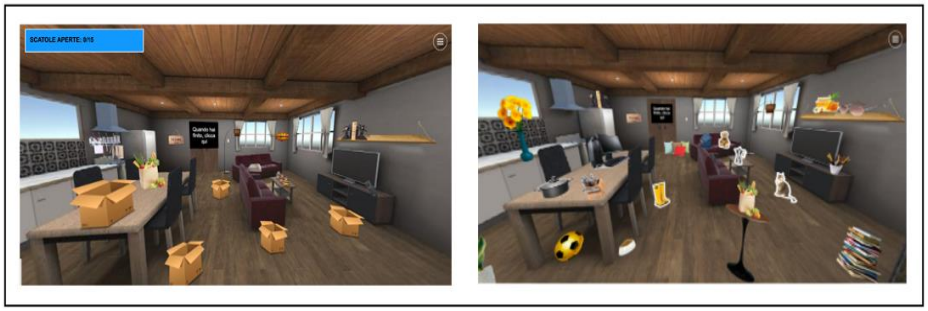

Figure 1. (a) encoding phase: patients have to explore the 360° panorama, click on each box, and label the object that appears; (b) retrieval phase: patients have to explore the 360° panorama and click only the objects they previously saw in the boxes.

Patients complete the second task, which tests spatial memory, by exploring a virtual home and then identifying the home's map (allocentric memory) (See Figure 2).

Figure 2. (a) encoding phase: patients have to explore the 360° panoramas, clicking on the doors to move from one room to another; (b) retrieval phase: patients have to choose the map that represents the house they have just explored

3. Discussion

As cognitive assessment and rehabilitation increasingly rely on immersive technologies, it is crucial to have user-friendly platforms that allow researchers and clinicians without engineering knowledge to build cognitive tasks. The use of immersive technologies in cognitive assessment and rehabilitation can be made more accessible and effective for a wider range of clinicians and researchers with the help of an easy-to-use platform. It may also result in the creation of more effective treatments that enhance cognitive function in various populations. Users of the platform can create 360-degree environments and tasks using a drag-and-drop user interface. Without the need for specialized engineering knowledge, researchers and clinicians can easily create immersive tasks for cognitive assessment and rehabilitation using MindScape. With the help of this platform, it is also possible to use these exercises for rehabilitation, such as the treatment of neurological conditions like stroke and traumatic brain injury. Clinicians can assist patients in engaging in cognitive and motor rehabilitation exercises in a more enjoyable and engaging way by immersing them in virtual environments and giving them interactive tasks. However, there are drawbacks and difficulties with the application of immersive technologies to cognitive evaluation and rehabilitation. One major issue is the requirement for standardization in the creation and execution of tasks to guarantee their validity and dependability. Another obstacle is the requirement for specialized tools and knowledge, which may restrict the applicability of these technologies to particular populations. In addition, more study is required to examine the efficiency of immersive technologies in cognitive assessment and rehabilitation and to create more interventions that are supported by evidence.

References

[1] G. Riva, V. Mancuso, S. Cavedoni, and C. Stramba-Badiale, "Virtual reality in neurorehabilitation: a review of its effects on multiple cognitive domains," *Expert Rev Med Devices*, vol. 17, no.10, pp. 1035–1061, 2020, doi: 10.1080/17434440.2020.1825939.

[2] [P. Cipresso, I. A. C. Giglioli, M. A. Raya, and G. Riva, "The past, present, and future of virtual and augmented reality research: A network and cluster analysis of the literature," *Front Psychol*, vol. 9, p. 2086, 2018, doi: 10.3389/fpsyg.2018.02086.

[3] A. Fernández-Baena, A. Susín, and X. Lligadas, "Biomechanical validation of upper-body and lower-body joint movements of kinect motion capture data for rehabilitation treatments," *Proceedings of the 2012 4th International Conference on Intelligent Networking and Collaborative Systems, INCoS 2012*, pp. 656–661, 2012, doi: 10.1109/INCOS.2012.66.

[4] A. Douglass-Bonner and H. Potts, "Exergame Efficacy in Clinical and Non-Clinical Populations: A Systematic Review and Meta-Analysis," *Presented at: 6th World Congress on Social Media, Mobile Apps, Internet/Web 2.0, London, UK. (2013)*, 2013, Accessed: Apr. 04, 2023.

[5] A. Chirico, P. Cipresso, D. B. Yaden, F. Biassoni, G. Riva, and A. Gaggioli, "Effectiveness of Immersive Videos in Inducing Awe : An Experimental Study," *Sci Rep*, vol. 7, no. 1, pp. 1–11, 2017, doi: 10.1038/s41598-017-01242-0.

[6] M. Slater, "A Note on Presence Terminology", Accessed: Feb. 15, 2023. [Online]. Available: www.cs.ucl.ac.uk/staff/m.slater

[7] S. Ventura, E. Brivio, G. Riva, and R. M. Baños, "Immersive Versus Non-immersive Experience: Exploring the Feasibility of Memory Assessment Through 360° Technology," *Front Psychol*, vol. 10, p. 2509, Nov. 2019, doi: 10.3389/FPSYG.2019.02509/BIBTEX.

[8] P. Cipresso, S. Serino, and G. Riva, "Psychometric assessment and behavioral experiments using a free virtual reality platform and computational science," *BMC Med Inform Decis Mak*, vol. 16, no. 1, Mar. 2016, doi: 10.1186/S12911-016-0276-5.

[9] G. Riva *et al.*, "NeuroVR 2 - A free virtual reality platform for the assessment and treatment in behavioral health care," *Stud Health Technol Inform*, vol. 163, pp. 493–495, 2011, doi: 10.3233/978-1-60750-706-2-493.

[10] [G. Riva, L. Carelli, A. Gaggioli, … A. G.-A. R. of, and undefined 2009, "NeuroVR 1.5 in practice: Actual clinical applications of the open source VR system," *ebooks.iospress.nl*, Accessed: Apr. 04, 2023. [Online]. Available: https://ebooks.iospress.nl/volumearticle/12192

[11] G. Riva *et al.*, "The VEPSY updated project: Virtual reality in clinical psychology," *Cyberpsychology and Behavior*, vol. 4, no. 4, pp. 449–455, Jan. 2001, doi: 10.1089/109493101750527006.

[12] G. Riva, "Applications of Virtual Environments in Medicine," *Methods Inf Med*, vol. 42, no. 5, pp. 524–534, 2003, doi: 10.1055/S-0038-1634379.

GALA Inspired by Klimt's Art: Text-to-image Processing with Implementation in Interaction and Perception Studies: Library and Case Examples

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Abstract. Objectives: (a) to develop a library with AI generated content (AIGC) based on a combinatorial scheme of prompting for interaction and perception research; (b) to show examples of AIGC implementation. The result is a public library for applied research in the cyber-psychological community (CYPSY). The Generative Art Library Abstractions (GALA) include images (Figures 1-2) based on the text-image model and inspired by the artwork of Gustav Klimt. They can be used for comparative analysis (benchmarking), end-to-end evaluation, and advanced design. This allows experimentation with complex human-computer interaction (HCI) architectures and visual communication systems, and provides creative design support for experimenting. Examples include: interactive perception of positively colored generative images; HCI dialogues using visual language; generated moods in a VR environment; brain-computer interface for HCI. Respectfully, these visualization resources are a valuable example of AIGC for next-generation R&D. Any suggestions from the CYPSY community are welcome.

Keywords. art library, Klimt, GALA, text-to-image, AIGC, dataset, neuropoem

1. Introduction

Creative HCI and AI-generated content (AIGC) are developing extremely rapidly in 2022 [1; 2; 3; 4; 5]. Human and machine intelligence need the collaboration and cooperation that arises when artificial models (such as «Zero-Shot Text-to-Image Generation»: DALL-E [2]; CLIP [3]) can already act as part of an intelligence ecosystem, as a member of a hybrid team. Text-to-image applications, as a type of creative HCI tool, provide useful assistance, creative expertise, and technical advantages. Any creator and engineer can harness the power of keywords, which are entered as prompts to calculate a digital drawing. Previous experiments [6] and Gustav Klimt's works inspired the creation of a library of images (called GALA) [7; 8]. It becomes a creative example of HCI and an object-material for further research on interaction and perception.

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[2] It was 1st experiments during the State of the (CHI)Art Workshop of the 2022 CHI Conference on Human Factors in Computing Systems.

Figure 1-2. "Word" (left); "Penrose mosaic" (right) [7; 8]. CC BY-NC-ND

2. Methods

The text-to-image model (DALL-E) was trained for 37 days on 512 TESLA V100 GPUs, and then for another 11 days on 128 TESLA V100 GPUs – a total of 20,352 GPU days on the supercomputer cluster. The generative models (ruDALL-E; ruCLIP) [4; 5] were used for the image processing.

The process of creating the images involved prompt engineering. A combinatorial scheme of prompting was formulated that utilized a formula:

$$P = (k_1 + k_n) + a_k,$$

where P – prompt; k_1, k_n = keywords of main query; a_k = artist name (art style).

This scheme with the keyword(s) [$k_1(k_n)$] and one phrase "abstraction in style of Klimt" [a_k] were applied. E.g., the images (Figure 3-14) were created by entering the following single keywords [as a "k"]: "love"; "hate"; "ceiba"; "jaboticaba".

Some prompts as individual word(s) were chosen spontaneously as an object for visualization (AIGC), and some as specific psychological states (mood's prompts), or attempts to reflect from a poetic works, where to use sets of words [phrase (k_1 + k_n)] as micro-quotes. The poems in pictorial form are demonstrated on Figures 15-18 (below). Where each set of images (neuropoems) has its own context.

Figure 3-14. [from left up to right №] "Love" (1,7,8); "hate" (2,3,9); "ceiba" (tree) (4,10,11); "jaboticaba" (tree) (5,6,12). [7; 8] CC BY-NC-ND.

Neuropoem #01:
Azure firmament. Autumn.
Clay earth and sky. Firmament. Autumn.
Golden foliage. Sky. Ultramarine.
Clay earth and sky. Hawk. Azure ultramarine.
Azure and clay.

Figure 15. Neuropoem #1 – Azure and clay. [7; 8] CC BY-NC-ND

Neuropoem #02: Embodiment of tomorrow, which does not exist
Boredom. Tomorrow without change.
Tomorrow without time – boredom.
Boredom – prophet of change.

Figure 16. Neuropoem #2 – Boredom. [7; 8] CC BY-NC-ND

Neuropoem #03: Peace and darkness.
Peace where there is no light, peace where anger is burning.
Rest. The immortal world is going out.
Peace and darkness, darkness and darkness peace.

Figure 17. Neuropoem #3 – Eternal darkness. [7; 8] CC BY-NC-ND

Neuropoem #04: Night is bright, twitter,
Mottled thrush is twittering
God has descended from heaven,
I'm dancing, God is from heaven.

Figure 18. Neuropoem #4 – Dancing when. [7; 8] CC BY-NC-ND

3. Case examples

3.1 Interactive perception of positively colored generative images, life satisfaction and well-being in the diagnostic mobile app (Case No. 1)

One example is a study of positive personality based on image perception. In doing so, we relied on the context (prompt) of the generated image and used a set of images in the same color scheme to exclude the influence of the emotional component on the color choice, as well as the semantic artistic theme of the abstract picture. Polar keywords such as “life – death”, “fear – courage”, “love – hate”, etc. were used as colored context for prompting [7].

3.2 HCI dialogs using visual language (Case No. 2)

The second example is the use of images in terms of visual language. Emotional visual interaction plays an important role in HCI R&D by providing a collaborative environment and improving team communication. The concept of HCI dialogue in teams is supported by visual dialogues. A prepared interactive framework allows users to interact with each other using a visual language (VL). A VL is some abstraction and/or symbol used in dialogs as words, similar to verbal dialogs with names, words or phrases; it is represented as a set of 2D cards with images [7]. The appearance of the card is a manifestation of the new VL with artistic symbols. The novelty of the application lies in the new VL-based in-group communication protocol, which speeds up the working processes in a single, collective and coherent group field.

3.3 Generated moods in VR settings (Case No. 3)

The mood-colored images (GALA) are embedded in the VR-space, and virtual rooms with different "emotional" settings have been developed. Users can virtually enter the atmosphere of abstract artistic images decorating the interior space and passively interact with them. At the same time, while in the space, users can evaluate the pleasantness and unpleasantness of selected rooms with a certain mood. On the one hand, this is a concrete example of the use of generative imagery (AIGC) in VR research. On the other hand, a similar approach can be used by researchers in other multimedia environments.

3.4 Brain-computer interface for HCI (Case No. 4)

The AIGC integrated in the Brain-computer interface (BCI) can support and accelerate HCI [9; 10]. BCI-derived images and preferences visually reproduce effects from social neuroscience, suggesting that individually human responses and AIGC provide a powerful tool for mapping individual differences by visualizing cognitive-affective processing, brain creative augmentation.

4. Discussion

Multimodal generative models (text-to-image) have a significant impact on the production and creation of synthetic artworks. They, being able to translate data from different modalities into a single semantic space (one digital frame), are an attractive tool for artistic R&D, since the concept of multimodality is an integral part of many art forms and has always played an important role in creative processes. With the advent of generative AI, the opportunities for human co-creation only increase with the quality and scale of the AIGC being created.

On the one hand, the current state of development of AI models that can generate content along with human artists and engineers is very compelling for new contextual and visual creations. On the other hand, many of our traditional assumptions, as well as the theoretical foundations and practical expectations associated with the classical approach to visual art, may be called into question.

5. Conclusion and Limitations

Knowledge of cyberpsychology is to promote the development of AI systems. AI tools with human psychological cognition cannot only simulate the rational thinking, but also reproduce the perceptual thinking, and can realize the emotional interaction between people and machines, machines and machines, similar to human communication.

Based on the results obtained, the state-of-the-art images were selected, systematized and uploaded to the GALA library [7], which is currently available to the community. The images and the proposed combinatorial scheme of prompting can be used in the future for benchmarking, end-to-end evaluation and advanced design.

It is important to emphasize that these digital fingerprints are valuable as objects of cyberart and as starting points for organizing and designing new research. The examples given (above) can only reveal some of the possibilities of using the AIGC to explore CYPSY in more depth. Limitations may concern the artistic value of the synthetic/artificial origin of the digital product.

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References

[1] Eva Cetinic, and James She. Understanding and Creating Art with AI: Review and Outlook. ACM Trans. Multimedia Comput. Commun. Appl. 2022, 18, 2, Article 66 (February): 1-22. URL: https://dl.acm.org/doi/10.1145/3475799; https://doi.org/10.1145/3475799

[2] Aditya Ramesh, Mikhail Pavlov, Gabriel Goh, Scott Gray, Chelsea Voss, Alec Radford, Mark Chen, Ilya Sutskever. Zero-Shot Text-to-Image Generation. arXiv:2102.12092. 2021. Retrieved January. 2, 2023 from https://arxiv.org/abs/2102.12092

[3] Aditya Ramesh, Prafulla Dhariwal, Alex Nichol, Casey Chu, Mark Chen. 2022. Hierarchical Text-Conditional Image Generation with CLIP Latents. arXiv:2204.06125 Retrieved May 2, 2022 from URL: https://arxiv.org/abs/2204.06125

[4] Github: ruDALL-E. Retrieved January 15 – May 15, 2022 from URL: https://github.com/ai-forever/ru-dalle

[5] Github: ruCLIP. Retrieved April 15 – May 15, 2022 from URL: https://github.com/ai-forever/ru-clip

[6] Github: neuroornament. The State of the (CHI)Art Workshop of the 2022 CHI Conference on Human Factors in Computing Systems. Retrieved May 2, 2022 from URL: https://github.com/toandreyhse/CHI22

[7] Github: GALA. Retrieved May 21, 2023 from URL: https://github.com/toandreyhse/cypsy26

[8] GALA KLIMT [synthecoder]. Digital art collection of pictorial poems. Ridero. 161 p. ISBN 978-5-0059-2526-8. Retrieved November 25, 2022 from URL: https://ridero.ru/books/gala_klimt/ URL: https://www.amazon.com/Gala-Klimt-Digital-Collection-Pictorial-ebook/dp/B0BN631CY4

[9] Michiel Spapé, Keith M. Davis III, Lauri Kangassalo, Niklas Ravaja, Zania Sovijärvi-Spapé, Tuukka Ruotsalo. 2023. Brain-computer interface for generating personally attractive images. *IEEE Transactions on Affective Computing*, Vol. 14, pp. 637-649. URL: https://doi.org/10.1109/TAFFC.2021.3059043

[10] Lauri Kangassalo, Michiel Spapé, Tuukka Ruotsalo. 2020. Neuroadaptive modelling for generating images matching perceptual categories. *Sci Rep*, 10, 14719. URL: https://doi.org/10.1038/s41598-020-71287-1

All-around Mental Flexibility: Psychometric Tool based on Ecological Immersive Situations

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Abstract. Action and thinking flexibility underpin human adaptability. However, there is no consensus regarding its definition or assessment. Hence, we developed a 360° video behavioral assessment of mental flexibility. The 360° scenarios evaluated cognitive and emotional flexibility in terms of behavioral and affective variability and dynamism. We presented a conceptual design of the 360° videos and an example for it.

Keywords. Mental Flexibility, 360-degree videos, psychometrics, assessment, affect dynamics, conceptual design

1. Introduction

Flexibility is a multidimensional transversal competence of several cognitive-affective processes [1,2]. It does, however, lack a clear and thorough definition [3,4]. Nevertheless, two components can be identified: a cognitive and psychological-affective one, denoted as Cognitive Flexibility (CF) and Psychological Flexibility (PF) [5]. Even if cognitive and psychological flexibility developed as two parts of the same "flexibility" notion, they have always been studied independently.

Cognitive Flexibility (CF) is a subset of executive functions (such as memory and attention] or processes required to govern goal-directed behavior: it is the capacity to adapt cognitive and behavioral processes in response to changing environmental demands. CF involve three executive function latent variables: mental set shifting ('shifting'), information updating and monitoring in working memory ('updating'), and inhibition of prepotent reactions ('inhibition') [4,6].

Psychological Flexibility (PF) is defined as the ability or willingness to be in contact with emotions, thoughts, or sensations [7–11]. Literature uses psychological and affective interchangeably. The paper names it "affective" for simplicity. It is described as the capacity to completely touch the present moment as a conscious human being and to change or persevere in one's conduct while serving cherished objectives [7,12]. The component of psychological flexibility involves emotional regulation flexibility [13,14]: it is the ability to implement and switch between emotion regulation strategies that are synchronized with contextual demands.

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Adaptive variability links cognitive and affective component of flexibility. *Variability* is the subject's capacity to experience, act, and comprehend events from multiple perspectives [15,16]. This requires examining numerous views and adapting one's actions accordingly [17]. *Adaptability* is linked to the concept of complex systems[18,19]. In particular, it is defined as the ability of the system to return to a state of homeostasis after an internal or external disruption. More specifically in terms of flexibility, *adaptivity* is the capacity to adjust swiftly and appropriately to environmental demands, after returning in a homeostatic state [20,21].

At the behavioral level, *adaptivity* is the capacity to respond adequately to environmental disturbances, whereas variability is the ability to select between different viewpoints, emotions, and beliefs [15,22]. Flexibility combines adaptive behavior with multiple variation-handling techniques. Flexibility behavior involves adapting to changing situations and changing techniques. It requires adapting to new settings, being open to new ideas, and changing one's behavior.

The definition's complexities can be observed in the involvement of behavioral measurement. In our study with the use of 360-degree videos, we want to investigate mental flexibility in ecological and realistic terms. Unlike self-reporting questionnaires, which are often used to explore separately components of flexibility, 360-degree video would allow for a direct and realistic measurement of flexibility: 360° videos expose the subject to real-life scenarios in which he must be affectively and cognitively adaptable.

2. Assessment of mental flexibility

Assessing mental flexibility is a difficult task. There is no unequivocal agreement on measuring, as there is on definition. Cognitive flexibility is tested through neuropsychological tests that examine executive function, such as Wisconsin Card Sorting Test [23], Trail Making Test [24], and Verbal and Semantic fluency [25]. All are founded on switching, inhibition or recall abilities. Affective flexibility, on the other hand, is assessed by indirect methods such as self-report questionnaire, e.g Cognitive flexibility scale (CFS) [26], Cognitive Flexibility Inventory (CFI) [27], Cognitive Control and Flexibility in the context of Stress and Depressive Symptoms (CCFQ) [28], and Flexible Regulation of Emotional Expression (FREE) [29]. Recent meta-analyses demonstrate how neuropsychological tests and self-report questionnaires officially refer to the same concept but really assess separate subcomponents that do not always correlate [10,30].

As a result, we decided to develop an ad hoc instrument capable of capturing the cognitive and affective components of flexibility in a daily life environment. 360° videos would be a feasible solution since they are ecologically friendly, realistic, and simple to use and enjoy (mobile phone/viewer/computer). 360° videos—also called panoramic, spherical, or omnidirectional—provide an immersive experience. 360° video/image material occupies a sphere with a 360 × 180° viewing range. 360° video/image surrounds the viewer and fills their vision, unlike 2D video/image, which covers a narrow plane. 360° videos might assess mental flexibility, allowing a unified test on mental flexibility, ecology in the creation of the scenes, versatility in administration, e.g by smartphone [31].

3. Conceptual design

All-around Flexibility (360° videos assessment) is our behavioral test, assessing mental flexibility in its cognitive-affective components. The structure of the test includes four main process components: Context, Event, Mental-flexibility/Rigidity, Response. Each 360° videos was built considered those features (Figure 1):

- ***Context*** is divided in formal (e.g work situations) or informal (e.g friendly or familiar one) and relational (e.g involving other people) or individual (e.g only the subject as the protagonist of situation).

- ***Event*** is a cardinal point. It may be a novelty (e.g. an unexpected element in the subject's life), internal (e.g a personal thought, belief and emotion with no apparent external trigger) or external (e.g an event that the subject has undergone), an event objectively (e.g an objectively impactful event in the subject's life such as an unexpected death) or subjectly (e.g subjectively experienced as impactful by the subject). An objectively event can be marked by different levels of valence (positive-negative) and arousal, extreme or medium [32].
- ***Mental flexibility and Rigidity*** are the characteristic that links unexpected events to the subject's behavioral response. *Mental flexibility* is characterized by *variability*, i.e. multi-layer approch (e.g being able to see situations from multiple points of view) and *adaptability* (e.g re-reconfigures itself without large loss of its own functionality). *Rigidity* is often defined in terms of a difficulty in switching from one set way of responding to a different way of responding and can be synonymous with set/task-switching difficulties [33].
- ***Behavioural Response*** is a direct result of mental flexibility or rigidity processes in which the subject behaves or feels, adjusting or not to changing.

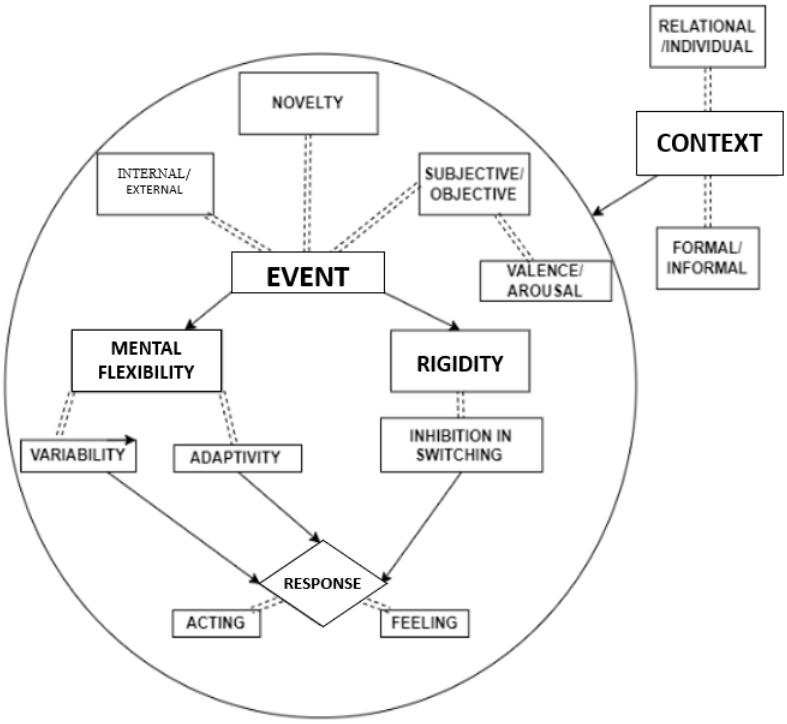

Figure 1. Conceptual design of All-around flexibility test: The *dashed arrows* represent subcomponents of the sceneries' primary elements (*squares with bold lettering*).

In 360° videos, there are a series of daily life scenes with one or more actors; the experimental subject observes the scene as an external viewer and, after each scene, answers questions about how he would have acted if he had been the protagonist of the scene. The *context* and *event* elements are the contextual elements in which the actors act. Scenes are produced for each combination and component of context and event (for example, events in formal or informal settings, solitary or in relational settings, and positive or negative valence contexts). After observing the roles everyday life plays, experimental subjects are given a behavioral response choice that characterizes their capacity to be flexible or inflexible.

Each 360° video get three behavioral responses: one that resembles rigid behavior, one that is midway between rigid and flexible, and one that mimics flexible behaviors, as determined by comparable self-report questionnaires [29,34].

Here we proposed a protypical 360° video, considering *Informal Context* and a *novelty, exterior and subjective event*, one with *positive valence* and one with *negative valence.*

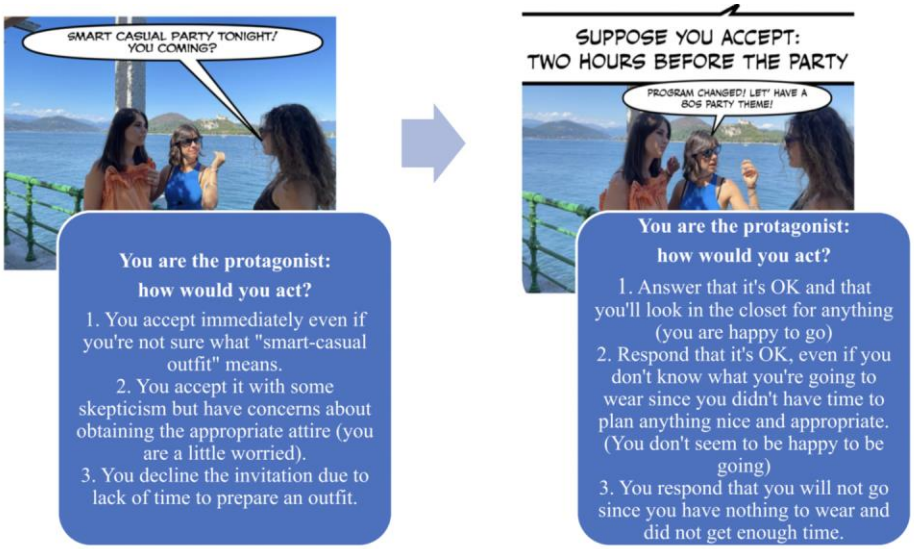

Figure 2. 360° video (left) with positive valence (party's invitation) and 360° video (right) with negative valence (an expected problems).

Testing the conceptual design of each scenario is crucial to assess whether the methodology effectively captures participants' flexible or inflexible behaviors, considering cultural influences on politeness, especially in relational situations (Figure 2).

4. Conclusion

Assessing mental flexibility is a multifaceted procedure that considers both cognitive and emotional factors. In cognitive terms, acting flexibly entails being able to observe circumstances from many perspectives, but emotionally, it influences the variability and dynamism of different affective states.

360° videos are a valid option for ecologically and directly analyzing the subject's flexible or inflexible behavior. Due to their versatility, they may be helpful in therapeutic settings to assess flexibility or inflexibility features in disease as anorexia [35], Parkinson disease [36] or obsessive compulsive disorder [37]. Using a single flexibility assessment method would enable to identify the most inadequate cognitive or affective components quickly and accurately.

5. Funding

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References

[1] Audet JN, Lefebvre L. What's flexible in behavioral flexibility? Behavioral Ecology. 2017 Aug 1;28(4):943–7.
[2] Correa J, de Paula H. Flexibility of generalized entropy for wandering dynamics. 2023
[3] Uddin LQ. Cognitive and behavioural flexibility: neural mechanisms and clinical considerations. Nature Reviews Neuroscience 2021 22:3

[4] Dajani DR, Uddin LQ. Demystifying cognitive flexibility: Implications for clinical and developmental neuroscience. Trends Neurosci 2015 ;38(9):571–8
[5] Southwick SM, Charney DS. Cognitive and emotional flexibility. Resilience 2012
[6] [Uddin LQ. Cognitive and behavioural flexibility: neural mechanisms and clinical considerations. Nature Reviews Neuroscience 2021 22:3
[7] Kashdan TB, Rottenberg J. Psychological Flexibility as a Fundamental Aspect of Health. Clin Psychol Rev 2010
[8] Cobos-Sánchez L, Flujas-Contreras JM, Becerra IG. Relation between psychological flexibility, emotional intelligence and emotion regulation in adolescence. Current Psychology. 2020;
[9] Yang X, Ebo TO, Wong K, Wang X. Relationships between psychological flexibility and internet gaming disorder among adolescents: Mediation effects of depression and maladaptive cognitions. PLoS One. 2023;18(2):e0281269.
[10] Fang S, Ding D. Which outcome variables are associated with psychological inflexibility/flexibility for chronic pain patients? A three level meta-analysis. Front Psychol. 2022;13.
[11] Edwards DJ, Lowe R. Associations Between Mental Health, Interoception, Psychological Flexibility, and Self-as-Context, as Predictors for Alexithymia: A Deep Artificial Neural Network Approach. Front Psychol 2021;12.
[12] Christodoulou A, Karekla M, Costantini G, Michaelides MP. A network analysis approach on the Psychological Flexibility/ Inflexibility model. Behav Ther. 2023 Jan;
[13] Aldao A, Sheppes G, Gross JJ. Emotion Regulation Flexibility. Cognit Ther Res 2015;39(3):263–78.
[14] Quattropani MC, Lenzo V, Sardella A, Bonanno GA. Expressive flexibility and health-related quality of life: The predictive role of enhancement and suppression abilities and relationships with trait emotional intelligence. Scand J Psychol. 2022;
[15] Cheng C, Lau HPB obo, Chan MPS ally. Coping flexibility and psychological adjustment to stressful life changes: a meta-analytic review. Psychol Bull. 2014 Nov 1;140(6):1582–607.
[16] Hardy J, Segerstrom SC. Intra-individual variability and psychological flexibility: Affect and health in a National US sample. J Res Pers. 2017 Aug 1;69:13–21.
[17] Lee R, Sturmey P, Fields L. Schedule-induced and operant mechanisms that influence response variability: A review and implications for future investigations. Psychological Record 2007 Jun 2 57(3):429–55.
[18] Berrios R. What is complex/emotional about emotional complexity? Front Psychol. 2019;10
[19] Scott WA. Cognitive Complexity and Cognitive Flexibility. Sociometry. 1962 Dec;25(4):405.
[20] Aldao A, Nolen-Hoeksema S. When are adaptive strategies most predictive of psychopathology? J Abnorm Psychol 2012 Feb 121(1):276–81.
[21] Wrosch C, Scheier MF, Miller GE, Schulz R, Carver CS. Adaptive Self-Regulation of Unattainable Goals: Goal Disengagement, Goal Reengagement, and Subjective Well-Being. Pers Soc Psychol Bull. 2003 Dec;29(12):1494–508.
[22] Macías-Escrivá FD, Haber R, Del Toro R, Hernandez V. Self-adaptive systems: A survey of current approaches, research challenges and applications. Expert Syst Appl. 2013 Dec 15;40(18):7267–79.
[23] Miles S, Howlett CA, Berryman C, Nedeljkovic M, Moseley GL, Phillipou A. Considerations for using the Wisconsin Card Sorting Test to assess cognitive flexibility. Behav Res Methods 2021;53(5):2083–91
[24] Kortte KB, Horner MD, Windham WK. The trail making test, part B: cognitive flexibility or ability to maintain set? Appl Neuropsychol 2002 ;9(2):106–9.
[25] [Kuppens P. Exploring the nature of cognitive flexibility. New Ideas Psychol 2012;30(2):190–200.
[26] Martin MM, Rubin RB. A New Measure of Cognitive Flexibility: 1995 [];76(2):623–6.
[27] Dennis JP, vander Wal JS. The Cognitive Flexibility Inventory: Instrument Development and Estimates of Reliability and Validity. Cognit Ther Res. 2010 Jun 11;34(3):241–53.
[28] Gabrys RL, Tabri N, Anisman H, Matheson K. Cognitive control and flexibility in the context of stress and depressive symptoms: The cognitive control and flexibility questionnaire. Front Psychol. 2018 Nov 19;9(NOV):2219.
[29] Burton CL, Bonanno GA. Measuring ability to enhance and suppress emotional expression: The Flexible Regulation of Emotional Expression (FREE) Scale. 2016 Aug 1;28(8):929–41.
[30] Howlett CA, Wewege MA, Berryman C, Oldach A, Jennings E, Moore E, et al. Back to the Drawing Board—The Relationship Between Self-Report and Neuropsychological Tests of Cognitive Flexibility in Clinical Cohorts: A Systematic Review and Meta-Analysis. Neuropsychology 2022 ;36(5):347–72.
[31] Borghesi F, Mancuso V, Pedroli E, Cipresso P. From Virtual Reality to 360° Videos. In 2022. p. 549–72.
[32] Russell JA. Mixed Emotions Viewed from the Psychological Constructionist Perspective: http://dx.doi.org/101177/1754073916639658 2017 ;9(2):111–7.
[33] Morris L, Mansell W. A systematic review of the relationship between rigidity/flexibility and transdiagnostic cognitive and behavioral processes that maintain psychopathology. 2018 Jul 19 [cited 2023 ;9(3).
[34] Aldi GA, Svicher A, Cosci F. Validation of the Italian Version of the Cognitive Distortion Scale as a Measure of Cognitive Bias in a Non-clinical Sample. Journal of Rational-Emotive & Cognitive-Behavior Therapy. 2020 Mar 12;38(1):56–75.
[35] Miles S, Gnatt I, Phillipou A, Nedeljkovic M. Cognitive flexibility in acute anorexia nervosa and after recovery: A systematic review. Clin Psychol Rev. 2020 Nov 1;81.
[36] Díaz-Santos M, Cao B, Yazdanbakhsh A, Norton DJ, Neargarder S, Cronin-Golomb A. Perceptual, Cognitive, and Personality Rigidity in Parkinson's Disease. Neuropsychologia 2015;69:183.

[37] Şahin H, Köşger F, Eşsizoğlu A, Aksaray G. The Relationship Between Obsessive Belief Level and Cognitive Flexibility in Patients with Obsessive Compulsive Disorder. Noro Psikiyatr Ars 2018 Dec; 55(4):376–9.

Can Virtual Reality Best Assess Peer Exclusion Affecting Mood and Emotions within an Experimental Design?

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Abstract. Peer exclusion is a pervasive phenomenon that can lead to negative mood states in affected individuals. To model peer exclusion experimentally, the Cyberball paradigm has been widely used. However, the effectiveness of this paradigm may vary depending on the presentation format. The primary objective of this study is to investigate the effectiveness of the Cyberball paradigm in a virtual reality (VR) environment and compare it to the traditional 2D version. Specifically, we aim to determine which paradigm is more effective in experimentally manipulating peer exclusion. To achieve this objective, we will recruit 150 children and adolescents aged 8-16 years. Participants will complete a background questionnaire, which will collect data on their social support, rejection experiences, and demographic variables. They will then be exposed to two peer exclusion situations, one in 2D and one in VR, in random order. After each situation, participants will be asked to report on their mood, satisfaction, and frustration with their basic psychological needs and immersion. We expect that both experimental situations will result in a decline in participants' negative mood on average. However, we hypothesize that the VR paradigm will be more effective in inducing negative mood states than the 2D situation. By exploring the differential effectiveness of the Cyberball paradigm in different presentation formats, this study will contribute to the existing literature on peer exclusion and pave the way for future research on the use of VR in this domain.

Keywords. Peer exclusion, Cyberball, Virtual Reality, 3D paradigm, Mood, Educational Psychology

1. Introduction

Research on peer relationships in schools is important to understand how they affect academic achievement and well-being. By identifying factors that contribute to positive relationships, schools can develop interventions to promote healthy social connections among students. Overall, this investigation is crucial in creating a positive and supportive learning environment for students, fostering positive peer relationships and improving academic achievement and well-being.

This study focuses on peer relationships as a proximal developmental context and the impact it has on the development outcomes of children and adolescents [1]. Although the literature on peer relationships has emphasized its role within the school context, there is no overall agreement on how peer relationships can be operationalized and measured in terms of short-term effects. Therefore, the main aim of the research presented in this paper, which is the first study of a PhD project, is to find the strongest way to investigate peer relationships within the school context, focusing on the

immediate and short-term impact of peer exclusion on students' mood and psychological needs.

Peer relationships within the school context can be considered a continuum, with peer inclusion at the positive pole and peer exclusion at the negative pole [2]. Peer inclusion describes the condition in which an individual feels accepted and included by peers or peer groups, while peer exclusion refers to the condition in which an individual feels excluded or rejected [3]. Children and adolescents can be excluded by peers both in an emotional and physical way, and exclusion can be acted directly or indirectly, implicitly or explicitly [4]. The literature on peer relationships emphasizes that peer exclusion can lead to negative mood, unsatisfaction of basic psychological needs, lower self-esteem, and meaningful existence, as well as internalizing problems, loneliness, and school disengagement in the long term [5]. Excluded children and adolescents show more learning difficulties and academic problems, absenteeism, discipline problems, poor academic skills, and higher dropout rates [6]. The transition from childhood to adolescence is an important factor to consider as peers become more important in satisfying adolescents' basic psychological needs [7]. Gender-specificity exists in the exclusion behaviours performed and the specific outcomes of peer exclusion [8]. Friendship and social support are important protective factors against peer exclusion, especially for females [9].

There is still no agreement on how to operationalize and measure the short-term and long-term effects of peer exclusion within both between-subjects and within-subjects designs. The Cyberball paradigm has been widely used to operationalize peer exclusion in experimental designs for short-term effects [10]. The Cyberball paradigm is an online ball-tossing game, in which participants believe they are playing with real peers but are playing with standardized computer players. In the peer exclusion condition, participants rarely or never receive the ball, whereas, in the neutral or inclusion condition, they often receive it. The Cyberball paradigm allows researchers to examine the individual effects of peer exclusion experiences without considering pre-existing relationships [11]. However, the Cyberball paradigm has limited ecological validity as it is a 2D paradigm. Therefore, a 3D paradigm using a virtual environment can work better in replicating reality, achieving higher ecological validity, and refining current findings to understand the mechanisms through which peer exclusion exerts its effect on children and adolescents [12].

Virtual Reality (VR) is a 3D immersive advanced technology that allows researchers to build experimental paradigms and lab situations closer to what people would experience in everyday life [12]. VR has higher ecological validity than other technologies used in educational contexts, making it a useful tool for educational activities and intervention [13]. Studies have shown that VR can help students to improve their writing skills, social skills, and learning outcomes [14].

VR, as a simulated experience that can be completely like the real world, has been used in a variety of settings, including entertainment, education, and therapy [15]. In recent years, the technology for VR has improved dramatically, and it has become more accessible to consumers [16]. VR is a technology that has been increasingly used in educational contexts, particularly in schools, providing a simulated experience that enables users to interact with a three-dimensional environment, allowing them to explore, manipulate and learn in a more engaging and interactive way [17]. The use of VR in education can provide an immersive learning experience that can enhance student engagement, improve knowledge retention and lead to better academic performance [18]. Additionally, VR can provide a safe and controlled environment for students to explore and experiment, particularly in subjects that require practical training, such as science or engineering [19].

Overall, the use of VR in education has shown great potential in improving student engagement, knowledge retention and academic performance. One example of the use of VR in schools is the use of virtual laboratories. Virtual laboratories can provide students with a safe and controlled environment to learn and experiment in subjects such as biology, chemistry, and physics [19]. VR laboratories can also provide students with access to equipment and experiments that may not be available in traditional classrooms

[20]. This can help to enhance their practical skills and understanding of scientific concepts. However, more research is needed to better understand the impact of VR on learning outcomes and how to effectively integrate VR into educational settings.

The present study's research question is focused on identifying the most effective paradigm to assess peer exclusion in an experimental design. Specifically, the study aims to address the question, "How can peer exclusion be best assessed in an experimental design?" To accomplish this, the study will evaluate the effectiveness of two paradigms, Cyberball and VR, in assessing peer exclusion. As the Cyberball paradigm has already shown no significant differences between 2D and 3D versions [21], and VR paradigms based on conversational situations have already shown significant results assessing social exclusion in adult samples [22], we aim to compare Cyberball with a VR paradigm built ad hoc by conversational situations. In this study, several hypotheses have been formulated to guide the investigation.

The first hypothesis (H1) predicts that peer exclusion will have a negative impact on children's exclusion perception, mood, and psychological needs, as already confirmed by worth noting literature [5].

The second hypothesis (H2) predicts that females will be more sensitive to peer exclusion than males, as the literature has shown females marked by stronger ethical feelings than males [8].

The third hypothesis (H3) predicts that adolescents aged 13-16 will be more affected by peer exclusion than children aged 8-12, as adolescents, compared to children, give higher importance to peer relationships and, consequently, they are more related to their peers feeling higher belongingness toward them [7].

The fourth hypothesis (H4) predicts that social support and previous rejection experiences will moderate the effects of peer exclusion, as these two variables have been widely demonstrated to be powerful moderators of peer exclusion [9][23].

The fifth hypothesis (H5) predicts that a VR version of the peer exclusion paradigm will be more effective and immersive than the classic 2D version, as already demonstrated by simulating a social exclusion experience within an adult sample [22].

2. Methods

2.1 Sampling plan

The study aims to enrol a minimum of 150 participants aged 8 to 16 years old to detect main and two-way interaction effects in a repeated measure ANOVA. The sample will be stratified by gender (male and female) and age (children aged 8-12 and adolescents aged 13-16). Based on Abrams et al. [5], we anticipate a small-to-medium effect size of f=0.15 for the impact of peer exclusion manipulation on mood and psychological needs, with a power of .80 and an alpha of 0.05 (using G*Power 3.1). We plan to recruit the sample through various primary and secondary schools by requesting at least one class per grade from 4th to 10th grade, ensuring gender and age balance. Upon receiving the approval and agreement of the headmasters, informed consent forms will be sent to the parents or legal guardians of the participants.

2.2 Design

We plan to collect our data by the end of the year 2023. We will schedule a timeframe with school headmasters to collect data at schools within two months. Meanwhile, parents will receive informed consent forms, a questionnaire to evaluate the family's socioeconomic status (SES), and a self-report questionnaire to collect demographic information from their children (gender, age, grade, and school type attended), previous rejection experiences, and perceived social support from parents, teachers, and friends. Parents will be requested to fill out and sign the informed consent forms, as well as to assist their children in completing all the questionnaires and bringing them to school. After obtaining informed consent from the parents or legal guardians, each participant will take part in the test in a quiet room at their school during school

hours. Children and adolescents will experience two peer exclusion situations using two different experimental paradigms: Cyberball and VR. We will administer the Williams Scale and the Basic Psychological Need Satisfaction and Frustration Scale through a Qualtrics questionnaire displayed on a computer screen before and after every exclusion condition to assess participant mood and psychological needs changes. We will include also an item aimed to measure immersion after every experimental condition. To prevent carry-over effects, the participants will experience the two experimental situations on different days, with one inclusion or neutral condition of both paradigms introduced after every exclusion condition for ethical reasons and to reset the exclusion effects on children and adolescents.

The Cyberball paradigm [11] is an online ball-tossing game played by three players, with participants believing they are playing with real peers, although their peers are actually standardized computer players. In the exclusion condition, the children and adolescents will receive the ball rarely or never, whereas in the inclusion or neutral condition, they will receive the ball frequently.

Regarding the VR paradigm, we will develop a virtual classroom environment in which a group of virtual and unreal children or adolescents will sit around a desk discussing a school group project. Participants will be seated around the desk with their peers and required to actively participate in the school group project. In the VR condition, the virtual peers will actively exclude the participants during the school group project.

2.3 Measures

The study will use several specific measures, including:

Descriptive variables:

Gender, Age, Socioeconomic and cultural status (SES) assessed using a questionnaire that includes three factors: parents' employment status, parents' educational level, and possession of specific properties.

Dependent variables:

Williams Scale: A 36-item scale developed by Williams to assess participants' perception of being excluded, mood, and psychological needs. It includes 5 items for each psychological need, 8 items related to mood, and 3 items related to the perception of being excluded [24].

Basic Psychological Need Satisfaction and Frustration Scale: A questionnaire consisting of 24 items, including 12 need satisfaction items and 12 need frustration items, assessing participants' psychosocial needs of autonomy, relatedness, and competence [25].

Immersion: Assessed using a specific close-ended item built in line with previous literature on VR.

Moderator variables:

Child and Adolescent Social Support Scale: A questionnaire aimed to evaluate children and adolescents' social support received and perceived, consisting of 40 items in 4 subscales: support received and perceived by parents, teachers, classmates, and close friends [26].

Previous rejection experiences: Assessed using a specific self-report measure built in line with the operationalization of peer exclusion, consisting of 25 items in 9 subscales.

To validate the last-mentioned measure, we will use factor analysis and Cronbach's Alpha. It's worth noting that the Italian validation of the Williams Scale has reported adequate internal consistency and the same is true for the Basic Psychological Need Satisfaction and Frustration Scale. Also, the internal consistency of the Child and Adolescent Social Support Scale in an Italian sample was reported to be high.

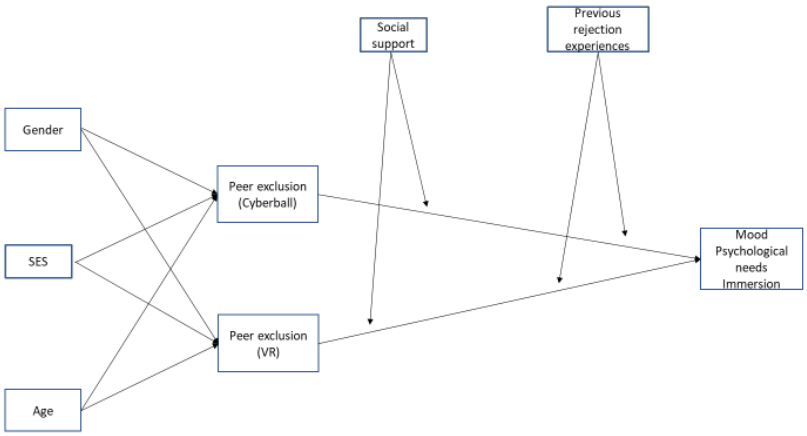

Figure 1. Analytic plan

2.4 Analytic plan

We will use repeated measures ANOVA to analyse the effect of peer exclusion manipulation on mood and psychological needs measured by the Williams Scale and Basic Psychological Need Satisfaction and Frustration Scale (see Figure 1). The independent variables will be the two experimental paradigms (Cyberball and VR) and the two exclusion conditions. The dependent variables will be the scores on the Williams Scale and the Basic Psychological Need Satisfaction and Frustration Scale before and after each experimental condition and immersion after each experimental condition. We will also examine the main effects of gender and age group (children aged 8-12 and adolescents aged 13-16) and the interaction effects between experimental condition and gender, and experimental condition and age group.

We will conduct post-hoc analyses using Bonferroni-corrected pairwise comparisons to determine which specific conditions differ significantly from each other. We will also calculate effect sizes (partial eta squared) to determine the practical significance of any significant findings.

In addition, we will examine the relationship between socioeconomic status and the dependent variables using regression analysis, controlling for gender and age group. We will also explore the potential moderating effects of social support (perceived by parents, teachers, and friends) and previous rejection experiences on the relationship between peer exclusion and mood/psychological needs. These analyses will provide a more comprehensive understanding of the impact of peer exclusion on psychological well-being among children and adolescents, as well as the potential mitigating factors.

3. Conclusion

In conclusion, this study proposes to investigate the effects of peer exclusion on mood and psychological needs in children and adolescents using two experimental paradigms: Cyberball and VR. The findings of this study may contribute to the understanding of the negative consequences of peer exclusion on children and adolescents' psychological well-being and provide insights for developing prevention and intervention programs for peer exclusion in schools. Furthermore, the study may also shed light on the effectiveness of using virtual reality as a tool for studying social exclusion in a controlled laboratory setting. Lastly, based on the results we will obtain, in a future study we can plan to investigate possible relations between dynamics and contents of "exclusion communication", changes in attitude, moderator variables already presented in this protocol and SES.

References

[1] Bronfenbrenner, U. (2005). Making human beings human: Bioecological perspectives on human development.

[2] Leary, M. R., Twenge, J. M., & Quinlivan, E. (2006). Interpersonal Rejection as a Deterimant of Anger and Aggression. Personality and social Psychology Review, 10(2), 111–132.

[3] Ladd, G. W., Herald-Brown, S. L., & Reiser, M. (2008). Does chronic classroom peer rejection predict the development of children's classroom participation during the grade school years? *Child Development, 79*, 1001–1015.

[4] Eck, J., & Riva, P. (2016). Social exclusion: Psychological approaches to understanding and reducing its impact.

[5] Abrams, D., Weick, M., Thomas, D., Colbe, H., & Franklin, K. M. (2011). On-line ostracism affects children differently from adolescents and adults. . *British Journal of Developmental Psychology, 29(1)*, 110-123.

[6] Kingery, J. N., Erdley, C. A., & Marshall, K. C. (2011). Peer acceptance and friendship as predictors of early adolescents' adjustment across the middle school transition. *Merrill-Palmer Quarterly, 57*(3), 215–243.

[7] Scholte, R. H., & Van Aken, M. A. (2020). Peer relations in adolescence. *Handbook of adolescent development*, 175-199.

[8] Warrington, M., & Younger, M. (2011). 'Life is a tightrope': reflections on peer group inclusion and exclusion amongst adolescent girls and boys. *Gender and Education, 23:2*, 153-168.

[9] Arslan, G. (2018). Social exclusion, social support and psychological wellbeing at school: A study of mediation and moderation effect. *Child indicators research, 11(3)*, 897-918.

[10] Williams, K. D., Forgas, J. P., von Hippel, W. v., & Zadro, L. (2005). The Social Outcast: An Overview. *The Sydney Symposium of Social Psychology, 7*.

[11] Williams, K. D. (2001). Ostracism. *The power of silence.* . New York.

[12] Parsons, T. D. (2015). Virtual Reality for Enhanced Ecological Validity and Experimental Control in the Clinical, Affective and Social Neurosciences. *Front. Hum. Neurosci. 9:660*.

[13] [13] Villena-Taranilla, R., Tirado-Olivares, S., Cózar-Gutiérrez, R., & González-Calero, J. A. (2022). Effects of virtual reality on learning outcomes in K-6 education: A meta-analysis. *Educational Research Review, 100434*.

[14] Fransson, G., Holmberg, J., & Westelius, C. (2020). The challenges of using head mounted virtual reality in K-12 schools from a teacher perspective. *Education and Information Technologies, 25(4), 3383-3404*.

[15] Southgate, E., Smith, S. P., Cividino, C., Saxby, S., Kilham, J., Eather, G., . . . Bergin, C. (2019). Embedding immersive virtual reality in classrooms: Ethical, organisational and educational lessons in bridging research and practice. *International Journal of Child-Computer Interaction 19, 19-29*.

[16] Brown , M., McCormack, M., Reeves, J., Brooks, C., & Grajek, S. (2020). 2020 EDUCAUSE Horizon report, teaching and learning edition.

[17] Huang, H. L., Hwang, G. J., & Chang, C. Y. (2020). Learning to be a writer: A spherical video-based virtual reality approach to supporting descriptive article writing in high school Chinese courses. *British Journal of Educational Technology, 51(4), 1386-1405*.

[18] Bourgonjon, J., Valcke, M., Soetaert, R., & Schellens, T. (2013). Students' perceptions about the use of video games in the classroom. Computers & Education, 61, 13-22.

[19] Tsai, C.-C., Chuang, S.-C., Liang, J.-C., & Tsai, M.-J. (2011). Self-efficacy in Internet-based learning environments: A literature review. *Journal of Educational Technology & Society, 14*(4), 222–240.

[20] Dunleavy, M., Dede, C., & Mitchell, R. (2009). Affordances and limitations of immersive participatory augmented reality simulations for teaching and learning. Journal of Science Education and Technology, 18(1), 7-22.

[21] Kassner, M. P., Wesselmann, E. D., Law, A. T., & William, K. D. (2012). Virtually ostracized: Studying ostracism in immersive virtual environments. Cyberpsychology, Behavior, and Social Networking, 15(8), 399–403.

[22] Prendergast, C. N., & Schubert, T. (2020). Investigating Reflexive Responses to Explicit and Implicit Forms of Social Exclusion Using Immersive Virtual Environment Technology. Front. Psychol. 11:575783.

[23] Will, G.-J., van Lier, P. A., Crone, E. A., & Güroğlu, B. (2016). Chronic childhood peer rejection is associated with heightened neural responses to social exclusion during adolescence. Journal of Abnormal Child Psychology, 44, 43–55.

[24] Williams, K. D., Cheung, C. K., & Choi, W. (2000). Cyberostracism: effects of being ignored over the internet. *Journal of Personality and Social Psychology, 79*, 748–762.

[25] Chen, B., Vansteenkiste, M., Beyers, W., Boone, L., Deci, E. L., Van der Kaap-Deeder, J., . . . Ryan, R. M. (2015). Basic psychological need satisfaction, need frustration, and need strength across four cultures. *Motivation and Emotion, 39(2)*, 216–236.

[26] Kerres Malecki, C., & Kilpatrick Demary, M. (2002). Measuring perceived social support: Development of the child and adolescent social support scale (CASSS). *Psychologhy in the Schools, 39 (1)*, 1-18.

Web-based Mental Imagery: a Feasibility Study with a Brief Guided Exercise

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Abstract. In current years, psychological web-based interventions had been increasingly used in the context of mental health and well-being. These approaches offer great pros in terms of cost and time-saving benefits. In addition, they can improve the possibility of reaching persons remotely, increasing participants' adherence to the intervention. Usually, such interventions make use of techniques and exercises taken from cognitive behavioral approaches and are traditionally carried out in a *vis-à-vis* setting. One of the approaches that often yield good results in treating anxiety and stress issues, is the mental imagery approach. The current pilot study aims to preliminary assess the feasibility and the subjective experience of a fully-automated web-based mental imagery experience, delivered through a digital platform and with a combination of cognitive, breathing, and bodily awareness instructions. 34 healthy volunteers were enrolled in an online survey and asked to listen to an audio clip with the mental imagery technique. The level of self-rated baseline anxiety, as well as changes in the emotional experience and the sense of presence during the exercise, were assessed. Results showed that the technique increased the pleasantness of the emotional state ($t = -4.56$, $p = .001$) and decreased the level of psychomotor activation ($t = 2.30$, $p = .014$). Furthermore, the sense of presence reached fair levels. These results highlighted that fully automated imaginary techniques with bodily instructions are feasible and perceived as effective in online and web-based interventions.

Keywords. Mental Imagery; eHealth; web-based interventions; relaxation; mental health

1. Introduction

In recent years, psychological digital and remote interventions have increasingly been applied, especially during the COVID-19 lockdown that lead to social isolation and emotional issue (depression and anxiety especially). Usually, these interventions make use of psychological 'traditional' techniques, which are derived from cognitive behavioral approaches or meditation and mindfulness exercises [1, 2]. Literature reported some relevant differences emerge in applying the same techniques remotely or in person (i.e., namely the presence of the therapist, the familiarity of the setting, and the possibility for the therapist to adjust the technique and for the patients to interact with his/her therapist and provide feedback). Thus, preliminary testing of the techniques to be inserted in these interventions is extremely important.

One of the psychological approaches that often yield good results in treating anxiety and stress issues is the mental imagery approach.

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Mental imagery can have a prominent role in mental health [3] and be a powerful way to improve cognition [4], and reduce psychological symptoms such as depression, anxiety, and anger [5, 6]. Mental imagery techniques guide and focus the imagination positively and with awareness, activating sensorial and bodily perception. Indeed, physical experience might shape cognition [7] and the technique instructions shift participants' attention to physically safe sensations to improve embodied processes at a subconscious level and bodily cognition.

In the present study, we aimed to preliminary test the feasibility and perceived efficacy of a fully-automated web-based mental imagery experience, delivered with an audio clip and through a digital platform. Specifically, the mental imagery exercise was proposed to healthy volunteers and aimed to increase resilience and the ability to stay in touch with unpleasant emotional sensations and anxiety, without entering into a distressing state and remaining calm and aware of their inner sensations.

2. Material and Methods

34 healthy volunteers were enrolled in this feasibility study (Mean Age: 47.56, SD: 11 Range: 26-66). All participants were Italian citizens; concerning the education level, most had a bachelor's degree (52.9%) and worked as white-collar employers (85.3%). As regards the marital status, 41.2% were married and 58.8% had one or more sons.

The study was conducted according to the Declaration of Helsinki and participants were informed of the aims of the research and were asked to express informed written consent. The time duration for the online survey and the audio clip was 15 minutes on average.

The entire study was conducted on a digital platform. Participants received a link with a Qualtrics survey containing an ad hoc survey assessing socio-demographical variables, and self-reported questionnaires and were asked to listen to 8-minute pre-registered audio clip with a mental imagery technique on stress reduction and emotional awareness. The audio clip was pre-tested on three healthy volunteers to assess the clarity of the instructions. Before the exercise, participants were instructed on the physical environment to choose to listen to the audio clip and the bodily position to be kept during the exercise. To increase the sense of engagement of participants during the session, the guiding voice repeatedly asked them to vividly imagine the perceptual and bodily sensations linked to the exercise and the imaginary scenario.

Participants first filled in a battery of self-report questionnaires on socio-demographical and psychological features and self-perception of emotional state. Specifically, they completed the State-Trait-Anxiety-Inventory, STAI [8]), for the assessment of state anxiety, and a three-item visual scale from 1 to 9 (Self-Assessment Manikin, SAM [9]) which asked to rate three features of the emotional state, namely pleasantness (valence), activation (arousal) and perceived control (dominance).

Then they received the 8-minute psychological intervention (audio clip) based on the imaginary technique combined with breathing exercises and instructions on bodily awareness was proposed to all participants. Finally, participants were asked if they listened to the entire audio clip and to fill in again the SAM for the emotional state. After the exercise, participants were also asked to complete a modified version of the sense of presence questionnaire (ITC-Sense of presence inventory [10]) to assess the sense of 'being inside the imaginary place' during the exercise. In the present study, the STAI Cronbach α was 0.94.

3. Results

Overall, 9 participants described themselves as anxious, while 12 were receiving psychotherapy treatment on their own (without the use of imaginary techniques).

Concerning the psychological state before and after the exercise, overall the pre-exercise mean score for state anxiety was 43.12 (SD: 12.36, Range: 24-67), which

indicates levels of moderate clinical anxiety [11, 12]. Interestingly, there was concordance between the self-description of being anxious and the scores of the state anxiety (STAI). Indeed, those who described themselves as anxious had a higher mean (M: 50.35, SD: 10.48) compared to the others (M: 35.9, SD: 9.7).

Concerning the experience during the exercise and the sense of presence (Table 1),overall participants rated with fair to good scores the sense of emotional engagement and presence they felt during the exercise, meaning that they felt to be engaged and psychologically focused during the technique.

As regards the differences in the perceived emotional state before and after the experience, relevant significant differences and large effect sizes (Cohen's *d* from .76 to .78) emerged in the dimensions of valence (i.e.: the pleasantness of the emotional state) and arousal (i.e.: the level of activation related to the emotional state). Specifically, the perceived emotional activation decreased (arousal), while the pleasantness of the emotional state increased significantly (valence). No significant effect was found for the perceived sense of control over the emotional states (Table 2).

Table 1. Descriptive statistics of the sense of presence and engagement during the exercise.

Variable	Min-Max	Mean	Standard Deviation
Emotional engagement	34-64	48.85	6.6
Perceived realism	6-16	10.2	2.8
Presence	33-89	58.7	12.2

Table 2. Differences in relevant variables before and after the exercise

Variable	M (SD) pre M (SD) post	Paired t-test	Cohen's D
SAM Valence	M_{pre}=5.8, SD_{pre}=1.7 M_{post}=6.9, SD_{post}=1.5	t = -4.56, df = 33, ***p* = .001***	D= .78; [95% CI: .39, 1.16]
SAM Arousal	M_{pre}=5.15, SD_{pre}=1.8 M_{post}=4.35, SD_{post}=2.3	t = 2.30, df = 33, ***p* = 0.014***	D= .76; [95% CI: .38, 1.14]
SAM Dominance	M_{pre}=4.62, SD_{pre}=2.0 M_{post}=4.76, SD_{post}=2.2	t = -.43, df = 33, *p* = .33	D= -.07; [95% CI: -.41, .26]

**p*-value < .05

4. Conclusion

The present study was meant to test the perceived efficacy of a mental imagery technique and the sense of presence and engagement during the technique.

Results showed that a web-based intervention featuring an effective mental imagery technique with fully automated instructions on mental imagery can be effective in significantly improving emotional states and providing a vivid experience to participants, as shown by the self-report rating on the emotional states and the emotional engagement during the exercise. Specifically, concerning the improvement of the pleasantness of emotional states and arousal regulation, the effect sizes showed relevant improvements.

Similarly, choosing the setting for listening to the technique impact on participants' well-being positively. Based on these preliminary results, such techniques can be then feasible for mental health interventions targeting anxiety and stress in laypeople samples and might be suitable for clinical samples too. Previous approaches with online and brief techniques already showed that they are relevant to promote a positive bodily self-characteristic, which can increase individuals' well-being [13]. Similarly, literature showed the positive impact of mental imagery to decrease emotional issues, in particular anxiety [14] Future studies might implement the use of such techniques combining more approaches within the same exercise, as well as testing these approaches with a clinical target of participants and using extensive and longitudinal approaches to train participants' mental imagery abilities and increase resilience.

References

[1] S. M. F. Pizzoli, C. Marzorati, D. Mazzoni, and G. Pravettoni, "An internet-based intervention to alleviate stress during social isolation with guided relaxation and meditation: Protocol for a randomized controlled trial," *JMIR Res Protoc*, vol. 9, no. 6, Jun. 2020, doi: 10.2196/19236.

[2] S. F. M. Pizzoli, C. Marzorati, D. Mazzoni, and G. Pravettoni, "Web-based relaxation intervention for stress during social isolation: Randomized controlled trial," *JMIR Ment Health*, vol. 7, no. 12, Dec. 2020, doi: 10.2196/22757.

[3] K. Tallon, M. M. Ovanessian, N. Koerner, and M. J. Dugas, "Mental imagery in generalized anxiety disorder: A comparison with healthy control participants," *Behaviour research and therapy*, vol. 127, Apr. 2020, doi: 10.1016/J.BRAT.2020.103571.

[4] A.Vranic, M. Martincevic, and E. Borella, "Mental imagery training in older adults: Which are benefits and individual predictors?," *Int J Geriatr Psychiatry*, vol. 36, no. 2, pp. 334–341, Feb. 2021, doi: 10.1002/GPS.5428.

[5] E. Landkroon, E. A. M. van Dis, K. Meyerbröker, E. Salemink, M. A. Hagenaars, and I. M. Engelhard, "Future-Oriented Positive Mental Imagery Reduces Anxiety for Exposure to Public Speaking," *Behav Ther*, vol. 53, no. 1, pp. 80–91, Jan. 2022, doi: 10.1016/J.BETH.2021.06.005.

[6] M. W. van Teffelen, M. J. Voncken, F. Peeters, E. D. Mollema, and J. Lobbestael, "The efficacy of incorporating mental imagery in cognitive restructuring techniques on reducing hostility: A randomized controlled trial," *J Behav Ther Exp Psychiatry*, vol. 73, Dec. 2021, doi: 10.1016/J.JBTEP.2021.101677.

[7] D. Kemmerer, L. Miller, M. K. MacPherson, J. Huber, and D. Tranel, "An investigation of semantic similarity judgments about action and non-action verbs in Parkinson's disease: implications for the Embodied Cognition Framework," *Front Hum Neurosci*, vol. 7, no. APR 2013, Apr. 2013, doi: 10.3389/FNHUM.2013.00146.

[8] C. Spielberger, "State-trait anxiety inventory for adults," 1983.

[9] M. M. Bradley and P. J. Lang, "Measuring emotion: the Self-Assessment Manikin and the Semantic Differential.," *J Behav Ther Exp Psychiatry*, vol. 25, pp. 49–59, 1994, doi: 10.1016/0005-7916(94)90063-9.

[10] J. Lessiter, J. Freeman, E. Keogh, and J. Davidoff, "A Cross-Media Presence Questionnaire: The ITC-Sense of Presence Inventory," *Presence: Teleoperators and Virtual Environments*, vol. 10, no. 3, pp. 282–297, Jun. 2001, doi: 10.1162/105474601300343612.

[11] R. G. Knight, H. J. Waal Manning, and G. F. Spears, "Some norms and reliability data for the State--Trait Anxiety Inventory and the Zung Self-Rating Depression scale," *Br J Clin Psychol*, vol. 22 (Pt 4), no. 4, pp. 245–249, 1983, doi: 10.1111/J.2044-8260.1983.TB00610.X.

[12] G. Addolorato *et al.*, "State and trait anxiety in women affected by allergic and vasomotor rhinitis," *J Psychosom Res*, vol. 46, no. 3, pp. 283–289, 1999, doi: 10.1016/S0022-3999(98)00109-3.

[13] V. Sebri, S. Triberti, and G. Pravettoni, "The self's choice: Priming attentional focus on bodily self promotes loss frequency bias", doi: 10.1007/s12144-021-01400-8/Published.

[14] Ji, Julie L., et al. "Mental imagery in psychiatry: conceptual & clinical implications." CNS spectrums 24.1 (2019): 114-126. https://doi.org/10.1017/S1092852918001487

A Mobile Application to Train Attention Processes after Traumatic Brain Injury: Rational, Design and Feasibility Evaluation

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Abstract. Traumatic brain injury is considered a silent epidemic because it affects many people every year, all over the world and several consequences are invisible. Post-traumatic sequelae are often significant and permanent, both physically, emotionally and cognitively. In terms of cognition, executive functions and attention are most frequently disrupted, hence the importance of putting in place a treatment that allows the transfer and generalization of knowledge in the daily life of the person. Mobile applications offer great potential as they can easily be inserted in daily routines, thus facilitating the transfer. Mindfulness approaches could also be useful because they allow a refocusing of attention, moment after moment. Thus, Mindfulness offers the opportunity to practice and develop a daily routine, which can help generalization. Inspired by the ORBIT model for the development of behavioral treatment, we have developed a mobile app for attentional focus training after moderate or severe traumatic brain injury. This article presents the methodology for developing the mobile application up to the subsequent testing phase. Based on a rigorous approach, scientifically validate, the development stages of the intervention program implemented in the mobile application guarantee its theoretical and content validity allowing us to hypothesize its clinical and social benefits in the context of post traumatic brain injury treatment plans.

Keywords. Mobile application, attention processes training, traumatic brain injury, cognitive remediation, mindfulness.

1. Introduction

Traumatic brain injury (TBI) is a major public health issue. Each year, at least 50,000 Canadians, including 12,000 Quebecers, are hospitalized with a TBI. Of these, 15% are moderate to severe. According to Menon et al. (2010) [1], TBI is defined as an impairment of brain function, or any other indication of brain pathology, caused by external force. Falls are the leading cause of TBI hospitalizations. Other major causes include motor vehicle accidents, bicycle accidents and sports and recreation accidents [2].

Many people who sustain a moderate to severe TBI will develop post-traumatic physical, affective, and cognitive sequalae. Physical sequelae are primarily manifested in severe orthopedic injury or motor injury [3]. Serious orthopedic injuries include injuries involving the musculoskeletal system. Affective sequalae include changes in mood, behaviour and personality [4]. In addition, post-traumatic anxiety and depression symptoms are frequently reported [5; 6]. Cognitively, memory and executive functions

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are frequently affected, and even more frequently, attention dysfunctions are present after a TBI.

Attention is usually defined as a wide assortment of skills, process, and cognitive states. It can influence reaction time, information processing, and vigilance. Problems reported by people who receive a TBI concern concentration, distractibility, forgetfulness, multitasking. Attention as a cognitive function is very important to complete instrumental activities of daily living (iADL) as well as to ensure security (for self and others). To help people to manage attentional problems after a TBI, neuropsychologists recommend cognitive remediation to stimulate or to compensate attention deficit. However, despite the many attempts to design interventions specific to attention process, generalisation or transfer in the iADL remains to be empirically supported. Recently, several researchers have coined the idea that a better approach could stem from adopting an ecological perspective [7]. In addition, it was proposed that if cognitive training is inserted within everyday life, generalisation and transfer should be better.

1.1 Intervention

Several interventions have been developed for people with moderate or severe TBI who are living with attentional deficits. Cicerone et al. (2019) [8] conducted a systematic review of the literature on attention remediation interventions. Attention Process Training (APT) [9, 10, 11] is the most validated tool among individuals with a brain injury. A randomized controlled study compared APT and traditional intervention for patients hospitalized following a stroke [12]. Participants who received APT showed greater improvement in attention, although the broader functional outcomes did not differ. This finding is consistent with existing evidence suggesting limited benefits of APT over standard brain injury rehabilitation during the acute recovery phase.

To overcome the limitations related to the generalization and transfer of knowledge of traditional cognitive interventions, some approaches, such as mindfulness-based interventions, seek to make everyday life a place of practice. Traditionally, mindfulness is defined as a state of consciousness that emerges from intentionally (and therefore controlled) paying attention to the present moment [13]. An analysis of the cognitive functions involved in mindfulness, according to Buttle (2011) [14] and Prakash (2021) [15], reveals that attention, working memory and their different processes are crucial. Indeed, Bishop et al. [16] proposed two key components of the mindfulness: self-regulation of attention (i.e., the ability to maintain attention) and orientation to the present with curiosity, openness, and acceptance. More specifically, in mindfulness practice, it is necessary to focus our attention on an object (e.g., breathing), by self-regulating attention. Self-regulation requires the participation of three mechanisms: the ability to direct, engage, and control attention [17]. However, maintaining attention on the present moment is not sufficient. Indeed, remembering the task and its purpose via working memory and retrospective memory is a key skill for mindfulness practice.

The few studies that have been conducted so far included people with mild TBI. The interventions offered to participants are based on the mindfulness-based stress reduction program (MBSR; [18]). Studies that have used MBSR-based interventions showed that there is a decrease in post-concussion symptoms, particularly in cognitive complaints, a significant improvement in quality of life and a significant improvement in the perceived effectiveness [19], and improved attentional skills and working memory [20]. Some authors, including Bay et al. [21], have also implemented mindfulness intervention in individuals with mild to moderate TBI and have demonstrated the acceptability and feasibility of using this type of intervention in this population. Finally, a study by Landry and Banville [22] showed that mindfulness training can improve the attentional skills of people who have had a mild TBI. The study was conducted on four participants with post-concussion symptoms and attentional complaints following mild TBI. The results showed significant and positive changes for selective attention, sustained attention, and cognitive flexibility after the intervention.

1.2 Mobile Applications

Mobile devices are ubiquitous in everyday life and their applications (apps) are increasingly being used and perfected, particularly in health domains [23]. In 2020, according to Statistics Canada [24], 84% of Canadians possessed a smartphone, including 96% of those aged 15 to 24, 54% of those aged 65 and over, and 63% of the unemployed. A study by Wong and colleagues [25], comparing the general population and clinical populations for smartphone ownership, showed that 62% of participants with a stroke and 76% of participants with a TBI possessed a smartphone compared to 86-85% for the control group. In another study of the use of mobile devices in adults with TBI or stroke (N=50), 64% of participants reported using them for cognition [26]. Of these participants, 46% would be interested in receiving personalized training related to their difficulties. However, it is difficult to find professional apps based on rigorous empirical data among the thousands of apps available [23; 27]. In addition, existing mobile apps in neuropsychology focus on cognitive assessment or supporting cognitive functioning through compensatory means (e.g., recall applications).

The aim of this study is to describe the steps used to develop a mobile app for attentional focus training using the ORBIT approach.

2. Method

This paper presents the ORBIT model for developing behavioral treatments to prevent and/or manage chronic disease [28]. The model was informed by the process of drug development and by previous efforts to define the behavioral treatment development.

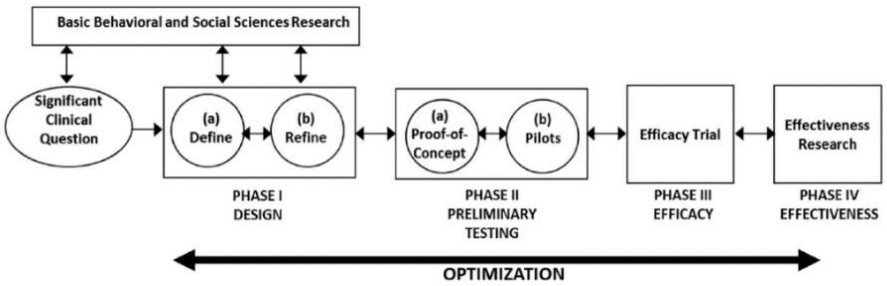

Figure 1. The ORBIT model for behavioral treatment development [28]

2.1 Phase Ia: Design

The goal of Phase I is to design the essential features of a behavioral treatment. In Phase Ia, the scientific foundation and the basic elements of the behavioral treatment are defined.

Intervention. An exploratory literature review was conducted in the Medline database with the keywords "traumatic brain injury", "attention training", "mindfulness", "mobile application" to document the following: (1) traditional attentional remediation interventions for moderate to severe TBI; (2) mindfulness interventions for TBI; and (3) interventions via mobile apps for TBI. This literature review documented the choice of theoretical orientations used in the development of the intervention, as well as the methodology and analyses to be performed for validation. The development of the attention process training is based on the neuropsychological model of attention of Sohlberg and Mateer [9]. This model was developed from a brain damaged population and includes the sub-components of attention that are frequently affected following a TBI. This includes focused, sustained, selective, alternating and divided attention. As with attention process training (APT-III) developed by these authors, our attentional focus training program needed to adhere to the following five principles: (1) Organize treatment tasks using a theoretically sound model; (2) Provide sufficient repetition; (3) Use patient performance data to guide treatment; (4) Include training in metacognitive strategies; and (5) Identify and practice functional attentional goals. In addition, complex

forms of attention should not be trained before simpler forms of attention. The order of the targeted processes should therefore be: focused attention, sustained attention, selective attention, alternating attention, and divided attention.

The development of the attentional remediation was also based on the five components model of mindfulness practice proposed by Baer and colleagues [29]. This model defines mindfulness as an overall psychological construct based on five main facets: (1) Observation: noticing or paying attention to internal and external experiences, such as sensations, cognitions, emotions, images, sounds, and smells; (2) Description: refers to labeling internal experiences with words; (3) Acting mindfully: includes being mindful of one's activities in the moment and can be contrasted with behaving mechanically while attention is focused elsewhere; (4) Non-judgment of inner experience: refers to not evaluating thoughts and feelings; (5) Non-reactivity to inner experience: allowing thoughts and feelings to come and go, without getting caught up in or carried away by them.

The proposed program is four weeks long and includes one session (60 minutes) per week and a daily homework assignment (10 minutes/day), all done using a mobile app on a device running an Android OS. The sessions are divided as follows: training of focused and sustained attention (session 1), training of selective attention (session 2), training of alternating attention (session 3) and training of divided attention (session 4).

Mobile application. The mobile app was developed using the Unity 3D game engine and is available for Android. The mobile app was developed with the collaboration of six trainee from University of Angers during the summers of 2021 and 2022. Three versions of the app have been released so far. During this development phase, we optimized the app by reducing polygons and simplifying textures to reduce the size (in terms of MB) of the environment. For this, we worked in collaboration with a developer. The challenge at this step was to allow the app to run easily on every device, rregardless of its memory and processor specifications. To allow for a minimum performance overhead from the environment, a low-poly style was chosen due to its simple design. It allows for very simple textures and 3D models which can be easily run on most Android devices released since 2017 whilst keeping the quality of a furnished environment. The environment is mostly static to allow for precalculated lighting, offering high quality shadows and global illumination for relatively cheap performance overhead.

The mobile app is composed of five sections (for example, see figure 2) : (1) About: contains a tutorial, a psycho-educational video about attention after TBI with a thought-provoking case example, and an explanatory text about mindfulness; (2) Exercises: contains all the exercises of the attention remediation program. (3) Homework: contains the list of homework assignments for each of the four weeks. It also contains a "goals" section allowing the participant to set goals and to consult them throughout the week; (4) Ambiences: contains ambient sounds representing nature and are aimed at practicing attentional focus; (5) Me: contains the participant's profile. The participant's mobile app usage data will be transmitted automatically after each use to a database. This data includes, for example, the time spent on the various sections, the exercises performed, the homework self-identified, etc. Supabase is used to interact with PostgreSQL, the database, and provides authentication with email and password to identify users across devices.

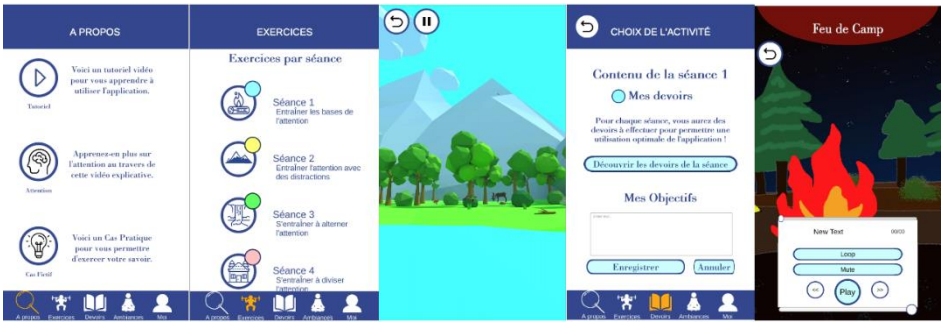

Figure 2. Example of some Mobile Application sections

2.2 Phase Ib: Refine

In phase Ib (refine) we precise here the methodology of validation. In the first step of validation (logic content validity), we contacted 14 experts in rehabilitation, mindfulness and cognition to validate the content of the exercises. Of these, 7 responded to the online questionnaire (Lyme Survey) built for this step. The aim was to confirm or infirm whether the exercises corresponded to the theoretical framework of attention and mindfulness as described above. At the end of this process, based on the average of the responses and on a group interview, all but one exercise (Exercise 4.4) was considered theoretically valid. In the second step of validation (ecologic content validity), in order to continue the development of the mobile app and reach phase II (preliminary testing), we will recruit 10 graduate students in sciences health domain to evaluate the heuristics, usability, user experience and tolerance of our attentional skills training. This is at this step that we will be able to assess the feasibility to use this mobile app to train attention.

2.3 Phase IIa: Preliminary testing - Proof-of-Concept

Further development. We expect to reach Phase II in the Fall of 2023. More specifically, as part of phase IIa (proof-of-concept), we will recruit 12 people with moderate or severe TBI. Each person will act as their own control (cross-over research design). The test phase will therefore include a waiting period and an intervention period, both marked by pre-tests and post-tests. At the end of this experiment, it will be possible to determine whether the intervention is clinically useful and whether it can be made available to a larger sample. For this phase III (efficacy) we can implement a randomized controlled design.

3. Conclusion

The ORBIT model has been very useful in guiding the development of this new app-based training program for people with moderate or severe TBI. From a methodological point of view, it made it possible to structure the stages of construction of the mobile app and the validation of the contents in addition to ensuring that the user experience is satisfying before proceeding to the test phases on the target population. The development of the mobile app has therefore been influenced by theoretical aspects and computer engineering. Several stakeholders have already contributed to improve the quality of treatment for a better acceptability and clinical utility.

To the best of our knowledge, this is the first study that examined the effects of mindfulness-based attentional focusing techniques on attentional processes post TBI. Scientifically, this project will provide a better understanding of the attentional processes modulated by the attentional focus techniques based on Mindfulness. At the theoretical level, this study attempts to dissect attentional processes from the angle of a theoretical model recognized in neuropsychology. Moreover, this mobile app would be one of the first to have a remedial focus to be scientifically validated. Clinically, this demonstration will be the first step in developing a cognitive neuropsychological intervention tool that can be used to improve attentional processes following moderate to severe TBI and their quality of life.

References

[1] Menon DK, Schwab K, Wright DW, Maas AI. Demographics and clinical assessement working group of the international and interagency initiative toward common data elements for research on traumatic brain injury. Position statement: definition of traumatic brain injury. Arch Phys Med Rehabil. 2010;91(1111): 1637-1640, doi: 10.1016/j.apmr.2010.05.017

[2] Public Health Agency of Canada. Injury study: Spotlight on traumatic head injuries across the life course. Injury in review. 2020 Aug, https://www.canada.ca/en/public-health/services/injury-prevention/canadian-hospitals-injury-reporting-prevention-program/injury-reports/2020-spotlight-traumatic-brain-injuries-life-course.html

[3] Capizzi A, Woo J, Verduzco-Gutierrez M. Traumatic brain injury: An overview of epidemiology, pathophysiology, and medical management. Med Clin North Am. 2020;104(2): 213/238, doi: 10.1016/j.mcna.2019.11.001
[4] Luauté J, Hamonet J, Pradat-Diehl P, SOFMER. Behavioral and affective disorders after brain injury: French guidelines for prevention and community supports. Ann Phys Rehabil Med. 2016;59(1): 68-73, doi: 10.1016/j.rehab.2015.10.007
[5] Demakis GJ, Hammond FM, Knotts A. Prediction of depression and anxiety 1 year after moderate-severe traumatic brain injury. Applied neuropsychology. 2010;17: 183-189, doi: 10.1080/09084282.2010.499752
[6] Ouellet M-C, Beaulieu-Bonneau S, Sirois M-J, Savard J, Turgeon A, Moore L, Swaine B, Roy J, Giguère M, Laviolette V. Depression in the first year after traumatic brain injury. Journal of Neurotrauma. 2018;35: 1620-1629, doi: 10.1089/neu.2017.5379.
[7] Zimmermann N, de Oliveira Cardoso C, Kochhann R, Jacobsen G, Paz Fonseca R. Contributions of the ecological approach to the neuropsychology of executive functions. Trends in Psychology. 2014;22(3): 639-654, doi: 10.9788/TP2014.3-09
[8] Cicerone KD, Goldin Y, Ganci K, Rosenbaum A, Wethe JV, Langenbahn DM, Malec JF, Bergquist TF, Kingsley K, Nagele D, Trexler L, Fraas M, Bogdanova Y, Harley JP. Evidence-based cognitive rehabilitation: systematic review of the literature from 2009 through 2014. Archives of Physical Medicine and Rehabilitation. 2019;100(15): 15-33, doi: 10.1016/j.apmr.2019.02.011
[9] Sohlberg MM, Mateer CA. Effectiveness of an attention-training program. J Clin Exp Neuropsychol. 1987;9: 117–130.
[10] Sohlberg MM, Mateer CA. (2001). Cognitive Rehabilitation: An integrative neuropsychological approach. 2001. New York, NY: Guilford.
[11] Sohlberg MM, Mateer CA. APT-III: Attention process training: A directattention training program for persons with acquired brain injury. 2010. Youngville, NC: Lash & Associates.
[12] Barker-Collo SL, Feigin VL, Lawes CMM, Parag V, Senior H, Rodgers A. Reducing attention deficits after stroke using attention process training: a randomized controlled trial. [Randomized Controlled Trial Research Support, Non-U.S. Gov't]. Stroke. 2009;40(10):3293-3298, doi: 10.1161/STROKEAHA.109.558239
[13] Kabat-Zinn, J. Mindfulness-Based Interventions in Context: Past, Present, and Future. Clinical Psychology: Science and Practice. 2003;10(2): 144-156, doi: 10.1093/clipsy.bpg016
[14] Buttle, H. Attention and working memory in mindfulness-meditation practices. The Journal of Mind and Behavior. 2011;32(2): 123-134.
[15] Prakash RS. Mindfulness Meditation: Impact on attentional control and emotion dysregulation. Archives of clinical neuropsychology. 2021;36(7): 1283-1290, doi: 10.1093/arclin/acab053
[16] Bishop SR, Lau M, Shapiro S, Carlson L, Anderson ND, Carmody J, Segal ZV, Abbey S, Speca M, Velting D, Devins G. Mindfulness: A proposed operational definition. Clinical Psychology: Science and Practice. 2004;11: 230–241, doi: 10.1093/clipsy.bph077
[17] Lutz A, Slagter HA, Dunne JD, Davidson RJ. Attention regulation and monitoring in meditation. Trends in Cognitive Sciences. 2008;12: 163–169, doi: 10.1016/j.tics.2008.01.005
[18] Kabat-Zinn J. An Outpatient Program in Behavioral Medicine for Chronic Pain Patients Based on the Practice of Mindfulness Meditation: Theoretical Considerations and Preliminary Results. General Hospital Psychiatry. 1982;4: 33-47.
[19] Azulay J, Smart CM, Mott T, Cicerone KD. A pilot study examining the effect of mindfulness-based stress reduction on symptoms of chronic mild traumatic brain injury/postconcussive syndrome. J Head Trauma Rehabil. 2013;28(4): 323-331, doi: 10.1097/HTR.0b013e318250ebda
[20] Cole MA, Muir JJ, Gans JJ, Shin LM, D'Esposito M, Harel BT, Schembri A. Simultaneous Treatment of Neurocognitive and Psychiatric Symptoms in Veterans with Post-Traumatic Stress Disorder and History of Mild Traumatic Brain Injury: A Pilot Study of Mindfulness-Based Stress Reduction. Mil Med. 2015;180(9): 956-963, doi: 10.7205/MILMED-D-14-00581
[21] Bay E, Ribbens-Grimm C, Chan RR. Development and testing of two lifestyle interventions for persons with chronic mild-to-moderate traumatic brain injury: Acceptability and feasibility. Applied Nursing research. 2016;30: 90-93, doi: 10.1016/j.apnr.2015.11.003
[22] Landry L. Entrainement à la pleine conscience via la réalité virtuelle immersive auprès de personnes ayant des symptômes post-commotionnels persistants suite à un traumatisme craniocérébral : une étude de cas. Essai doctoral, Université de Montréal, Papyrus. 2019. https://papyrus.bib.umontreal.ca/xmlui/bitstream/handle/1866/23277/Landry_Lysanne_2020_essai.pdf?sequence=1&isAllowed=y
[23] Wang K, Varma DS, Prosperi M. A systematic review of the effectiveness of mobile apps for monitoring and management of mental health symptoms or disorders. Journal of Psychiatric Research. 2018;107: 73-78, doi: 10.1016/j.jpsychires.2018.10.006
[24] Statistics Canada. Connecting Canadians: Telecommunications in Canada. 2020. https://www.statcan.gc.ca/en/subjects-start/digital_economy_and_society/telecommunications
[25] Wong D, Sinclair K, Seabrook E, McKay A, Ponsford J. Smartphones as assistive technology following traumatic brain injury: a preliminary study of what helps and what hinders, Disability and Rehabilitation. 2017;39(23): 2387-2394, doi: 10.1080/09638288.2016.1226434
[26] Beaulieu-Bonneau S, Dubois L, Lafond-Desmarais S-J, Fortin S, Forest-Dionne G, Ouellet M-C, Poulin V, Monetta L, Best K, Bottari C, Bier N, Gullo HL. Use of smartphones and tablets after acquired brain injury to support cognition. Disability and rehabilitation : Assistive technology. 2023, doi:10.1080/17483107.2023.2199036East-Richard C, Laplante L, Vézina J, Cellard C. L'évaluation psychologique par le biais des applications mobile. Association Psychologie Canadienne. 2017;59(3): 262-271, doi: 10.1037/cap0000113
[27] Czajkowski SM, Adler N, Reynolds KD, Laraia B, Perna FM, Epel E, Charlson ME, Powell LH, Naar-King A, Hunter CM, Olster DH, Peterson JC, Boyington JE. From ideas to efficacy: the ORBIT model for developing behavioral treatments for chronic diseases. Health Psychology. 2015;34(10): 971-982, doi: 10.1037/hea0000161

[28] Baer RA, Smith GT, Hopkins J, Krietemeyer J, Toney L. Using self-report assessmentmethods to explore facets of mindfulness. Assessment. 2006;13(1): 27-45

Feasibility of Virtual Reality Environments Use in Reduction of Dental Anxiety during Treatment

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Abstract. Dental procedural pain and anxiety present a significant challenge for a substantial proportion of the population, often resulting in reduced frequency of dental care. This issue affects both patients and dentists, with the latter frequently encountering patient resistance during treatment. This study investigates the efficacy of virtual reality (VR) as a method of distraction for dental patients, using subjective and objective measures to assess the impact of a VR system on patient-reported anxiety levels and physiological factors. A clinical trial was conducted, enrolling 37 patients who were divided into two groups: an experimental group of 26 patients and a control group of 11 patients. The results of this study are encouraging, indicating that VR is effective in shielding the patient from distracting stimuli in the treatment environment.

Keywords. Dental care, dental phobia, distraction, analgesia, virtual reality

1. Introduction

Dentophobia, also known as odontophobia, refers to the fear of dental procedures that stems from the misguided belief that such interventions are dangerous and harmful. Dental procedures are often stressful situations for most patients worldwide. According to research, dental anxiety ranks fourth among common fears and ninth among intense fears [1]. This fear is frequently multifactorial in nature, with negative past experiences, negative thoughts about treatment and expected pain, patient's perception of the procedure, general anxiety and personality, and some clinical factors, such as the type of dental procedure and dentist behavior, being potential causes [2, 3]. These manifestations of anxiety can potentially pose challenges for dentists in managing patients. Patients with dental anxiety tend to delay their appointments, compromising their oral health [4].

Dentophobia can lead to a reduction in the number of regular dental visits and endanger people's oral health. When phobia leads to avoidance or anticipatory anxiety, it can also interfere with one's daily routine, job functionality, social activities, or social relationships in frightening situations or cause significant fear of dental procedures. Conversely, individuals who visit the dentist more frequently and those without previous traumatic dental experiences tend to be less anxious.

Traditionally, psychotherapy has been the primary method used in the treatment of dental anxiety. Various techniques validated in scientific literature can be used either alone or in combination with other psychological therapies or integrated with psycho-pharmacological treatments. Some of these techniques aim to achieve physical and psychological relaxation by using conscious breathing and muscle relaxation to exploit mind-body feedback [1]. Another approach, called the Distraction Technique (DT) [1, 5], involves diverting the patient's attention away from the unpleasant surgical experience by exposing them to a range of pleasant stimuli. Passive distraction can be

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achieved through the reproduction of audio-visual content, while active distraction requires the patient's direct participation.

New technologies such as virtual reality (VR) are now commonly used in the treatment of psychological problems. VR allows people to imagine a different experience in the real world to break free from routine life [6]. By using attractive images, visual effects, sounds, and activities, VR captures patients' attention and distracts them from pain. By encouraging patients to focus on other thoughts, less attention is available to the pain [7, 8]. In line with previous studies on the use of virtual reality as a distraction tool from anxiety and/or pain [9, 10, 11], we aimed to evaluate the validity and reliability of the intervention with virtual reality in this specific field, assessing the response to the therapy by patients undergoing dental procedures.

2. Methods

2.1. Participants

A group of 37 patients who required elective dental surgical treatment in local anesthesia were recruited from two public hospitals and a private clinic in Palermo, Italy. These patients were randomly divided into an experimental group and a control group.

The experimental group consisted of 26 patients, 14 females and 12 males, between 18 and 78 years old (mean 34.65 ± 15.43), while the control group consisted of 11 patients, 4 females and 7 males, between 19 and 60 years old (mean 36.64 ± 14.49).

Table 1. Clinical samples

	Experimental group	**Control group**
N	26	11
Age (Mean ± SD)	34.65 ± 15.43	36.64 ± 14.49
(range)	18 ± 78	19 ± 60
Gender, (M, F)	12, 14	7, 4

2.2. Instruments and Procedures

Before the treatment, both groups were given a questionnaire developed specifically for this study. The questionnaire aimed to gather sociodemographic variables and information about the patients' relationship with dentists, such as familiarity with the dental setting, frequency of visits, satisfaction rate, previous dental treatments and type of dental procedures.

In addition, the patients completed self-administered questionnaires such as the Dental Anxiety Scale of Corah (DAS), the State-Trait Anxiety Inventory (STAI form Y1 and Y2), and the Beck Depression Inventory-II (BDI-II) to assess their anxiety and depression levels. Subjective levels of anxiety were reported by the patient using the Subjective Units of Distress Scale (SUDS) visual scale at three distinct time points during the dental treatment, namely before (T1), during (T2), and immediately after (T3), and the patient's heart rate (HR) was measured at the same intervals through a fingertip pulse oximeter. At the end of the operation, both groups completed the STAI-Y1 questionnaire again to evaluate variations in state anxiety levels.

The presence of depression was also assessed through the Beck Depression Inventory-II, as it can be a contributing factor to the perception of more pain during dental procedures and phobic avoidance of further dental procedures [12, 13].

2.3. Interventions

The experimental procedure involved a single exploration of virtual environments designed to elicit relaxation and facilitate deep breathing during the dental procedure.

We used two VR scenarios, "Dream Castle" and "Cliff," which were developed by The Virtual Reality Medical Center in San Diego, CA. Both environments were designed

to evoke relaxation and deep breathing in patients [14]. They were developed to provide relief and distraction in patients with chronic pain, but their characteristics make them suitable for a wide range of conditions, particularly where perceived levels of stress and tension play a crucial role. These simulations are rich in stimuli that can attract, engage, and relax the individual who explores them, allowing them to divert their attention from painful or anxious stimuli elicited by the situation. The software ran on an ASUS laptop, while the video and audio information were reproduced on a head-mounted display (Vuzix iWear) to provide an immersive VR experience. Patients used a joystick to navigate the environments and were trained to use it before the start of the treatment.

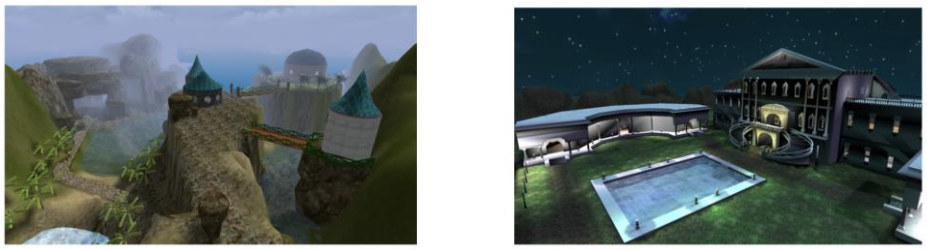

Figure 1. Cliff and Dream Castle VR scenarios.

3. Results

Wilcoxon test was used to compare values pre- and post-treatment in both the experimental and the control group. This non-parametric test was chosen due to the size and heterogeneity of subjects in both groups. Additionally, Spearman's rank test was used to examine the correlations between the variables collected through the questionnaires. All analyses were processed using the IBM SPSS Statistics v25 software.

The initial tests conducted before the treatment showed that the sample did not exhibit excessive trait-anxiety (STAI-Y2<40) or excessive depression state (BDI-II<16). The DAS mean scores for both groups indicated a physiological anxiety level towards the dental setting and related procedures (experimental group, 9.192 ± 3.699; control group, 11.273 ± 2.687).

The study results demonstrated a significant reduction in anxiety levels in the experimental group, as evidenced by a decrease in the State-Trait Anxiety Inventory score (STAI-Y1) ($p = 0.000$) and the decrease in Subjective Units of Distress Scale (SUDS) score from T1 to T3 ($p = 0.009$). Additionally, there was a significant reduction in heart rate (HR) between T2 and T3 ($p = 0.049$). On the other hand, the control group did not show a significant reduction in SUDS score ($p = 0.236$) but showed a less significant improvement in STAI-Y1 score (T1 vs T3, $p = 0.041$). Finally, the control group also showed a statistically more significant reduction in heart rate from T2 to T3 ($p = 0.009$). (Table 2).

Table 2. Results at Wilcoxon test

Test-retest	**Experimental** (n=26)	**Control** (n=11)
STAI Y-1	z= -3.881, p= 0.000*	z= -2.047, p= 041*
HR T2-T3	z= -1.970, p= 0.049*	z= -2.601, p= 009*
SUDS	z= -2.618, p= 0.009*	z= -1.185, p= 0.236

*****Significant p<0.05

Analyzing all interviewed patients through the Spearman correlation coefficient, relationships between pre-treatment questionnaire variables were examined. The following correlations emerged:

- Significant correlation between high levels of dental anxiety (DAS) and high levels of trait anxiety (STAI Y2) (r_s= 0.430, p= 0.008), state anxiety (STAI Y1) (r_s= 0.766, p= 0.000), and depression (BDI-II) (r_s= 0.528, p= 0.001);

- Significant correlation between low satisfaction in dialogue with the dentist and high levels of dental anxiety (DAS) (r_s= -0.402, p= 0.014), trait anxiety (STAI Y2) (r_s= -0.616, p=0.000), state anxiety (STAI Y1) (r_s=-0.532, p=0.001), and depression (BDI-II) (r_s= -0.649, p= 0.000);
- Significant correlation between satisfaction and age (r_s= 0.402, p=0.014), education (r_s= 0.415, p= 0.011), profession (r_s= 0.389, p= 0.017);
- Trend towards significance between low satisfaction and number of past dental treatments received (r_s= -0.323, p= 0.051), and between profession prestige and frequency of dental visits in a year (r_s= 0.302, p= 0.069).

4. Discussion and Conclusion

After analyzing the data, the results show a significant reduction in the measured parameters in the experimental group after the VR treatment. The most noteworthy improvement was observed in the post-intervention scores of STAI-Y1, which measures the level of anxiety experienced by patients while completing the questionnaire. The reduction in the score obtained in this test implies that patients had a more positive perception of themselves (e.g., “I feel confident”, “I feel happy”) and the events they will face, without feeling indecisive or worried about possible mishaps. This positive change may suggest that these patients are more willing to return to the dentist in the future, thus breaking the vicious circle of fear and avoidance behaviors toward dental treatments.

The SUDS test proved to be an effective tool for measuring the anxiety levels of the participants [15], with both groups showing an increase in anxiety levels during the first part of the surgery. However, the group that received VR treatment showed a more significant reduction in anxiety levels by the end of the intervention (T1 vs T3), especially during the second half, which included the more stressful and painful aspects of dental treatment. Although the SUDS, as a subjective rating scale, may be influenced by the patient's personal expectations of the treatment received, this positive result suggests that the VR treatment was effective in reducing anxiety and promoting patient satisfaction. Further studies with larger sample sizes could validate this finding.

The FC showed similar variations to the SUDS in the different moments in which it was measured. A statistically significant reduction was highlighted for the experimental group in the second part of the intervention (T2 vs T3), which supports the hypothesis of the effectiveness of VR in reducing patients' agitation. However, this parameter underwent more significant fluctuations than the SUDS in both groups studied, reducing its statistical significance in line with other studies [16].

Additionally, it is noteworthy that the higher anxiety levels observed in the experimental group, as evidenced by DAS scores, could potentially be attributed to the patient-dentist relationship, which is known to play a crucial role in patient anxiety levels. This find reinforces the concept that a good patient-dentist relationship from the first visit positively affects patient compliance and cooperation. Therefore, it is important to further investigate the impact of the patient-dentist relationship on anxiety levels in patients undergoing dental treatment, in order to optimize the effectiveness of interventions aimed at reducing anxiety and improving patient outcomes. In this regard, our study also revealed that lower educational attainment, previous dental experience, and frequency of dental surgical treatments were associated with increased state anxiety and stress related to dental procedures.

Overall, these findings are consistent with the benefits reported in other publications regarding the use of VR in dentistry [17]. In this study, we introduced and evaluated the use of our virtual environments in clinical practice to reduce dental anxiety. The software proved to be easily applicable, particularly in the dental surgery department of a public hospital in Italy. Our technique demonstrated several advantages, including low implementation costs, simulation of real-life experiences, and a duration not exceeding 60 minutes. This ensured that patients did not experience fatigue or boredom. Furthermore, the utilization of our questionnaire allowed us to gather sociodemographic

parameters and information on patients' prior attitudes towards dental care, facilitating the assessment of the relationship between these factors and the effectiveness of the treatment.

However, the results of the present study are limited by the small sample size, and further investigation is warranted through follow-up studies of recruited patients. To clarify the efficacy of the virtual environment as a method of distraction for dental patients, further studies are needed. Analyzing comparable samples of patients with different tooth disorders, such as tooth decay, abscess, and tooth injuries, could be relevant because the heterogeneity of the disorder can lead to different results for each subtype.

References

[1] Appukuttan DP. Strategies to manage patients with dental anxiety and dental phobia: Literature review. Clin Cosmet Investig Dent., 2016; 8: 35-50. doi.org/10.2147/CCIDE.S63626
[2] Brahm CO, Lundgren J, Carlsson SG, Nilsson P, Hagglin C. Evaluation of the Jonkoping dental fear coping model: A patient perspective. Acta Odontol Scand. 2019; 77(3): 238-47,
[3] doi: 10.1080/00016357.2018.1564837
[4] Armfield JM. The extent and nature of dental fear and phobia in Australia. Aust Dent J.2010; 55(4):368-77, doi: 10.1111/j.1834-7819.2010.01256.x.
[5] Gordon D, Heimberg RG, Tellez M, Ismail AI. A critical review of approaches to the treatment of dental anxiety in adults. J Anxiety Disord 2013; 27: 365-378, doi.org/10.1016/j.janxdis.2013.04.002
[6] Prado IM, Carcavalli L, Abreu LG, Serra-Negra JM, Paiva SM, Martins CC. Use of distraction techniques for the management of anxiety and fear in paediatric dental practice: A systematic review of randomized controlled trials. Int J Paediatr Dent. 2019; 29 (5):650-68, doi.org/10.1111/ipd.12499
[7] Park MJ, Kim DJ, Lee U, Na EJ, Jeon HJ. A literature overview of virtual reality (VR) in treatment of psychiatric disorders: Recent advances and limitations. *Front Psychiatry*. 2019, 10:505,
[8] doi: 10.3389/fpsyt.2019.00505
[9] Hodes RL, Howland EW, Lightfoot N, et al. The effects of distraction on responses to cold pressor pain. Pain 1990; 41:109-114, doi: 10.1016/0304-3959(90)91115-Y
[10] Miron D, Duncan GH, Bushnell MC. Effects of attention on the intensity and unpleasantness of thermal pain. Pain 1989; 39: 345-352, doi.org/10.1016/0304-3959(89)90048-1
[11] Guarino D, La Paglia F, Daino M, Maiorca V, Zichichi S, Guccione F, Pintabona A, Wiederhold MD, Riva G, Wiederhold BK, La Barbera D. "Chronic pain treatment through virtual reality", Annual Review of CyberTherapy and Telemedicine, 15(Summer), December 2017, 181-184.
[12] Wiederhold M., Gao K., Wiederhold B., "Clinical use of virtual reality distraction System to reduce anxiety and pain in dental procedures", *Cyberpsychology, Behavior and Social Networking*, 17, 2014, 359-365, doi:10.1089/cyber.2014.0203
[13] La Paglia F, Daino M, Guarino D, Zichichi S, Riva G,. Wiederhold BK, La Barbera D "Virtual Reality environments to reduce dental anxiety" Annual Review of CyberTherapy and Telemedicine, 16, 2018, 175-178
[14] Engin, B., Uguz, F., Yilmaz, E., Özdemir, M., Mevlitoglu, I.: The levels of depression, anxiety and quality of life in patients with chronic idiopathic urticaria. Journal of European Academy of Dermatology and Venereology, 2008, 22, 36-40, doi.org/10.1111/j.1468-3083.2007.02324.x.
[15] Klages, U., Kianifard, S., Ulusoy, O., Wehrbein, H.: Anxiety sensitivity as predictor of pain in patients undergoing restorative dental procedures. Community Dentistry Oral Epidemiology, 2006, 34, 139-145, doi.org/10.1111/j.1600-0528.2006.00265.x
[16] B. Wiederhold, Virtual reality as a distraction technique in chronic pain patients, Cyberpsychol Behav Soc Netw, 17, 2014, 346-52, doi: 10.1089/cyber.2014.0207
[17] Tanner, B.A. Validity of Global Physical and Emotional SUDS. Appl Psychophysiol Biofeedback, 2012, 37, 31–34, doi.org/10.1007/s10484-011-9174-x
[18] Alghareeb Z, Alhaji K, Alhaddad B, Gaffar B. Assessment of Dental Anxiety and Hemodynamic Changes during Different Dental Procedures: A Report from Eastern Saudi Arabia. Eur J Dent. 2022.
[19] Gujjar KR, van Wijk A, Sharma R, de Jongh A. Virtual Reality Exposure Therapy for the Treatment of Dental Phobia: A Controlled Feasibility Study. Behav Cogn Psychother. 2018; 46 (3): 367-73, doi.org/10.1017/S1352465817000534

Promoting Emotional and Psychological Well-being of Patients with Chronic Obstructive Pulmonary Disease: A Feasibility Study Combining Virtual Reality and Savoring

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Abstract. Chronic Obstructive Pulmonary Disease (COPD) is a globally widespread pathology that causes an irreversible obstruction of airflow and it is associated with low levels of emotional and psychological well-being. In this context, Virtual Reality (VR) enhanced with savoring, that is the ability to generate and intensify positive emotions, can be employed to promote well-being and relaxation in patients with COPD. This ongoing study aims to investigate the feasibility of a two-week VR-based relaxation intervention enhanced with savoring in COPD patients in increasing emotional and psychological well-being, positive emotions, relaxation, oxygen saturation levels (SpO_2) and decreasing negative emotions. Seventeen hospitalized patients of the Pulmonary Rehabilitation Unit of IRCCS INRCA Casatenovo have been enrolled so far in this randomized controlled trial study. Together with the traditional pulmonary rehabilitation, the experimental group took part in the four-session VR-based intervention, while the active control group listened to relaxing music. In each session, the experimental group experienced a relaxing virtual scenario, and then participants completed a savoring exercise. Both groups complete the questionnaires before and after the intervention, and before and after each session. Independent samples t-tests based on delta scores revealed significant differences between the two groups in positive emotions and psychological well-being, suggesting that VR enhanced with savoring can be a promising path for promoting well-being in COPD patients. Indeed, savoring can amplify the positive effects of VR and create a connection with the positive experiences in patients' lives. Consequently, participants can build positive resources to counteract the harmful psychological effects caused by COPD.

Keywords. COPD, psychological well-being, emotional well-being, virtual reality, savoring, positive emotions

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1. Introduction

Chronic obstructive pulmonary disease (COPD) is a progressive lung disorder marked by persistent low-grade inflammation and irreversible airflow obstruction. According to statistics, it is a globally prevalent pathology that, in 2019, affected 212.3 million people [1]. COPD patients can experience a variety of extra-pulmonary adverse reactions and face frequent hospitalizations [2]. Consequently, COPD is often associated with high levels of anxiety, depression, stress, and low levels of emotional and psychological well-being [3].

An innovative and promising tool for promoting relaxation in patients with COPD is Virtual Reality (VR). VR has been successfully employed in promoting relaxation and stress reduction and has also shown relevant potential in improving and regulating emotional and psychological well-being and positive emotions [4-5]. One advantage of VR is its possibility to immerse the user in different digital environments, including relaxing natural scenarios that can have restorative effects, especially for hospitalized patients who cannot move to natural outdoor environments [5]. For example, a recent study showed the positive effects of relaxing virtual scenarios on the intensity of depressive, anxiety, and stress symptoms in hospitalized COPD patients [6].

In this perspective, positive psychology techniques, like savoring, can be integrated with VR experiences to promote relaxation and well-being. Savoring is a technique for appreciating and relishing positive experiences [7], and it is closely related to the broaden and build theory that posits that positive emotions expand individual resources for well-being [8]. Savoring has indeed been shown to be effective in increasing positive emotions and reducing negative ones [7], but it has not yet been applied to COPD patients.

This ongoing study explores the feasibility and preliminary effectiveness of a VR-based relaxation intervention enhanced with savoring in COPD patients [9]. This intervention is being conducted in collaboration with the Italian VR company Become-Hub and the Pulmonary Rehabilitation Unit of IRCCS INRCA (Italian National Research Centre on Aging) Casatenovo. We hypothesize that the intervention would (1) increase positive affect and reduce negative affect, (2) improve emotional and psychological well-being, and (3) enhance relaxation, as indicated by self-report measures and peripheral oxygen saturation (SpO2).

2. Methods

2.1. Participants and design

So far, this randomized controlled trial study has involved seventeen patients from the Pulmonary Rehabilitation Unit of IRCCS INRCA Casatenovo. The study was approved by the Ethics Committee of IRCCS INRCA Casatenovo. Participants were randomly assigned to the experimental and the control group. The inclusion criteria were age over 18 years and a diagnosis of COPD according to ERS/ATS criteria [10]. Exclusion criteria were a diagnosis of dementia or cognitive impairment reported within the medical records and the Mini Mental State Examination score of < 26. Other exclusion criteria were pre-existing medical conditions that preclude the use of the Oculus Quest 2 headset, such as (1) the presence of binocular vision abnormalities, (2) a positive history of seizures and epileptic conditions, (3) the presence of cardiac pacemakers, defibrillators, or implanted devices, and (4) the presence of hearing aids. Demographic characteristics, including age, gender, educational level, employment status, marital status, and COPD severity, were collected at baseline and are reported in Table 1.

Table 1. Participants' characteristics.

		Experimental group (N = 8)	**Control group (N = 9)**
Age, Mean (SD)		71.63 (8.58)	72.70 (7.74)
Gender, N (%)	Male	4 (50%)	6 (66.7%)

	Female	4 (50%)	3 (33.3%)
Education level, N (%)	Elementary school	2 (25%)	3 (33.3%)
	Middle school	6 (75%)	3 (33.3%)
	Senior high school	-	2 (22.2%)
	Master's degree	-	1 (11.1%)
Marital status, N (%)	Single	1 (12.5%)	-
	Married	3 (37.5%)	6 (66.7%)
	Divorced	1 (12.5%)	1 (11.1%)
	Widowed	3 (37.5%)	2 (22.2%)
Employment status, N (%)	Worker	1 (12.5%)	1 (11.1%)
	Retired	6 (75%)	8 (88.9%)
	Other	1 (12.5%)	-
COPD severity, N (%)	Mild (FEV1≥80%)	2 (25%)	2 (22.2%)
	Moderate (79%>FEV1≥50%)	3 (37.5%)	3 (33.3%)
	Severe (49%>FEV1≥ 30%)	3 (37.5%)	4 (44.5%)
	Very severe (FEV1≤ 29%)	-	-

2.2. Measures

Both groups completed the following questionnaires.

Before the intervention, the Italian Version of the Mini Mental State Examination (MMSE), consisting of 11 items, was used to evaluate participants' cognitive functions [11], and the score was used as an exclusion criterion (see point 2.1.).

To assess positive and negative affect before and after the intervention, the Italian version of the Scale of Positive and Negative Experiences (SPANE) was used [12]. This 12-item self-report scale includes two subscales: the SPANE-P ($\omega = .84$, $\alpha = .81$), which refers to positive emotions (6 items: positive, good, pleasant, happy, joyful, contented), and the SPANE-N ($\omega = .79$, $\alpha = .78$) which measures negative emotions (6 items: negative, bad, unpleasant, sad, afraid, angry). A 5-point Likert scale can be used to answer (1 = very rarely or never and 5 = very often or always).

Before and after the intervention, emotional and psychological well-being were measured using the emotional well-being subscale (EWB, $\omega = .93$, $\alpha = .93$) (3 items) and the psychological well-being subscale (PWB, $\omega = .70$, $\alpha = .66$) (6 items), derived from the Italian Mental Health Continuum Short Form (MHC-SF) [13]. A 6-point Likert scale can be used to answer (1 = never and 6 = every day).

Before and after the intervention and each session, two relaxation measures were used. First, a single item, measured on a 10-point Visual Analogue Scale (VAS) (1 = not at all relaxed; 10 = very relaxed), was used as a self-report measure of relaxation. Second, the NONIN Palm Saturimeter was used to measure peripheral oxygen saturation (SpO2), the proportion of oxygen-saturated hemoglobin to total hemoglobin in the blood, which further served as a relaxation index.

2.3. Procedure

After giving informed consent, participants completed the pre-intervention questionnaires (MMSE, SPANE, MHC-SF, relaxation VAS), and SpO_2 was measured. Then, together with the traditional pulmonary rehabilitation, the experimental group (N = 8) took part in the VR-based intervention, while the active control group (N = 9) listened to relaxing music. This 2-week intervention included four 25-minute sessions. In each session, participants in the experimental group experienced a 10-minute relaxing virtual scenario with the Oculus Quest 2 headset integrated with a narrative voice. To consolidate and amplify the positive emotions elicited in the VR experience, participants completed a savoring exercise proposed through pre-recorded audio after each virtual scenario (Table 2). At the end of the intervention, both groups completed the questionnaires (SPANE, MHC-SF, relaxation VAS), and SpO_2 was measured.

Table 2. Sessions of the VR-based intervention enhanced with savoring.

Sessions	VR experiences	Savoring exercises
Session 1	*The secret garden*: participants walked on a sunny day through a Japanese garden	Participants were invited to recall and savor a positive past experience
Session 2	*The waterfall in the prairie*: participants encountered flowers, lakes, and waterfalls during a walk in the prairie	Participants were invited to recall and savor a positive past experience shared with a loved one
Session 3	*The beach at sunset*: participants were guided on a walk along the beach until sunset	Participants were invited to mentally build and savor a nice personal place
Session 4	Participants selected the scenario they liked the most among those experienced in the previous sessions	Participants were guided throughout the exercises completed in the previous sessions to consolidate them

3. Results

Data analysis was conducted using IBM SPSS Statistics 27.0. Independent sample t-tests were performed to evaluate the differences between the two groups before the intervention. A trend toward significance emerged in the positive affect (SPANE-P) ($t(15) = -1.98$, $p = .066$) and the psychological well-being (MHC-SF PWB) ($t(15) = -1.86$, $p = .082$). For this reason, we calculated the delta scores for each variable by subtracting the baseline scores from the post-intervention scores and the pre-session scores from the post-session scores. After this, independent sample t-tests based on the delta scores revealed significant differences in positive affect (SPANE-P) and in psychological well-being (MHC-SF PWB) between groups (Table 3). No significant differences in negative emotions (SPANE-N), emotional well-being (MHC-SF EWB), relaxation, or SpO_2 were found between groups (Table 3). Furthermore, in each session, no significant differences in relaxation or SpO_2 were found between groups (Table 4).

Table 3. Psychological dimensions and SpO_2 pre- and post-intervention.

		Experimental group M (SD)	Control group M (SD)	Independent sample t-tests	
				t	***p***
SPANE-P	Baseline	17.63 (4.59)	22.33 (5.12)		
	Post-intervention	25.38 (5.31)	23.67 (4.79)		
	Delta score	7.75 (6.04)	1.33 (2.39)	2.94	.010[a]
SPANE-N	Baseline	12.00 (5.55)	10.89 (4.64)		
	Post-intervention	9.50 (6.93)	8.78 (2.28)		
	Delta score	-2.50 (4.17)	-2.11 (3.51)	-.209	.838
MHC-SF EWB	Baseline	2.83 (1.70)	3.56 (1.42)		
	Post-intervention	4.21 (0.94)	4.04 (1.17)		
	Delta score	1.33 (1.15)	0.48 (0.74)	1.82	.088
MHC-SF PWB	Baseline	3.23 (1.00)	4.00 (0.70)		
	Post-intervention	4.13 (0.73)	4.17 (0.75)		
	Delta score	0.89 (0.55)	0.16 (0.80)	2.13	.049[a]
Relaxation	Baseline	8.88 (1.72)	7.22 (3.19)		
	Post-intervention	9.63 (0.74)	9.56 (0.88)		
	Delta score	0.75 (1.83)	2.33 (3.50)	-1.14	.270
SpO_2	Baseline	91.88 (5.51)	91.33 (4.87)		
	Post-intervention	96.13 (0.99)	95.56 (2.01)		
	Delta score	4.25 (5.44)	4.22 (6.09)	0.01	.992

[a]Significant ($p < 0.05$).

Table 4. Relaxation and oxygen saturation levels before and after each session.

		Experimental group M (SD)	Control group M (SD)	Independent sample t-tests	
				t	*p*
Relaxation 1	Pre-session 1	7.13 (3.52)	7.89 (1.45)		
	Post-session 1	9.13 (1.25)	9.00 (1.12)		
	Delta score	2.00 (2.39)	1.11 (1.36)	0.95	.354
Relaxation 2	Pre-session 2	6.63 (2.92)	8.67 (1.32)		
	Post-session 2	8.25 (2.38)	9.00 (2.29)		
	Delta score	1.62 (2.87)	0.33 (2.44)	1.01	.333
Relaxation 3	Pre-session 3	7.00 (3.21)	7.78 (1.86)		
	Post-session 3	8.88 (1.46)	9.11 (1.54)		
	Delta score	1.87 (2.58)	1.33 (1.73)	0.51	.616
Relaxation 4	Pre-session 4	8.71 (1.98)	8.63 (1.77)		
	Post-session 4	9.71 (0.49)	9.50 (0.93)		
	Delta score	1.00 (1.91)	0.87 (1.24)	0.15	.882
SpO_2 1	Pre-session 1	91.88 (5.51)	91.33 (4.87)		
	Post-session 1	94.63 (1.60)	95.56 (2.30)		
	Delta score	2.75 (4.23)	4.22 (3.92)	-0.74	.469
SpO_2 2	Pre-session 2	93.75 (3.20)	93.22 (3.03)		
	Post-session 2	95.75 (1.75)	96.33 (2.12)		
	Delta score	2.00 (1.85)	3.11 (3.01)	-0.90	.382
SpO_2 3	Pre-session 3	92.25 (4.20)	91.89 (3.98)		
	Post-session 3	95.25 (1.98)	95.78 (2.28)		
	Delta score	3.00 (2.97)	3.88 (3.82)	-0.53	.604
SpO_2 4	Pre-session 4	93.71 (1.80)	94.00 (2.20)		
	Post-session 4	95.86 (0.69)	95.88 (1.89)		
	Delta score	2.14 (1.77)	1.87 (2.41)	-2.24	.813

*Significant ($p < 0.05$).

4. Discussion

This ongoing study aims to test the feasibility and efficacy of a VR-based relaxation intervention enhanced with savoring in COPD patients to increase positive affect, emotional and psychological well-being, relaxation, and SpO_2, and reduce negative affect. Preliminary results are consistent with our hypotheses. First, we found a significantly greater increase in positive affect and psychological well-being in the experimental group than in the control group. Furthermore, although no differences between groups were found, negative affect and emotional well-being increased in both groups. With respect to each session, we also found an increase in relaxation, as measured by both self-reports and SpO_2 levels, in both groups, but no differences between groups were found.

To the best of our knowledge, this ongoing feasibility study is among the few VR-based relaxation interventions for COPD patients and the only one enhancing VR with savoring. These results indicate that this intervention is as beneficial as widely used techniques with COPD patients, like listening to relaxing music [14], already within single sessions, and potentially even more effective in enhancing positive emotions and psychological well-being. Specifically, these findings suggest that savoring can amplify the positive emotions experienced during VR and extend them beyond the virtual environment, enabling patients to shift their attention and reflect on the positive aspects of their lives.

To conclude, although we observed a positive effect of the VR-relaxation intervention enhanced with savoring, the long-term impact is uncertain. Therefore, it will be interesting to investigate the effects of this intervention with suitable statistical power and verify its effects in the one-month follow-up. Finally, it would also be valuable to explore patients' acceptance of VR, user experience, and their level of immersion and sense of presence during the intervention.

References

[1] Safiri S, Carson-Chahhoud K, Noori M, Nejadghaderi SA, Sullman MJM, Ahmadian Heris J, et al. Burden of chronic obstructive pulmonary disease and its attributable risk factors in 204 countries and territories, 1990-2019: results from the Global Burden of Disease Study 2019. BMJ 2022;378:e069679.

[2] Rutkowski S, Szczegielniak J, Szczepańska-Gieracha J. Evaluation of the efficacy of immersive virtual reality therapy as a method supporting pulmonary rehabilitation: A randomized controlled trial. J Clin Med. 2021;10(2):352.

[3] Zoeckler N, Kenn K, Kuehl K, Stenzel N, Rief W. Illness perceptions predict exercise capacity and psychological well-being after pulmonary rehabilitation in COPD patients. J Psychosom Res. 2014;76(2):146–51.

[4] Villani D, Riva G. Does interactive media enhance the management of stress? Suggestions from a controlled study. Cyberpsychol Behav Soc Netw. 2012;15(1):24–30.

[5] Riches S, Azevedo L, Bird L, Pisani S, Valmaggia L. Virtual reality relaxation for the general population: a systematic review. Soc Psychiatry Psychiatr Epidemiol. 2021;56(10):1707–27.

[6] Rutkowski S. Management challenges in chronic obstructive pulmonary disease in the COVID-19 pandemic: Telehealth and virtual reality. J Clin Med. 2021;10(6):1261.

[7] Bryant FB, Veroff J. (2007) Savoring: a new model of positive experience. Mahwah, NJ: Lawrence Erlbaum Associates.

[8] Fredrickson BL. Positive emotions broaden and build. In: Advances in Experimental Social Psychology. Elsevier; 2013. p. 1–53.

[9] Pancini E, Villani D, Riva G. OVeRcomING COPD: Virtual reality and savoring to promote the well-being of patients with chronic obstructive pulmonary disease. Cyberpsychol Behav Soc Netw. 2023;26(1):65–7.

[10] Stanojevic S, Kaminsky DA, Miller MR, Thompson B, Aliverti A, Barjaktarevic I, et al. ERS/ATS technical standard on interpretive strategies for routine lung function tests. Eur Respir J. 2022;60(1):2101499.

[11] Folstein MF, Robins LN, Helzer JE. The mini-mental state examination. Archives of general psychiatry. 1983;40(7):812–812.

[12] Diener E, Wirtz D, Tov W, Kim-Prieto C, Choi D-W, Oishi S, et al. New well-being measures: Short scales to assess flourishing and positive and negative feelings. Soc Indic Res. 2010;97(2):143–56.

[13] Keyes CLM. The mental health continuum: from languishing to flourishing in life. J Health Soc Behav. 2002;43(2):207–22.

[14] McBride S, Graydon J, Sidani S, Hall L. The therapeutic use of music for dyspnea and anxiety in patients with COPD who live at home. J Holist Nurs. 1999;17(3):229–50.

Awareness Integration Theory: A Comprehensive Telehealth and Virtual Psychotherapy Tool for the Treatment of Anxiety and Depression

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Abstract. The psychotherapy profession continuously seeks multi-modality strategies to meet the client's needs. In recent decades, virtual client services have grown; the need for telehealth magnified by the Covid-19 pandemic shifted, deviating from the traditional in-person client-clinician interaction. Comparative studies have shown comparable virtual and face-to-face (F2FC) psychotherapy efficacy in patient-positive outcomes. Many studies comparing in-person therapy with online telehealth resulted in participants reporting improvements in anxiety, better access to support and advice, greater satisfaction with the support they received, and improvements in self-management and health literacy. The Awareness Integration Theory (AIT) has created a comprehensive cyberpsychology and telehealth model that can be narrated in multiple languages and cultural competencies to address the scarcity of global mental health resources proactively. Numerous studies on using AIT have validated its effectiveness in reducing depression and anxiety while increasing self-esteem and self-efficacy in in-person psychotherapy and self-help journaling modalities. This paper demonstrates the mechanism of AIT and its universality of usage in multi-modality applications helping individuals gain skills in creating healthy building blocks to achieving a holistic self and a fulfilling life.

Keywords. Telehealth, Anxiety, Depression, Psychotherapy, APP, Awareness Integration Theory

1. Introduction

The first Telehealth has existed since the infancy of the internet. One of its first Internet demonstrations was a simulated psychotherapy session between computers at Stanford University and the University of California, Los Angeles, during the 1972 international conference on computer communication. Psychotherapists who had previously used telephone therapy found the transition to online therapy straightforward[1]. In the past sixty years, the option to provide mental healthcare remotely has been the subject of many research studies[2]. Providers have been using videoconferencing for therapy, assessment, evaluations, and managing patients' medication to supplement in-person treatments [3].

In February 2023, the World Health Organization reported that Covid19 pandemic has resulted in an unprecedented increase in mental health adversity. Since the prevalence of Covid19 pandemic, the global community has experienced a 25% increase in anxiety and depression, which calls for an urgent response by heads of state to increase funding for mental health care. The heightened acuity in anxiety and depressive symptoms catalyzed by the COVID-19 pandemic presents an urgent need for practical

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yet feasible alternatives to in-person mental health treatment. A survey of APA members found that 76% of the practitioners who stopped seeing patients in person because of COVID-19 have been treating all their patients remotely[4]. A randomized clinical trial comparing Telepsychiatry using videoconferencing with face-to-face (F2FC) conventional psychological methods showed that virtual mental health treatments have an efficacy equivalency as the F2FC alternatives[5]. In 2016, Salisbury and colleagues conducted a mega study comparing in-person therapy with telehealth online. Participants reported improvements in anxiety, better access to support and advice, greater satisfaction with the support they received, and improvements in self-management and health literacy[6]. Other studies also suggested no significant differences between telehealth care and F2FC in-person and telehealth groups in depressive symptom reduction [3]. As discussed in the next section, innovative telehealth modalities, such as the Awareness Integration Theory (AIT) online telehealth modality, have also shown consistently favorable efficacy results in virtual psychotherapy in-patient treatment.

2. Awareness Integration Theory

Awareness Integration Therapy (AIT) is a multi-modality psychological model that promotes self-awareness of one's thought process, beliefs, dualities, and schemas. AIT also allows for awareness of feelings and emotions in the body by observing, naming, containing, and releasing the feelings. AIT fosters observation of one's behaviors, including communication styles and their impact on one's life and other people's life. This mode of observation and awareness is toward relation to others, in projections and assumptions about others relating to the self and the relation toward oneself. Through this practice in multiple areas of life, one becomes aware of the negative core beliefs and has the opportunity to revisit previous or childhood traumas, experiences, and memories that have been the source of the personalization and generalization of concepts to self. Clearing, healing, and re-narrating past experiences allows one to integrate and complete the unfinished matters of the past. By becoming whole and accessible to all parts of the self, including skills, strengths, and resiliency, one can envision the desired future. Setting goals, skill building, actions plan, and structures to reach and sustain short, long, and maintenance goals are thought[7].

AIT operates based on the following nine principles: 1) Reality is based on the observer's subjective perception; therefore, one can co-create Reality. 2) Every person has the aptitude to acquire the knowledge and abilities to lead a fulfilling life. 3) Skills are acquired through personal experiences, physical and psychological developmental stages, and role modeling with parents, peers, teachers, and from culture, media, and society. 4) The human mind interprets all external stimuli and assigns meaning internally, developing beliefs, schemas, and individual identity to relate to oneself, others, and the world. 5) Humans cognitively, emotionally, and physically store experiences in the body. The significant unintegrated memories resurface automatically triggered by an event needing attention. 6) As the unintegrated belief-emotion-body state is experienced, healed, released its meaning, and integrated into the whole system, neutral and positive attitudes, beliefs, and emotions are experienced. 7) Self-awareness and integrated self can create conscious choices and commitments regarding beliefs, emotions, and actions toward a new and positive result. 8) New skills are learned and practiced enhancing one's capabilities toward obtaining the desired results. 9) Conscious Intentionality toward an envisioned result, with practical and structured planning, raise the probability of achieving one's desired results in all areas of life toward living a fulfilled life[7].

3. The Structural Mechanism of AIT as a Psychotherapeutic Construct

AIT Interventions are implemented in 6 phases encompassing all areas of an individual's life: **Phase 1**: Awareness of the participant's thoughts/ perceptions/ beliefs, emotions, and behaviors about their external environment, their relation to others, and how those constructs impact their lives. **Phase 2:** This phase has three essential functions

- 1) one's awareness of personal projections toward others; 2) One's recognition of inner meanings assigned to observations; 3) Comparing internal projections to other's reality. **Phase 3:** Awareness of assigned identity and recognition of negative core self-beliefs. **Phase 4:** AIT focuses on simultaneously experiencing the connection between beliefs, feelings, and the body areas that have stored and maintained intense emotions with the origin of a traumatic event that has produced the negative core belief. In this phase, irrational thoughts and decision-making strategies are reevaluated, integrated, and contained, and the narrative is replaced with the recognition of strengths. **Phase 5**: One can be responsible and accountable for their perception intentionally, thought, and emotional process as well as their action and the impact of their behaviors on their life and others. To set values to live by, visualize and commit to goals in all areas of life, and develop action plans toward tangible desired goals toward creating a fulfilled life. **Phase 6:** Set sustainable structures to ensure reaching and maintaining goals in all areas of life[7].

AIT has been used as a telehealth model since its inception due to working with international clients transitioning globally for their careers. The model naturally adapts itself to new technologies. Depending on the telehealth laws of the country the clinician is licensed or certified in, the service can be adjusted, offered, or refused. Some clinicians who are also certified offer Life Coaching when serving clients beyond their licensing jurisdiction.

4. AIT in Telehealth

The administrative process for utilizing AIT in telehealth varies. AIT can be used via the asynchronous written method through secured email or text messaging; synchronous written mode via end-to-end encryption chat (Imessage, WhatsApp, Telegram); real-time audio conversation via phone; synchronous audio messages via the apps; or video conferencing (Zoom, WhatsApp, Telegram, etc.).

The first session aims to create a therapeutic alliance by identifying the presenting problem, exploring the client's history, identifying crisis management issues, and setting therapy/ coaching goals. The therapist and the client choose one area of life related to the presenting problem (i.e., Marriage, career). Intervention phases 1-4 will be utilized in as many relevant areas of life as a subsidiary of the central area of focus. After completing the 4 phases with all relevant life areas, phase 5 guides the client to set a personal vision and mission statement of values to operate from. The client will attend to each life area and is encouraged to set short/extended/maintenance goals and action plans to actualize their goals. The client is requested to create a sustainable structure to maintain the commitment and actions to create a fulfilling life as designed and intended in Phase Six. A termination session is advised to evaluate the therapy process. Although structured, the AIT interventions are client-centered and can be adapted to the need of the client and the therapist's style.

5. AIT in Synchronistic Online Mental Health Multi-Modality

From its conception, the AIT psychotherapy method has been offered in various modalities and applications, yielding positive results in reducing anxiety and depression via face-to-face (F2FC), group settings, hybrid, virtual, and online training. Multiple published studies on the efficacy of AIT have shown consistent positive outcomes. A study conducted at the Personal Growth Institute using AIT in F2FC therapeutic sessions showed depression decreased by % 76 and anxiety by %60 while increasing self-esteem by %43 and self-efficacy by %20[7]. A study on the American college student population using the Awareness Integration Theory in a hybrid modality showed an overall 68% decrease in depression and a 21.72% decrease in anxiety[8]. In a group workshop setting, the AIT has also been tested on separated or divorced individuals, resulting in a 27.5% improvement in depressive moods, a 37% decrease in feelings of anxiousness and anxiety while showing a 15% increase in self-esteem, and a 13% boost in self-

efficacy[9]. Additional studies utilizing AIT via telehealth resulted in decreasing anxiety by %50 and an increase in self-esteem by %60[10], and in another case study, decreased depression by %66, anxiety by %75, and post-traumatic stress disorder (PTSD) symptoms by %66[11] (See Figure 1).

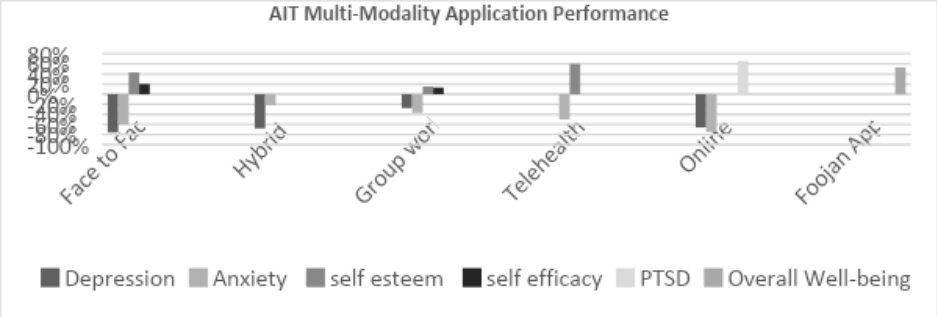

Figure 1. Multi-Modality of AIT Consistent Results

4. AIT in a Mobile App for Clients' Ease of Accessibility

The value of remote mental health services to clients who do not have remedial access to such services has been under research studies for several decades. The efficacy of such programs has since been measured and deemed beneficial on so many levels[12]. As a forerunner of telehealth, remote, and affordable client services, the AIT methodology has been developed in a mobile App name "Foojan," launched in Jan. 2023. The FoojanApp is now accessible to people globally via the Apple Store and google play. The user can subscribe to a monthly plan or a yearly plan. Every month the app offers three new areas of life and skill-building videos relevant to those areas. The user can choose between 3 life areas and begin the AIT process. The user can complete phases 1-6 for each area of life before moving on to the next area. The app explains the purpose of each phase through an animated video or audio recording. In Phase Five, the user will be asked about the skills they need to create their goals and are directed to www.foojan.com to choose from skill-building videos created by experts in the field[13].

The users can also access AIT-certified professionals for individual, couple, or family psychotherapy or life coaching sessions. The Foojan app aims to facilitate access globally and affordably to all that need to foster mental health. The results of the survey have shown improvements in the following areas of relationship with Self-%64; Career-%43; Intimate relationship-%57; Child-%55; Siblings-%57; In-Law-%53; Mother-%55; and Father-%53. Next phase Foojan App will offer the app in 6 languages, in an audio version with an avatar, and incorporate Artificial Intelligence in creating more individualized, interactive responses and processes[13]. Foojan App has shown high-performing efficacy, as shown in Figure 2 below.

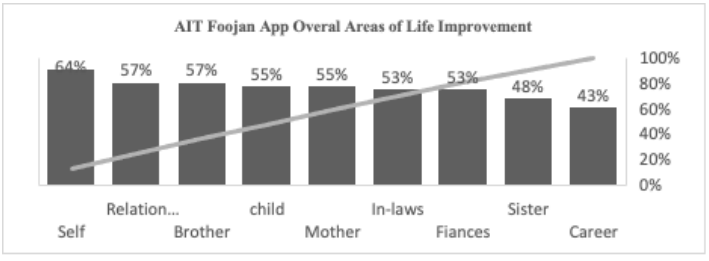

Figure 2. Foojan App Consistent Efficacy Performance

7. Discussion

The field of psychology has continuously sought strategies to improve patients' mental health and well-being. Throughout the history of this profession, different modalities have been tested for improvement in ease of accessibility to mental health professionals, connecting to resources, simplifying scheduling, and record-keeping, to mention a few. The transition from telephone therapy to email, chat, video therapy, and online sessions has created an integrated and holistic approach while improving patient care. With transforming technology, the added value of real-time online video has made it as similar as it could be to in-person therapy. Although the efficacy of online and telehealth psychotherapy methods has been the subject of scientific studies by many researchers, the result has been favorable and compatible with the traditional in-person approach. Many countries have explored the potential of psychological intervention programs using telehealth to respond to the rising demands of patients with chronic disorders. From its early days, AIT set out to be a forerunner in easy conversion from in-person to online therapy, particularly for treating individuals and couples with anxiety and depression.

Numerous studies have been conducted on the efficacy of AIT, both online and in-person, have shown that regardless of the modality, the results have continuously been favorable in reducing anxiety/depression while improving self-esteem in individuals. Proactively, AIT has taken all the necessary measures to comply with the Health Insurance Portability and Accountability Act - HIPAA securing patient record keeping, privacy, confidentiality, and ethical code of conduct in serving clients via online and telehealth modes. Additionally, taking patient care and accessibility to a higher level, Foojan App now offers the same quality, high-efficacy psychotherapy of AIT to a mobile app to reach a larger demographic needing such services. More than ever before, Mental health and well-being have become urgent at a global level. The field of psychology is responding to this sense of urgency by utilizing technology as an instrumental tool to provide mental health care services globally and transnationally.

References

[1] Derrig-Palumbo, K., Zeine, F. (2005). Online Therapy: A Therapist's Guide to Expanding Your Practice
[2] W.W. Norton Publishers; 2005
[3] Hilty, D.M., Ferrer, D.C., Parish, M.B., Johnston, B., Callahan, E. J., Yellowlees P.M. (2013). The effe-ctiveness of telemental health: 2013 review. *Telemed. e-Health.* 2013;19(6):444–454.
[4] Bulkes, N., Davis, K., Kay, B. Riemann B. C., (2022). Comparing the efficacy of telehealth to in-person Mental health care in intensive treatment-seeking adults. Journal of Psychiatric Research, volume 145, January 2022, Pages 347-352
[5] American Psychological Association (APA) (2022). Telehealth guidance by the state during COVID-19. https://www.apaservices.org/practice/clinic/covid-19-telehealth-state-summary
[6] De Las Cuevas, C., Arredondo, T. M., Cabrera, F., Sulzenbacher, H., Meise, U. (2006). Randomized
[7] Clinical Trial of Telepsychiatry through Videoconference versus Face-to-Face Conventional Psychiatric Treatment. Telemedicine and e-Health 2006 12:3, 341-350.
[8] Salisbury, C., O'Cathain, A., Edwards, L., Thomas, C., Gaunt, D., Hollinghurst, S., Nicholl, Large, S., Yardley, L., Lewis, G., Foster, A., Garner, K., Horspool, K., Man, M.S., Rogers, R., Pope, C. Dixon
[9] P.,Montgomery A, A. (2016). Effectiveness of an integrated telehealth service for patients with
[10] depression: a pragmatic randomized controlled trial of a complex intervention. Lancet Psychiatry; 3:515-525. Published Online April 27, http://dx.doi.org/10.1016/ S2215-0366(16)00083-3
[11] Zeine, F. (2016). Awareness Integration: A New Therapeutic Model, International Journal of Emergency Mental Health and Human Resilience, Vol. 16, No. 60-65, pp. ISSN 1522-4821
[12] Zeine, F., Jafari, N., Forouzesh, M. (2017). Awareness Integration: A Non-Invasive Recovery Method-ology in Reducing College Student Anxiety, Depression, and Stress", TOJET– Nov. 2017, Special Issue for IETC (2017) www.tojet.net/special/2017_11_1.pdf (Pg. 105-114), Presented at Harvard University.
[13] Zeine, F. Jafari, N., Haghighatjoo, F. (2017). Awareness Integration: An Alternative Therapeutic Method-ology to Reducing Depression, Anxiety, While Improving Low Self-Esteem and Self-efficacy in Separated or Divorced Individuals". Mental Health in Family Medicine.13: 451-458
[14] Madani, H., Zeine, F. (2022). Awareness Integration Therapy for Generalized Anxiety Disorder"
[15] International Journal of Psychiatry Research, Vol. 5, Issue 4, 1-7.

[16] Zarbakhsh, L. Zeine, F. (2023).Awareness Integration Theory Case Report: Therapeutic Intervention for Anxiety and Depression in Transsexual Male College Students. International Journal of Scientific Research, Vol. 12, Issue 3.
[17] Rabinowitz, T., Murphy, K. M., Amour, J. L., Ricci, M.A., Caputo, M. P., Newhouse, P. A.(2010).
[18] Benefits of a telepsychiatry consultation service for rural nursing home residents. *Telemed.-eHealth:* 16(1):34–40.
[19] Foojan App (2022). Design the Life You Desire. https://foojan.com/
[20] Heealth Insurance Portability and Accountability Act - HIPAA (2023). Health Information Privacy. https://www.hhs.gov/hipaa/for-professionals/privacy/index.html

Using Virtual Reality to Improve Nurses' Students' Clinical Surveillance in a Critical Care Context: A Psychological Perspective on Learning

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Abstract. Nurse's clinical judgement is important to provide optimal and safe care, particularly in a critical care unit. Clinical surveillance is an activity that nurses use every day and which requires crucial components to manage patients' risk of complications. To carry out this process, several cognitive functions and psychological attitudes are needed such as information and attention processing, judgement, decision-making, stress, and anxiety regulation. Since 2018, Milhomme, Banville et al. have been working to develop a Virtual Care Unit (VCU), using immersive virtual reality, intended to train future nurses to improve their competence towards clinical surveillance process skills. The aim of this qualitative descriptive study was to determine the pertinence to use VCU simulation with graduating nurses' students to improve clinical surveillance skills in a critical care context. Thirteen nursing students were recruited to test the scenario through the VCU. Participants were instructed to carry surveillance process on a specific patient who suffer of an instability after a surgery. An interview guide of 11 questions was used for the data collection. The results show there are 10 facilitating and 9 restricting factors in the VCU that may play a role in nursing students' learning clinical surveillance processes. Among these elements, four of them have an important link with a psychological perspective: 1) sense of presence; 2) cybersickness; 3) reflexive environment; 4) stress reduction. Results show an important contribution of several cognitive function in the clinical surveillance process learning by the virtual reality technology.

Keywords. Virtual Reality, Learning, Nursing, Clinical surveillance, Virtual car

1. Introduction

Nursing practice is complex and involves careful nurse engagement in clinical activities essential to provide quality and safe health care. Milhomme et al. [1] reported that clinical surveillance is a process closely related to patient safety. Clinical surveillance implies that nurses must be able to collect data, recognize the patient's instability, detect problems, and make appropriate decisions. A simple error of inattention or a wrong

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decision could have important consequences for the patient, especially in cases where interventions must be initiated promptly.

To avoid errors and improve quality in clinical surveillance, university education becomes an important key for the development of nurses' competencies. When nursing students are on clinical placements, there is always the possibility that they will unintentionally affect patient safety. That is why it was decided to use virtual reality (VR) to teach clinical surveillance in nursing and prepare students before clinical placements. In fact, virtual environment provides students with a standardized clinical setting that gives them the opportunity to practice in a safe, reproducible, and accessible way [2]. This technology also gives students the opportunity to choose the time and place for their learning [3]. In addition, it allows students to be exposed to a high level of interactivity and realism to the point where the use of virtual scenarios has been widely adopted for the training of health professionals [4]. As reported by Gu et al. [5], virtual reality offers several benefits and should be considered necessary in education.

With the objective to promote the development of nursing skills in a safe way, Milhomme et al. [1] have developed a Virtual Care Unit (VCU). It is intended to be an environment of practice *in virtuo*. However, by immersing students in these stressful worlds (i.e., as in real life), they will be able to develop their clinical judgment and decision-making skills in a multitasking context that is common to clinical settings. This virtual educational environment thus represents a safe environment that will allow the action, the reflexive and the constructive feedback on the decisions and interventions made by the students. It is also possible to use the student's progress data to personalize their immersion, to expose them to less well-mastered concepts and to propose realistic and gradual goals [6]. The analysis of actions through the analysis of learning (Learning Analytics) and the development of a form of artificial intelligence will allow this customization to promote student learning [7].

The aim of this qualitative descriptive study was to determine the pertinence to use the VCU with graduating nursing's students to improve clinical surveillance skills in a critical care context. In this qualitative study, we focused on the psychological perspectives of these results.

2. Method

2.1. Participants

Recruitment took place from May to September 2022 among students enrolled in a critical care internship at each participating universities. Potential participants have received an email invitation that included 1) a link towards a promotional video of the VCU study and 2) a link to a secure portal. From this portal, participants could read the information and consent form and express their interest in participating in the study. An automated system sent an email to a research assistant who contacted the participants to plan the experimentation.

To participate in the study, students had to have successfully completed their critical care class, be enrolled in the critical care internship, and speak and read French. The exclusion criteria were: 1) suffering from epilepsy, impairment of the vestibular system (e.g., motion sickness, labyrinthitis, etc.) or any conditions that may affect balance; 2) Those who agreed to take part in the study had to confirm in writing or verbally that they had not consumed alcohol or other substances (pain medications, psychotropic substances, etc.) that may interfere with their participation in a 3D environment in the 24 hours preceding the experiment. 13 students agreed to participate in the study (Table 1).

Table 1. Description of the sample (*n*=13)

Characteristics	n = 13
Sex	
Women	10

Men	3
Age mean (SD)	30.23 (10.88)
Working experience (ICU, ED, PACU)	
None	7
> 1 year	2
1 < 5 years	2
5 to 10 years	2
Department (where critical care experience was gained)	
Intensive care unit (ICU)	2
Emergency Département (ED)	3
Post Anesthesia care unit (PACU)	1
Experience with VR	
Yes	5
No	8

2.2. Data collection

Pre-immersion. After consenting to participate in the study by completing the online consent form, each participant was invited to review the preparatory material from a hyperlink sent by the research assistant. This material consisted of: 1) a learner's guide that explains the scenario and the objectives; 2) teaching clips videos that aim to refresh basic knowledge related to the scenario that was to be tested in immersive virtual reality; 3) a tutorial on the use of immersive virtual reality. This preparation period was estimated at about three hours. Each participant then made an appointment to complete the immersion phase at their home university.

Immersion. After completing the socio-demographic questionnaire, participants were invited to begin the immersion phase which was divided into two main parts. First, the participants were exposed to a familiarization phase in the UVS in which they could move freely in the environment and manipulate virtual objects. This initial immersion was approximately 15 minutes long, followed by a 5-minute rest period. The second part consisted of the immersion of the participant in the "Postoperative Hemorrhage" scenario. All interactions in the virtual environment were done in the first person and the participant could see her virtual hands and manipulate the interactive objects around them as is usually the case in this type of simulation. When used, interactive objects revealed a framework in which participants had to choose information or interventions relevant to the situation. The proposed scenario was approximately 25 minutes in duration. During immersion, participants were assisted by the professor in charge of the study at their institution. He remained with the participants throughout the simulation without intervening in the clinical aspect. Cues for the use of the technology could be provided so that participants do not remain at an impasse.

Post-immersion. At the end of the immersion, participants were invited to participate in a semi-directed interview by Zoom conducted by a member of the research team. All interviews were conducted by the same person to ensure consistency. Each interviews lasted approximately 45 minutes long.

3. Results

3.1 Data analyses

Each transcript was replayed before being analyzed using the NVivo 12 QSR software. To foster the emergence of data, interviews were analyzed using from the first step of coding (open coding) of Strauss and Corbin's [8] grounded theorizing approach. Open coding was used to describe the students' experience during the preparation and immersion phase. The interviews and data analysis were conducted by one of the co-investigators (A.P.) and validated by the principal investigator of this study (D.M.) who specializes in qualitative research. The results of these analyses were then validated by

each participant following the email submission of a summary of the results to meet the scientific criteria.

3.2 Psychological facilitators

Sense of presence. The first factor that emerged was the sense of presence in virtual reality. Students enjoyed the feeling to be immersed in the virtual world. “At the level of virtual reality, when you really get into it, you really feel like you’re in it” (uvs23). This feeling was compared with the so-called “conventional” simulation in which the participants are in the real world. One participant noted that “… I was being watched and the teacher is next door, he takes notes when you do something, so now you’re stressing to say… Did I do this wrong? But it seems that with the glasses, you are in your head and OK, you think less about the outside world if I can say” (uvs23). This was also reinforced by another participant: “I didn’t have the stress of… someone who looks at me, I knew someone was looking at me, but I couldn’t see him, I was in my virtual reality, so I was fine” (uvs25).

Anticipation. The results of the study also show that the VCU help to anticipate the reality. This anticipation is expressed as follows: “[…] it also really allows us to see how the intensive care unit is done even before we have been there […]” (uvs28) while another adds: “This is really typical of a case you can have in the critical care hospital, it’s the same. The scenario is well done, it is realistic as scenario” (uvs24). Anticipating reality would therefore facilitate preparation for practice in the clinical setting. In fact, another participant reinforces the point and says: "Of course, it can also help us to see concretely how we could act to prepare ourselves if our patient is going to be worse" (uvs27).

Stress reduction. One of the main factors highlighted in the participants' responses was the sense of safety brought by the environment. In particular, the participants mentioned that the right to make mistakes is an especially important element that helps reduce stress and thus create a sense of security. One participant said that “…we have the right to make mistakes and that’s how we learn from our mistakes so that we don’t have to do it again in reality…I had less stress than if I were actually in a real internship” (uvs23). Another participant with no experience in the critical care field who will be doing her internship soon adds: “[…] I think that there is still a 20% of students like me who are not necessarily in the field, but who have to go through it, well it would bring a kind of security to be able to live it before…” (uvs26). One of the reasons that might justify this feeling was made clear in the following words: “[…] it’s less stressful because you know it’s a game” (uvs25).

3.3 Psychological contraints

Person-machine interfaces. There are also constraints that have emerged. The most important seems to have been the interaction with the environment via the Oculus controllers. Moving in the virtual environment was identified as one of the main constraining factors. Indeed, the participants mentioned that they had difficulty with controls related to the joysticks: “…I tend to mix teleportation and mix everything that is… to take the objects.” (uvs31). Another participant reinforces this observation by adding: “Sometimes I wanted to like to move to put the panel to go click on the buttons and I weighed in the wrong place. There… oops! I’m outside” (uvs43). Finally, another participant mentioned that the sensitivity of the controls on the joysticks makes it more difficult to travel a short distance. Another constraint was the difficulty of clicking on objects. Indeed, it was noted that participants had no difficulty locating interactive objects, but rather clicking on them. “… I wasn’t able to look at the arterial cannula because the button didn’t work and now, I wanted to go faster, so I passed that one” (uvs23). Another participant also said, “I wasted two, three minutes just trying to close the alarm, because there was like… It didn’t work, it looks like my pointer was clicking in the wrong place, so it wasn’t closing” (uvs27). Another participant added: “[…] when

I wanted to click on the orange dot … it was as if there was just a place where it worked" (uvs24).

4. Discussion

The aim of this qualitative descriptive study was to determine the pertinence to use the VCU with graduating nursing' students to improve clinical surveillance skills in a critical care context. We focused on the psychological perspectives of these results.

Data analysis has shown that there are facilitators who make the use of virtual reality relevant in an academic context, primarily for skills development. These include the sense of presence that allows the learner to feel immersed in the simulation while ignoring the surrounding observers. This reduces the stress of being assessed and increases the focus on tasks. It is therefore possible to think that the feeling of presence caused by immersion frees attentional processes from an unnecessary mental load. Anticipation, a component of executive functions, is also facilitated by the fact that environmental feedbacks are predictable and realistic. Finally, we note that our virtual environment is perceived as being safe, allowing the student to experiment without fear of making mistakes, which reduces stress and, once again, frees cognitive functioning from an unnecessary mental load. The work conducted by Bouchard et al. [9] clearly demonstrated the importance of the feeling of presence in virtual reality for the person's involvement in the scenarios presented to him. The authors also demonstrated that EVs can provoke as much a feeling of confidence as a feeling of fear depending, once again, on the immersion contexts presented. Finally, the work of Banville et al. [10] also showed that tasks required of participants in virtual environments are able to realistically solicit executive functions.

The most important constraints remain the difficulties related to the person-machine interface which reduce the efficiency in the accomplishment of tasks and which, unlike the facilitators, unnecessarily increase the mental load, which overloads the cognitive system. It seems, therefore, that the VCU, which requires a lot of monitoring and interventions, may slow the development of clinical surveillance skills because the student is focused on learning interactions with objects. The work carried out in our laboratories has shown that the person-machine interfaces represent the main limitation of the use of virtual reality when the cognitive system is significantly used [11, 12, 13]. Banville et al. [14] have proposed, concerning a previous study with the VCU, that the design of the tasks, the number of it AND human-computer interface influence the subjective perception of an elevation of the workload based on NASA-TLX answers. In fact, in this study, the participants were pleased of their performance in the virtual environment (as in this study). However, they expressed that the task AND the use of human-computer interface increased the workload, because they had to work harder to achieve the same level of performance as in real life.

To conclude, within this research, we found that the VCU was helpful to expose students to authentical situations in a critical care context. This research pinpoints main factors that researchers must consider in the future studies related to the topic that is learning with virtual reality. Some other development and modification must be plan to allow to the VCU to be especially useful for the learning of clinical surveillance.

References

[1] Milhomme D, Gagnon J, Lechasseur K. The clinical surveillance process as carried out by expert nurses in a critical care context: A theoretical explanation. Intensive and Critical Care Nursing, 2018;44: 24-30, doi: 10.1016/j.iccn.2017.07.010

[2] Cobbett S, Snelgrove-Clarke E. Virtual versus face-to-face clinical simulation in relation to student knowledge, anxiety, and self-confidence in maternal-newborn nursing: A randomized controlled trial. Nurse Educ Today. 2016 Oct;45: 179-184, doi: 10.1016/j.nedt.2016.08.004

[3] Foronda CL, Shubeck K, Swoboda SM, Hudson KW, Budhathoki C, Sullivan N, Hu X. Impact of virtual simulation to teach concepts of disaster triage. Clinical Simulation in nursing. 2016:12(4): 137-144, doi: 10.1016/j.ecns.2016.02.004
[4] Huang, G, Reynolds, R, & Candle, C. (2007). Virtual patient simulation at US and Canadian medical schools. Academic medicine, 446 – 451.
[5] Gu, W. (2017). The application of virtual reality in education. 2nd International Conference on Artificial Intelligence and Engineering Applications. 116-121.
[6] Alonso-Fernandez, D, Lima-Correa, F, Gutierrenz-Sanchez, A & De vicuna, O. (2017). Effect of a high-intensity interval training protocol based on functional exercises on performance and body composition in handball female players. Journal of human sport & exercise, 4 (12), 1186-1198.
[7] Prakash, BR, Hanumanthappa, M., & Kavitha, V. (2014). Big data in educational data mining and learning analytics. International journal of innovation research in computer and communication engineering, 2 (12), 7515-7520
[8] Strauss A, Corbin J. Basics of qualitative research: Techniques and procedures for developing grounded theory (2nd ed.). 1998, Sage Publications, Inc.
[9] Bouchard S, Bernier F, Boivin É, Dumoulin S, Laforest M, Guitard T, Robillard G, Monthuy-Blanc J, Renaud P. (2013). Empathy toward virtual humans depicting a known or unknown person expressing pain. Cyberpsychol Behav Soc Netw. 2013 Jan;16(1):61-71.
[10] Banville F, Provencher M, Verhulst E, Richard P, Couture JF, Flores T, Allain, P. Using the virtual multitasking test to assess the realization of intentions: A preliminary psychometric study. Annual Review of CyberTherapy and Telemedicine. 2018;16: 94–100.
[11] Banville F, Nolin P, Verhulst E, Rosinvil T, Allain P. Assessment and rehabilitation using virtual reality after traumatic brain injury: a systematic literature review and discussion concerning human-computer interactions. In A. S. Rizzo & S. Bouchard. Virtual reality for Psychological and Neurocognitive interventions. 2019, volume 2. Springer. 327-360
[12] Verhulst E, Banville F, Laverdière R, Richard P, Allain P. Évaluation neuropsychologique par la réalité virtuelle : considérations psychométriques. In P. Allain, G. Aubin, F. Banville, S. Willems (eds.), Neuropsychologie clinique et technologies. 2021: 167-186. De Boeck Supérieur. Belgique.
[13] Verhulst, E, Banville, F, Richard, P, Allain, P. (submitted). How interaction techniques affect workload in a virtual environment during multitasking. Computers in human behavior.
[14] Banville, F, Parent, AA, Trépanier, M & Milhomme, D, (2021). Virtual critical care unit (VCCU) : A powerful simulator for e-learning. Springer, 225-265

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