



# Annual Review of CyberTherapy and Telemedicine

Roots and Future of Using Technologies to  
Foster Physical and Mental Wellbeing

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**ANNUAL REVIEW OF CYBERTHERAPY  
AND TELEMEDICINE 2018**

# Annual Review of Cybertherapy And Telemedicine 2018

Brain and Virtual Reality:  
What Do They Have in Common  
and How to Exploit Their Potential

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### About the Journal

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.

### Manuscript Proposal and Submission

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We would like to extend a warm and heartfelt thank you to all members of the review board whose help made this year's publication possible:

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## **Ethical Standards.**

Authors published in the Annual Review must uphold and respect ethical standards in the preparation and realization of their research, as well as in the writing style of the papers (avoid prejudice, protect confidentiality of the patients, etc.). Research involving human subjects must have been conducted with respect to current ethical practices and after participants expressed their free and informed consent (e.g., with a signed consent form or other appropriate method). Ethical standards also apply to research that is not conducted with humans (e.g., animal protection protocol), and to publishing issues (e.g., plagiarism, research fraud, authorship misappropriation, duplication of publications).

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

Identifying information such as names, initials and hospital numbers must be avoided. Also, authors should disguise identifying information when discussing patients' characteristics and personal history.



## 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 importance 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 Stéphane Bouchard- 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.
7. **Brief Communications:** These chapters include brief papers reporting preliminary data on-going research work and/or new developments.

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 several areas, including the development of easy-to-use and more affordable hardware and software, the development of objective measurement tools, the need to address 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 Silvia Serino from Università Cattolica di Milano for her work in collecting and coordinating chapters and Ian T. Miller from Interactive Media Institute Virtual Reality Medical Center for his work in editing 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  
Stéphane Bouchard

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# SECTION I

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## EDITORIAL

The position of the authors of this text is shared by the Editors– Brenda K. Wiederhold, Giuseppe Riva, Stéphane Bouchard – and provides a relevant introduction to this issue.

*Brenda K. Wiederhold  
Giuseppe Riva  
Stéphane Bouchard*



# Brain and Virtual Reality: What Do they Have in Common and How to Exploit their Potential

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**Abstract.** Different studies suggest that Virtual Reality (VR) is an effective tool for behavioural health, with long-term effects that generalize to the real world. Here we suggest that the efficacy of VR can be explained by how it works. Specifically, VR shares with our brain the same basic mechanism: embodied simulations. Different major discoveries in the field of neuroscience suggest that our brain produces and updates an embodied simulation of the body in the world. This simulation is actively used by different cognitive processes to represent and predict actions, concepts, and emotions. VR works in a similar way: through the integration of data from trackers and contents of a simulated 3D world, a VR system builds a model (simulation) of the body and the space around it. Like the brain, the VR system uses the simulation to predict the sensory consequences of the individual's movements. In this view, the more the VR model is similar to the brain model, the more the individual feels present in the VR world. The paper discusses the potential of this link, by suggesting the emergence of a new clinical approach that uses the simulative potential of VR to exploit/empower (transformation of flow) and/or correct/update (embodied medicine) the predictive/simulative mechanisms of the brain.

**Keywords.** Virtual Reality, behavioural health, neuroscience, predictive coding, embodied simulation, embodied medicine

## 1. Virtual Reality: Why does it work clinically?

Virtual reality (VR) has been used for more than twenty years in behavioural health [1; 2]. Specifically, different researchers have used VR to successfully integrate and extend actual treatments in this area. As suggested by two recent meta-reviews [3; 4] VR compares favourably to existing treatments in anxiety disorders, eating and weight disorders, and pain management with long-term effects that generalize to the real world. Moreover, VR is also an effective assessment tool with practical applications that range from social and cognitive deficits to addiction.

But why VR is an effective clinical tool? Most researchers underline the high level of control and customization allowed by this technology [4-8]. On one side, in VR the therapist has a total control – limited only by the specific features of the used software – on the contents of the experience. On the other side, it offers a safer and private context for the patient. Furthermore, VR can be considered an advanced imaginal system [9; 10]: an advanced form of imagery that is as effective as reality in inducing experiences and emotions. This allows a level of self-reflectiveness that is both more predictable and controllable than the one offered by reality, but higher than the one provided by memory and imagination [4]. However, a new argument

suggested by different major discoveries in the field of neuroscience is that VR shares with our brain the same basic mechanism: embodied simulations [11; 12].

## 2. Predictive Coding and Embodied Simulation

Our body is the most multisensory “object” in the world. Its representation is complex, involving the encoding and integration of a wide range of multisensory (somatosensory, visual, auditory, vestibular, visceral) and motor signals [13]. This multisensory representation is controlled by the “body matrix”, a complex network including higher-order areas, such as the posterior parietal cortex, involved in the coding of visual, tactile, and proprioceptive information [11; 14]. The body matrix sustains a multisensory representation including both somatotopic and peripersonal sensory data, but also integrating body-centred spatial sensory data with an object-centred body image from vision and memory [15]. Moreover, these contents are shaped by predictive multisensory integration [16]: in agreement with the predictive coding framework [17-19], the body matrix actively maintains a mental model of the body and the space around it (peripersonal space), which provides predictions about the expected sensory input and tries to minimize the amount of free energy (or ‘surprise’).

In other words, the contents of the body matrix are adjusted on the basis of the (dis)agreement [16] between the perceived sensory activity, and the activity predicted through the integration of the contents of the different representations that define the satisfaction conditions of the intentions of the individual. This process is bi-directional [20], i.e., the body matrix can be changed to accommodate unexpected sensory signals (perceptual inference and learning), and actions are performed to confirm the sensory predictions made by the body matrix according to the intentions of the individual (active inference).

If low free-energy states are so important for survival, their detection should be a critical goal for any biological system, including humans. Therefore, the human brain learns to model and predict incoming sensory input to minimize the average of surprise across the different the body representations. Riva [11] recently suggested that the feeling of “presence,” i.e., the feeling of being in the body matrix and in the space surrounding it (peripersonal space), is the tool used by the brain to achieve this goal [21; 22]. In this view, through the pre-reflexive monitoring of the feeling of presence [23], the brain tries to overcome any threat or breakdown in its activity (break in presence), and it searches for engaging and rewarding activities (optimal experiences). According to Winograd and Flores [24], a breakdown is a disruption in the flow of presence, i.e., a breakdown occurs when the self, during an intentional action, is forced to shift its attention from the prior intention to the object/environment to cope with it, e.g., when we stumble on a tree root. If we use the framework discussed here, the breakdown experienced by stumbling on the root is the result of the mismatch between the predicted and the actual position of the legs, which does not allow the minimization of free energy. However, the self preferentially engages in activities associated with a positive, complex, and intrinsically-rewarding state [25]. Csikszentmihalyi [26; 27] defined these activities as “optimal experiences” or “flow.” During these activities the individual experiences absorption, a full sense of control and experiential immersion. Specifically, the use of the term “flow” underlines the experience of continuity and fluidity during the actions, which characterizes them. Riva [11] suggested that what makes an activity optimal is free energy minimization, i.e., having correctly predicted the outcome of its prior intention, the self can use the body to enact it pre-reflexively. In this view, the minimization of free energy and the feeling of presence have key roles in the process of “psychological selection,” and they drive the attention of the self towards experiences that are associated with flow, thereby facilitating their replication [28; 29]. Thus, flow triggers the direct investment of the self in the practice and cultivation of the intrinsically rewarding experiences.

### 3. Virtual Reality and Embodied Simulation

Since 1986, when Jaron Lanier used the term for the first time, VR is described as a collection of technological devices [30]: a computer capable of interactive 3D visualization, a head-mounted display, and data gloves equipped with one or more position trackers. The trackers sense the position and orientation of the user and report that information to the computer that updates (in real time) the images for display. Specifically, through the integration of data from trackers and the contents of a simulated 3D world, a VR system builds a model (simulation) of the body and the space around it.

If we compare this process with the one used by the brain discussed before, the VR system - like the brain - uses the simulation to predict the sensory consequences of the individual's movements [11]. This prediction is then used to provide, using the VR hardware, the expected sensory input: the same scene the user would see in the real world after the tracked movements. Obviously, to be realistic, the VR model tries to mimic as much as possible the brain model: the more the VR model is similar to the brain model, the more the individual feels present in the VR world [11; 31].

### 4. Virtual Reality 2.0

Given the existing similarities between VR and the brain, a new clinical opportunity is the use of VR for hacking the predictive/simulative mechanisms of the brain. Specifically, here we suggest using the simulative potential of VR to exploit/enhance (transformation of flow) and/or to correct (embodied medicine) the embodied simulations used by the brain to drive perception, action and emotions. As underlined by Positive Psychology [32; 33], to cope with dramatic changes in daily life and to access new environmental opportunities for action, individuals may develop a strategy defined as transformation of Flow [34]: the ability of the subject to use an optimal experience for identifying and exploiting new and unexpected resources and sources of involvement. A specific optimal experience that is connected to the transformation of flow is awe [35; 36]. In fact, awe consists of two central features [35; 36] – (i) a need for accommodation following the (ii) perception of vastness – that can induce a significant reorganization of the predictive/simulative mechanisms of the brain:

- *Perception of Vastness*: an update of the predictive coding given the mismatch with current representations of others [35; 36], the world, and ourselves [37], at the base of social order maintenance [35; 36];
- *Need for Accommodation*: the tension arising from the mismatch can translate into a drastic update of the predictive coding to accommodate unexpected experiences [35; 36].

A clearer picture of the complex relationship among awe and brain activity was recently provided by a recent voxel-based morphometry (VBM) study. As demonstrated by Guan and colleagues [35] awe involves multiple brain regions associated with cognitive conflict control, attention, conscious self-regulation, and socioemotional regulation, suggesting its potential role in adjusting/improving their functioning. Moreover, different studies demonstrated [38-40] that both immersive videos and interactive VR can induce awe. In this view, awe-inducing VR experiences may be used to induce transformation of flow. The proposed approach is the following: first, to identify a possible experience that contains functional real-world demands; second, using VR for producing the experience and inducing awe; third, allowing cultivation, by linking the awe experience to the actual experience of the subject. Different studies support the feasibility of this approach [41; 42].

Another approach, based on a similar rationale, is the use of VR to correct a dysfunction of the predictive coding mechanisms (embodied medicine [43; 44]). Different authors [43] recently suggested that an altered functioning of the predictive and simulative mechanisms of the brain might be the causes of different neurological and psychiatric conditions. In this view should be possible to compensate these deficits through the modulation and/or integration/replacement of the different components of the Body Matrix [11]. Specifically, VR can be used to generate new crossmodal associations between bodily stimuli that have not been experienced as

systematically related before [45]. Moreover, the crossmodal association has to produce a *significant prediction error* (high surprise), reducing the level of estimation uncertainty, to update the predictive internal models of the body matrix through the generation of new priors [43]. Using this approach, technology can be used:

1. to facilitate the integration of external and inner body signals [46-48] and,
2. to induce a controlled mismatch between the predicted/dysfunctional content and the actual sensory input [49].

The emerging fields of interoceptive feedback [46; 50], sonoception, i.e, the use of sound and vibration to modify inner body signals [43; 48] - and body illusion techniques [51], support the feasibility of this approach.

In conclusion, even if VR is already effectively used in behavioural health, the exploitation of the link between core brain process and the simulative potential of VR may be the centre of a new trans-disciplinary research field that uses VR to improve (transformation of flow) and correct (embodied medicine) the embodied simulations produced by the brain.

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## References

- [1] D. Knox, C. Schacht, and J. Turner, Virtual reality: A proposal for treating test anxiety in college students, *College Student Journal* **27** (1993), 294-296.
- [2] Wiederhold, M.D. and Wiederhold, B.K. From Virtual Worlds to the Therapist’s Office: Are Virtual Reality Techniques Useful Tools in Psychotherapy and Diagnosis? *IEEE Engineering in Medicine and Biology*, Vol. **15**(1996), 44-46.
- [3] G. Riva, B.K. Wiederhold, and F. Mantovani, Neuroscience of Virtual Reality: From Virtual Exposure to Embodied Medicine, *Cyberpsychol Behav Soc Netw* (2018).
- [4] G. Riva, R.M. Baños, C. Botella, F. Mantovani, and A. Gaggioli, Transforming Experience: The Potential of Augmented Reality and Virtual Reality for Enhancing Personal and Clinical Change, *Frontiers in Psychiatry* **7** (2016).
- [5] D. Freeman, S. Reeve, A. Robinson, A. Ehlers, D. Clark, B. Spanlang, and M. Slater, Virtual reality in the assessment, understanding, and treatment of mental health disorders, *Psychological Medicine* (2017), 1-8.
- [6] J.L. Maples-Keller, B.E. Bunnell, S.J. Kim, and B.O. Rothbaum, The use of virtual reality technology in the treatment of anxiety and other psychiatric disorders, *Harvard Review of Psychiatry* **25** (2017), 103-113.
- [7] Wiederhold, B.K., & Wiederhold, M.D. *Virtual Reality Therapy for Anxiety Disorders: Advances in Education and Treatment*. New York: American Psychological Association Press, 2004
- [8] F. Pallavicini, A. Ferrari, A. Zini, G. Garcea, A. Zancchi, G. Barone, and F. Mantovani, What Distinguishes a Traditional Gaming Experience from One in Virtual Reality? An Exploratory Study, in: *Advances in Human Factors in Wearable Technologies and Game Design*, T. Ahram and C. Falcão, eds., Springer, Cham, 2017, pp. 225-231.
- [9] F. Vincelli and G. Riva, Virtual reality as a new imaginative tool in psychotherapy, *Studies in Health Technology and Informatics* **70** (2000), 356-358.
- [10] G. Riva, E. Molinari, and F. Vincelli, Interaction and presence in the clinical relationship: virtual reality (VR) as communicative medium between patient and therapist, *IEEE Transactions on Information Technology in Biomedicine* **6** (2002), 198-205.
- [11] G. Riva, The Neuroscience of Body Memory: from the Self through the Space to the Others, *Cortex* **104** (2018), 241-260.
- [12] G. Riva and S. Gaudio, Locked to a wrong body: Eating disorders as the outcome of a primary disturbance in multisensory body integration, *Consciousness and cognition* (in press).
- [13] O. Blanke, Multisensory brain mechanisms of bodily self-consciousness, *Nature reviews. Neuroscience* **13** (2012), 556-571.
- [14] G.L. Moseley, A. Gallace, and C. Spence, Bodily illusions in health and disease: physiological and clinical perspectives and the concept of a cortical 'body matrix', *Neuroscience & Biobehavioral Reviews* **36** (2012), 34-46.
- [15] A. Maselli, Allocentric and egocentric manipulations of the sense of self-location in full-body illusions and their relation with the sense of body ownership, *Cognitive Processing* **16** (2015), 309-312.
- [16] D. Talsma, Predictive coding and multisensory integration: an attentional account of the multisensory mind, *Front Integr Neurosci* **9** (2015), 19.
- [17] K. Friston, The free-energy principle: a unified brain theory?, *Nat Rev Neurosci* **11** (2010), 127-138.
- [18] K. Friston, Embodied inference and spatial cognition, *Cognitive Processing* **13 Suppl 1** (2012), S171-177.

- [19] A. Clark, Whatever next? Predictive brains, situated agents, and the future of cognitive science, *Behav Brain Sci* **36** (2013), 181-204.
- [20] K. Friston, J. Daunizeau, J. Kilner, and S.J. Kiebel, Action and behavior: a free-energy formulation, *Biol Cybern* **102** (2010), 227-260.
- [21] G. Riva, J.A. Waterworth, E.L. Waterworth, and F. Mantovani, From intention to action: The role of presence, *New Ideas in Psychology* **29** (2011), 24-37.
- [22] G. Riva, J.A. Waterworth, and D. Murray, eds., *Interacting with Presence: HCI and the sense of presence in computer-mediated environments*, De Gruyter Open - Online: <http://www.presence-research.com/>, Berlin, 2014.
- [23] G. Riva and J.A. Waterworth, Being present in a virtual world, in: *The Oxford Handbook of Virtuality*, M. Grimshaw, ed., Oxford University Press, New York, 2014, pp. 205-221.
- [24] T. Winograd and F. Flores, *Understanding Computers and Cognition: A New Foundation for Design*, Ablex Publishing Corporation, Norwood, NJ, 1986.
- [25] M.E.P. Seligman and M. Csikszentmihalyi, Positive psychology, *American Psychologist* **55** (2000), 5-14.
- [26] M. Csikszentmihalyi, *Beyond Boredom and Anxiety*, Jossey-Bass, San Francisco, 1975.
- [27] M. Csikszentmihalyi, *Flow: The psychology of optimal experience*, HarperCollins, New York, 1990.
- [28] M. Csikszentmihalyi and F. Massimini, On the Psychological Selection of Bio-Cultural Information, *New Ideas in Psychology* **3** (1985), 115-138.
- [29] F. Massimini and A. Delle Fave, Individual development in a bio-cultural perspective, *American Psychologist* **55** (2000), 24-33.
- [30] G. Riva, Medical Clinical Uses of Virtual Worlds, in: *The Oxford Handbook of Virtuality*, M. Grimshaw, ed., Oxford University Press, New York, 2014, pp. 649-665.
- [31] M.V. Sanchez-Vives and M. Slater, From presence to consciousness through virtual reality, *Nature Review Neuroscience* **6** (2005), 332-339.
- [32] A. Delle Fave, Il processo di trasformazione di Flow in un campione di soggetti medullosei [The process of flow transformation in a sample of subjects with spinal cord injuries], in: *La selezione psicologica umana*, F. Massimini, A. Delle Fave, and P. Inghilleri, eds., Cooperativa Libreria IULM, Milan, 1996, pp. 615-634.
- [33] A. Delle Fave, F. Massimini, and M. Bassi, *Psychological Selection and Optimal Experience Across Cultures: Social Empowerment through Personal Growth*, Springer, New York, 2011.
- [34] G. Riva, G. Castelnovo, and F. Mantovani, Transformation of flow in rehabilitation: the role of advanced communication technologies, *Behav Res Methods* **38** (2006), 237-244.
- [35] F. Guan, Y. Xiang, O. Chen, W. Wang, and J. Chen, Neural Basis of Dispositional Awe, *Front Behav Neurosci* **12** (2018), 209.
- [36] Y. Bai, L.A. Maruskin, S. Chen, A.M. Gordon, J.E. Stellar, G.D. McNeil, K. Peng, and D. Keltner, Awe, the diminished self, and collective engagement: Universals and cultural variations in the small self, *J Pers Soc Psychol* **113** (2017), 185-209.
- [37] A. Newen, The Embodied Self, the Pattern Theory of Self, and the Predictive Mind, *Frontiers in psychology* **9** (2018), 2270.
- [38] A. Chirico, D.B. Yaden, G. Riva, and A. Gaggioli, The Potential of Virtual Reality for the Investigation of Awe, *Frontiers in psychology* **7** (2016), 1766.
- [39] 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* **7** (2017), 1218.
- [40] D. Quesnel and B.E. Riecke, Are You Awed Yet? How Virtual Reality Gives Us Awe and Goose Bumps, *Frontiers in psychology* **9** (2018), 2158.
- [41] G. Riva, R.M. Banos, C. Botella, B.K. Wiederhold, and A. Gaggioli, Positive technology: using interactive technologies to promote positive functioning, *CYBERPSYCHOLOGY, BEHAVIOR AND SOCIAL NETWORKING* **15** (2012), 69-77.
- [42] A. Gaggioli, G. Riva, D. Peters, and R.A. Calvo, Chapter 18 – Positive Technology, Computing, and Design: Shaping a Future in Which Technology Promotes Psychological Well-Being, in: *Emotions and Affect in Human Factors and Human-Computer Interaction*, M. Jeon, ed., Elsevier, London, 2017, pp. 477-502.
- [43] G. Riva, S. Serino, D. Di Lemia, E.F. Pavone, and A. Dakanalis, Embodied Medicine: Mens Sana in Corpore Virtuale Sano, *Frontiers in Human Neuroscience* **11** (2017).
- [44] D. Di Lemia, P. Cipresso, E. Pedroli, and G. Riva, Toward an Embodied Medicine: A Portable Device with Programmable Interoceptive Stimulation for Heart Rate Variability Enhancement, *Sensors (Basel)* **18** (2018).
- [45] Y.C. Chen and C. Spence, Assessing the Role of the 'Unity Assumption' on Multisensory Integration: A Review, *Frontiers in psychology* **8** (2017), 445.
- [46] K. Suzuki, S.N. Garfinkel, H.D. Critchley, and A.K. Seth, Multisensory integration across exteroceptive and interoceptive domains modulates self-experience in the rubber-hand illusion, *Neuropsychologia* **51** (2013), 2909-2917.
- [47] R.T. Azevedo, V. Ainley, and M. Tsakiris, Cardio-visual integration modulates the subjective perception of affectively neutral stimuli, *International journal of psychophysiology : official journal of the International Organization of Psychophysiology* **99** (2016), 10-17.
- [48] R.T. Azevedo, N. Bennett, A. Bilicki, J. Hooper, F. Markopoulou, and M. Tsakiris, The calming effect of a new wearable device during the anticipation of public speech, *Sci Rep* **7** (2017), 2285.
- [49] S. Serino, E. Pedroli, A. Keizer, S. Triberti, A. Dakanalis, F. Pallavicini, A. Chirico, and G. Riva, Virtual Reality Body Swapping: A Tool for Modifying the Allocentric Memory of the Body, *Cyberpsychol Behav Soc Netw* **19** (2016), 127-133.
- [50] P.L. Schoenberg and A.S. David, Biofeedback for psychiatric disorders: a systematic review, *Appl Psychophysiol Biofeedback* **39** (2014), 109-135.
- [51] M. Costantini, Body perception, awareness, and illusions, *Wiley Interdisciplinary Reviews: Cognitive Science* **5** (2014), 551-560.



## SECTION II

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### 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, 2004*



# An Overview of Factors Associated with Adherence and Dropout to Ecological Momentary Assessments in Depression

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**Abstract.** The use of technology-based Ecological Momentary Assessments (EMAs) allows to repeatedly assess patients during daily life, in naturalistic settings and in precise moments of the day. To date, EMAs have been broadly adopted for the investigation of Major Depressive Disorder (MDD). Nevertheless, adherence still represents a clinical challenge, as depressed patients may be less prone to regularly complete daily reports. Through a systematic narrative review, we qualitatively investigated factors affecting adherence and dropout of MDD patients to EMA protocols. The mean adherence rate across studies was generally encouraging (mean: 80.66%, SD 11.71%), and was higher in studies collecting self-reports by means of smartphones, prompting patients less than 8 times per day and using a prefixed sampling method. Dropouts were mainly related to technical problems or under-threshold number of collected answers, often occurring in studies collecting data by means of Personal Digital Assistants (PDAs). The implications of these results are discussed.

**Keywords.** Ecological Momentary Assessment, Major Depressive Disorder, mHealth, Adherence, Dropout

## 1. Introduction

According to the last estimates of the World Health Organization, Major Depressive Disorder (MDD) is one of the leading causes of disease and disability in the world, affecting approximately the 4.4% of the general population [1]. Notably, many of these patients do not receive an adequate assessment and, consequently, suitable psychological support [2]. In that sense, the clinical field tried for a long time to shed light upon new possible techniques to provide innovative self-help and low-cost ways

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for symptoms monitoring. Our current knowledge about MDD is mainly based on studies conducted in laboratory settings and on the retrospective recall of symptoms. On the one hand, there is evidence showing that depression is a dynamic disease, characterized by large symptoms fluctuations over time [4]. On the other hand, the recall of thoughts, feelings and behaviors was shown to be strongly biased by the time elapsing between real experiencing and retrieval [5]. Accordingly, the need for a more ecological understanding of depression and its underlying mechanisms is raising increasing interest. Ecological Momentary Assessments (EMAs) represent an innovative method for the repeated assessment of patients during daily life [6]. Originally administrated by means of paper-and-pencil daily diaries, EMAs subsequently started to be digitalized and provided to patients on Personal Digital Assistants (PDAs) or smartphones, in which all the needed processes could be easily included (i.e. signaling, data collection, data storage and transfer) and further integrated with the use of data from sensors and biosensors [7]. An increasing body of studies adopted EMAs for a more ecological investigation of different conditions, including depression [8,9]. Nevertheless, no specific guidelines have been proposed. Above all, the commitment required to constantly complete daily assessments may result in low adherence, i.e. a low percent of completed surveys. Especially when dealing with depression, the lack of energy and motivation that typically characterize this disease are likely to increase the number of patients dropping out from such studies, or to decrease their compliance to the procedure. The aim of this narrative review is to investigate factors that are likely to influence adherence and dropout rates of depressed patients in technology-based EMA protocols.

## **2. Method**

### *2.1. Search Strategy*

We followed the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines [10]. To collect relevant publications, the following string was used in two high-order databases, PubMed and Web of Science: ((EMA) OR ("ecological momentary assessment") OR ("mobile health") OR (mHealth) OR (smartphone) OR (ESM) OR ("experience sampling method") OR ("ambulatory assessment") OR ("personal digital assistant") OR ("ambulatory monitoring") OR ("real time data capture") OR ("real time monitoring") OR ("electronic diary")) AND ((depression) OR (MDD) OR ("major depressive disorder") OR ("unipolar depression")). The search was performed by two individual researchers (D.C. and J.F.A.) for publications in English language. Based on that string, 3684 articles were retrieved (PubMed: n=1792; Web of Science: n=1892). After a first selection based on the deletion of duplicate papers and of the analysis of titles and abstracts, a total of 84 articles were retrieved. After applying the inclusion/exclusion criteria (excluded papers: type of manuscript, n=13; EMA as an adjunctive therapeutic tool, n=3; sample criteria, n=33; lack of data on adherence rate, n=11; paper-and-pencil EMAs, n=11), 13 articles were included.

## 2.2. Inclusion/exclusion criteria

We considered studies adopting technology-based EMAs for the investigation and/or assessment of clinical and mental-health related variables in a sample of adults ( $\geq 18$  years old) with a primary diagnosis of MDD, defined by a valid criterion standard. Only studies reporting compliance rates (i.e. percent of completed surveys across the duration of the study) were included. When available, dropout rates were also considered. We excluded from the analysis non-English papers, studies that omitted the inclusion criteria and did not have an available full-text. Moreover, we excluded the following types of manuscripts: Conference papers, reviews, case reports, letters to the editor, extended abstracts, proceedings, editorials and other editorial materials.

## 2.3. Quality Assessment

To control for the risk of bias, PRISMA recommendations for systematic literature analysis were strictly followed [10].

# 3. Results

## 3.1. Adherence

Among the selected studies (see Table 1), the overall adherence to EMA protocols ranged between 64.5% and 96.05% ( $n=13$ , mean 80.66%, SD 11.71%) (Figure 1).

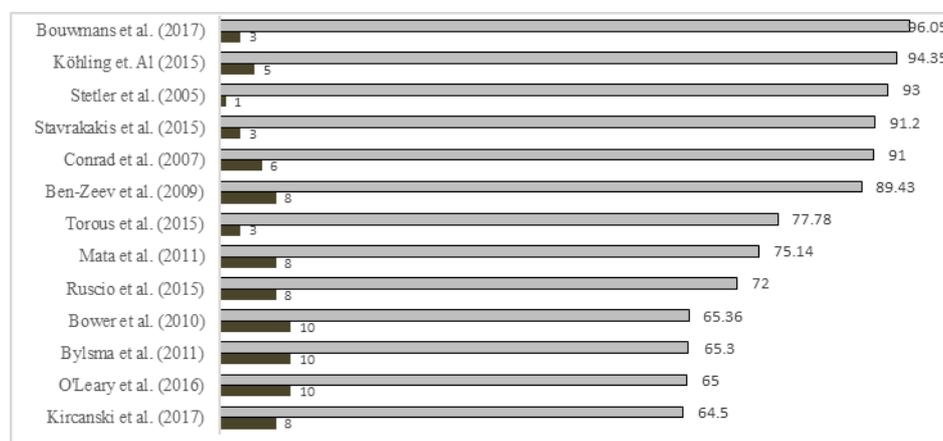


Figure 1. Adherence rates (light grey) and number of daily prompts (dark grey) of the selected studies.

Most of the included studies adopted a PDA for the daily completion of self-reports; only four studies were conducted with the use of a smartphone. Interestingly, smartphone-based EMAs could achieve higher adherence rates (PDAs:  $n=11$ , mean 76.02%, SD 10.98%; Smartphones:  $n=4$ , mean 89.85%, SD 7.18%). Compensation for participating in the protocol did not particularly influence the adherence of users (compensation:  $n=8$ , mean 81.92%, SD 10.27%; without compensation:  $n=5$ , mean

76.94%, SD 14.39%). Taking into consideration sampling methods, adherence rate was quite similar between studies adopting semi-randomized and randomized samplings (Semi-randomized: n=6, mean 74.27%, SD 13.20%; Randomized sampling: n=4, mean 79.82%, SD 8.64%). On the contrary, studies adopting a prefixed schema could achieve higher compliance (mean 91.73%, SD 0.90%). While the total duration of the protocol did not seem to affect participants' compliance, studies with a lower number of daily prompts obtained higher adherence: Generally, when 8 or more daily assessments were required, a higher number of missing answers were likely to be reported (see Figure 1). Finally, we considered the effect of the number of items composing each single daily assessment on adherence. As it was not possible to obtain the exact items count, we divided studies in 4 categories (<10 items; between 11 and 15 items; between 16 and 20 items; >21 items). Just a slight decrease in adherence was observed in correspondence to the increase of the number of items, especially when assessments were composed by more than 20 questions (10 items: n=2, mean 84.39%, SD 6.61%; between 11 and 15 items: n=2, mean 84.75%, SD 9.61%; between 16 and 20 items: n=3, mean 83.61%, SD 13.19%; >20 items: n=6, mean 75.17%, SD 12.24%).

**Table 1.** More detailed information about the selected studies. vNote: SR: Semi-randomized; P: Prefixed; R: Randomized; P: Personal Digital Assistant; S: Smartphone; MDD: Major Depressive Disorder; HCG: control group; BPD: Borderline Personality Disorder; GAD: Generalized Anxiety Disorder; mD: minor Depression.

Study	Sample size	Adherence (%)	Sampling	Device	Duration (days)	Prompts	Money	N° items
[1]	MDD (n=27), HCG (n=27)	96.05	SR	S	30	3	No	16-20
[2]	MDD (n=21), MDD + BPD (n=20)	94.35	R	S	7	5	Yes	11-15
[3]	MDD (n=37), HCG (n=36)	93	P	P	3	1	No	>21
[4]	MDD (n=10), HCG (n=10)	91.2	P	S	30	3	Yes	>21
[5]	MDD (n=46), HCG (n=19)	91	P	P	1	6	Yes	<10
[6]	MDD (n=26), HCG (n=25)	89.43	SR	P	7	8	Yes	16-20
[7]	MDD (n=13)	77.78	R	S	29.4	3	Yes	<10
[8]	MDD (n=53), HCG (n=53)	75.14	R	P	7	8	Yes	11-15
[9]	MDD (n=38), GAD (n=36), MDD + GAD (n=38), HCG (n=33)	72	R	P	7	8	Yes	>21
[10]	MDD (n=35), mD (n=25), HCG (n=36)	65.36	SR	P	3	10	No	16-20
[11]	MDD (n=35), mD (n=26), HCG (n=38)	65.3	SR	P	3	10	No	>21
[12]	MDD and mD (n=60), HCG (n=35)	65	SR	P	3	10	No	>21
[13]	MDD (n=16), GAD (n=15),	64.5	SR	P	6.5	8	Yes	>21

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MDD + GAD  
(n=20), HCG  
(n=19)

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### 3.2. Adherence

Eleven out of thirteen selected studies reported the main reasons for dropout, that included: Technical problems, data lost, change in diagnosis, backfilling, under-threshold number of answered prompts, time/scheduling difficulties. The two most frequent problems, reported in six of the thirteen included studies [11,18,19,22–24], were the occurrence of technical problems and the collection of a too low number of self-reports. Six out of these seven studies adopted a PDA rather than a smartphone and prompted participants 8 or more times per day.

## 4. Discussion

Despite that technology-based EMAs have been widely used for the understanding and assessment of depression, no study specifically focused on features that could improve patients' adherence to EMA protocols.

According to our results, participants complete more self-reports when allowed to use their own smartphone rather than an additional external device. Consistently, the use of smartphones for the daily administration of EMAs seems to be associated not only with higher adherence, but also with lower technical problems and under-threshold number of answered prompts, i.e. the two main reasons for dropout. Currently, 2.32 billion people in the world are using smartphones and it is estimated that by 2020 the 70% of the world's population will own one, suggesting the potential of this device for the research and clinical field [25]. Familiarity with smartphones as well as their current integration into our daily life could therefore encourage adherence to EMAs' protocols. Secondly, the number of daily prompts seems to play a key role both for adherence and dropout. Our results suggest indeed that a high number of daily assessments could be perceived as too invasive and demanding and decrease participants' compliance to the protocol. Finally, studies adopting a prefixed sampling schema reported higher rates of compliance, probably because users were already expecting the time of the prompt. Nevertheless, the use of randomization should always be taken into consideration when investigating variables with high daily fluctuations. Notably, other variables could play a fundamental role in increasing adherence and decreasing dropout rates to EMA protocols, including the administration of a training before the beginning of the experiment, the ability of researchers/clinicians in motivating patients' participation, data safety issues and the usability/engagement of the adopted device and/or mobile application. In the future, a meta-analysis could help to better clarify the features associated with adherence and dropout in EMA protocols for MDD.

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## References

- [1] World Health Organization, Depression and other common mental disorders: global health estimates, *World Health Organization* (2017) 1–24. doi:CC BY-NC-SA 3.0 IGO.
- [2] C. Henderson, S. Evans-Lacko, and G. Thornicroft, Mental illness stigma, help seeking, and public health programs, *American Journal Public Health*. **103** (2013) 777–780. doi:10.2105/AJPH.2012.301056.
- [3] F. Peeters, J. Berkhof, P. Delespaul, J. Rottenberg, and N.A. Nicolson, Diurnal mood variation in major depressive disorder., *Emotion*. **6** (2006) 383–391. doi:10.1037/1528-3542.6.3.383.
- [4] A. Wirz-Justice, Diurnal variation of depressive symptoms., *Dialogues Clinical Neuroscience* **10** (2008) 337–43. <http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=3181887&tool=pmcentrez&rendertype=abstract>.
- [5] D. Ben-Zeev, M.A. Young, and J.W. Madsen, Retrospective recall of affect in clinically depressed individuals and controls, *Cognition & Emotion* **23** (2009) 1021–1040. doi:10.1080/02699930802607937.
- [6] S. Shiffman, A.A. Stone, and M.R. Hufford, Ecological Momentary Assessment, *Annual Review of Clinical Psychology* **4** (2008) 1–32. doi:10.1146/annurev.clinpsy.3.022806.091415.
- [7] A. Gaggioli, G. Pioggia, G. Tartarisco, G. Baldus, D. Corda, P. Cipresso, and G. Riva, A mobile data collection platform for mental health research, *Personal Ubiquitous Computing* **17** (2013) 241–251. doi:10.1007/s00779-011-0465-2.
- [8] U.W. Ebner-Priemer, and T.J. Trull, Ecological momentary assessment of mood disorders and mood dysregulation., *Psychological Assessment* **21** (2009) 463–475. doi:10.1037/a0017075.
- [9] M. Aan het Rot, K. Hogenelst, and R.A. Schoevers, Mood disorders in everyday life: A systematic review of experience sampling and ecological momentary assessment studies, *Clinical Psychological Review* (2012). doi:10.1016/j.cpr.2012.05.007.
- [10] A.D. The Prisma Group from Moher D, Liberati A, Tetzlaff J, Preferred reporting items for systematic reviews and meta analyses: The Prisma Statement., *PLoS Medicine* **6** (2009) 1–15. doi:10.1371/journal.pmed1000097.
- [11] M.E.J. Bouwmans, E.H. Bos, H.J.R. Hoenders, A.J. Oldehinkel, and P. de Jonge, Sleep quality predicts positive and negative affect but not vice versa. An electronic diary study in depressed and healthy individuals, *Journal of Affective Disorders* **207** (2017) 260–267. doi:10.1016/j.jad.2016.09.046.
- [12] J. Kohling, M. Moessner, J.C. Ehrental, S. Bauer, M. Cierpka, A. Kammerer, H. Schauenburg, U. Dinger, J. Köhling, M. Moessner, J.C. Ehrental, S. Bauer, M. Cierpka, A. Kammerer, H. Schauenburg, and U. Dinger, Affective Instability and Reactivity in Depressed Patients With and Without Borderline Pathology, *Journal of Personality Disorders* **30** (2015) 1–20. doi:10.1521/pedi\_2015\_29\_230 PM - 26623534 M4 - Citavi.
- [13] C. Stetler, and G.E. Miller, Blunted cortisol response to awakening in mild to moderate depression: regulatory influences of sleep patterns and social contacts., *Journal of Abnormal Psychology*. **114** (2005) 697–705. doi:10.1037/0021-843X.114.4.697.
- [14] N. Stavrakakis, S.H. Booi, A.M. Roest, P. de Jonge, A.J. Oldehinkel, and E.H. Bos, Temporal dynamics of physical activity and affect in depressed and nondepressed individuals., *Spec. Issue eHealth/mHealth*. **34** (2015) 1268–1277. doi:10.1037/hea0000303 M4 - Citavi.
- [15] A. Conrad, F.H. Wilhelm, W.T. Roth, D. Spiegel, and C.B. Taylor, Circadian affective, cardiopulmonary, and cortisol variability in depressed and nondepressed individuals at risk for cardiovascular disease, *Journal of Psychiatry Research*. **42** (2008) 769–777. doi:10.1016/j.jpsychires.2007.08.003.
- [16] J. Torous, P. Staples, M. Shanahan, C. Lin, P. Peck, M. Keshavan, and J.-P. Onnela, Utilizing a Personal Smartphone Custom App to Assess the Patient Health Questionnaire-9 (PHQ-9) Depressive Symptoms in Patients With Major Depressive Disorder, *JMIR*. **2** (2015) e8. doi:10.2196/mental.3889.

- [17] J. Mata, R.J. Thompson, S.M. Jaeggi, M. Buschkuhl, J. Jonides, and I.H. Gotlib, Walk on the bright side: Physical activity and affect in major depressive disorder., *Journal of Abnormal Psychology* **121** (2012) 297–308. doi:10.1037/a0023533.
- [18] A.M. Ruscio, E.L. Gentes, J.D. Jones, L.S. Hallion, E.S. Coleman, and J. Swendsen, Rumination Predicts Heightened Responding to Stressful Life Events in Major Depressive Disorder and Generalized Anxiety Disorder, *Journal of Abnormal Psychology*. **124** (2015) 17–26. doi:10.1037/abn0000025.
- [19] B. Bower, L.M. Bylsma, B.H. Morris, and J. Rottenberg, Poor reported sleep quality predicts low positive affect in daily life among healthy and mood-disordered persons: Sleep quality and positive affect, *Journal of Sleep Research*. **19** (2010) 323–332. doi:10.1111/j.1365-2869.2009.00816.x.
- [20] L.M. Bylsma, A. Taylor-Clift, and J. Rottenberg, Emotional reactivity to daily events in major and minor depression., *Journal of Abnormal Psychology* (2011). doi:10.1037/a0021662.
- [21] K. O’Leary, B.J. Small, V. Panaite, L.M. Bylsma, and J. Rottenberg, Sleep quality in healthy and mood-disordered persons predicts daily life emotional reactivity, *Cognition & Emotion* **31** (2017) 435–443. doi:10.1080/02699931.2015.1126554.
- [22] K. Kircanski, R.J. Thompson, J. Sorenson, L. Sherdell, and I.H. Gotlib, The everyday dynamics of rumination and worry: precipitant events and affective consequences, *Cognition & Emotion* (2017) 1–13. doi:10.1080/02699931.2017.1278679.
- [23] K. O’Leary, B.J. Small, V. Panaite, L.M. Bylsma, and J. Rottenberg, Sleep quality in healthy and mood-disordered persons predicts daily life emotional reactivity, *Cogn. Emot. Cognition & Emotion* (2017). doi:10.1080/02699931.2015.1126554.
- [24] J. Mata, R.J. Thompson, S.M. Jaeggi, M. Buschkuhl, J. Jonides, and I.H. Gotlib, Walk on the bright side: Physical activity and affect in major depressive disorder., *Journal of Abnormal Psychology* (2012). doi:10.1037/a0023533.
- [25] J. Firth, J. Torous, J. Nicholas, R. Carney, A. Prata, S. Rosenbaum, and J. Sarris, The efficacy of smartphone-based mental health interventions for depressive symptoms: a meta-analysis of randomized controlled trials, *World Psychiatry*. **16** (2017) 287–298. doi:10.1002/wps.20472.

# EHealth4MDD: A database of e-health systems for the prevention and treatment of depressive disorders

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**Abstract.** To date, meta-analyses of e-mental health systems for major depressive disorder (MDD) have largely overlooked the technological side of interventions. This warranted the creation of an open access database, EHealth4MDD, for the systematic study of the technological implementation in relation to intervention content, study design, and study outcomes. E-health systems were identified by conducting an exhaustive search on PubMed, Scopus, and Web of Science in 2017. The 5379 retrieved records yielded 267 systems. One coder extracted information from the records on 45 variables, organized into 14 tables in EHealth4MDD. A sample of each high-inference variable was double coded by a second coder to assess reliability. Percent agreement was satisfactory given that coders received no training and the number of possible categories was large. Furthermore, scales were developed to rate the degree of technological sophistication of system functions for each of five function types. Four of these scales demonstrated concurrent validity, as evidenced by the substantial to strong correlations observed when comparing the scales with the results of an unlabeled ordering task. For researchers in both computer science and clinical psychology, the database presents a useful tool to systematically study e-mental health interventions for depression.

**Keywords.** e-mental health systems, major depressive disorder, systematic review tool, relational database, reference database, information retrieval, clinical psychology, software engineering

## 1. Introduction

Although depression can be treated effectively, more than half of the approximately 300 million people worldwide suffering from the illness are receiving inadequate or no treatment [1]. E-mental health presents a promising direction in overcoming many of the barriers to and shortcomings of face-to-face treatment [2].

To date, both systematic reviews and meta-analyses in the field have largely focused on delivery aspects (e.g. guidance as a factor of influence [3]) and therapy aspects (e.g. limiting the scope to a specific therapeutic approach [4]) in relation to outcomes while neglecting influences of technology. To the best of our knowledge, only Zhao et al. [5] systematically reviewed the presence of certain technological features (communication tools, instructional ICT features, and self-monitoring tools) in psychoeducational e-mental health systems for depression, reaching the conclusion that most interventions lack in technological sophistication.

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As has been pointed out in recent surveys, the field would benefit from a clearer picture of the features of e-mental health systems for depression that contribute to outcomes and those that are superfluous [2]. This warranted the creation of an open access database of e-mental health systems for the treatment and prevention of major depressive disorder (MDD), enabling the systematic examination of the composition of these systems and how this relates to their evaluation context and dropout rates.

## 2. Method

### 2.1 Search Strategy

Considered for inclusion was primary research published in English describing e-mental health support systems, i.e. interventions with therapeutic content delivered on information and communication technology platforms, for the prevention or treatment of major depressive disorder in adults developed and evaluated between 2000 and 2017. To ensure quality, only support systems having been scientifically evaluated with end users were included. The time frame was lower-bounded to give an accurate overview of the state-of-the-art: in earlier systems the technological sophistication is limited by the availability of technology rather than being a design choice. Additionally, we excluded research on systems (1) serving only as a medium between therapist and user or between users (2) targeting children, targeting women with postpartum, perinatal, or prenatal depression, targeting caregivers or family members of people with depression, targeting a comorbid psychotic condition, (3) aiming to reduce stigma associated with depression, (4) diagnostic tools or decision aids, (5) lacking psychotherapeutic functionality (e.g. only supporting adherence to antidepressant treatment), (6) having a very narrow scope (i.e. system developed for one specific patient with very specific combination of conditions). The full search-query is given on the database website (see Footnote 2 below).

An exhaustive search was conducted for articles and papers published up until 2017 describing eHealth interventions for depression on Scopus, PubMed, and Web of Science. A total of 5379 records were retrieved from the three databases (5359) and research syntheses in the field (20). All records were filtered first on title, then on abstract, and finally on full article by the first author, C1. Due to resource restrictions, a sample of the records at each stage was double coded by a second, independent coder, C2, a computer science student. Table 1 presents sample sizes and agreement scores at each stage. Sample sizes were determined by trading off the available resources against the margin of error of the percent agreement using the methods proposed by Gwet [6].

### 2.2 Data extraction

Included articles were coded by C1 on a total of 45 variables and entered into a relational database. This database consists of 14 tables grouped into three larger clusters. The *systems* cluster details the e-mental health systems, their versions, their functionality, and their therapeutic purposes (four tables). In this cluster, systems were characterized on a macro-level (year of completion; whether its purpose is to prevent,

treat, or monitor; whether it is guided, unguided, or an adjunct to face-to-face therapy; etc.) and on a micro-level, i.e. their functions. An instantiation of a function is its concrete implementation in a system. Functions were of two types: support functions and intervention functions. Support functions aim at increasing adherence to the intervention. They were again categorized into four subtypes: support functions for treatment planning (e.g. scheduling of sessions), treatment execution (e.g. reminders), monitoring (e.g. monitoring of symptoms), and social support (e.g. therapist support). To determine possible support functions in the domain, adherence strategies as defined in, for example, [7] were considered. Intervention functions support patient activities aimed at reducing depression symptoms. They are linked to specific classes of therapeutic interventions. The second cluster of tables in the database is the *evaluations* cluster, detailing the empirical studies of the systems in the systems cluster, their design, the employed measurement instruments, and dropout rates per study arm (four tables). Finally, the *publications* cluster details articles describing systems and their evaluations and the authors of these articles (three tables). The remaining three tables link systems to evaluations, systems to publications, and publications to evaluations.

Of the 45 variables, 41 were identified as low-inference (e.g. intended duration of the intervention) as they could be extracted directly from the literature, and 4 were identified as high-inference, since extraction required interpretation of the literature. The four high-inference codes were (1) identifying functions in a system description (e.g. SuperBetter implements the intervention function *3 good things*), (2) classifying an instantiation as a particular function (e.g. “Participants were instructed to follow one module per week” describes *Tunneling*), (3) linking an intervention function to a therapeutic intervention class (e.g. *3 good things* is a technique in Positive Psychology), and (4) assigning a degree of technological sophistication to an instantiation. For each of the high-inference variables, a random sample was selected and double coded by a second coder to assess reliability.

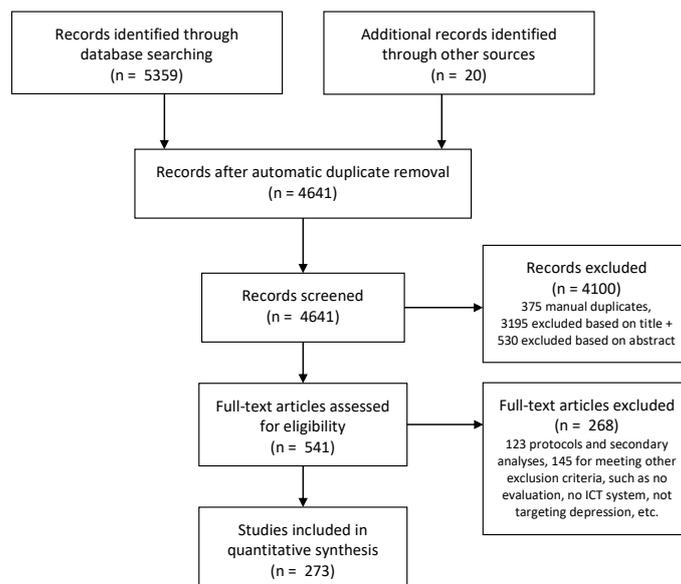


Figure 1. PRISMA diagram detailing the literature screening process of C1.

To *identify functions in a system description*, a graduate student in clinical psychology, C3, was provided with articles describing systems and the complete list of 184 functions. The percentage agreement was calculated as the percentage of overlap in all assigned functions of C1 and C3. To *classify an instantiation of a function*, C3 was again provided with the list of 184 functions as well as with a list of 125 snippets of text from articles describing functions. If C1 and C3 appointed the same function to the description of an instantiation, it was scored as agreement. In *linking a therapeutic intervention class to an intervention function*, C3 was provided with a list of all intervention functions and a set of 25 possible therapeutic intervention classes. While C1 always only selected one therapeutic intervention class, C3 was permitted to select multiple. Coder agreement was calculated by coding as agreement whenever C1's class was a subset of the class(es) assigned by C3. C3 received no training for the tasks other than a detailed coding manual. Furthermore, C1 *rated all instantiations of functions on their degree of technological sophistication* with the respective e-mental Health Degree of Technological Sophistication scale (eHDTS) developed specifically for this purpose<sup>1</sup>. Reliability was examined by regarding agreement in a sample that was recoded by C2 (Table 1).

Concurrent validity of the eHDTS scales was examined by correlating eHDTS scores assigned to instantiations of functions with knowledge of the scale levels (informed scores) with rank scores obtained when coders with computer science or related degrees were asked to sort the same instantiations according to their intuitive understanding of "technological sophistication" (naïve scores). Each of five coders, C4-8, received only instantiation descriptions of a specific category (e.g. intervention, treatment planning, monitoring). C2, however, received a large sample of component descriptions taken from all the categories to allow for the examination of comparability of the different eHDTS scales. At least one week after the naïve sorting, the coders were asked to rate the same sample component on their respective eHDTS. Spearman correlations were calculated to examine agreement between informed and naïve scores within coders (Intra-Coder Correlation, Table 2). All raw data and analysis scripts can be accessed online<sup>2</sup>.

### 3. Results

#### 3.1 Reliability Analyses

Both the screening procedure and high-inference codes were subjected to a reliability analysis. Table 1 presents the agreement scores obtained between the coders. In the literature screening process, coders agreed in approximately 80% of cases. Inter-coder reliability was moderate to substantial according to the classification proposed by Landis and Koch [8]. Since agreement and reliability could only be assessed on a

<sup>1</sup> The exact definitions for the levels of the five scales, eHDTS\_I (intervention), eHDTS\_Sp (planning), eHDTS\_Se (execution), eHDTS\_Sm (monitoring), and eHDTS\_Ss (social) as well as the specific search queries, detailed descriptions of all coded variables, a diagram of the database structure, diagrams of the methodology of the reliability and validity analyses, and querying functionality for database content can be found on the database website <http://insyprojects.ewi.tudelft.nl:8888/>.

<sup>2</sup> Data and analyses can be accessed at the 4TU.Center for Research Data national research data archive under the following doi: 0.4121/uuid:7e7e91ab-7afc-4b48-8915-e2bc80b23c99 or for quick access <https://tinyurl.com/y7k25uqp>.

sample, particularly *false positives* (C1 excluded while C2 included, indicating that other relevant articles of the population may have been missed entirely by C1 and hence may not be in the database) had to be examined closely. Four reasons could be identified: mistakes by C1 (full-paper: 1 record), mistakes by C2 (title: 2 records), C2 misunderstanding an exclusion criterion (title: 4 records, abstract: 2 records, full-paper: 3 records), and precaution on the part of C2 as he was instructed to include records when in doubt (title: 5 records, abstract: 3 records). Cautiously included records were unanimously excluded by re-evaluation at the next filtering stage. False negatives were not analyzed further as they did not pose a threat to database content.

**Table 1.** Results of the reliability analyses conducted for the literature screening process and selected variables coded for in the database. For assigning a degree of technological sophistication to a function instantiation, a weighted Cohen’s kappa was calculated since the scale is ordinal.

	Coders	Population	Sample	Percent Agreement, 95% CIs	Cohen’s kappa, 95% CIs
<i>Literature Screening</i>					
Title Filter	C1, C2	4266	100	.81 [.71, .87]	.50 [.31, .69]
Abstract Filter	C1, C2	1071	44	.80 [.64, .89]	.58 [.34, .82]
Full Article Filter	C1, C2	541	25	.84 [.60, .92]	.69 [.42, .95]
<i>Coding</i>					
Identify functions of system	C1, C3	273	10	.37 [.30, .43]	-
Classify function of instantiation	C1, C3	2224	125	.58 [.49, .66]	.57 [.48, .65]
Map intervention functions to therapeutic intervention class	C1, C3	141	141	.81 [.73, .87]	-
Assign degree of technological sophistication to instantiation	C1, C2	2224	132	.48 [.39, .55]	.60 [.51, .69]

### 3.2 Scale validation

To determine concurrent validity of the different eHDTS scales, we correlated the informed scores of the coders with their own naïve scores (intra-coder correlation) as well as with the informed scores of C1 (inter-coder correlation). Table 2 shows the Spearman correlations for each scale.

**Table 2.** Results of the scale validation conducted to assess concurrent validity of the degree of technological sophistication scales. Confidence intervals were obtained by bootstrapping.

	Coders	Population	Sample	Intra-Coder Correlation, 95% CIs	Inter-Coder Correlation, 95% CIs
Intervention	C1, C4	1344 (60%)	27	.59 [.21, .80]	.81 [.58, .92]
Treatment Planning	C1, C5	29 (1.3%)	20	.82 [.62, .92]	.70 [.21, .92]
Treatment Execution	C1, C6	445 (20%)	27	.52 [.08, .78]	.67 [.31, .86]
Monitoring	C1, C7	140 (6.3%)	29	.27 [-.14, .61]	.52 [.07, .78]
Social Support	C1, C8	266 (12%)	29	.52 [.11, .79]	.65 [.24, .87]
All types mixed	C1, C2	2224 (100%)	117	.47 [.31, .60]	.58 [.43, .70]

### 3.3 Distribution over system functions

Analyses concerning the content of the database exceed the scope of this work. We therefore only briefly describe the distribution over function instantiations here. As can be seen in the Population column of Table 2, approximately 60% of function

instantiations across systems are of the intervention type. Of the support instantiations, 3% support the user in establishing adherence strategies initially, while more than half aim at reeling the user back in. In line with research indicating that adherence to the systems is higher when human support is included, one third of support instantiations strive to provide human contact.

#### 4. Discussion and Conclusion

The EHealth4MDD database is a systematic inventory of e-mental health systems for the treatment and prevention of depression. It contains 267 such systems with a total of 2224 function instantiations. Approximately 60% of these functions are of a psychotherapeutic nature while 40% aim to support the user in adhering to the intervention. In the literature screening process for populating the database, moderate to substantial reliability was obtained. Double coding of high-inference codes yielded satisfactory percent agreement scores in light of the vast number of possible categories. Therefore, the findings show clear consistency between coders and, as common in high-inference coding, some degree of individual subjectivity. Significant correlations of naïve with informed ratings indicate that four of the five different eHDS scales capture the intuitive understanding of “technological sophistication” as held by those with a computer science or related degree. Furthermore, correlations between pairs of coders using the scales were significant and high on the same four scales, indicating that technological sophistication can be reliably assessed with the scales. However, the database is not without limitations as a single coder coded most data and reliability of this coding could only be assessed on samples. This resulted in large differences between coders in exposure to the data and therefore possibly lower scores of inter-coder agreement and reliability than might otherwise be expected.

For researchers in both computer science and clinical psychology, the database presents a useful tool for the systematic study of e-mental health interventions for depression. It allows for a better understanding of system composition and of how functionalities contribute to clinical outcomes. Since the database is open access and implemented as a standard MySQL database, it can be linked with other databases, for example, databases of clinical trials. Furthermore, the accessibility allows the research community to contribute to the maintenance of the database.

#### References

- [1] World Federation for Mental Health, Depression: A global Crisis, *World Health Organization. Federation for Mental Health.*, 2012.
- [2] J. Schröder, T. Berger, S. Westermann, J. P. Klein, and S. Moritz, Internet interventions for depression: new developments, *Dialogues Clin. Neurosci.*, **18** (2016),. 203.
- [3] D. Richards and T. Richardson, Computer-based psychological treatments for depression: A systematic review and meta-analysis, *Clinical Psychology Review.*, **32** (2012) 329–342.
- [4] P. S. Ferooshani, J. Schneider, and N. Assareh, Meta-review of the effectiveness of computerised CBT in treating depression, *BMC Psychiatry*, **11** (2011), 11-131
- [5] D. Zhao, M. L. A. Lustria, and J. Hendrickse, Systematic review of the information and communication technology features of web-and mobile-based psychoeducational interventions for depression, *Patient Education and Counselling.*, 2017.
- [6] K. L. Gwet, *Handbook of Inter-Rater Reliability: the definitive guide to measuring the extent of agreement among raters.* 2010.

- [7] H. Oinas-Kukkonen and M. Harjuma, Persuasive systems design: Key issues, process model, and system features,” *Communications of the Association for Information Systems*, **24** (2009), 28
- [8] J. R. Landis and G. G. Koch, “The Measurement of Observer Agreement for Categorical Data,” *Biometrics*, 1977.

# Enhancing empathic interactions in mental health care: Opportunities offered through social interaction technologies

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**Abstract.** Therapeutic rapport and empathy are essential parts of the relationship between mental health care professionals and their clients and are considered key elements of good therapeutic outcome. There are various social interaction technologies that have proven to be beneficial to current psychotherapeutic practice. Despite their proven efficacy, the adoption of these technologies among therapists is still relatively low. A prominent reason for this is the perception that mediated communication does not allow for satisfying empathic interactions. However, new technological developments offer opportunities that could help overcome this barrier and possibly even enhance the empathic interaction. The current paper explores these novel technologies in a systematic way by mapping them to the three components of empathy (cognition, affect, behavior). By identifying these opportunities, we hope to encourage a new way of thinking about technology, emphasizing its potential added value to the quality of psychological treatment, and eventually aiming to broaden the array of available treatment possibilities for mental healthcare professionals.

**Keywords.** Mental healthcare, social interaction technologies, empathy, therapeutic rapport

## 1. Introduction

Therapeutic rapport is considered a fundamental part of the therapeutic interaction process, and highly related to successful therapeutic outcomes [1-2]. Rapport can be defined as “the spontaneous, conscious feeling of harmonious responsiveness that promotes the development of a constructive therapeutic alliance” [3]. An integral part of therapeutic rapport is empathy [4], that is, the ability to understand and share the feelings of another person. Meta-analytic reviews have consistently shown that the level of therapists’ empathy perceived by their clients is a key element of therapeutic change, accounting for about 9% of the variance in therapy outcome, even more than the specific intervention used [5]. Current understanding of empathy suggests that it consists of three components: a cognitive, an affective and a behavioral one [4, 6-7]. Cognitive empathy is the process of understanding another’s feelings by reasoning about their internal states [8].

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The second, affective component, is concerned with emotions. Mirror neurons are thought to play an important role in this process, causing the emotions of interacting individuals to converge because they adjust to each other's affective states [6]. Last, the behavioral component consists of one's behavioral response as a result of empathizing with the other's emotion. There are many different ways to express feelings of empathy, either verbally through for example empathic reflections and questions [5], or non-verbally by making meaningful eye contact [10] or through comforting touches [11]. With respect to empathy in psychotherapeutic interactions, a prominent model is the Empathic Cycle formulated by Barret-Lennard [12]. According to this model, client and therapist are cycling together through four steps during their interaction. First, clients express their experience. Therapists then try to empathically resonate with their clients' experience, actively trying to 'tune in' and enter the clients' world. Third, the therapist expresses her empathic feelings. As a final step the client receives this, followed by a new cycle. The Empathic Cycle underlines the different but interrelated roles played by therapist and client [13], which is not a symmetric relationship, as one would expect in a friendship or spousal relationship. Clients unconsciously observe their therapists' responses in order to monitor their appraisal. This allows them to receive their therapist's empathy. Therapists, on the other hand, are actively trying to resonate empathically with their clients, a process which is referred to as empathic attunement. In this process, therapists form internal representations of the clients' emotions, intentions, cognitions and physical states based on the client's expression in order to respond in a way that supports the client in giving a more accurate expression during the next cycle. Every response of the client, either verbal or non-verbal, is a cue conveying information to the therapist that facilitates this attunement and allows her to respond more empathically.

Over recent decades, communication technologies have found their way into psychotherapeutic practice. Multiple benefits are associated with the use of these technologies, such as increased access to psychological treatment, convenience, as well as enhanced self-reflection and increased emotional disinhibition of the client [14-17]. Several studies have been conducted to investigate whether technological mediation affects the therapeutic relationship. From a client perspective, results are primarily positive, with the majority of studies indicating that it is possible to establish good therapeutic rapport in mediated settings [18]. However, from a therapists' perspective, the results appear to be more mixed (e.g. [19-20]). Many practitioners have doubts whether mediated interactions sufficiently support the expression and reception of affective cues, and the consequent development and maintenance of therapeutic rapport [21]. They often report that 'something' is missing; a feeling that seems to originate in having access to fewer social cues in mediated interaction [18, 22]). Importantly, therapists critically rely on these cues for empathic attunement [14, 18]. Thus, it is essential to investigate how interaction technologies should be developed or optimized in a way that satisfies therapists' needs and helps to overcome the limitations of communication technologies in supporting the empathic relationship.

With respect to the incorporation of social interaction technologies in mental healthcare, two different approaches can be distinguished. The traditional approach is to support or simulate face-to-face interactions as closely as possible, thereby attempting to overcome limitations imposed by the medium (e.g., supporting eye contact or gesturing). Developing and applying technologies to meet a basic level of empathic interaction is in line with this approach. However, a second, complementary

approach is to use unique affordances of the medium to transform the interaction into something that could add value above and beyond what would be possible even in an unmediated encounter. This type of approach was already argued for by Hollan and Stornetta in 1992 [23]. Research on empathic accuracy has shown that empathy in humans is a teachable skill that can be improved when appropriately supported [24-25]. Following this second line of thinking, one could imagine the potential of technology to not just support a basic level of empathy in technology-mediated settings, but to *augment* empathic interactions, both in mediated as well as media-assisted co-located settings.

When applying this second approach, a variety of opportunities arise as a consequence of the development and application of new sensors and actuators for measuring and representing social and affective cues. In addition, the mediated nature of the interaction allows for the transformation of the communicated social and affective cues. The aim of the current paper is to explore the ways in which novel communication technologies can be used to support and enhance empathic attunement in therapeutic interactions. To structure this exploration, the three components of empathy will serve as a framework to which the various technologies are mapped. By identifying these opportunities, we hope to encourage another way of thinking about the use of technology in psychological treatment, that is, not merely as a digital copy of traditional face-to-face therapy, but as an opportunity to use some of the unique affordances of technology to add value to the treatment ways that were not possible before. Thus, we hope to broaden the range of possible treatment options for psychotherapists and so contribute to the quality of mental health care

## **2. Opportunities to augment empathic interactions**

### *2.1 Cognitive component*

Technology can add relevant information during therapy that would normally be unavailable, even in a face-to-face setting. This information can improve therapists' understanding of their clients' internal states, i.e., the cognitive component of empathy. A major part of the relevant studies in the field of affective computing has been focused on emotion recognition [25]. An extensive body of research shows that current technologies can do this relatively accurately (for example, see [26]). Emotion recognition is usually based on facial expressions, speech parameters, and/or physiological measures (for a review, see [27]). So far, a lot of attention has been given to the application of these measures in assessing stress, but other uses are increasingly being explored [28]. For example, research shows positive results for applying affective technologies in assisting persons with autism in understanding the context during social interactions, i.e. supporting the cognitive component of empathy [29]. A challenging factor that needs to be taken into account is the way in which the feedback on physiological measures is presented, as research shows that different representations result in different interpretation of the same information [30].

### *2.2 Affective component*

Emotional convergence, the process related to the affective component of empathy, is assumed to result from a human tendency to mimic and synchronize with the other's non-verbal behavior (e.g. facial expressions, speech, body movements and posture [6]).

Feedback on physiological states cannot only be used to increase understanding of the client's state (i.e., the cognitive component), but also to enhance the affective component. By *exchanging* this information, implicit socio-emotional information can be made explicit, which facilitates therapists to 'feel with' their clients. Indeed, first exploratory studies have shown that using physiological feedback as a communication cue, i.e., social biofeedback, significantly enhances interpersonal intimacy [31], as does information on non-verbal interactional behavior [32-33]. Most of the studies on social biofeedback have either used graphical or auditory representations to show the information [e.g. 30-33]. However, research shows that touch is the primary modality for conveying intimate emotions [34]. Hence, transferring physiological information through a haptic pathway could serve as a powerful affective cue that increases emotional convergence and subsequently enhances the empathic interaction.

In addition, social perspective taking [35] is known to enhance emotional convergence. A technology that quite literally allows you to put yourself in someone else's shoes is Virtual Reality (VR). A key feature of VR is its ability to experience someone else's world from a first-person perspective [36]. That, in combination with a strong sense of embodiment, allows you to become an actor in the environment instead of merely a spectator [37]. In this way, VR can heighten feelings of empathy in a unique way. Indeed, studies show that experiencing someone else's viewpoint in VR led to more positive feelings about the relationship [36] and increased feelings of concern and helping behavior [38]. In addition, studies have been conducted with virtual simulations of mental illnesses such as schizophrenia [39] and dementia [40], showing that participants held more positive attitudes towards people suffering from these disorders and after being exposed to the simulations. They reported that it enabled them to truly experience what it feels like to live with such disorders, which resulted in increased feelings of empathy during subsequent interactions.

### 2.3 Behavioral component

The possibilities of VR can also be used to support the behavioral component of empathy, that is, facilitating therapists in expressing appropriate levels of empathy towards their clients. The increased feelings of closeness in shared VEs may increase self-disclosure from the client [41], which in turn is expected to further increase feelings of interpersonal closeness and empathy between therapists and their clients [12]. Moreover, it is also argued that some clients feel more secure in the controlled surroundings of a virtual environment [17, 41-42], which also facilitates self-disclosure.

An important behavioral aspect of empathy is interpersonal touch, which can help to convey interpersonal understanding and alleviate stress and anxiety in a patient [34]. Touch implies direct physical interaction and co-location and therefore inherently evokes feelings of social presence. However, current social interaction technologies mostly rely exclusively on vision and audio. Not allowing the expression of emotions through touch compromises the experience of being together and will likely decrease perceived empathy. Recently, multiple systems have been developed that incorporate some kind of social touch [43-44]. Even though most systems are still research prototypes and not broadly available, the ability of empathic touch to provide support suggests that it is worthwhile to explore the potential of appropriate mediated social touch in remote interactions between therapists and their clients. It has to be noted that psychotherapeutic approaches and cultures differ in their opinions about consoling touches between therapist and client, being more usual and considered appropriate in

some therapeutic approaches (i.e., schema-therapy) than in others (i.e. psychoanalysis). Having said that, mediated social touch has a number of unique affordances that would offer an interesting alternative to physical touch in therapeutic settings. As there is no direct skin-to-skin contact, it is assumed to be less intimate than real touch. Moreover, in mediated social touch, being touched or not is under the control of the client. They can turn the ‘touch option’ on or off, much like turning video on or off during a Skype session. Mediated touch may even offer ways to practice human touch for people that have difficulties with that in their social life. Investigating whether remote social touch can serve these purposes offers an important direction for future research.

### 3. Conclusion

In this paper, we have identified several opportunities for novel technologies to support empathic attunement between therapists and their clients. We have structured this exploration by mapping these technologies to the three key components of empathy: cognition, affect and behavior.

With respect to the implementation in psychotherapeutic practice, there are still significant steps to take. First, whereas some technologies are already more mature, many of the suggested applications are research prototypes that are still under development, and therefore not yet sufficiently robust, versatile, user-friendly, and cost-effective to be deployed in current practice. Second, despite the clear potential of several types of technologies to enhance the empathic relationship and thus benefit mental health care practice, much research is still needed to empirically establish this and also to gain more insights into which technologies are most suitable for which clients and mental disorders. It is only after convincing and well-controlled demonstrations of clinical efficacy that we can expect larger-scale acceptance and uptake of such innovations by mental health care professionals. Nevertheless, with this exploration we hope to have underlined the importance of empathy for an effective psychotherapeutic relationship, and the positive roles that communication technology may play, both in supporting as well as potentially augmenting empathy.

### References

- [1] A.O. Horvath, A.C. Del Re, C. Flückiger, and D. Symonds, Alliance in Individual Psychotherapy, *Psychotherapy*, **48** (2011), 9–16.
- [2] D.J. Martin, J.P. Garske, and M. Katherine Davis, Relation of the therapeutic alliance with outcome and other variables: A meta-analytic review, *Journal of Consulting and Clinical Psychology*, **68** (2000), 438–450.
- [3] B.J. Sadock, and V.A. Sadock, *Synopsis of Psychiatry*, Wolter Kluwer Health, Philadelphia, 2007.
- [4] J.B. Nienhuis, J. Owen, J.C. Valentine, S. Winkeljohn Black, T.C. Halford, S.E. Parazak, S. Budge, and M. Hilsenroth, Therapeutic alliance, empathy, and genuineness in individual adult psychotherapy: A meta-analytic review, *Psychotherapy Research*, **28** (2018), 593–605.
- [5] R. Elliott, A. Bohart, J. Watson, and L. Greenberg, Empathy, in: J. Norcross (Ed.), *Psychother. Relationships That Work*, 2nd ed., Oxford University Press, New York, NY, 2011: pp. 132–152.
- [6] J. Decety, and P.L. Jackson, The Functional Architecture of Human Empathy, *Behavioral and Cognitive Neuroscience Review*, **3** (2004), 71–100.
- [7] J.H. Janssen, A three-component framework for empathic technologies to augment human interaction, *Journal on Multimodal User Interfaces*, **6** (2012), 143–161.
- [8] B.M.P. Cuff, S.J. Brown, L. Taylor, and D.J. Howat, Empathy: A review of the concept, *Emotion Review*, **8** (2014), 144–153.

- [9] R.J.R. Blair, Responding to the emotions of others: Dissociating forms of empathy through the study of typical and psychiatric populations, *Consciousness Cognition*, **14** (2005), 698–718.
- [10] C. Marci, and H. Riess, The Clinical Relevance of Psychophysiology: Support for the Psychobiology of Empathy and Psychodynamic Process, *American Journal of Psychotherapy*, **59** (2005), 213–226.
- [11] D.J. Dolin, and M. Booth-Butterfield, Reach out and touch someone: Analysis of nonverbal comforting responses, *Management Communication Quarterly*, **41** (1993), 383–393.
- [12] G.T. Barrett-Lennard, The empathy cycle: Refinement of a nuclear concept., *Journal of Counselling Psychology*, **28** (1981), 91–100.
- [13] M. Dekeyser, R. Elliott, and M. Leijssen, Empathic Responding: Sympathy and Personal Distress, in: J. Decety, and W. Ickes (Eds.), *Soc. Neurosci. Empathy*, The MIT Press, Cambridge, UK, 2009: pp. 113–124.
- [14] M.A. Feijt, Y.A.W. De Kort, I.M.B. Bongers, and W.A. IJsselsteijn, Perceived drivers and barriers to the adoption of eMental health by psychologists: The construction of the levels of adoption of eMental health model, *Journal of Medical Internet Research*, **20** (2018),.
- [15] G. Andersson, Internet-Delivered Psychological Treatments, *Annual Review of Clinical Psychology*, **12** (2016), 157–179.
- [16] A.B. Rochlen, J.S. Zack, and C. Speyer, Online Therapy: Review of Relevant Definitions, Debates, and Current Empirical Support, *Journal of Clinical Psychology*, **60** (2004), 269–283.
- [17] J. Suler, The Online Disinhibition Effect, *CyberPsychology Behavior and SocialNetworking* **7** (2004), 321–326.
- [18] D. Glueck, *Establishing Therapeutic Rapport in Telemental Health*, First Edit, Elsevier Inc., 2013.
- [19] T.W. Ertelt, R.D. Crosby, J.M. Marino, J.E. Mitchell, K. Lancaster, and S.J. Crow, Therapeutic factors affecting the cognitive behavioral treatment of bulimia nervosa via telemedicine versus face-to-face delivery, *International Journal of Eating Disorders*, **44** (2011), 687–691.
- [20] M. Wells, K.J. Mitchell, D. Finkelhor, and K.A. Becker-Blease, Online Mental Health Treatment: Concerns and Considerations, *CyberPsychology Behavior and SocialNetworking*, **10** (2007), 453–459.
- [21] M. Fenichel, J. Suler, A. Barak, E. Zelvin, G. Jones, K. Munro, V. Meunier, and W. Walker-Schmucker, Myths and Realities of Online Clinical Work, *CyberPsychology Behavior and SocialNetworking*, **5** (2002), 481–497.
- [22] V. Germain, A. Marchand, S. Bouchard, S. Guay, and M.-S. Drouin, Assessment of the Therapeutic Alliance in Face-to-Face or Videoconference Treatment for Posttraumatic Stress Disorder, *CyberPsychology Behavior and SocialNetworking*, **13** (2010), 29–35.
- [23] J. Hollan, and S. Stornetta, Beyond being there, in: Proc. SIGCHI Conf. Hum. Factors Comput. Syst. - CHI '92, ACM Press, New York, New York, USA, 1992: pp. 119–125.
- [24] D.F. Barone, P.S. Hutchings, H.J. Kimmel, H.L. Traub, J.T. Cooper, and C.M. Marshall, Increasing Empathic Accuracy Through Practice and Feedback in a Clinical Interviewing Course, *Journal of Social and Clinical Psychology*, **24** (2005), 156–171.
- [25] C. Marangoni, S. Garcia, W. Ickes, and G. Teng, Empathic Accuracy in a Clinically Relevant Setting, *Journal of Personality and Social Psychology*, **68** (1995), 854–869.
- [26] J.H. Janssen, P. Tacken, J.J.G. de Vries, E.L. van den Broek, J.H.D.M. Westerink, P. Haselager, and W.A. IJsselsteijn, Machines Outperform Laypersons in Recognizing Emotions Elicited by Autobiographical Recollection, *Human-Computer Interaction*, **28** (2013), 479–517.
- [27] Z. Zeng, M. Pantic, G.I. Roisman, and T.S. Huang, A survey of affect recognition methods, in: Proc. Ninth Int. Conf. Multimodal Interfaces - ICMI '07, ACM Press, New York, New York, USA, 2007: p. 126.
- [28] J. Healey, Physiological Sensing of Emotion, *Oxford Handb. Affect. Comput.*, (2014), 204–216.
- [29] R.E. Kaliouby, R.W. Picard, and S. Baron-Cohen, Affective Computing and Autism, *Ann. N. Y. Acad. Sci.*, **1093** (2006), 228–248.
- [30] C.S.S. Tan, K. Luyten, J. Van Den Bergh, J. Schöning, and K. Coninx, The Role of Physiological Cues during Remote Collaboration, *Presence Teleoperators Virtual Environ.*, **23** (2014), 90–107.
- [31] J.H. Janssen, J.N. Bailenson, W.A. IJsselsteijn, and J.H.D.M. Westerink, Intimate heartbeats: Opportunities for affective communication technology, *IEEE Trans. Affect. Comput.*, **1** (2010), 72–80.
- [32] M. Balaam, G. Fitzpatrick, J. Good, and E. Harris, Enhancing interactional synchrony with an ambient display, in: Proc. 2011 Annu. Conf. Hum. Factors Comput. Syst. - CHI '11, ACM Press, New York, New York, USA, 2011: p. 867.
- [33] A.L. Hartzler, R.A. Patel, M. Czerwinski, W. Pratt, A. Roseway, N. Chandrasekaran, and A. Back, Real-time Feedback on Nonverbal Clinical Communication, *Methods of Information in Medicine*, **53** (2014), 389–405.

- [34] T. Field, Touch for socioemotional and physical well-being: A review, *Developmental Review*, **30** (2010), 367–383.
- [35] H. Gehlbach, G. Marietta, A.M. King, C. Karutz, J.N. Bailenson, and C. Dede, Many ways to walk a mile in another's moccasins: Type of social perspective taking and its effect on negotiation outcomes, *Computers in Human Behavior*, **52** (2015), 523–532.
- [36] J.N. Bailenson, A.C. Beall, J. Loomis, J. Blascovich, and M. Turk, Transformed Social Interaction: Decoupling Representation from Behavior and Form in Collaborative Virtual Environments, *Presence Teleoperators Virtual Environments*, **13** (2004), 428–441.
- [37] A. Haans, and W.A. IJsselsteijn, Embodiment and telepresence: Toward a comprehensive theoretical framework, *Interacting with Computers*, **24** (2012), 211–218.
- [38] S.J. (Grace) Ahn, A.M.T. Le, and J. Bailenson, The Effect of Embodied Experiences on Self-Other Merging, Attitude, and Helping Behavior, *Media Psychology*, **16** (2013), 7–38.
- [39] S. Kalyanaraman, D.L. Penn, J.D. Ivory, and A. Judge, The virtual doppelganger: Effects of a virtual reality simulator on perceptions of schizophrenia, *Journal of Nervous and Mental Disease*, **198** (2010), 437–443.
- [40] E.M. Wijma, M.A. Veerbeek, M. Prins, A.M. Pot, and B.M. Willemsse, A virtual reality intervention to improve the understanding and empathy for people with dementia in informal caregivers: results of a pilot study, *Aging Mental Health*, **22** (2018), 1115–1123.
- [41] G. Riva, R.M. Baños, C. Botella, F. Mantovani, and A. Gaggioli, Transforming Experience: The Potential of Augmented Reality and Virtual Reality for Enhancing Personal and Clinical Change, *Frontiers in Psychiatry*, **7** (2016),.
- [42] J.B. Walther, Computer-Mediated Communication, *Communication Research*, **23** (1996), 3–43.
- [43] J.B.F. van Erp, and A. Toet, Social Touch in Human-Computer Interaction, *Frontiers in Digital Humanities*, **2** (2015),.
- [44] A. Haans, and W. IJsselsteijn, Mediated social touch: A review of current research and future directions, *Virtual Reality*, **9** (2006), 149–159.



## SECTION III

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### 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*





# Online and Offline Life: the Functional Use of the Internet During the Life Cycle

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**Abstract.** This research aims to clarify when, how and under which conditions the Internet usage is functional for people during the life cycle in 574 adolescents, 671 younger emerging adults, 163 older emerging adults, 722 adults. Starting from Leontev studies, it is possible to consider the Internet as a functional organ. The goal is to verify which factors (Gender, Hours per day spent Online, Online Social-Support, Number of Online Contacts (NOCs), Life Satisfaction, Job Satisfaction) lead people to a Functional Internet Use (FIU). Significant results were found in all factors considered, including gender differences.

**Keywords.** Functional internet use, life cycle, functional organ.

## 1. Introduction

The Internet is an important part of our daily lives and it represents a basic tool for finding information, social interactions, and the consequent construction of knowledge [5-18]. The previous Web and the current Web 2.0 and its ubiquity due to new devices (e.g. smartphone and tablet) have changed people's behavior; never before have we had such easy and rapid access to information and communication. However, there is a downside. Web 2.0 requires a lot of our attention during use and It often distracts us from tasks we are involved in during our daily activities such as studying, working or cultivating offline relationships. The integration between being online and offline is an important part of the psychology of human beings [24]. In some cases, it is possible to find a balance between these two aspects of human life. The Web can be functional for work, studying and for carrying out daily activities. Considering these aspects, the theoretical perspective of this research assumes that the Internet could be a functional tool depending on how it is used and the reasons behind such use [15-16]. In this regard, Leontev [10-12] proposed the construct of functional organ to describe how a tool (e.g. the Internet) allows people to achieve better and more powerful performances which would not be attainable individually without that tool (e.g. sharing photos or documents with several people in different parts of the world at the same time). Therefore, the goal of this research is to explain which processes and conditions make it possible for a massive and pervasive use of the Web to become a source of

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empowerment (functional organ) throughout a person's lifecycle, specifically in the phases of adolescence, emerging adulthood (early and late) and adulthood.

## **2. When the Internet is a Functional Tool**

An important point in studying Functional Internet Use (FIU), is the analysis of the processes which lead us to consider the Internet (and its applications) as a culturally mediated artifact/tool. To understand this role, it is fundamental to consider the processes deriving from Cultural Historical Activity Theory (CHAT). The core of CHAT is characterized by three fundamental aspects: the social origin of mind, the centrality of culture and the artifact mediation [13,14]. In this regard, Leontev [12,13] emphasized the dual nature of the fundamental aspects of human activity. The subject and object of an activity are in a mutual relationship. The object is modified by the action of the subject and by the tool that it is used. However, at the same time, the tool itself modifies the way of acting and the way of thinking of the person who uses it. Leontev defines these tools that act as mediators in human activities as functional artifacts (and according to Kaptelinin [9] Information and Communication Technologies should be renamed as functional organ), which are artifacts representing the physical and/or mental extensions of the body and human abilities [18]. For instance, scissors allow a human to do something (cut) that he/she would not be able to do with his/her physical abilities, while his/her eyeglasses allow he/she to restore an inadequate human ability (sight) to an optimal state. In this regard, it is possible to think of the Internet (and the applications that characterize it) as a functional organ [9] capable of exalting human ability so intuitively as to become a natural component that supports humans in their daily activities.

## **4. Factors Related to Functional Internet Use**

Factors related to FIU are: Online Social-Support, Number of Online Contacts, Life Satisfaction and Job Satisfaction. Online social-support is considered the whole set of information which comes to a person through social interactions [3] in an online environment. Recent research has shown how the use of Social Networking Sites (SNSs) could lead to a greater level of well-being in people [22], and consequently lead them to FIU [20,21]. People preferred online social-support (e.g. chatting, vocal messaging) to offline social-support (face-to-face interactions), because online social-support is characterized by anonymity and more expressive and uninterrupted communication. Regarding this point, during the transition from school to university or from school/university to work, it is central to consider a person's number of online contacts (NOCs) [2]. New connections are very important for receiving and sharing relevant information (e.g. how to rent a room). From this point of view, the Internet, and consequently NOCs, could be mediation tools in constructing a bridge between schools and university or schools and working environments [1,2,5,17,23].

Finally, the concept of life satisfaction is strictly related to Internet use in maintaining and creating social connections (both in free time and at work) and in increasing and integrating job satisfaction [19]. According to the workplace Internet leisure browsing model (WILB) [4], using the Internet in the workplace increases employees' productivity, improves their performance and balances their working and

living. In this regard, since job satisfaction is one of the most important predictors of life satisfaction and self-esteem, in a functional use of the Internet perspective, it is reasonable to think that high levels of job satisfaction predict high levels of FIU.

a. Research Hypothesis

Hypotheses directly concerning FIU will be described in order to analyze when and under which conditions is the Internet functional for people. Three hypotheses were tested.

H1. The hours per day spent online (X) affect FIU (Y), through the moderation of gender (M) and Age (W) (see fig. 1).

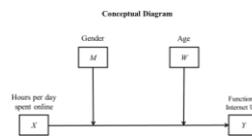


Figure 1: Graphical representation of H1 concerning the conceptual diagram of multiple moderation hypothesis [7]

Considering the previously described literature concerning FIU [2,15], it is expected that: decreasing connection hours increases FIU, both for males and females in all age groups.

H2. Online-social-support (X) affect FIU (Y) through the mediation of NOCs (Mi) (see fig. 2).

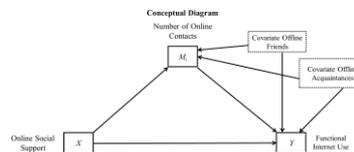
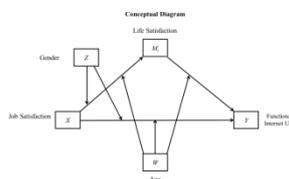


Figure 2: Graphical representation of H2 concerning the conceptual diagram of mediation hypothesis [7]

It is expected that high levels of online-social-support (predictor) could lead to high levels of FIU (outcome) only when there is a high number of NOCs (mediator). Specifically, following on from previous literature [1,2,15,17,23], younger and older emerging adults are the groups with more transitions than the others (adolescent and adults), and it is therefore plausible to assume that they have high scores of online social-support, high NOCs and consequently high levels of FIU. Literature shows an imbalance towards the problematic side of Internet use, compared to the functional one [6,25]. Thus, following the research’s goal it is reasonable to assume that high levels of job satisfaction affect FIU. This direct relationship is affected by life satisfaction (mediator). Different studies have shown how high levels of job satisfaction could have an influence on life satisfaction [8,11]. Therefore, it is reasonable to assume that those who are satisfied with their job tend to be satisfied with their lives, and this can lead to greater FIU. Finally, the last hypothesis is the following:

H3. Job satisfaction (X) affects FIU (Y) through the mediation of life satisfaction (Mi) and the moderation of age (W) and gender (Z) (see fig. 3).



**Figure 3:** Graphical representation of H6 concerning the conceptual diagram of mediated moderated hypothesis [7]

### b. Method

The research involved 2,130 participants, divided in: 574 adolescents, 671 younger emerging adults, 163 older emerging adults, 722 adults. A cross-sectional study based on the compilation of an online self-report questionnaire was proposed. The questionnaire's distribution took place at three different times. Campaigns were broadcast on SNSs (Facebook, YouTube, Google +), based on the penetration of SNSs monthly use in Italy and targeted to gender and age considering the selected sample age groups. The questionnaire's measures include validated scales for the factors involved in FIU. The scale that measure FIU was made on purpose for this research and is not validated yet.

### c. Results

All the hypotheses were tested with PROCESS MACRO using Hayes models [7]. The results show that for the H1, total model is significant ( $b=8.5$ ;  $t=.27$ ;  $p < .001$ ), but the total amount of hours per day spent online is not a significant direct predictor of FIU. The age is the total significant mediator in this relationship ( $b=.09$ ;  $t=.10$ ;  $p < .001$ ), including conditional relationships (age \* hours per day spent online:  $b=.01$ ;  $t=2.7$ ;  $p > .001$ ). Moreover, gender as a single mediator is significant ( $b=1.6$ ;  $t=3.5$ ;  $p < .001$ ), though not when it is associated with age.

The H2 results for the adolescents show how online social support positively affects NOCs ( $b=377$ ;  $t= 3.03$ ;  $p < .001$ ). Furthermore, in this relationship the covariate which influences NOCs is offline acquaintances ( $b=236$ ;  $t=2.4$ ;  $p > .001$ ). Moreover, online social-support positively predicts FIU with the covariation of offline friends ( $b=.69$ ;  $t=3.5$ ;  $p < .001$ ). The mediation effect of NOCs in this case is not significant. Unlike the case of adolescents, the direct relationship online social-support/NOCs is not significant for the younger emerging adults, although the covariate of offline acquaintances is significant for NOCs ( $b=172$ ;  $t=2.7$ ;  $p > .001$ ). Furthermore, online social-support positively directly predicts FIU ( $b=.53$ ;  $t=2.4$ ;  $p > .001$ ): high levels of online social-support correspond to high levels of FIU, with the covariation of offline acquaintances ( $b=.48$ ;  $t=2.8$ ;  $p > .001$ ). For older emerging adults there are no significant relationships in this model. Finally, for the adults the results show that there is not a significant direct relationship between online social-support and NOCs. On the other hand, offline friends seem to play an important role in NOCs ( $b=154$ ;  $t=2.8$ ;  $p > .001$ ). Moreover, offline social-support does not predict FIU. The only significant relationship is that concerning the covariate of the offline acquaintances which is a significant positive indicator of FIU ( $b=.48$ ;  $t= 2.7$ ;  $p > .001$ ). As previously observed, NOCs are not a significant mediator in this age group.

The results of H3 model show that job satisfaction is a direct positive predictor of life satisfaction ( $b=.26$ ;  $t=4.7$ ;  $p <.001$ ), but that it is a direct negatively predictor of FIU ( $b=-.92$ ;  $t=-2.9$ ;  $p <.001$ ). When associated with age, job satisfaction positively predicts FIU ( $b=.02$ ;  $t= 3.5$ ;  $p <.001$ ). Moreover, life satisfaction positively predicts FIU ( $b=.90$ ;  $t= 2.9$ ,  $p <.001$ ). Furthermore, life satisfaction negatively affects FIU when associated with age ( $b=.02$ ;  $t= 3.5$ ;  $p <.001$ ). Finally, gender is a significant moderator in this model and it predicts FIU, but only when associated with age ( $b=.44$ ;  $t=2.8$ ;  $p >.001$ ).

## 5. Discussion and Conclusion

Considering the H1 model of FIU, the more age increases, the hours per day spent online decrease and, consequently, the more FIU increases. Adults have the highest scores in FIU followed by older emerging adults, adolescents and, lastly, younger emerging adults. Moreover, gender affects the relationship between the number of hours per day spent online and FIU. Males of all ages have the highest levels of Internet use (considering the number of hours per day) and higher FIU scores than females (of all ages).

The H2 model shows that: for adolescents' high levels of online social-support increase NOCs which are mainly made up of offline acquaintances. Moreover, according to the results, when adolescents present high levels of online social-support, they tend to have FIU. In summary, adolescents' NOCs are mainly composed of offline acquaintances, though they do reach FIU if their online social-support is made up of the network of friends they have in their offline lives like the younger emerging adults. These findings show that offline acquaintances play an important role. For instance, for the emerging adults, if one of a person's offline acquaintances (who are also part of their online networks) has already gone to university he or she may be able to provide information to that person about how to find an apartment, or simply which website could help them find a roommate. Regarding adults, they use the Internet in a functional way when they are in contact with their offline acquaintances. In this regard, it could be relevant to focus our attention on the fact that adults use e-mail more than other age groups. Online contacts that adults use the most are those which coincide with their online acquaintances, those acquaintances are very likely to be their colleagues who are part of their online social support.

The final hypothesis, H3, shows that high levels of job satisfaction correspond to high levels of life satisfaction, and the lower a person's job satisfaction, the higher his/her FIU. Thus, adults have the highest levels of job satisfaction. A relevant finding is that people with low levels of job satisfaction (in this sample younger and older emerging adults) show high levels of FIU. However, this could be connected to the transitional phases they are facing which push them to search around for new work positions, also by using the Internet. In this regard, younger and older emerging adults use the Internet as a functional organ as they search for possible job positions online, thus leading them towards FIU. Finally, concerning gender differences, for males, FIU increases as age increases: adult males present higher levels of FIU compared to females of all age groups.

In summary, two aspects are particularly relevant. The first concerns online social-support and self-esteem, which are the factors to which it is necessary to pay more attention, especially for adolescents, who are going through the most important phase

of physical and psychological change, in order to avoid a possible misuse of the Internet or any risky behavior that may compromise their reputation (e.g. spreading nude photos). The second concerns younger emerging adults. The most relevant result is the use of online contacts in a functional way during transitions and in order to look for work.

## References

- [1] J.J Arnett, *Emerging Adulthood: The Winding Road from the Late Teens Through the Twenties*, Oxford University Press, New York, 2015.
- [2] M. Benvenuti, E. Mazzoni, G. Piobbico, Being Online in Emerging Adulthood: Between Problematic or Functional. In: *Identity, Sexuality, and Relationships among Emerging Adults in the Digital Age*, 226, IGI Global, Hershey, 2016.
- [3] S. Cobb, Social support as a moderator of life stress, *Psychosomatic medicine*, **38**(1976), 300-314.
- [4] B.L. Coker, Freedom to surf: the positive effects of workplace Internet leisure browsing, *New Technology, Work and Employment*, **26**(2011), 238-247.
- [5] G., Frozzi, E. Mazzoni, On the importance of social network sites in the transitions which characterize "emerging adulthood, *ICST Transactions on E-Education and E-Learning*, **11**(2011),1-11.
- [6] D.F. Galletta, P. Polak, An empirical investigation of antecedents of Internet abuse in the workplace, *SIGHCI 2003 Proceedings*, 14, 2003.
- [7] A.F. Hayes, *Introduction to mediation, moderation, and conditional process analysis: A regression-based approach*, Guilford Publications, 2017.
- [8] T.A., Judge, S. Watanabe, Another look at the job satisfaction-life satisfaction relationship, *Journal of applied psychology* **7**(1993), 939.
- [9] V. Kaptelinin, Activity theory: Implications for human-computer interaction. *Context and consciousness: Activity theory and human-computer interaction* **1** (1996), 103-116.
- [10] V. Kaptelinin, B.A. Nardi, *Acting with technology: Activity theory and interaction design*, Mit Press, Cambridge, Massachusetts, Stati Uniti, 2006.
- [11] E. Kossek, C. Ozeki, Work-family conflict, policies, and the job-life satisfaction relationship: A review and directions for organizational behavior-human resources research, *Journal of applied psychology*, **83** (1998), 139.
- [12] A.N. Leont'ev, The problem of activity in psychology, *Journal of Russian and East European Psychology*, **13**(1974), 4-33.
- [13] A.N. Leont'ev, *Problems of the development of mind*, Progress, Moscow, 1981.
- [14] A.R. Luria, M. Cole, S. Cole, The making of mind: A personal account of Soviet psychology, *Studies in Soviet Thought*, **23** (1982), 248-252.
- [15] E. Mazzoni, L. Baiocco, D. Cannata, I. Dimas, Is Internet the cherry on top or a crutch? Offline social support as moderator of the outcomes of online social support on Problematic Internet Use, *Computers in Human Behavior*, **56** (2016), 369-374.
- [16] E. Mazzoni, D. Cannata, L. Baiocco, Focused, not lost: the mediating role of Temporal Dissociation and Focused Immersion on Problematic Internet Use, *Behaviour & Information Technology*, **36** (2017), 11-20.
- [17] E. Mazzoni, M. Iannone, From high school to university: Impact of social networking sites on social capital in the transitions of emerging adults, *British Journal of Educational Technology*, **45**(2014), 303-315.
- [18] E. Mazzoni, L. Zanazzi, Comparing the Use of SNSs Among Adults and Emerging Adults. *Journal of e-Learning and Knowledge Society*, **10** (2014), 25-36.
- [19] V. Mishra, I. Nielsen, R. Smyth, A. Newman, The Job Satisfaction-Life Satisfaction Relationship Revisited: Using the Lewbel Estimation Technique to Estimate Causal Effects Using Cross-Sectional Data, Monash University, Department of Economics, 26-14, 2014.
- [20] H.J. Oh, E. Ozkaya, R. LaRose, How does online social networking enhance life satisfaction? The relationships among online supportive interaction, affect, perceived social support, sense of community, and life satisfaction, *Computers in Human Behavior*, **30** (2014), 69-78.

- [21] T. Silverman, The Internet and relational theory, *American Psychologist*, **54** (1999), 780-781.
- [22] C. Steinfield, N.B. Ellison, C. Lampe, (2008). Social capital, self-esteem, and use of online social network sites: a longitudinal analysis, *Journal of Applied Developmental Psychology*, **29** (2008), 435-445.
- [23] T. Tuomi-Gröhn, Y. Engeström, Between school and work: New perspectives on transfer and boundary crossing, Pergamon, Amsterdam, 2003
- [24] S. Turkle, Alone together: Why we expect more from technology and less from each other, Basic books, New York, 2012.
- [25] J. Vitak, J. Crouse, R. LaRose, Personal Internet use at work: Understanding cyberslacking. *Computers in Human Behavior*, **27** (2011), 1751-1759.
- [26] L.S. Vygotsky, Mind and society: The development of higher psychological processes, Harvard University Press Cambridge, 1978.
- [27] J.B., Walther, S. Boyd, Attraction to computer-mediated social support. in C.A. Lin, D. Atkin, Communication technology and society: Audience adoption and uses, Hampton Press, Cresskill, 2002, 153-188.

# Acceptability study of a novel immersive cognitive care platform for remediation of cognitive deficits

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**Abstract.** We introduce bWell, a clinician-centric immersive research platform for the assessment and remediation of cognitive deficits using virtual (VR) and augmented reality (AR). Virtual cognitive rehabilitation has been gaining clinical acceptance, with fully immersive VR experiences hypothesized to generate high levels of user engagement and potentially better transfer to real life outcomes. However, discomfort due to cybersickness remains a concern for clinicians. In the current experiment, the acceptability of the bWell platform was evaluated using a cohort of twenty-six healthy adults. The goal was to measure user engagement and to evaluate the risk of cybersickness as a prerequisite to testing the system on cognitively-impaired clinical populations. Results show that immersive VR cybersickness symptoms were minor and engagement was high. As well, user engagement was significantly higher in the immersive vs non-immersive version of one of the exercises, with statistically significant differences in components of engrossment, enjoyment and personal gratification. This demonstrates that the bWell platform has high user acceptability, both in terms of engagement and comfort in a healthy population.

**Keywords.** Immersive, virtual reality, cognitive remediation, rehabilitation, cybersickness, engagement, acceptability

## 1. Introduction

Immersive virtual reality (VR) has been widely used for assessment of cognitive deficiencies [1-3]. In parallel, several research projects have studied cognitive remediation using PC-based virtual environments [4-6]. While full immersion (head mounted displays (HMDs) and cave automatic virtual environment (CAVE)) has been shown to add benefits to physical rehabilitation [7] and psychological therapy [8,9], few studies have used fully immersive VR for remediation in the cognitive domain. Three studies used HMDs for fully immersive remediation of cognitive deficiencies, respectively for attention training in teenagers [10], memory training in memory-impaired elderly adults [11] and improvement of activities of daily living in stroke patients [12]. A study using CAVE immersion [13] reported perceptual-

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cognitive improvement in healthy older adults. The findings from all studies support the hypothesis that the use of immersive virtual reality can be applied towards cognitive remediation. Nonetheless, the risk of cybersickness remains a significant concern for medical professionals [14], and especially since cognitively-impaired patients might be more vulnerable [15, 16].

The bWell project is an initiative of the National Research Council Canada (NRC), and is designed as a general non-commercial research platform for the assessment and remediation of cognitive deficits using immersive virtual and augmented reality (VR/AR). The goal of the current study was to measure user engagement in immersive versus non-immersive tasks as well as cybersickness in fully immersive environments on healthy adults prior to testing on target populations.

## **2. Background**

### *2.1. bWell*

Instead of focusing on a single pathology, bWell targets general aspects of cognition which are common to several disorders: working memory, divided and sustained attention, impulse control, sensory processing, emotional regulation and executive functions. It comprises seven exercises targeting one or several of these cognitive functions and designed from the ground up to be immersive and gamified.

The platform uses industry-standard game development techniques. It is built in Unity® (Unity Technologies) - a widely used game engine with native VR support. It is unique in that it is hardware-agnostic, seamlessly supporting multiple AR/VR systems ranging from low-end mobile devices to high-end consumer devices (HTC Vive™, Oculus Rift, Microsoft HoloLens) in order to facilitate its adoption in a clinical or home setting.

### *2.2. Managing Cybersickness and Promoting Engagement*

According to the leading theory [17], cybersickness would be due to a mismatch between the vestibular and visual systems. In order to minimize this phenomenon in bWell, the exercises are designed to avoid scene movements which are not synchronized with real world displacements, such as using teleport locomotion technique [18]. Diegetic user interfaces and tactile feedback [14] are also used to reduce symptoms.

One important aspect of the study was to measure if engagement was superior in an immersive VR platform versus a non-immersive mobile version of the same exercise. Several research projects observed higher engagement in VR versus non-VR versions of cognitively-challenging exercises [10,19]. To facilitate engagement, a minimal form of avatar (user hands) was used to help with presence. Also, some properties of interaction and physics were used to improve the suspension of disbelief. For instance, textiles move realistically when touched, objects can be grabbed, handles vibrate and particles fall out of bottles when they are tipped.

### 3. Method

#### 3.1. The cognitive exercises

Three exercises in bWell (Figure 1) were selected. The LAB exercise requires users to complete two parallel “recipes” following a specific timed sequence, challenging divided attention and executive functions. The user is presented with color-coded bottles and tablets displaying the recipes. The MOLE exercise is a visual processing and impulse control task. The user hits targets with two virtual hammers, one in each hand. The color of the target must match the color of the hammer; the color of the hammers changes over time. A top-down non-immersive one-handed tablet version of the MOLE exercise was also created as a comparative. The TENT exercise is designed as a relaxation and sensory exploration scene. There is no specific goal; the user can explore the environment and change the scenery using a virtual book. A pulsing sphere is presented to guide the user towards a relaxing breathing pace. Also, the handles vibrate when the sphere is touched, enhancing the sense of presence and providing sensory stimulation.

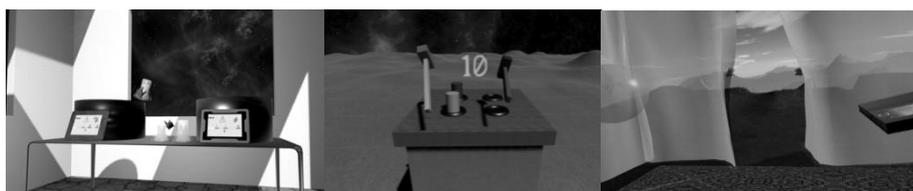


Figure 1. LAB, MOLE and TENT exercises.

#### 3.2. Method

The configuration tested was using an HTC Vive™ HMD installed on a Dell Aurora R5 computer. The headset was fitted with an aftermarket replacement face pad to facilitate cleaning. The dedicated physical play area was 3 m by 3 m. A cohort of 26 healthy adult volunteers from the NRC site in Boucherville participated in the study (f/m = 40%/60%; age: [20-60],  $\bar{x}$  = 43; VR experience: [0 (none) - 4 (good)],  $\bar{x}$  = 0.9). Exclusion criteria were epilepsy, cardiac problems, psychotic disorders and unresolved or recent (<2 years) concussions. Each participant was made aware of the risk of cybersickness and signed a consent approved by the NRC Review Ethics Board. Subjects were randomly divided in two groups. One group (n=11) was to compare a single VR exercise (MOLE) with its non-immersive version to evaluate engagement. For the non-immersive version, the same software is deployed to an Android tablet and users click the moles with their finger. Users were randomized to test either the immersive (n=4) or non-immersive (n=7) version first. The other group (n=15) was to try two different VR exercises for cybersickness assessment: the MOLE exercise and either the LAB (n=8) or TENT (n=7) exercise. All test sessions were limited to three minutes but subjects could interrupt the session at any time in case of discomfort or boredom. Two standard questionnaires were used for cybersickness and engagement assessment: the French-Canadian version of the Simulator Sickness Questionnaire (SSQ) [20] and the Game User Experience Satisfaction Scale (GUESS) [21]. The forms

were filled by the subjects immediately after each exercise. The entire test session lasted 20 minutes per subject.

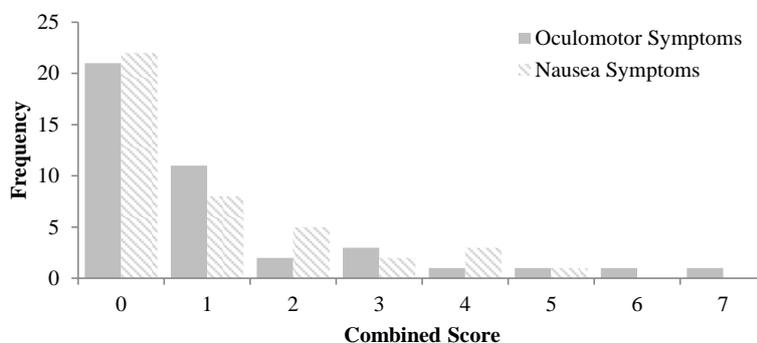
## 4. Results

### 4.1. Cybersickness

Raw results from the SSQ questionnaire, pooled from both groups and all immersive exercises, are summarized in Table 1. They depict the number of times a symptom within the list was reported and its level of intensity. For each participant, a combined score was calculated by adding the individual scores obtained per symptom (none=0; slight=1; moderate=2; severe=3). Furthermore, data from Table 1 was regrouped into indicators of nausea and oculomotor problems as proposed by Bouchard [20]. Figure 2 depicts the occurrence frequency of those symptoms as a function of their combined score. When summing the responses for each symptom and participant, mean values of 1.0 (out of 27) and 1.1 (out of 21) were obtained for nausea and oculomotor factors respectively. The maximum combined scores reported by a single user were 5 for nausea and 6 for oculomotor. However, the same user also reported very strong engagement and desire to play again, and cybersickness symptoms did not appear to hinder acceptability.

**Table 1.** Cybersickness reported symptoms for all VR sessions combined. Nausea symptoms are marked with \*; oculomotor symptoms with †. (total of 41 represents n = 11 in the first group + 2×n = 15 in the second group)

Symptoms (# of times reported)	General Discomfort*	Fatigue†	Headache†	Eye strain†	Difficulty focusing†	Salivation increasing*	Sweating*	Nausea*	Difficulty concentrating†	Fullness of the head†	Blurred vision†	Dizziness eyes open*	Dizziness eyes closed*	Vertigo*	Stomach awareness*	Burping*
None	37	41	37	31	34	40	31	40	39	32	32	34	31	38	40	41
Slight	4	0	4	9	6	1	7	1	1	9	8	7	10	3	1	0
Moderate	0	0	0	1	1	0	2	0	1	0	0	0	0	0	0	0
Severe	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0



**Figure 2.** Frequency of reported oculomotor and nausea symptoms.

It is important to note that the headset prevents wearing large prescription eyeglasses; five users self-reported that their vision issues were related to this constraint. In fact, all moderate and severe reports of these three symptoms were reported by the same user who was not wearing his glasses (nausea: 0, oculomotor: 7). Ten users also reported sweating due to the material type and closed nature of the headset itself. The after-market face mask might have played a role in the comfort of the headset and the compatibility with glasses. Although these issues are not directly related to cybersickness, they may play a non-negligible role in the system acceptability. Finally, none of the sessions had to be interrupted due to discomfort. However, we do need to keep in mind that the sessions were fairly short due to time constraints.

#### 4.2. Engagement

The GUESS questionnaire participant answers were regrouped and analyzed considering four sub-scales (usability, enjoyment, engrossment, personal gratification) out of the nine available as the others did not apply to the exercises. A combined score was calculated per participant for each of the subscale. Self-reported user engagement was significantly higher in the immersive versus non-immersive version of the MOLE exercise. Statistically significant differences (paired t-test, two-tailed distribution) were obtained for three components of engagement: engrossment ( $P = 0.0015$ ), enjoyment ( $P = 0.002$ ) and personal gratification ( $P = 0.01$ ). Usability was comparable for both versions of the game (Figure 3). Comparable satisfaction scores were also observed for the other two VR exercises.

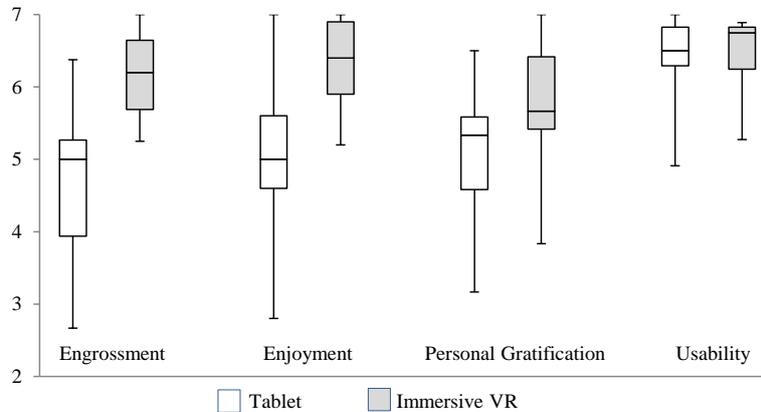


Figure 3. Comparison of user engagement for immersive vs. tablet versions of the MOLE exercise.

## 5. Conclusion

Results obtained on healthy adults demonstrate that the bWell cognitive care platform manages to efficiently mitigate cybersickness risks as no severe nausea symptoms were reported. The oculomotor symptoms reported indicate that, in the context of clinical use, careful consideration should be given to individuals wearing glasses, individuals with visual impairments as well as potentially the duration of exposure. Furthermore, results show strong user engagement for all the immersive VR exercises and higher engagement for immersive VR than for the tablet exercise. The study presented here demonstrates that the bWell platform has high user acceptability on healthy subjects, in terms of engagement and comfort, and encourages future trials on cognitively-impaired clinical populations.

## References

- [1] A.A. Rizzo, J.G. Buckwalter, T. Bowerly, C. Van Der Zaag, L. Humphrey, U. Neumann, C. Chua, C. Kyriakakis, A. Van Rooyen, and D. Sisemore, The virtual classroom: a virtual reality environment for the assessment and rehabilitation of attention deficits, *CyberPsychology & Behavior* **3** (2000), 483-499.
- [2] F.D. Rose, B.M. Brooks, and A.A. Rizzo, Virtual reality in brain damage rehabilitation, *CyberPsychology & Behavior* **8** (2005), 241-262.
- [3] H. Shin and K. Kim, Virtual reality for cognitive rehabilitation after brain injury: a systematic review, *Journal of physical therapy science* **27** (2015), 2999-3002.
- [4] J.A. Anguera, J. Boccanfuso, J.L. Rintoul, O. Al-Hashimi, F. Faraji, J. Janowich, E. Kong, Y. Larraburo, C. Rolle, and E. Johnston, Video game training enhances cognitive control in older adults, *Nature* **501** (2013), 97.
- [5] B.R. Kim, M.H. Chun, L.S. Kim, and J.Y. Park, Effect of virtual reality on cognition in stroke patients, *Annals of rehabilitation medicine* **35** (2011), 450-459.
- [6] M. Jacoby, S. Averbuch, Y. Sacher, N. Katz, P.L. Weiss, and R. Kizony, Effectiveness of executive functions training within a virtual supermarket for adults with traumatic brain injury: a pilot study, *IEEE transactions on neural systems and rehabilitation engineering* **21** (2013), 182-190.
- [7] M.C. Howard, A meta-analysis and systematic literature review of virtual reality rehabilitation programs, *Computers in Human Behavior* **70** (2017), 317-327.
- [8] M. Slater and S. Wilbur, A framework for immersive virtual environments (FIVE): Speculations on

- the role of presence in virtual environments, *Presence: Teleoperators & Virtual Environments* **6** (1997), 603-616.
- [9] S. Bouchard, S. Côté, J. St-Jacques, G. Robillard, and P. Renaud, Effectiveness of virtual reality exposure in the treatment of arachnophobia using 3D games, *Technology and health care* **14** (2006), 19-27.
- [10] B.-H. Cho, J. Ku, D.P. Jang, S. Kim, Y.H. Lee, I.Y. Kim, J.H. Lee, and S.I. Kim, The effect of virtual reality cognitive training for attention enhancement, *CyberPsychology & Behavior* **5** (2002), 129-137.
- [11] G. Optale, C. Urgesi, V. Busato, S. Marin, L. Piron, K. Priftis, L. Gamberini, S. Capodieci, and A. Bordin, Controlling memory impairment in elderly adults using virtual reality memory training: a randomized controlled pilot study, *Neurorehabilitation and neural repair* **24** (2010), 348-357.
- [12] P. Gamito, J. Oliveira, C. Coelho, D. Morais, P. Lopes, J. Pacheco, R. Brito, F. Soares, N. Santos, and A.F. Barata, Cognitive training on stroke patients via virtual reality-based serious games, *Disability and rehabilitation* **39** (2017), 385-388.
- [13] I. Legault, R. Allard, and J. Faubert, Healthy older observers show equivalent perceptual-cognitive training benefits to young adults for multiple object tracking, *Frontiers in psychology* **4** (2013), 323.
- [14] L. Rebenitsch and C. Owen, Evaluating Factors Affecting Virtual Reality Display, in: International Conference on Virtual, Augmented and Mixed Reality, Springer, 2017, pp. 544-555.
- [15] P. Nolin, A. Stipanovic, M. Henry, C.C. Joyal, and P. Allain, Virtual reality as a screening tool for sports concussion in adolescents, *Brain injury* **26** (2012), 1564-1573.
- [16] J.O. Brooks, R.R. Goodenough, M.C. Crisler, N.D. Klein, R.L. Alley, B.L. Koon, W.C. Logan Jr, J.H. Ogle, R.A. Tyrrell, and R.F. Wills, Simulator sickness during driving simulation studies, *Accident Analysis & Prevention* **42** (2010), 788-796.
- [17] J.T. Reason and J.J. Brand, Motion sickness, Academic press, 1975.
- [18] E. Bozgeyikli, A. Raij, S. Katkooi, and R. Dubey, Point & teleport locomotion technique for virtual reality, in: Proceedings of the 2016 Annual Symposium on Computer-Human Interaction in Play, ACM, 2016, pp. 205-216.
- [19] G. Loup, A. Serna, S. Iksal, and S. George, Immersion and persistence: Improving learners' engagement in authentic learning situations, in: European Conference on Technology Enhanced Learning, Springer, 2016, pp. 410-415.
- [20] S. Bouchard, G. Robillard, P. Renaud, and F. Bernier, Exploring new dimensions in the assessment of virtual reality induced side effects, *Journal of computer and information technology* **1** (2011), 20-32.
- [21] M.H. Phan, J.R. Keebler, and B.S. Chaparro, The development and validation of the game user experience satisfaction scale (GUESS), *Human Factors* **58** (2016), 1217-1247.

# Immersive Virtual Reality to Improve Police Interaction Skills in Adolescents and Adults with Autism Spectrum Disorder: Preliminary Results of a Phase I Feasibility and Safety Trial

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**Abstract.** Individuals with social and cognitive challenges, including autism spectrum disorder (ASD), are at elevated risk of poor outcomes when interacting with police. This paper describes safety and feasibility testing for an immersive virtual reality (VR) application designed to teach essential skills for interacting with law enforcement (Floreo Police Safety Module; PSM). First, we present evidence that using immersive VR in verbally able adolescents and adults with ASD is feasible. Of 28 participants, 100% were able to complete one session of Floreo PSM. Second, we show that Floreo PSM is safe; no severe adverse events occurred during or after study participation. Third, we report that Floreo PSM is highly usable. An industry-standard measure of usability – the System Usability Scale (SUS) – was carefully modified to meet the particular needs of our clinical sample, resulting in an improved SUS-ASD. The SUS-ASD demonstrates good internal reliability and broad range, with scores that are statistically independent of age, IQ, and autism symptomology. In Phase II of this government-funded research project, we will test the efficacy of Floreo PSM to improve targeted behaviors during a live police interaction, and will conduct a community-based randomized controlled trial that lays the groundwork for deploying Floreo PSM to schools, homes, clinics, prisons, and halfway houses. The long-term goals of this project are to improve safety outcomes for vulnerable civilians while reducing stress on law enforcement personnel.

**Keywords.** Autism spectrum disorder, ASD, immersive virtual reality, police, law enforcement, intervention, feasibility, safety, system usability

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## 1. Introduction

Autism spectrum disorder (ASD) is characterized by social communication deficits and repetitive behaviors/restricted interests that significantly impair everyday functioning [1]. Despite many overarching commonalities in ASD, heterogeneity is the rule. While ASD is clearly recognizable in some individuals, particularly those who are minimally verbal (approximately 30% of children with ASD never acquire fluent speech [2]) or produce visible motor stereotypies such as hand flapping, others have less recognizable symptoms, and may initially appear unaffected to the naïve observer. This apparent “normalcy” could be problematic when individuals with ASD are required to interact with strangers during low-likelihood, high-impact and/or high-risk events like crimes, fires, or natural disasters.

Most autism research focuses on children, but ASD is a lifelong condition that persists into adulthood. As children with ASD mature into their late teens and 20s, and begin to engage with the public sphere, it is increasingly likely that they will interact with public servants, including police officers. Given adequate preparation, many individuals with ASD are capable of handling a wide variety of situations (e.g., maintain a job, go to the store, take public transportation, etc). Much of this preparation is accomplished through supported practice, wherein role-playing and repetition help solidify adaptive behavior patterns [3]. However, supported role-playing and repetition are more difficult for certain scenarios that have a very low likelihood of occurring, but carry high risk when they go poorly. Novel approaches are necessary for teaching appropriate skill sets for these types of interactions. In this paper, we focus on police encounters.

Civilian fatalities at the hands of police are more common in the United States than any other developed country [4]. Furthermore, these fatalities disproportionately affect people with disabilities [5]. In recent years, police departments have aimed to heighten their own autism awareness and safety protocols via training videos, in-person seminars, and informational pamphlets. However, given that 1 in 5 young adults with ASD will be stopped and questioned by police before age 21 [6], it is critical to prepare individuals with ASD themselves for police interactions. Existing text-based curricula and educational videos available for individuals with ASD rarely involve active participation, reducing potential generalizability to actual encounters with police. Training that involves direct practice (role-playing) in a simulated real-world environment has significant potential to improve police interaction skills more effectively than traditional approaches.

The Floreo Police Safety Module (PSM) uses next-generation mobile immersive virtual reality (VR) to help adolescents and adults with ASD acquire critical safety skills when interacting with law enforcement (e.g., keeping hands in sight, looking at officers when they speak). The Floreo system is unique; its paired design includes an iPhone in an inexpensive VR headset, and an iPad that is wirelessly linked to the iPhone in real time. Thus, while participants wear the headset and participate in an immersive virtual environment, the monitor (e.g., teacher, parent, therapist) is able to see what the participant sees, and can provide live feedback. Furthermore, monitors are able to control certain aspects of the virtual environment from the Floreo iPad platform, further personalizing the Floreo PSM experience.

Here, we report results from Cycle A of a Phase I safety, feasibility, and usability trial designed to determine whether Floreo PSM is appropriate for use with verbally

able adolescents and adults with ASD. This project lays the groundwork for future efficacy testing to assess whether Floreo PSM improves real-world police interaction skills (Phase IIa). Finally, a community-based randomized controlled clinical trial will test the community-based efficacy of Floreo PSM for improving police interaction skills, as compared with video-based instruction (Phase IIb).

## 2. Methods

This on-going safety and feasibility trial is being conducted at the Center for Autism Research (CAR) at the Children’s Hospital of Philadelphia (CHOP). All aspects of the research protocol were approved by the CHOP Institutional Review Board. Adult participants provided written informed consent to participate in the present study, while the parents of adolescent participants and some legal guardians of adult participants provided written informed consent on the participants’ behalf. All participants, regardless of age, were informed that they could cease participation at any time, for any reason, without consequence, and that participation was entirely voluntary.

*Participants.* Twenty-eight individuals with ASD have participated in Cycle A to date. Demographic information, family/medical history, and clinical characterization questionnaires were completed online in advance, with IQ estimates derived at the study visit (Wechsler Abbreviated Scales of Intelligence (WASI-II); [7]; Table 1). Participants were included if they were 12 years of age or older, had a documented diagnosis of ASD, and had full-scale IQ estimates in the average range (>75; 2 missing). Participants were excluded if they had a known genetic syndrome, blindness or deafness, strabismus or eye muscle problems, had previously undergone eye surgery, had been hospitalized for a concussion or other brain-related problem, had medical conditions like Fetal Alcohol Syndrome, brain injury, stroke, or brain tumor that could affect cognitive, sensory, or motor functioning, or reported a personal or family history of seizures, migraines, or vertigo. A technology experience questionnaire revealed that 29% of participants had never used VR before, 54% had used VR ‘rarely’ or ‘occasionally’, and 23% of participants had used VR ‘frequently’ or ‘very frequently’.

**Table 1.** Participant characteristics. AQ = Autism quotient, self-report (1 missing) [8]; SCQ = Social Communication Questionnaire, parent/guardian report (2 missing) [9]; higher scores = greater impairment; SD = Standard deviation.

	<b>Age (years)</b>	<b>Full-scale IQ</b>	<b>AQ score</b>	<b>SCQ score</b>
Mean (SD)	16.36 (5.99)	100 (11.31)	25.37 (8.82)	18.27 (6.84)
Min-Max	12-37	76-120	12-40	7-30

*Materials.* Equipment for this study included an iPhone, iPad, lightweight head mounted display (HMD), and the Floreo PSM software application. Floreo PSM is a mobile immersive virtual environment that includes interactive police officers (1 or 2, male/female, diverse appearances) and background distractors (e.g., cars driving by, dogs barking in the background). The PSM includes multiple scenarios, including an officer walking by without interacting, officers approaching the participant and asking about current or recent activity, and officers asking for personal information (i.e., “What’s your name?”). There are also daytime and nighttime scenes. Officer speech is pre-recorded, but can be controlled to some extent by the monitor. For example, if the

participant does not reply to a question, the monitor can press a button that prompts the officer to say, “Did you hear me?”



**Figure 1.** Example screen shot of the Floreo PSM virtual environment and police officers.

*Procedure.* Participants engaged in one session of Floreo PSM in a quiet room at the Center for Autism Research, with trained study staff. This session included approximately 8 total minutes of VR, with breaks approximately every 2 minutes. After the session, participants completed a questionnaire about system usability and reported any side effects in a qualitative interview. *Statistical approach.* Three primary outcome variables were assessed: Feasibility, safety, and system usability. Feasibility was gauged by measuring the percentage of participants who successfully completed an entire session of Floreo PSM. Safety was assessed via a self-report questionnaire item about side effects, a post-VR qualitative interview, and through clinical observation of behaviors that might indicate side effects (e.g., eye rubbing). Safety included recording whether Serious Adverse Events (adverse events requiring a visit to a hospital Emergency Department) or mild Adverse Effects (e.g., persistent headache, nausea, dizziness) occurred during or immediately after Floreo PSM. System usability was measured using the industry-standard System Usability Scale [10], modified for participants with ASD. In this study, we set satisfactory usability criteria as group mean SUS scores  $> 70$ , and measured internal reliability via Cronbach’s alpha. Spearman’s Rho assessed relationships between system usability scores and age, IQ, and autism symptoms.

### 3. Results

*Feasibility.* All 28 participants who began Floreo PSM completed the entire session (100%), suggesting that immersive VR utilizing a lightweight HMD is highly feasible in verbal adolescents and adults with ASD. Evidence of feasibility was found for individuals with milder autism symptoms as well as for participants with greater symptomology and worked equally well for participants with lower IQ estimates and higher IQ estimates within our participant IQ range.

*Safety.* No serious adverse events occurred, defined as events requiring hospitalization. Two brief headaches were reported, which resolved upon follow-up the next day. Twenty-seven out of 28 participants (96%) responded “no” when asked whether negative side effects (like serious nausea or disorientation, or fear and anxiety) were bad enough that they wouldn’t use the app again.

*System Usability.* The System Usability Scale (SUS) is a widely used measure of usability that is designed to be modified to fit the parameters of individual systems [10]. It consists of 10 questions that alternate wording in opposite directions, to control for positive response biases and to reduce the likelihood of automatic responding without reading (e.g., circling all 5s without reading each question). The SUS is coded on a 1-5 Likert scale. In the course of running the first 12 participants through Floreo PSM, it became clear that a significant percentage of participants were not picking up on reverse-worded questions, and were responding in ways that contradicted their earlier answers. For example, two items asked exactly the same question with reversed wording: (3) “The app was easy to use”; and (8) “The app was too hard to use”. Of 12 participants, 4 (33%) gave these two questions contradictory or inconclusive ratings. Importantly, we found that this pattern covaried with participant clinical phenotype. SCQ scores were nearly twice as high in participants that rated these two questions inconsistently or inconclusively (Mean=23.00) vs. participants who rated them consistently (Mean=12.66), suggesting that autism symptom severity was related to difficulty switching back and forth from positively to negatively worded questions. Given significant prior research showing attention switching challenges in children, adolescents, and adults with ASD [11] our study team assembled a panel of expert autism researchers and clinicians to determine whether the original format of the SUS was appropriate for this clinical population, and to advise on possible changes. The result of this effort was the SUS-ASD, which has been administered to 16 participants.

The SUS-ASD is collected on paper and presents statements about “this VR” rather than “the app”. Standardized instructions are read to participants beforehand to ensure that they understand the purpose of the SUS and understand the way the questions are rated (1 = lowest, 5 = highest). A visual aid was added at the top of the page; a sad face emoticon was placed on the left side of the scale (indicating disagreement with each statement) and a happy face emoticon on the right side (indicating agreement with each statement). Due to the elimination of negatively worded questions, the SUS-ASD has a simplified scoring system (item scores are reduced by 1 to render the scale 0-4, summed, and multiplied by 2.5 for interpretability; final range is 0-100). Potential concerns with the new format include the “audience effect,” wherein typically developing participants change their behavior to please or impress observers, resulting in artificially high ratings. However, research suggests that individuals with ASD are less susceptible to performance changes in the presence of an audience [12], thus reducing this concern in our sample. Second, it is possible that participants will generate homogeneous positive responses (e.g., straight 4s or 5s)

because they do not read each question individually. To check this possibility, we examined intra-question range. We found that participants were still willing to give low ratings on the SUS-ASD (40% of questions received at least one score of 1 or 2, 80% of questions received at least one 3, and only 20% of questions received only 4s and 5s). Finally, there is the possibility that changing the wording of questions in the SUS-ASD could reduce internal reliability relative to the original SUS. However, we found that Cronbach's alpha is in the "good" range for the SUS-ASD (Mean = .81; 95% CI: .68-.95).

Results from 16 participants tested thus far reveal that average participant score on the recoded SUS-ASD is 85.00 (N=16), with a standard deviation of 12.42 and a median score of 88.75. Scores range from 52.5 to 100, demonstrating good range. Seventy-five percent of participants rated average usability at 80% or higher, which corresponds to a rating of 4 on a 1-5 scale. Chronological age, full-scale IQ, AQ scores, and SCQ scores did not significantly correlate with SUS-ASD scores (all  $ps > .05$ ). These preliminary results indicate that Floreo PSM has good system usability, and that usability ratings are independent of clinical phenotype in our sample of verbal adolescents and adults with ASD.

#### 4. Discussion and Conclusion

The preliminary results of this on-going Phase I trial suggest that Floreo PSM is safe and feasible for use with verbal adolescents and adults with ASD, laying the initial groundwork for deploying Floreo PSM to homes, outpatient clinics, schools, prisons, and halfway houses. The newly developed SUS-ASD demonstrates good internal reliability, and participant ratings thus far strongly suggest that Floreo PSM is a usable system. Of note, the new SUS-ASD was developed and administered with advice from a panel of expert clinical psychologists and researchers and will be valuable for other groups interested in collecting technology usability ratings from verbally able adolescents and adults with ASD. Future iterations of this innovative mobile VR technology will include adaptations for individuals with neurodevelopmental and psychiatric conditions other than ASD. Floreo, Inc.'s unique approach holds promise as an inexpensive, flexible, scalable platform for future social and community skills interventions targeting a variety of social and behavioral needs across multiple populations, and serves the critical long-term goal of improving safety outcomes for vulnerable civilians while reducing stress on law enforcement personnel.

#### References

- [1] American Psychiatric Association, Diagnostic and Statistical Manual of Mental Disorders, 5th Edition: DSM-5, 5 edition. Washington, D.C: American Psychiatric Publishing, 2013.
- [2] H. Tager-Flusberg and C. Kasari, Minimally Verbal School-Aged Children with Autism Spectrum Disorder: The Neglected End of the Spectrum: Minimally verbal children with ASD, *Autism Research*, **6** (2013), 468–478.
- [3] L. P. Lattimore, M. B. Parsons, and D. H. Reid, Enhancing job-site training of supported workers with autism: a reemphasis on simulation, *Journal of Applied Behavior Analysis*, **39** (2013), 91–102
- [4] J. Swaine et al., "The Counted: people killed by police in the United States – interactive," the Guardian. [Online]. Available: <http://www.theguardian.com/us-news/ng-interactive/2015/jun/01/the-counted-police-killings-us-database>. [Accessed: 28-Nov-2016].
- [5] D. M. Perry and L. Carter-Long, The Ruderman White Paper on media coverage of law

enforcement use of force and disability. The Ruderman Family Foundation (2016).

[6] J. Rava, P. Shattuck, J. Rast, and A. Roux, The Prevalence and Correlates of Involvement in the Criminal Justice System Among Youth on the Autism Spectrum, *Journal of Autism and Developmental Disorders*, **47**(2017):340-346

[7] D. Wechsler, Wechsler Abbreviated Scale of Intelligence® - Second Edition (WASI®-II). Pearson Clinical, San Antonio, TX, 2011.

[8] S. Baron-Cohen, S. Wheelwright, R. Skinner, J. Martin, and E. Clubley, The Autism-Spectrum Quotient (AQ): Evidence from Asperger syndrome/high-functioning autism, males and females, scientists and mathematicians. *Journal of Autism and Developmental Disorders*, **31**(2001), 5–17

[9] M. Rutter, A. Bailey, and C. Lord, SCQ: The Social Communication Questionnaire. Los Angeles, CA: Western Psychological Services., 2003.

[10] J. Brooke, SUS - A 'quick and dirty' usability scale., in Usability Evaluation In Industry, CRC Press, 1996, 189–194.

[11] E. L. Hill, Executive dysfunction in autism, *Trends in Cognitive Sciences*, **8**(2004) 26–32.

[12] C. Chevallier et al., Measuring social attention and motivation in autism spectrum disorder using eye-tracking: Stimulus type matters: Stimulus matters, *Autism Research.*, **8** (2015), 5-17

# Can Twitter act as a tool of psychological resistance? The use of #StopEnslavingSaudiWomen among Saudi Arabian women

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**Abstract.** This study analyses the psychological dynamics of interactive, politically engaged Twitter usage amongst Saudi Arabian women, focusing on the feminist hashtag #StopEnslavingSaudiWomen. The social media analytic tool Keyhole was used to track tweets in both Arabic and English for the hashtag #StopEnslavingSaudiWomen, over a period of one month, from 29 March 2017 to 28 April 2017. Following the application of exclusion criteria, the total number of tweets was 7,219. Tweets were then coded and analyzed using the thematic analysis (TA) approach. Final theme categories were *shared common experience of subordination/shared identity, illegitimacy, cognitive alternatives, leadership, third-party support, and oppositional disruption*. Results suggested that Twitter offers a means of social psychological resistance, but that this resistance is performed in ways partially determined by the affordances of the medium in question, and by the wider context of Saudi Arabian society.

**Keywords.** Online resistance, shared identity, social media

## 1. Introduction

This study analyses the psychological dynamics of interactive, politically-engaged Twitter usage amongst Saudi Arabian women, focusing on the feminist hashtag #StopEnslavingSaudiWomen. It is proposed that while the West has arguably spun a narrative of decline around social media usage [1], online social networks can potentially offer individuals in highly restrictive contexts, such as Saudi Arabia, the ability to speak relatively freely. Such networks can thus be perceived as offering an ‘everyday utopia’ [2], a place of temporary norm suspension. In line with this, much recent research explores social media as both a powerful online source of self-affirmation and identity politicization [3] and a potentially revolutionary instrument, influential in recent political upheavals in Moldova, Iran and Egypt [4]. Might such potential be hindered by Saudi Arabia’s ultra-conservatism, if tweeting against the dominant conservative hegemony can lead to harsh repercussions from the government,

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the religious establishment, or other members of society [4]? This is the question that prompted this paper, thus designed to explore how such politically-engaged Twitter

usage will reflect characteristics of the larger organizational structure of Saudi Arabia, creating a distinct protest 'ecology' [5] and subsequently, a unique protest psychology. For example, such a high risk context means online protest is often conducted anonymously, and even so, users can potentially still be traced via their IP addresses [6]. Within such restricted online spaces, can opportunities for psychological resistance – opportunities for the disadvantaged to “assert their own view of themselves and the world despite dominant pressures to accept societal messages to the contrary” [7] – still occur? Will the traditionally-accepted functions of social media alter within such environments, where the potential for self affirmation, identity politicization and collective offline political action is severely restricted?

This is the main concern of this research; several insights that prompted this line of inquiry can be found in recent social psychology literature. For example, Leach and Livingstone's [7] rich argument for psychological resistance as a valid alternative to direct, confrontational action, Foster's [8] exploration of the beneficial effects of tweeting about sexism for US females; the confirmation offered by Bergman et al. [9] of the reduced efficiency of direct confrontation in specifically gender-driven contexts: each validates the exploration of mediums of psychological resistance as opposed to an overly narrow focus upon direct collective action. In addition, Ayanian & Tausch [10] point out that collective action in high-risk contexts is an under-explored area within social psychology, while Segerberg & Bennett [5] criticize existing social media research as being overly focused on communication, ignoring the other functions platforms such as Twitter might provide in contexts where communication is restricted.

### *1.1 The social identity model of resistance dynamics*

The understanding of collective resistance advanced in this paper is informed by Haslam and Reicher's [11] social identity model of resistance dynamics, which in turn is based in the social identity approach, established by Tajfel and Turner's [12] social identity theory and Turner's [13] self-categorization theory. The social identity model is based on the assumption that the groups to which people belong contribute to their members' identity, and act as a source of self-esteem. Group identity does not emerge in a vacuum, but is defined by contrast with the outgroup [14, 15]. Self-categorization theory expands upon these premises by seeking to identify the conditions in which people will identify themselves as belonging to a group, and the consequences of this process of self-categorization.

Although much of the evidence on which Haslam and Reicher base their model is taken from prison studies, both real and artificial, their findings still have relevance for other contexts. The situation under consideration here is that of women in Saudi Arabia. Despite recent changes to Saudi Arabian law that allow women to drive, vote and serve in the military, there still exists significant inequality between the sexes. For example, women still require the permission of a male guardian to travel abroad, while the testimony of a male witness in a court of law is held equivalent to that of two female witnesses. In the Global Gender Gap Report [16], from a total of 144 countries, Saudi Arabia ranked 142<sup>nd</sup> for economic participation and opportunity, 130<sup>th</sup> for health and survival, 124<sup>th</sup> for political empowerment, and 138<sup>th</sup> overall.

It was within this context that the online protest movement #StopEnslavingSaudiWomen was established. The hashtag first achieved popularity in 2016 against a backdrop of increasing disaffection among Saudi women with the many perceived injustices they faced; in particular, the guardianship law [17].

## 2. Method

The social media analytic tool Keyhole was used to track tweets in both Arabic and English for the hashtag #StopEnslavingSaudiWomen, over a period of one month, between 29 March 2017 and 28 April 2017 inclusive. A total of 25,942 tweets were collated, comprising 24,758 tweets in English and 1,184 in Arabic. Prior to the process of coding, the data were scrutinized for exclusion criteria. Excluded tweets were retweets, tweets that featured only the hashtag and no other text, links to other sources, and pictures/videos. These were identified and excluded using the qualitative data analysis software NVivo. Following this, the total number of tweets was 7,219.

Tweets were then coded and analyzed using the thematic analysis (TA) approach. Some advantages of this approach are laid out by Braun and Clarke [18], who emphasize the flexibility of TA – whereas many qualitative methods stem from a particular epistemological position, thematic analysis is compatible with both realist and constructionist approaches to knowledge. The coded data set was then given to a second coder to analyze, to indicate whether the coding schema was plausible.

### 2.1. Limitations and future directions

Limitations of this study include the absence of demographic information on Twitter profiles, thus making it impossible to know exactly who is composing the tweets. Moreover, Twitter users are not representative of the offline population, or even of Internet users in general. The data that Twitter produces may also not be representative of Twitter users, as a relatively small number of active users account for a substantial proportion of tweets [19]. These considerations should be held in mind when drawing conclusions based on the data discussed in the current paper.

## 3. Results

The first theme, *Shared common experience of subordination*, can be understood as ‘a sense of common fate and a strong sense of “us” versus “them”’ [11, p.168]. Saudi women, as a group, vary according to age, wealth, social status, education and ethnic background. For the purposes of those wishing to reduce gender inequality, however, it is important to emphasize the commonalities between Saudi women – and the salient factor which unites all Saudi women is their perceived status as second-class citizens. The ‘Saudi woman’, therefore, is constructed in tweets that make reference to an absence rather than a presence – i.e. the activities withheld from them (‘Women in Saudi can’t drive, travel, work, or leave the house without the permission of a man’). In some instances, in-group differences are dismissed as inconsequential in comparison to the pressing need to change the status quo (‘Saudi women of all classes, conservative or open-minded/educated or ignorant, want to overthrow the guardianship’).

As Haslam and Reicher [11, p.169] point out, shared experience of subordination is a necessary condition for resistance to occur, but it is not sufficient.

An additional condition that needs to be present for the establishment of opposition is a shared belief that the existing situation lacks legitimacy. The theme of *Illegitimacy*, therefore, refers to tweets that express the belief that inequality between men and women, as expressed in law, customs and behavior, is unfair and should be redressed. Perhaps unsurprisingly, given the prominence of religion in Saudi Arabian culture, it frequently takes center stage in the online debate over the perceived illegitimacy of women's subordinate status ('In the Quran it is said that males should protect their females. But not by 'guarding' them by stripping their rights!'). Thus, the illegitimacy of the status quo is highlighted by drawing a contrast with the teachings of Islam as delineated in the Quran. Others appeal to humanist concepts of equality and human rights ('We need our rights as humans') or use personal testimony ('I'm a surgeon yet I get sexually harassed with no valid law to protect me!').

A further condition that is necessary for resistance to develop is a belief in the possibility that the current situation can be changed, and that group members possess the capability to effect that change – this is referred to as *cognitive alternatives* [12]. Perhaps because the status of women in Saudi Arabia has changed so little over recent decades, or possibly because the hashtag was in its infancy while data for this study were being collected, the data gathering process unearthed relatively few tweets expressing the possibility of cognitive alternatives. One tweeter points to the expected benefits for Saudi society as a whole, not just women ('The resulting happiness of granting women their rights will be positively reflected on society and completes the cycle of happiness among its members'). Others retain a focus on the present, and make reference to changes they have witnessed ('Today the Koran memorization professor asked for the student's consent from her guardian, to which the student replied "I can be independent without guardianship"... Campaign succeeded').

According to Turner [20], the most valuable resource which an oppressed group possesses is not material in nature, but resides rather in the ability of the group to organize its actions. *Leadership* is seen by scholars of group resistance as vital for the organizational process. Among the tweets analyzed in the current study, leadership was demonstrated in two spheres: firstly, in shaping the message itself ('Saudi women are not objects nor slaves. We can make our own decisions. We can have control over ourselves and lives.') and secondly, in establishing how best to spread this message ('Tweet using the English hashtag, not the Arabic, so that everyone can read it'). The latter tweet leads us to the next theme, which recognizes that a feature of many successful resistance movements is that they look beyond the immediate context in order to glean support (material, ideological, or both) from outsiders.

Haslam and Reicher [11] remark that the struggle between oppressor and oppressed is, in nearly all cases, situated within a wider social context. A key strategy for members of a resistance movement is to enlist *Third-party support* from those outside of the groups immediately involved in the struggle. As mentioned above, tweets in English are more likely to reach a wider audience, and are therefore be more effective in spreading the message of Saudi women's liberation. Moreover, tweets which actively sought to enlist third-party support tended to be less confrontational in tone than tweets coded in other categories. Some publicized instances of men supporting their aims ('This man is supporting women's and human rights in general and criticizing some institutions [link to other Twitter account]') existed. Others sought to draw a distinction between 'good' or 'righteous' men, and 'bad' men – i.e. those who wish to suppress the rights of women. This tweeter invoked the support of the

monarch in order to add legitimacy to her position ('Please please god bless you King Salman, help protect us from those men who control our lives').

The final category in the current analysis focuses not on tweets that support the Saudi women's rights movement, but on those that oppose it (*Oppositional disruption*). The current paper goes further than Haslam and Reicher in its analysis of resistance dynamics by considering the opposition's response to protest. In this study, *Oppositional disruption* tended to take the form of delegitimization: denying the lower status of women in Saudi Arabia ('Don't be fooled by Western voices, women in Saudi are treated like queens'), or comparing the situation favorably with that of other countries ('While Saudi women protest, the British girl is working to pay off university loans'). The implication is that Saudi women should be grateful for their apparent advantages and should therefore refrain from protesting about what they do not have.

#### 4. Discussion

The use of the Twitter hashtag #StopEnslavingSaudiWomen can be seen as the application of soft power [21], i.e. the means to attract support for cause through means other than coercion. The use of soft power is necessary because of the hard power possessed by the Saudi Arabian establishment, and because those protesting are mainly female, while those resisting the protest are mainly male. As open conflict between the sexes is undesirable and unlikely to attract many supporters, a softer touch is necessary; one that seeks to persuade others to join the protest, even if they are not members of the oppressed group themselves. Hence the sentiment repeated throughout the tweets analyzed in the current study, that the dispute is not between women and men, but between women and the establishment. It may also be a reflection of the inherent difficulty of challenging the status quo within a collectivistic society. Expressions of individuality were vastly outweighed by conciliatory or inclusive messages, such as one would expect within a traditionalist context.

There is some evidence that the mechanisms described in this paper do not always need to be present, or that they can be expressed in different ways. For example, the concept of cognitive alternatives states that, for change to occur, group members must believe in their own ability to bring about this change. However, in the case of Jewish resistance during the Holocaust, resistance often took place only to the extent that Jewish populations believed that they would inevitably be killed [11]. Furthermore, the traditional notion of leadership has been challenged in the era of the Internet, where the strength of a protest movement is frequently distributed across a population, as opposed to concentrated within a prominent but vulnerable leadership cadre (e.g. Black Lives Matter, which consciously avoids anointing leaders). These considerations notwithstanding, Haslam and Reicher provide a useful framework for understanding online resistance and its commonalities with resistance in the offline world.

#### 5. Conclusion

The current study has shown that Twitter offers a means of social psychological resistance and demonstrated the relevance of Haslam and Reicher's social identity model of resistance dynamics to online protests. A caveat may be added, in that users of social media, on the whole, interact with people in the same country who share their own opinions [22]. Despite the efforts of tweeters to enlist third-party support, they may in many cases be 'preaching to the choir'. Nevertheless, this study

has provided an insight into how social media and its tools (in this case, the hashtag) are used to effect societal change. Saudi Arabia has already witnessed progress in recent times, with women being granted the right to drive and securing limited voting rights. Crown Prince Mohammad bin Salman, who assumed office in June 2017, has expressed a wish to modernize the country, including the reduction of disparity between the sexes. If women's rights are to maintain a central role in this modernization, it is likely that social media will continue to play a role in publicizing the struggle.

## References

- [1] D. Gambs, Occupying social media, *Democracy* **26** (2012), 55-60.
- [2] D. Cooper, *Everyday utopias: The conceptual life of promising spaces*, Duke University Press, Durham, NC, 2013.
- [3] M. Kende, A. van Zomeren Ujhelyi, & N.A. Lantos, The social affirmation use of social media as a motivator of collective action, *Journal of Applied Social Psychology* **46** (2016), 453-469.
- [4] N. Agarwal, M. Lim & R.T. Wigand, Online collective action and the role of social media in mobilizing opinions: A case study on women's right-to-drive campaigns in Saudi Arabia. In C. G. Reddick and S. K. Aikins (Eds.), *Web 2.0 technologies and democratic governance, public administration and information technology 1* (pp. 99-123) Springer, New York, 2012.
- [5] A. Segerberg & L.W. Bennett, Social media and the organization of collective action: Using Twitter to explore the ecologies of two climate change protests, *The Communication Review* **14** (2011), 197-215. doi: 10.1080/10714421.2011.597250
- [6] W.A. Hachten & J.F. Scotton, *The world news prism: Challenges of digital communication*. John Wiley & Sons, Chichester.
- [7] C.W. Leach & A.G. Livingstone, Contesting the meaning of intergroup disadvantage: Towards a psychology of resistance, *Journal of Social Issues* **71** (2015), 614-632. doi: 10.1111/josi.12131
- [8] M.D. Foster, Tweeting about sexism: The well-being benefits of a social media collective action, *British Journal of Social Psychology* **54** (2015), 629-647. doi: 10.1111/bjso.12101
- [9] M. Bergman, R. D. Lanhou, P. A. Palmieri, L. M. Cortina & L. F. Fitzgerald, The (un)reasonableness of reporting: Antecedents and consequences of reporting sexual harassment, *Journal of Applied Psychology* **87** (2002), 230-242. doi:10.1037/0021-9010.87.2.230
- [10] A.H. Ayanian & N. Tausch, How risk perception shapes collective action intentions in repressive contexts: A study of Egyptian activists during the 2013 post-coup uprising, *British Journal of Social Psychology* **55** (2016), 700-721. doi: 10.1111/bjso.12164
- [11] S.A. Haslam & S.D. Reicher, When prisoners take over the prison: A social psychology of resistance, *Personality and Social Psychology Review* **16** (2012), 154-179.
- [12] H. Tajfel & J.C. Turner, An integrative theory of intergroup conflict, in W.G. Austin & S. Worchel, *Psychology of intergroup relations* (pp. 33-47). Brooks/Cole, Monterey, CA, 1979.
- [13] J.C. Turner & R.J. Oakes, Self-categorization theory and social influence. In R.B. Paulus (Ed.), *Psychology of group influence* (2nd ed.,) (pp. 233-275). Erlbaum, Hillsdale, NJ, 1989.
- [14] P. C. Zimbardo, On the ethics of intervention in human psychological research with specific reference to the 'Stanford Prison Experiment'. In J. Murphy, M. John and H. Brown (Eds.) *Dialogues and debates in social psychology*. Erlbaum, London, 1984.
- [15] S.D. Reicher, Social influence in the crowd: Attitudinal and behavioural effects of deindividuation in conditions of high and low group salience, *British Journal of Social Psychology* **23** (1984), 341-50.
- [16] World Economic Forum, *Global Gender Gap Report*, [http://reports.weforum.org/global-gender-gap-report-2016/?doing\\_wp\\_cron=1522405705.1550259590148925781250](http://reports.weforum.org/global-gender-gap-report-2016/?doing_wp_cron=1522405705.1550259590148925781250).
- [17] C.C. Davis, The male guardianship system: #StopEnslavingSaudiWomen. <https://www.ccdigitaldiaries.com/single-post/2016/11/29/The-Male-Guardianship-System-StopEnslavingSaudiWomen>.
- [18] V. Braun & V. Clarke, Using thematic analysis in psychology, *Qualitative Research in Psychology* **3** (2006) 77-101.
- [19] C. Miller, S. Ginnis, R. Stobart, & M. Clemence. The Road to Representivity: Demos and Ipsos Mori report on sociological research. Demos September 2015, [https://www.demos.co.uk/files/Road\\_to\\_representivity\\_final.pdf?1441811336](https://www.demos.co.uk/files/Road_to_representivity_final.pdf?1441811336).
- [20] J.C. Turner, Explaining the nature of power: A three-process theory, *European Journal of Social*

*Psychology* **35** (2005), 1-22.

- [21] J. Nye, Soft power, *Foreign Policy* 80 (1990), 153-71. Donaldson, The soft power of Twitter (2016), <https://www.britishcouncil.org/organisation/policy-insight-research/insight/soft-power-twitter>.

## SECTION IV

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### 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 Continuum of Self-transcendence: Flow Experience and the Emotion of Awe

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**Abstract.** When the boundaries between the Self and the others dissolve, people are prone to enter a self-transcendent experience (STE). A recent model (Yaden, Haidt, Vago, & Newberg, 2017) posited that STEs can be placed on a continuum ranging from a low to a higher intensity. Both the optimal psychological state of flow and the complex emotion of awe have been considered as STEs and placed on this continuum. Despite this promising theoretical underpinning their relationship has not been empirically tested yet. Here, we involved 38 participants (20 females) to investigate the relationship between flow and awe as self-transcendent experiences, in response to three virtual environments (VREs) previously validated to elicit awe (i.e., Forest of tall trees, Mountains and the vision of the Earth from outside its atmosphere). We assumed that since flow is a lower intensity STE than awe, it would be elicited at some extent also when people experienced awe, and that the two experiences would be correlated within each VRE. We assessed flow levels (Flow State Scale) and sense of presence (ITC-SOPI) after the navigation of each environment in a within-subjects design. Our results showed that all environments induced high levels of flow and presence. After Bonferroni correction, we found that only Mountains elicited higher significant levels of Global flow compared to Earth view. Earth view was the lowest-flow conducive scenario. Paired sample T-Test Bayes Factor (BF) showed that Mountain and Forest induced statistically similar levels of Global flow. Then, awe and flow were significantly correlated, in line with the STE reference model. Overall, dimensions related to self-transcendence showed significantly high correlations in awe and flow. This study provided the first empirical evidence of the relationship between two phenomena, which are so fleeting but so relevant for individuals' wellbeing, health, and mutual connectedness.

**Keywords:** self-transcendence; flow experience; awe; virtual reality; emotion-induction; emotions.

## 1. Introduction

Awe is an emotion arising from both perceptually and conceptually vast stimuli, which requires the need to change our current mental frames [1]. Awe has several beneficial effects on individuals' lives [for a review, see 2]. For instance, awe can promote a sense of mutual connections among people, and between individuals and the surrounding world [3, 4]. This, in turn, would induce a sense of diminished self-entitlement, well-known as the “small-self” [5] at the base of prosocial attitudes towards others [3, 4]. This sense of “connectedness” as well as the “small-self” are two key features of self-transcendent states [6]. Indeed, recently, awe was explicitly included among self-transcendent states. Specifically, a recent model on Self-

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transcendent experiences (STE) posited that STEs can be placed on a continuum ranging from a low to a higher intensity. At one point of this continuum dwells awe, a rare, intense and transformative emotion characterized by a sense of self-diminishment in front of something perceived as much larger than life. Immediately before, it has been placed the experience of flow, i.e., the psychological state of full involvement in a perceived engaging task. Flow is usually defined as the psychological state of full involvement in a perceived engaging task. This state is composed of nine dimensions: Challenge-skills balance; Action-awareness merging; Clear Goals; Unambiguous Feedback; Concentration on the task at hand; Sense of control; Loss of self-consciousness; Transformation of time; Autotelic experience [7-9]. Flow is usually defined as the psychological state of full involvement in a perceived engaging task. Specifically, it would include an autotelic dimension, an altered perception of time, a sense of total absorption into the task, and a loss of self-consciousness resulting in a self-transcendent experience [6]. Despite this promising theoretical underpinning of the relationship between these two STEs, their link has not been tested yet. In this study we aimed to explore the relationship between flow and awe as self-transcendent states. However, inducing higher intensity instances of awe in the lab, which are closer to the equivalent real ones, has always been referenced as a key challenge for researchers [10]. Recently, Virtual Reality (VR) has emerged as a new experiential methodology able to elicit an intense version of awe, even in lab settings [11-14], through the manipulation of the sense of presence (i.e., the feeling of being ‘there’; [15-20]). Therefore, we exposed participants to three validated VR awe-inspiring environments [14], assessing their levels of flow, awe and sense of presence after each induction. We assumed that since flow is a lower intensity STE than awe, it should be elicited at some extent also when people live awe, and that the two experiences should be correlated within each VRE, especially concerning their ST components. Specifically, we hypothesize that:

(i) Awe and Flow are significantly correlated. However, since the aim of this study is explorative, we cannot predict exactly which dimensions would be the highest correlated.

(ii) Flow elicited by each VRE is specular to awe elicited by each VRE. Specifically, Mountain and Tall Trees would elicit significantly higher levels of flow compared to Earth view environments.

Due to limited space, we focused our analyses of flow and awe at the Global level for comparison across conditions, while we carried out correlations between each single dimension.

## 2. Methodology

### 2.1. *Sample and procedure*

The study sample comprised 38 adults (20 females – mean age = 23.01; S.D. = .307; 18 males -mean age = 23.67; S.D. = .404) volunteers living in the Piedmont and Lombardy regions of Italy. We chose a within-design in which each participant navigated each VRE once using a head-mounted device. The order of video presentation was counterbalanced for each subject. Participants stood up in an isolated room wearing Oculus Rift DK2. Each video session was followed by a rest phase, in which participants were invited to fill out a questionnaire concerning several different emotions they could have experienced during video exposure and their flow level.

### 2.2. *Measures and instruments*

**Self-reports.** Participants were required to report the extent to which they lived Flow [21], awe [14], and their sense of presence [22].

**VREs.** We used three ad hoc awe-inducing environments that were previously created using Unity software (version 5.5.1.) and validated according to guidelines provided by literature [14]: (i) Forest; (ii) Mountains; (iii) Earth view [14].

## 3. **Data Analysis**

An inspection of skewness and kurtosis to test of normality showed that all measures drew near a normal distribution. Consequently, a repeated measures ANOVA was carried out to test for significant differences among conditions regarding each Sense of presence dimension, and Global flow, which was computed by summing all scores from other flow dimensions. We used the Bonferroni correction for multi-comparison in paired groups, to correct p-value (i.e., p-value should be less than  $0.016 = [N(N-1)/2]$  to indicate a statistically significant difference). Moreover, we carried out Paired Samples T-test with Bonferroni correction, in order to indicate which environment was the most flow-conductive one, and we computed Paired Samples T-Test Bayes Factor (BF) searching for significant similarities. Finally, internal Pearson Correlation were carried out between flow and awe for each condition.

## 4. **Results**

Since sphericity assumption was violated, we utilized the Greenhouse correction. There was a main significant effect of condition [ $F(3,1.561) = 7.321$ ;  $p < .01$ ;  $\eta^2 = 0.165$ ]. Paired samples T-tests with Bonferroni correction showed that Forest (mean = 131.626; S.D. = 20.291) elicited less Global flow than Mountain, though not significantly. Only Mountain (mean = 134.474; S.D. = 23.604) elicited a significantly higher level of flow [ $t(37) = 3.469$ ;  $p < .01$ ;  $\eta^2 = .245$ ] compared to Earth view (mean = 124.026; S.D. = 23.901), which resulted as the least flow-conductive environment.

We computed Paired Samples T-Test Bayes Factor (BF) to test for significant similarities between Forest and Mountain VRE in terms of flow, using JASP. BF is a ratio between the likelihood of the data given null-hypothesis and the one given the alternative one [23-25]. Results evidenced a moderate effect for the condition (BF01 = 1.951; IC: -.555, 0.079). In other words, Mountains elicited levels of flow significantly similar to the Forest condition. A one-way repeated measures ANOVA was carried out for each dimension of presence (i.e., physical presence, engagement, ecological validity and negative effect). Results showed a main effect of condition on physical presence dimension [ $F(1.781) = 45.183$ ;  $p < .001$ ;  $\eta^2 = .550$ ], with Mountain (mean = 3.427; S.D. = .136) eliciting significantly higher levels of physical presence, than Earth view (mean = 2.613; S.D. = .148). Regarding the sense of engagement, a significant main effect of condition emerged [ $F(1.856) = 11.001$ ;  $p < .001$ ;  $\eta^2 = .229$ ], again with Mountain (mean = 3.794; S.D. = .142) eliciting significantly higher levels of sense of physical presence than Earth view (mean = 3.279; S.D. = .164). A significant main effect of condition [ $F(1.927) = 17.502$ ;  $p < .001$ ;  $\eta^2 = .333$ ] revealed that Mountain was the most realistic VRE (mean = 3.994; S.D. = .152) compared to Earth view (mean = 3.172; S.D. = .197). Finally, although a significant main effect for condition emerged for negative effects dimension [ $F(1.977) = 5.092$ ;  $p < .01$ ;  $\eta^2 = .121$ ], the three VREs did not significantly differ regarding negative effects dimension of presence.

We carried out Pearson correlations that showed a recurrent pattern between awe and flow across different environments. Specifically, in the Forest VRE awe resulted positively and significantly correlated with one of the main dimension of flow, that is “Challenge and skills balance” ( $r = .374$ ;  $p = .021$ ), “Distortion of the sense of time” ( $r = .385$ ;  $p = .017$ ), one of the main features of STEs, the “Autotelic” dimension of flow ( $r = .642$ ;  $p < .0001$ ), sense of Control ( $r = .323$ ;  $p = .048$ ), and “Global Flow” (i.e., calculated as the sum of scores from other dimensions) ( $r = .409$ ;  $p = .011$ ). In the Mountains VRE, again, awe correlated with “Challenge and skills balance” ( $r = .508$ ;  $p = .001$ ), “Distortion of the sense of time” ( $r = .605$ ;  $p < .001$ ), “Autotelic” dimension of flow ( $r = .772$ ;  $p < .001$ ) “Global Flow” ( $r = .633$ ;  $p < .001$ ). More, in this condition, awe was positively and significantly correlated with “Loss of Self-consciousness” ( $r = .359$ ;  $p = .027$ ), a key dimension of STEs, “Concentration” on the task ( $r = .569$   $p < .001$ ), and “Clear goals” ( $r = .441$ ;  $p = .006$ ), and Unambiguous feedback ( $r = .328$ ;  $p = .025$ ). Finally, also in the Earth view condition there were significantly positive correlations between awe and “Distortion of the sense of time” ( $r = .729$ ;  $p < .001$ ), “Autotelic” dimension of flow ( $r = .814$ ;  $p < .001$ ) “Global Flow” ( $r = .477$ ;  $p = .002$ ) and “Concentration” ( $r = .419$ ;  $p = .009$ ).

## 5. Discussions and conclusion

In this work, we explored the relationship between the two self-transcendent states (STEs) of awe and flow. Awe is usually considered as a complex, rare emotion arising from a blend of fear, wonder, surprise and amazement. Flow is an optimal psychological state occurring when people execute a task perceived as challenging but manageable. A recent model on STEs by Yaden et al. [6] posited a link between these two states, since they would be placed on a continuum ranging from less intense and usual states to most rare and intense ones. Awe and flow should be placed quite near on this continuum. However, their relationship has never been tested yet, maybe due to the difficulty to reproduce intense version of awe in the lab. Here, we adopted a VR as a new experiential methodology able to elicit complex and intense instances of awe in a controlled setting, to explore link between flow and awe in three ad hoc validated VR awe-inspiring environments [14]. We found that each VRE could elicit flow as well as a sense of awe and sense of presence at high levels. Specifically, as hypothesized, flow elicitation followed the same patterns of awe elicitation: Mountains and Tall Trees environments elicited the highest levels of flow compared to Earth view condition, as reported for awe.

Moreover, awe and flow showed high positive correlations regarding the main self-transcendent dimensions of flow, such as the merging between action and awareness, the perception of losing the sense of time, the loss of self-consciousness, and the feeling of living an autotelic dimension of experience. STE model's predictions proved reliable and an interesting starting point for future research interested in deepening the phenomenological characteristics of these two states, as well as their relationship with sense of presence elicited by VR. However, we showed an overlap between the two phenomena that concerns also dimensions not included in the theorization of Yaden [6] on the continuum of self-transcendence, which should be deepened by future studies. Although preliminary, this study offered evidence for a close connection between this emotion and the experience of flow, thus hinting at a more complex nature of awe as more than a simple emotional state and as closer to an experience. Finally, VR resulted as an effective and reliable methodology to elicit even complex instances of STEs in the lab. VR paves the way for a new approach to study fleeting and composited phenomena, which are hard to reproduce within the boundaries of a lab. This is another step towards the scientific study of STEs, drawing from William James' original lesson [26].

## References

- [1] D. Keltner, and J. Haidt, Approaching awe, a moral, spiritual, and aesthetic emotion. *Cognition & Emotion*. **17**(2003), 297-314.
- [2] A. Chirico et al., The Potential of Virtual Reality for the Investigation of Awe. *Frontiers in Psychology*. **7**(2016).
- [3] J.E. Stellar, et al., Awe and humility. *Journal of personality and social psychology*, **114**(2018), 258.
- [4] J.E. Stellar, et al., Self-transcendent emotions and their social functions: Compassion, gratitude, and awe bind us to others through prosociality. *Emotion Review* (2017), 1754073916684557.
- [5] P.K. Piff, et al., Awe, the small self, and prosocial behavior. *Journal of personality and social psychology*. **108**(2015), 883.
- [6] D.B. Yaden, et al., The Varieties of Self-Transcendent Experience. *Review of General Psychology*, 2017.
- [7] M. Csikszentmihalyi, *Beyond boredom and anxiety*. 1975, San Francisco, CA Jossey-Bass.

- [8] M. Csikszentmihalyi, *Beyond boredom and anxiety*. 2000, San Francisco, CA Jossey-Bass.
- [9] M.E. Seligman, and M. Csikszentmihalyi, *Positive psychology: An introduction*. Vol. 55. 2000: American Psychological Association.
- [10] P.J. Silvia, et al., Openness to experience and awe in response to nature and music: Personality and profound aesthetic experiences. *Psychology of Aesthetics, Creativity, and the Arts*, **9**(2015), 376-384.
- [11] A. Chirico, P. Cipresso, G. Gaggioli, *A Process for Selecting and Validating Awe-Inducing Audio-Visual Stimuli*. , in *6th EAI International Symposium on Pervasive Computing Paradigms for Mental Health*. 2017: Barcellona.
- [12] A. Chirico, P. Cipresso, and A. Gaggioli, *Psychophysiological correlate of complex spherical awe stimuli*. *Neuropsychological Trends*, 2016.
- [13] A. Chirico, et al., Effectiveness of Immersive Videos in Inducing Awe: An Experimental Study. *Scientific Reports*, **7**(2017): p. 1218.
- [14] A. Chirico, et al., *Designing Awe in Virtual Reality: An Experimental Study*. *Frontiers in Psychology*, **8**(2018).
- [15] G. Riva, J.A. Waterworth, and E.L. Waterworth, *The layers of presence: a bio-cultural approach to understanding presence in natural and mediated environments*. *CyberPsychology & Behavior*. **7**(2004): p. 402-416.
- [16] G. Riva, and J.A. Waterworth, *Being present in a virtual world*. *The oxford handbook of virtuality*. Oxford University Press, New York, 2014, 205-221.
- [17] Riva, G., et al., From intention to action: The role of presence. *New Ideas in Psychology*. **29**(2011): p. 24-37.
- [18] J. Waterworth, and G. Riva, *Feeling present in the physical world and in computer-mediated environments*. Basingstoke, UK: Palgrave Macmillan, 2014
- [19] J.A. Waterworth, et al., On feeling (the) present. *Journal of Consciousness Studies*, 2010. **17**(2010),167-188.
- [20] J.A. Waterworth, et al., *Presence: Form, content and consciousness*, in *Immersed in Media: Telepresence Theory, Measurement & Technology* B.F. Lombard M., Freeman J., IJsselsteijn W., Schaevitz Editor., Springer: Berlin, 2015, 35-58.
- [21] B. Diana, et al., *La validazione italiana della Flow State Scale - FSS.*, in *Flow, benessere e prestazione eccellente. Dai modelli teorici alle applicazioni nello sport e in azienda*, M. Muzio, G. Riva, and L. Argenton, Editors., FrancoAngeli. 2012, 123-142.
- [22] J. Lessiter, et al., A cross-media presence questionnaire: The ITC-Sense of Presence Inventory. *Presence*, **10**(2001), 282-297.
- [23] M.E. Masson, A tutorial on a practical Bayesian alternative to null-hypothesis significance testing. *Behavior research methods*, **43**(2011), 679-690.
- [24] F. Liang, et al., Mixtures of g priors for Bayesian variable selection. *Journal of the American Statistical Association*, 2012. **103**(2012): p. 410-423.
- [25] J.N. Rouder, Optional stopping: No problem for Bayesians. *The Journal of Problem Solving*. **21**(2014): p. 301–308.
- [26] W. James, *The varieties of religious experience: A study in human nature*. in *Gifford Lectures on Natural Religion, University of Edinburgh, Edinburgh, Scotland; The chapters in this text were presented at the aforementioned lectures in 1901-1902*. Longmans, Green and Co, 1902

# Gender differences in attentional bias after owning a virtual avatar with increased weight.

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**Introduction:** Eating Disorder (ED) patients selectively attend to appearance cues in preference to other information, in a phenomenon known as Attentional Bias (AB). The latest VR Head Mounted Displays (HMD) offer the chance to include Eye-Tracking (ET) devices, and thus provide more objective measures of body-related attention. This study aims to combine VR and ET technologies and use a VR-based embodiment technique while measuring real-time attention patterns. Specifically, we assess gender differences in eye-gaze behaviors towards specific weight-related or non-weight-related body parts when participants own a virtual avatar with different body sizes. **Method:** Thirty-five college students (25 women and 10 men) were exposed to an immersive virtual environment in which they were embodied in three avatars with different body sizes: first, one with the same body size as the participant; second, one larger than

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the participant; and finally, repetition of the avatar with the same body size as the participant. To analyze the gaze data Weight-related Areas of Interest (W-AOIs) and Non-Weight-related Areas of Interest (NW-AOIs) were defined. Fixation points and complete fixation time on each AOI were recorded at the three different assessment times. Raw data from the Pupil Labs eye tracking add-on for the HTC-Vive headset were subsequently transformed into percentages for further analysis. **Results:** Mixed between (Gender)-within (Time) analyses of variance showed non-statistically significant interaction between gender and time ( $p > .05$ ) and a non-statistically significant difference in fixation points and complete fixation times ( $p > .05$ ), over the three assessment times. However, a statistically significant gender difference was found in fixation points ( $F(1,33) = 10,030$ ,  $p = .003$ ,  $\eta^2 = 0.233$ ) and complete fixation time ( $F(1,33) = 13,017$ ,  $p = .001$ ,  $\eta^2 = 0.28$ ). Overall, women reported significantly higher levels of fixation points and complete fixation times in W-AOIs than men. Women showed an increasing gaze pattern towards W-AOIs at the three different assessment times, while men showed an opposite gaze pattern towards NW-AOIs at the three different times. Interestingly, the greatest differences between men and women were found at the third assessment, when they once again owned an avatar with the same body size as themselves. Conclusion: This study provides useful information about gender differences in gaze pattern behaviors while participants owned a virtual avatar with different body sizes. To our knowledge, this is the first study to compare gaze pattern behaviors between women and men using VR-based embodiment techniques and ET attentional bias assessment. The use of these two technologies opens a promising new area in the assessment or treatment of Eating Disorders and body image disturbances.

**Keywords:** Eye-tracking, virtual reality, gender differences, eye-gaze pattern behaviors.

## 1. Introduction

Cognitive models of Eating Disorder (ED) have suggested the presence of a dysfunctional body-related attention. According to these models, ED patients show a preference for attending to disorder-relevant information, such as body-related stimuli, over other sorts of information, in a phenomenon known as Attentional Bias (AB) [1]. According to DSM 5, all ED patients tend to over-evaluate their shape and weight [2]: some of them by repeatedly checking and scrutinizing their weight-related body parts, for example by looking at themselves in the mirror (body checking), and others by actively avoiding any such inspection (body avoidance). The use of eye-tracking (ET) techniques has provided a direct and continuous measure of AB [3] which may represent a useful way to assess both attentional strategies. In clinical studies, some authors suggest that female ED patients tend to attend more to self-defined unattractive body areas, while healthy participants tend to show a more general scanning behavior, covering either the whole body or the most attractive body parts [4]. However, a recent ET study showed that female adolescents with different types of ED and healthy participants pay more attention to self-attributed unattractive body parts [5].

To date, most studies have assessed visual attention bias only in females, while little research has focused on the study of gender differences in body-related attention. The suggestion is that women and men differ in their body image concerns and present different ways of evaluating their appearance: while women tend to check body areas related with weight (e.g., the thighs), men tend to check body areas related with muscularity (e.g., the arms) [6]. Two previous studies have assessed AB for different body shapes in women and men, and its relationship with body dissatisfaction. The results show that both genders attend more to idealized bodies (i.e., muscular male

bodies or thin female bodies) over other types of bodies, and that body dissatisfaction seems to be strongly related with an AB toward idealized bodies in both genders [7,8].

However, eye-movement research also presents some important limitations, such as the lack of external validity. The use of VR technology may help to overcome these drawbacks by adding eye-tracking devices into the Head-mounted display (HMD). The combination of the two technologies can capitalize on the possibilities of VR scenarios by measuring real-time attention patterns objectively and accurately [9]. In addition, the use of embodiment VR-based techniques provides participants with the chance to see their own virtual bodies in a first-person perspective or by looking at themselves in a mirror [10] and creating real-size 3D virtual avatars to assess and change their mental representations of their body image [11].

This study aims to assess gender differences in eye-gaze behaviors towards specific weight-related or non-weight-related body parts in a situation in which participants own a virtual avatar with different body sizes. It is expected that female participants will spend a greater proportion of time and frequency of fixations looking at weight-related body parts, while males will show an opposite gaze behavior pattern, looking more at the non-weight-related body parts.

## 2 Method

### 2.1 Participants

Thirty-five college students from the University of Barcelona, 25 women and 10 men ( $M_{age} = 22.30$ ,  $SD = 2.76$ ,  $M_{BMI} = 21.78$ ,  $SD = 2.47$ ) participated in the study. They were recruited through campus flyers and advertisements in social network groups. The exclusion criteria were diagnosis of a current ED, a BMI less than 17 (moderate thinness) or more than 30 (obesity) and a current Severe Mental Disorder Diagnosis.

### 2.2 Instruments

The HMD HTC-VIVE with a Pupil Labs Eye-Tracking device add on was used in this experiment, connected to a computer with sufficient graphic and processor power to move VR environments. Two programs were used to develop the virtual simulations: Blender 2.78 v. to create the virtual avatars (male and female) and Unity 3D 5.5.v to integrate all the elements within a virtual environment. The virtual environment was a simple room without any furniture, and with a large mirror on the front wall. This mirror, placed 1.5 meters in front of the subject, was not visible at the beginning of the experiment (first-person perspective) and was activated only during the third-person perspective condition. Two different avatars were created, one male and one female. Both male and female avatars wore a standard black t-shirt with black jeans and black trainers. Both avatars wore a swimming cap so as to reduce the idiosyncratic influence of hairstyle on each participant.

*Visual selective attention measures.* In accordance with the Weight Scale body items of the Physical Appearance State and Trait Anxiety Scale questionnaire [12], the same areas of interest (AOIs) were individually drawn in a 2D frontal view picture of the female or male avatar and were labelled as weight related body-parts (W-AOIs): e.g., thighs, buttocks, hips, stomach (abdomen), legs, waist. Muscle tone was not included, due to the impossibility of reproducing it. The remaining body areas were

labelled as non-weight related body parts (NW-AOIs): e.g., head, shoulders, arms, décolletage, neck and chest. The participant's visual fixation, defined as the visual act of sustaining the gaze on a single location over a minimum duration (typically 100–200 ms) [13], was estimated by the following variables:

- *Proportion of fixations in AOIs*: Proportion of available fixations on the specified area of interest group (weight-related body-parts or non-weight body parts) divided by the total number of fixations available across all areas of interest.
- *Complete fixation time in AOIs*: Proportion of the fixation time on the specified area of interest group (weight-related body-parts or non-weight body parts) divided by the complete fixation time available across all areas of interest.

### 2.3 Procedure

This study was approved by the ethical committee of the University of Barcelona. Before entering the study, participants signed an informed consent form and were then weighed and measured to calculate their BMI. Afterwards, a photo of the whole body of each participant was taken by the experimenters, using a camera. The photo was adapted to the different virtual avatar measures (e.g. arms, legs, hip, waist, chest, breast, shoulders...).

*Visuo-tactile stimulation procedure*: To enhance the illusion of owning an avatar with different body sizes, a visuo-tactile stimulation procedure was applied, consisting of a series of continuous touches to some specific body parts (the arms, the abdomen, and the legs) by the experimenter with one of the HTC-VIVE controllers, while the participants looked at themselves (first-person perspective) and at the avatar reflected in a mirror in front of them (third-person perspective).

*Eye-tracking assessment task*: The device used to record the eye movements was Pupil Labs HTC Vive Eye-Tracking, a 120 Hz contact free binocular eye-tracking add-on for the VR HMD (HTC VIVE) with a spatial accuracy of one degree. The accuracy of the eye-tracking recordings was measured by a nine-point calibration procedure. After the calibration and validation procedure, participants were instructed to gaze at the avatar reflected in the mirror for 30s while spontaneous eye movements were recorded. Throughout this process they were advised to avoid abrupt head-movements.

Following the two procedures, each participant was exposed to three virtual bodies (assessment time condition): the first with the same body size as the participant (Real-size VB-1); the second 40% larger than the participant (Larger-size VB); and finally, a repetition of the first avatar with the same body size as the participant (Real-size VB-2).

### 2.4 Statistical analysis

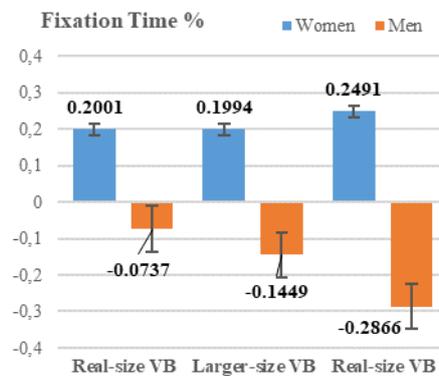
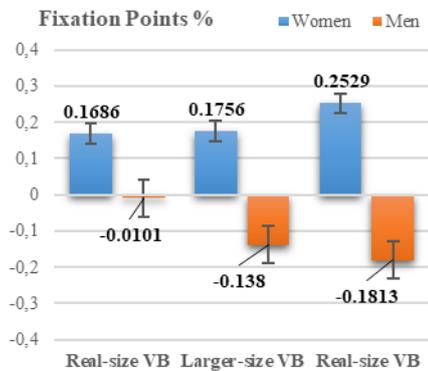
The analysis software Ogama (Open Gaze Mouse Analyzer) was used to transform the eye-tracking raw data into suitable quantitative data. An additional data transformation was conducted by subtracting the difference between weight-related and non-weight-related AOIs (e.g., in Fixation Points (W AOIs: 10 - NW AOIs: 8 = 2) Therefore, a positive outcome would mean that the participant had been looking more at the W-related body parts than at the NW-related body parts, while a negative outcome would mean the opposite. Finally, the previous data were subsequently transformed into percentages for further analysis. The outcome of the intervention, including the AOIs data, was analyzed by the statistical software IBM SPSS Statistics v.23.

### 3. Results

Mixed between (gender)-within (assessment time) analyses of variance (ANOVA) were conducted. All the assumptions were met; there was homogeneity of variances, sphericity, and normal distribution of the data in both variables. There were no statistically significant interactions between gender and assessment time ( $p > .05$ ) in ET Fixation points or in ET Fixation Time. There was neither a main effect of the assessment time condition in any of the ET variables ( $p > .05$ ). On the other hand, there was a significant main effect of gender in ET Fixation points  $F(1,33) = 10.030$ ,  $p = .003$   $\eta^2 = .233$  and in ET Fixation Time  $F(1,33) = 13.017$ ,  $p = .001$   $\eta^2 = .283$ . Thus, women and men displayed a completely different gaze-behavior toward the W-related and NW-related AOIs, regardless of the sort of avatar that they owned.

Additional independent-samples t-tests were run to assess gender differences specifically in each assessment time condition (see figures 1

and 2). The largest significant differences between men and women were found at the second assessment time (larger-size virtual body) in Fixation Points ( $MD = 0.31$ , 95% CI [0.04, 0.58],  $p = .026$ ) and Fixation Time ( $MD = 0.34$ , 95% CI [0.0, 0.66],  $p = .034$ ), and especially at the third assessment time when they again



owned the real-size virtual body, in both AB gaze variables: Fixation Points ( $MD = 0.39$ , 95% CI [0.12, 0.69],  $p = .005$ ) and Fixation Time ( $MD = 0.49$ , 95% CI [0.20, 0.78],  $p = .002$ ).

**Figures 1 and 2.** Gender differences in means of AB data in each assessment time condition. Error bar represents standard errors.

### 4. Discussion and conclusions

Our results suggest that women and men differ significantly in the use of gaze patterns toward specific body parts, and that these patterns result in different body checking behaviors. Women attended significantly more to weight-related body parts than men in all body size conditions, with greater fixation frequencies and greater proportion of fixation times, while men attended more to non-weight related body parts in all body size conditions. Interestingly, these gender differences were significantly greater in the larger-size virtual body, and especially when they owned the real-size virtual body for the second time.

The tendency among women to attend more to weight-related body parts supports previous studies that female ED patients and healthy participants tend to gaze more at self-attributed unattractive body parts [5], in contrast to other studies reporting a more general visual scanning behavior covering the whole body in healthy females [4]. As for men, they present the opposite gaze behavior, looking at non-weight-related body parts such as arms, shoulders or chest; this may imply an AB toward body parts that are more related with muscularity. The gender differences in our study may be related with different “ideals of body image” between the genders; while women show a preference for thinner bodies, men tend to desire a more muscular and lean body [14], resulting in different body image concerns and the use of different body checking strategies [6]. Our results support this idea; at all three assessment points, both men and women showed significantly increased body checking behavior toward their respective body areas of higher concern. Furthermore, in a previous study it was found that exposure to a larger-size VB elicited high body anxiety levels in healthy participants [15]. Therefore, this body checking behavior may also be enhanced by the discomfort elicited after owning the larger-size VB, especially when participants owned the real-size virtual body for the second time.

To our knowledge, this is the first study to assess gender differences in visual selective attention toward specific weight- or non-weight-related body parts while participants own a virtual avatar with different body sizes. However, some important limitations should be considered, such as the small sample size, the unequal gender distribution in the sample, and the lack of control of important variables such as BMI and body dissatisfaction. These findings constitute a step forward in the study of gender differences in body image assessment and body checking behaviors. The use of VR-HMD with eye-tracking devices add on may significantly improve future ED assessment and treatment by providing an objective, accurate measure of visual selective attention while taking advantage of the innumerable possibilities of VR.

**Acknowledgments.** This study was supported by the Spanish Ministry of Science and Innovation (MINECO/FEDER/UE/ Project PSI2015-70389-R: Development of virtual reality-based exposure techniques for improving anorexia nervosa treatment); and by “Postgrado Actualización en Psicopatología clínica de la Universidad de Barcelona”.

## References

- [1] D. A. Williamson, M. A. White, E. York-Crowe, T. M. Stewart, Cognitive-behavioral theories of eating disorders, *Behavior Modification* **28** (2004), 711-738.
- [2] American Psychiatric Association, Diagnostic and Statistical Manual of Mental Disorders: DSM-V, American Psychiatric Association, Washington, 2013.
- [3] M. Y. Jiang, L. R. Vartanian, A review of existing measures of attentional biases in body image and eating disorders research, *Australian Journal of Psychology* **70** (2017), 3–17.
- [4] A. Jansen, C. Nederkoorn, S. Mulken, Selective visual attention for ugly and beautiful body parts in eating disorders, *Behaviour research and therapy* **43** (2005), 183-196.
- [5] A. Bauer, S. Schneider, M. Waldorf, K. Braks, T. J. Huber, D. Adolph, S. Vocks, 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* **45** (2017), 1-15.
- [6] L. Alfano, T. Hildebrandt, K. Bannon, C. Walker, K. E. Walton, The impact of gender on the assessment of body checking behavior, *Body Image* **8** (2011), 20–25.

- [7] A. Cho, J. H. Lee, Body dissatisfaction levels and gender differences in attentional biases toward idealized bodies, *Body Image* 10 (2013), 95–102.
- [8] C. Joseph, V. LoBue, L. M. Rivera, J. Irving, S. Savoy, M. Shiffrar, An attentional bias for thin bodies and its relation to body dissatisfaction, *Body Image* 19 (2016), 216–223.
- [9] O. Hans-Martin Lutz, C. Burmeister, L. Ferreira dos Santos, N. Morkisch, C. Dohle, J. Krüger, Open Access Application of head-mounted devices with eye-tracking in virtual reality therapy, *Current Directions in Biomedical Engineering* 3 (2017), 53–56.
- [10] M. Ferrer-García, J. Gutiérrez-Maldonado, The use of virtual reality in the study, assessment, and treatment of body image in eating disorders and nonclinical samples: A review of the literature, *Body Image* 9 (2012), 1–11.
- [11] Perpiñá, C. Botella, R. M. Baños, Virtual reality in eating disorders, *European Eating Disorders Review* 11 (2003), 261–278.
- [12] L. Reed, J. K. Thompson, M. T. Brannick, W. P. Sacco, Development and validation of the Physical Appearance State and Trait Anxiety Scale (PASTAS), *Journal of Anxiety Disorders* 5 (1991), 323–332.
- [13] R. J. Jacob, K. S. Karn, Eye tracking in human-computer interaction and usability research: Ready to deliver the promises. In: *The Mind's Eye: Cognitive and Applied Aspects of Eye Movement Research* (2003), 531–553.
- [14] M. Algars, P. Santtila, M. Varjonen, K. Witting, A. Johansson, P. Jern, N. K. Sandnabba, The adult body: how age, gender, and body mass index are related to body image, *Journal of Aging and Health* 21 (2009), 1112–1132.
- [15] M. Ferrer-García, B. Porras-García, C. González-Ibañez, M. Gracia-Blanes, F. Vilalta-Abella, J. Pla-Sanjuanelo, et al., “Does owning a “fatter” virtual body increase body anxiety in college students?” *Annual Review of Cybertherapy and Telemedicine* 15 (2017), 147–153.

# Educational Robotics to develop executive functions visual spatial abilities, planning and problem solving.

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**Abstract.** Educational robotics is an innovative learning tool that offers students the opportunities to develop higher-order thinking skills. This research aims to verify the effectiveness of educational robotics on the mental processes of planning and problem solving. Robotics education involved in a curricular laboratory (10 meetings, two hours each, once a week) with 15 children, attending their fifth year at primary school. The proposed methodology was divided into three phases: Pre-test, Practice and Post-Test. The main finding was a significant improvement in visuo-spatial attention and a significant effect on robot programming skills. These data provide scientific support to the hypothesis that robotics activities are suitable in progressively improving abilities in planning and controlling complex tasks in children, fostering executive functions development.

**Keywords.** Educational Robotics, Metacognition, Learning, Problem solving, New Technology

## 1. Introduction

This work presents and discusses a specific didactic approach to support the development of visual spatial attention, planning and problem solving skills in activities of educational robotics. Educational robotics (ER) are being introduced in many schools as an innovative learning environment that offers students the opportunities to develop higher order thinking skills and abilities, and solve complex problems [1]. It is a powerful and flexible teaching and learning tool which engages students in activities of robot construction and control using specific programming

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tools [2]. In a typical ER activity, students work in groups to address complex problems. Through iterative design and testing, students get immediate feedback on their actions and learn how to deal with challenging situations in a real-world context.

Recent studies suggest the ER as an innovative model of empowerment of the transversal skills such as reasoning, problem solving [3-4], metacognition [5-8], programming [9-10] and collaboration [11]. Programming the actions of a robot to make it achieve an objective, requires the ability to anticipate the action mentally, select the appropriate procedure, and update it continuously. The programming of small mobile autonomous robots into the physical environment requires planning, precision in the use of language, the generation and testing of hypotheses, the ability to identify action sequences and a variety of other skills that seem to reflect what thinking is all about. Furthermore, working with programmable robots allows children to test the robots' actions in the real environment with all its variables, such as the indeterminacies and the typical uncertainties of the environment (different from the simulation in virtual contexts where everything is still predefined) and their own reasoning strategies. The feedbacks (positive and negative) provided by the robot/environment interaction require a continuous revision of the programming algorithms [12].

In order to create a successful program, children must use procedural thinking and understand the logic of instructions. When creating a program, children are thinking in terms of next, before, and until, which are all components of sequencing—in particular, temporal sequencing [9]. Given these characteristics, the robotics activities can enhance mental processes that belong to the cognitive domain of the Executive Functions: problem solving, planning, working memory, inhibition, mental flexibility, initiation and monitoring of actions. Executive functions refer to a family of adaptive, goal-directed, top-down mental processes needed when you have to focus and pay attention and when an automatic response would be insufficient [13-14]. Executive functions make “mentally playing with ideas, taking the time to think before acting, meeting novel, unanticipated challenges, resisting temptations, and staying focused” possible [15].

This research aims to verify the effectiveness of educational robotics on the executive functions and in particular on the mental process of visuo-motor planning, attention skills, and planning and problem solving.

For this purpose, we implemented a sample of students attending their fifth year at primary school involved in a robotics laboratory.

## **2.Methods**

### *2.2. Participants*

The sample consisted of thirty healthy children, attending their fifth year at primary school of Palermo (Italy). Participants were randomly assigned to the control and the experimental group, each composed of fifteen subjects (9 males and 6 females; 10 years).

Children of the experimental group followed the LEGO robotics laboratory described below. Children of the control group followed the regular school activities.

**Table 1:** Sample characteristics

	<b>Experimental group</b>	<b>Control group</b>
	<i>n</i> = 15	<i>n</i> = 15
Age (Mean ± SD)	10 ± .000	10 ± .000
Gender (M, F)	9, 6	9, 6

### 2.3. Instruments and procedure

The children of the experimental group were divided into small groups (three or four children per group) and each was provided with a robotic kit that involved a curricular laboratory based on robotics activities (10 meetings; two hours each, once a week). The participants had to build a robot body and subsequently plan and program different behavioral repertoire.

For the intervention, we used LEGO Mindstorms EV3 and assembled the robot as a small vehicle, equipped with motor, ultrasonic sensors at the front, one pointed straight ahead, and an LED color light mounted on top. LEGO Mindstorms is a programmable robotic kit released by Lego. This robot is low cost, modular, has a user-friendly interface, and also the robot configuration can gradually evolve. First, children familiarized themselves with robotics artifacts and the hardware and software elements of the kit. During these sessions, the robotics kits were introduced to the children, explaining programming characteristics and main commands. Successively, they built a small-mobile robot, following the instruction provided by the LEGO manual. After building their robot, children were trained with LEGO programming interface. Then, all the students were given programming tasks having an increasing level of difficulty measured by the number of commands necessary for programming the robot. Incrementally, more difficult activities were proposed allowing the children to gradually achieve a greater competence, with an approach based on the “error-less learning” method. Each of the tasks provided opportunities for subject to program and observe the robotic toy and to reflect on the toy’s movement. One of the most important tasks of the robot is the ability of collecting data about the environment in which it is located through different sensors. Interacting with the environment the robots can be in a position to simultaneously detect and process information coming from different sources, such as a light sensor and a contact sensor. Then, working with programmable robots allows children to test the robots’ actions in the physical environment with all its variables, such as the indeterminacies and the typical uncertainties of the environment (different from the simulation in virtual contexts where everything is still predefined) and to test their own reasoning strategies. The feedbacks (positive and negative) provided by the robot/ environment interaction require a continuous revision of the programming algorithms.

The dynamic actions of the toy created a “shared moment” which was highly visual and in turn provided opportunities for shared attention and group work. Programming robot actions requires, for each step, mental anticipation of the action, selection of the appropriate robot command and continuous updating of the programming in order to obtain the goal. The emphasis during the problem-solving exercises is the analysis of the problem, not the generation of code.

#### 2.4. Assessing cognitive abilities

The proposed methodology was divided in three phases: Pre-test, Practice and Post-Test.

During the pre/post-test phases the cognitive and executive functions were measured using the following tests: Frontal Assessment Battery (FAB), reduced version that includes only three subtests [16], to investigate mental flexibility, motor planning and executive control. Motor planning and executive action control were explored by means of Luria's motor tasks. In the "contrast" task, exploring the ability to prevent interference effects, subjects had to perform an action opposite to that performed by the examiner, refraining from the tendency to imitate the examiner's action. Inhibition of control was evaluated by a "Go/No-Go" task. Scores ranged from 0 (no correct responses) to 3 (all correct responses) for each subtest. The overall score was the sum of the three subtest scores (range: 0-9).

The Trail Making Test (TMT, Forms A, B and B-A), version for children under 15 [17], assessed attentional skills, visuo-motor planning, sustained attention and working memory. This version has the same characteristics as that of adults, and only differs in the number of stimuli presented. The 25 numbers in part A are reduced to 15, and the 13 numbers and 12 letters in part B are replaced by 8 and 7 elements respectively.

Tower of London (ToL) [18] for the capacity of planning and problem solving. The Tower of London test is widely used for measuring planning and aspects of problem solving in neuro- psychological patients and normal populations. Participants are asked to preplan mentally a sequence of moves to match a start set of discs to a goal, and then to execute the moves one by one. The mental preplanning stage has been identified as critical to efficient performance.

All the test were administered to participants by a team of trained psychologists in a classroom setting.

#### 2.5. Educational robot activities

In line with a consolidated methodology [6-7], each group performed different programming task having an increasing level of difficulty.

First, they were invited to create a narrative scenario for the robot behavior and to build a physical environment (i.e. the arena or city map) using pasteboard, colors and other materials. After, robot programming was proposed, asking the child to move the robot to reach a specific goal.

The steps of programming and the length of path were progressively incremented, requiring the child to display a more complex ability to plan and to visuo-spatial update.

Specifically, the subjects were requested to perform the following tasks:

- Build and program a robot able to move along a linear route;
- Program the robot able to move and describe a geometric figure as a square;
- Program the motors and the color detection sensor- Create and program a robot able to move and change trajectory if there is a red line along its route;
- Program the motors, the color detection sensor and the ultrasonic sensor- Create and program a robot able to move and shoot balls if there an object along its route.

### 3. Results

All participants of experimental group maintained a high level of motivation during laboratory activities period.

The effectiveness of treatment was analyzed through repeated measures ANOVA, with two levels of the between-subject factor (experimental group and control group) and two levels of the within-subject Time factor (pre-test and post-test).

For the univariate test, the Time factor was statistically significant on all the variables considered. Furthermore, the univariate tests showed that the effect of Time x Group interaction was statistically significant on the scores of TMT A ( $F_{1-28}= 9,375$ ,  $p < .01$ ,  $\eta_p^2 = .251$ ), TMT B ( $F_{1-28}= 4,004$ ,  $p= .055$ ,  $\eta_p^2 = .125$ ); ToL ( $F_{1-28}= 9,618$ ,  $p < .01$ ,  $\eta_p^2 = .256$ ) and on the reduction of attempts to the Tower of London test ( $F_{1-28}= 51,746$ ;  $p < .01$ ,  $\eta_p^2 = .649$ ).

As reported in Table 2, after robotics activities, the experimental group showed a significant reduction of execution time for TMT-A ( $F_{1-28}=12,997$ ,  $p = .001$ ,  $\eta^2 = .317$ ), while it was not significant for TMT-B ( $F_{1-28}=6,270$ ;  $p = n.s.$ ), suggesting an improved performance in the following attentional skills: visuo-motor planning and sustained attention.

At the FAB, the performance of experimental group increased from pre-test to post-test because of treatment ( $F_{1-28}=7,646$ ,  $p= .010$ ,  $\eta^2 = .214$ ):

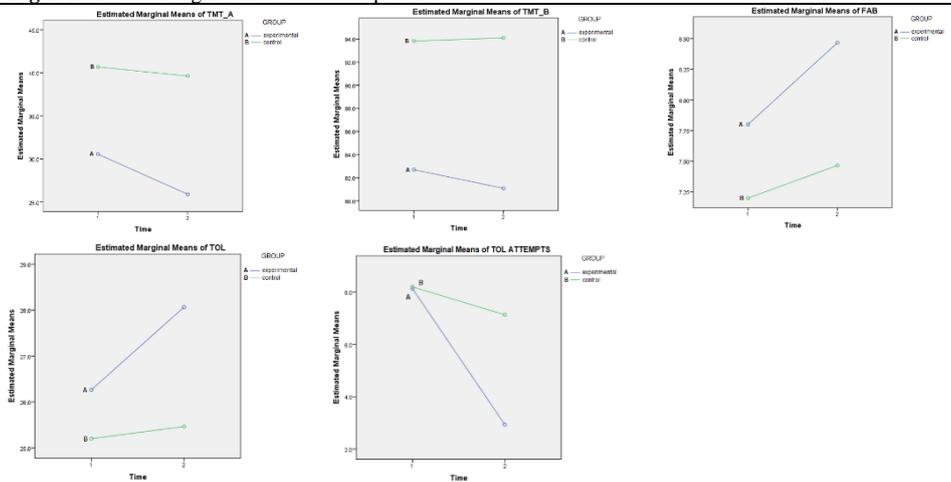
Regarding the Tower of London, the difference between experimental group and control group was statistically significant ( $F_{1-28}=5,531$ ,  $p= .026$ ,  $\eta^2 = .165$ ): the subjects of the experimental group increased their score and showed improvement on the capacity of planning and problem solving.

Furthermore, the experimental group showed a reduction of attempts to complete the Tower of London test ( $F_{1-28}=15,392$ ,  $p= .001$ ,  $\eta^2 = .355$ ).

**Table 2.** Repeated Measures ANOVA between subject and within subject (before and after training)

	Experimental group				Control group			
	Pre-test		Post-test		Pre-test		Post-test	
	M	SD	M	SD	M	SD	M	SD
<b>TMT-A</b>	30,560	6,941	25,907	5,925	40,693	14,625	39,640	13,771
<b>TMT- B</b>	82,693	14,733	81,080	14,940	93,820	32,783	94,100	31,957
<b>FAB</b>	7,800	1,207	8,467	0,743	7,200	1,320	7,467	1,187
<b>TOL</b>	26,267	2,815	28,067	1,907	25,200	4,126	25,467	3,833
<b>TOL attempts</b>	8,133	3,888	2,933	2,404	8,200	3,967	7,133	3,737

The estimated marginal means showed a significant difference between the two groups over all measurement time (figure 1).

**Fig 1.** Estimated marginal means for Group\*Time

#### 4. Conclusions

The results of the present research confirm the importance of using educational systems based on robotics to encourage the use of specific cognitive and attentive abilities.

This study supports the hypothesis that activities of Educational Robotics have repercussions on executive functions because they can be a vehicle for the development of higher-level control components, such as forecasting, planning, and problem solving skills. Indeed, this research provides quantitative data for evaluating the effects of a robotics laboratory on transversal high-level cognitive functions in children.

In general, the results showed that the involvement and the improvement of the logical reasoning ability allows subjects to anticipate and to plan the sequence of the actions needed to solve a particular behavioral task.

#### References

- [1] S. Blanchard, V. Freiman, & N. Lirrete-Pitr, Strategies used by elementary schoolchildren solving robotics-based complex tasks: innovative potential of technology. *Procedia - Social and Behavioral Sciences*, **2** (2010), 2851-2857.
- [2] J. Chambers, & M. Carbonaro. Designing, developing, and implementing a course on LEGO robotics for technology teacher education. *Journal of Technology and Teacher Education*, **11** (2003), 209–241
- [3] S. Turner, & G. Hill. *Robots in problem-solving and programming*. In 8th Annual Conference of the Subject Centre for Information and Computer Sciences (2007), 82–85.
- [4] R. Castledine, & C. Chalmers, LEGO robotics: An authentic problem solving tool? *Design and Technology Education*, **16** (2011) 19–27. H. Lin, & E. Z. F. Liu A pilot study of Taiwan elementary school students learning motivation and strategies in robotics learning. In International Conference on Technologies for E-Learning and Digital Entertainment (2011), 445–449.
- [5] F. La Paglia, R. Rizzo, D. La Barbera, Use of robotics kits for the enhancement of metacognitive skills of mathematics: a possible approach, *Studies in Health Technology and Informatics*, **167** (2011), 26–30
- [6] F. La Paglia, F. La Cascia, M. M. Francomano, D. La Barbera. Educational Robotics to Improve Mathematical and Metacognitive Skills, *Annual Review of Cybertherapy and Telemedicine*, **15** (14), (2017) 70–75.

- [7] F. La Paglia, B. Caci, D. La Barbera, M. Cardaci Using robotics construction kits as metacognitive tools. A research in an Italian Primary School, *Studies in Health Technology and Informatics*, **154** (2010), 110-114.
- [8] M. U. Bers, Project InterActions: A multigenerational robotic learning environment. *Journal of Science Education and Technology*, **16** (2007), 537–552.
- [9] Alimisis. *Teacher education on robotics-enhanced constructivist pedagogical methods*. Athens: School of Pedagogical and Technological Education, 2009
- [10] S. Atmatzidou, & S. N. Demetriadis. *Evaluating the role of collaboration scripts as group guiding tools in activities of educational robotics: Conclusions from three case studies*. In IEEE 12th International Conference on Advanced Learning Technologies (2012), 298-302.
- [11] S. Turkle, S. Papert Epistemological pluralism and the reevaluation of the concrete, *Journal of Mathematical Behaviour*, **11** (1992) 3-33
- [12] P. W. Burgess. & J. S. Simons. *Theories of Frontal Lobe Executive Function: Clinical Applications*. Effectiveness of Rehabilitation of Cognitive Deficits. Oxford University Press, 211-232., 2005
- [13] N. Garon, S. E. Bryson, I.M Smith Executive function in preschoolers: A review using an integrative framework. *Psychological Bulletin*, **134**, (2008) 31-60.
- [14] Diamond. Executive functions. *Annual Review of Psychology*, **64**, (2013) 135-68
- [15] P. Scarpa, A. Piazzini, G. Pesenti, P. Brovedani, A. Toraldo. et al., Italian neuropsychological instruments to assess memory, attention and frontal functions for developmental age, *Neurological Sciences*, **27** (2006), 381-396.
- [16] R. M. Reitan. The validity of the Trail Making Test as an indicator of organic brain damage. *Perceptual and Motor Skills*, **8** (1958) 271-276
- [17] T. Shallice. Specific impairments of planning. *Philosophical Transactions of the Royal Society of London B*, **298** (1982), 199–209.

# The Relaxing Effect of Virtual Nature: Immersive Technology Provides Relief in Acute Stress Situations

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**Abstract.** The present study investigates the possibility to provide relaxation using virtual reality (VR) technology and natural virtual environments (VE) during acute stress situations (e.g. medical treatments). To explore the relaxing and mood enhancing effect of immersion, 62 participants were exposed to a realistic underwater VE either in VR or on a desktop screen after stress induction using a VR-Trier Social Stress Test (TSST). Systematic changes in physiological (heart rate variability, cortisol) and psychological (anxiety, affect) measures were observed: The VR group experienced significantly lower stress and higher positive affect than the desktop group and a control group. Our findings demonstrate the mood enhancing effect of immersion in virtual nature and thus the benefit of VR in situations of acute emotional strain.

**Keywords.** Virtual Reality, natural virtual environments, stress, anxiety, affect, mood induction, Trier Social Stress Test (TSST), immersion, presence

## 1. Introduction

Findings from environmental psychology highlight the numerous advantages of certain natural environments in their relaxing and calming effects. In particular, research on attention restoration theory [2] brought evidence on the recreational effect of natural environments on humans [1]. Nature visits provide relief from everyday stress but are especially valuable for those suffering from acute stress and emotional strain. However, circumstances limiting access to such *restorative environments* [3] are manifold. For instance, certain working environments [4], immobility or health-related isolation, or certain medical treatments [5] may preclude from pursuing uplifting

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outdoor activities. In these cases, virtual reality (VR) technology can be beneficial since it is assumed that immersion in *natural virtual environments* (VE) has comparable positive effects as exposure to nature [6]. This is due to the innate capability of VR to create an illusion of being in another place, that is to elicit the experience of presence in the virtual world. Thus, immersion can be utilized to distract people from situations causing acute emotional distress [17]. It has been shown that confronting users with positive images of bright colors and high saturation using VR technology positively affects mood, motivation, and self-efficacy [7]. VR can also be used to elicit specific emotions by the design of the respective VE (i.e. joy, sadness, anger, anxiety) [8,9]. Moreover, a reciprocal interaction between presence and affect is assumed: While affective design elements in VEs increase the perceived level of presence, higher levels of presence again influence affect [9,10]. However, what is perceived as relaxing is a matter of individual preferences [4]. Thus, investigating the relaxing and mood enhancing effects of certain VEs as well as identifying facilitating factors enables researchers and designers to build effective VR applications for a wide range of target groups even in distress situations.

## 2. Method

### 2.1 Stimulus Material

The Trier Social Stress Test (TSST) [11] is a widely applied protocol for experimental induction of social stress. Despite its efficacy, the TSST suffers from limited replicability and comparability as well as a demand for considerable amount of resources [12]. Addressing these drawbacks, we developed a VR version of the original protocol (VR-TSST). To ascertain efficacy and validity, we conducted a pilot study ( $N = 47$ ) comparing the VR-TSST with the real world TSST. We observed an increased salivary cortisol concentration after exposition to the VR-TSST (from  $M = 12.7$  nmol/l,  $SD = 7.32$  nmol/l to  $M = 17.1$  nmol/l,  $SD = 11.9$  nmol/l) comparable to the original TSST (from  $M = 13.1$  nmol/l,  $SD = 10.9$  nmol/l to  $M = 20.2$  nmol/l,  $SD = 15.5$  nmol/l). Other physiological (HRV) and psychological (self-reported anxiety and affect) measures resembled these findings. Thus, we consider the VR-TSST as a reliable and efficient stress induction method comparable to the original TSST.

The restorative effect of green environments (e.g. parks, forests) has widely been researched. Complementing this research, we used a realistic audiovisual VR underwater simulation (“theBlu”, Wevr, 2016) to induce relaxation. To investigate whether the level of immersion influences the effect of the VE, we prepared a screen recording as a less immersive version of the original VR application and presented on a 17-inch desktop screen. All VR content was displayed on an Oculus Rift CV1. Sounds of the VR-TSST and the underwater simulation were played on either the built-in headphones of the HMD or on additional desktop speaker.

### 2.2 Objective and Subjective Measures

Heart rate variability (HRV) was calculated with the *standard deviation of successive differences* (SDSD) method from five-minute intervals. Therefore, heart rate was recorded using a commercial heart rate monitor and chest belt. A low HRV is associated with stress and emotional strain, a high HRV indicates relaxation and well-

being respectively. Besides HRV, an increased salivary cortisol concentration is another indicator of physiological stress and emotional strain. Hence, saliva samples were collected using cotton swabs and sent to an endocrinological laboratory for analysis. The subjective experience of emotional strain was assessed with the State-Trait Anxiety Inventory [13]. Additionally, the Positive and Negative Affect Schedule [14] was used to identify current mood. Sense of presence was measured using the Igroup Presence Questionnaire [15]. Moreover, immersion was determined with the corresponding dimension of the Game Experience Questionnaire [16]. The original phrasing of the items was slightly adapted to fit the stimulus material (Cronbach's  $\alpha = .70$ ).

### 2.3 Participants and Procedure

62 healthy subjects (58% female) aged 18 to 48 ( $M = 22.6$ ,  $SD = 5.36$ ) participated. Subjects were mostly students at the University of Duisburg-Essen. To avoid demand characteristics, it was proclaimed that the study investigates the influence of VR on concentration. Prior to the experiment, all participants were informed about the possibility to experience emotional strain and gave written consent before filling out a screening questionnaire to ensure physical and mental health. The experiment started with a *baseline* phase (1), that is the collection of a first saliva sample and the fitting of heart rate monitor and chest belt. At this point, HRV measurement started. Thereafter, the participants filled out the questionnaires. In the subsequent *induction* phase (2), all subjects underwent the VR-TSST procedure (20 min), with the instruction to fulfill all presented tasks. This phase ended with the announcement of a second part of this treatment to keep stress at a consistent level, thus the subjects anticipated more unpleasant tasks. In the *post-induction* phase (3), subjective measures were again recorded with the questionnaires. Since cortisol responses to mental stress are delayed, a second saliva sample was collected 15 minutes after stress induction. In the subsequent *manipulation* phase (4), the subjects were randomly assigned either to the VR ( $N = 22$ ), the desktop ( $N = 17$ ) or the control condition ( $N = 23$ ). The control group was left waiting without any distraction. In the control group, the experimenter asked the subjects to wait a few minutes before the experiment continued. In each condition, this phase took seven minutes. Subjects in VR and desktop group were asked to just watch the simulation. In the final *post-manipulation* phase (5), questionnaires were filled out and a third saliva sample was collected.

## 3 Results.

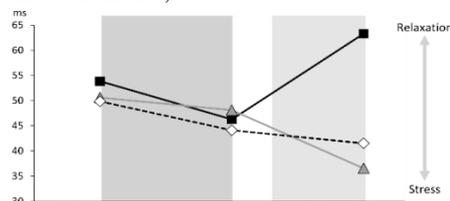
### 3.1 Heart Rate Variability and Salivary Cortisol

Data of four subjects was excluded from analysis due to measurement errors. Requirements for parametric testing were checked (Kolmogorov-Smirnov and Levene's test) for all following analyses reported in this paper.

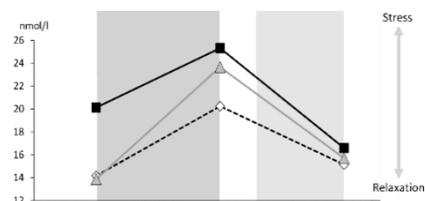
A repeated measures ANOVA revealed a significant difference between the mean HRV values in the three phases baseline, induction, and manipulation (Figure 1),  $F(2.51, 138.1) = 3.35$ ,  $p = .028$ ,  $\eta_p^2 = 0.06$ , a significant interaction,  $F(5.02, 138.1) = 3.62$ ,  $p = .004$ ,  $\eta_p^2 = 0.12$ , but no significant group difference,  $F(2, 55) = 0.72$ ,  $p = .493$ . To analyze the influence of the three conditions, we conducted a univariate ANOVA on

the HRV values in the manipulation phase,  $F(2, 55) = 5.46$ ,  $p = .007$ ,  $\eta_p^2 = 0.17$ . The post hoc analysis indicated significant differences between VR and desktop group ( $p = .019$ ) as well as between VR and control group ( $p = .020$ ). Desktop and control group did not differ significantly ( $p > .999$ ). We calculated the difference  $\Delta$  of the HRV levels from induction to manipulation phase and compared the differences between the three groups (Table 1). After manipulation, the VR group exhibited the lowest stress level as indicated by HRV compared to desktop and control group.

We observed cortisol concentrations high above the usual average of 10.0 - 14.6 nmol/l for some participants. Thus, we excluded data of 10 participants with cortisol levels higher than one standard deviation above the sample's average ( $> 32.5$  nmol/l). A repeated measures ANOVA showed a significant difference between the measurements,



**Figure 1.** Mean HRV values for each phase.  
■ = VR, ▲ = desktop, ◇ = control group.



**Figure 2.** Mean cortisol levels for each phase.  
■ = VR, ▲ = desktop, ◇ = control group.

$F(1.21, 59.4) = 10.8$ ,  $p = .001$ ,  $\eta_p^2 = 0.18$ , no significant interaction,  $F(2.43, 59.4) = 0.29$ ,  $p = .789$ , and no group difference,  $F(2, 49) = 0.11$ ,  $p = .900$ . Post hoc comparison indicated a significant difference between the measurements baseline and induction ( $p = .007$ ) as well as between induction and manipulation ( $p < .001$ ). No difference was found between baseline and manipulation ( $p > .999$ ). Mean cortisol levels were higher than the baseline ( $M = 12.8$  nmol/l,  $SD = 6.9$  nmol/l) after stress induction ( $M = 21.3$  nmol/l,  $SD = 18.5$  nmol/l) and lower again after the manipulation ( $M = 14.2$  nmol/l,  $SD = 11.1$  nmol/l), as shown in Figure 2. As for HRV, we calculated the difference  $\Delta$  of the cortisol levels from induction to manipulation (Table 1). We found a medium effect size of  $\eta_p^2 = 0.7$  and descriptive statistics indicated a stronger decrease in the VR and desktop group as compared to the control group. A univariate ANOVA did not show significant difference between the three groups,  $F(2, 49) = 1.72$ ,  $p = .190$ .

### 3.2 Anxiety and Affect

A repeated measures ANOVA indicated a significant difference in the anxiety levels between the measurements,  $F(2.59) = 58.82$ ,  $p < .001$ ,  $\eta_p^2 = 0.50$ , a significant interaction,  $F(2,59) = 6.19$ ,  $p < .001$ ,  $\eta_p^2 = 0.17$ , but no group difference,  $F(2,59) = 2.12$ ,  $p = .129$ . The post hoc tests showed a significant difference between baseline ( $M = 42.52$ ,  $SD = 8.13$ ) and post-induction ( $M = 49.81$ ,  $SD = 10.79$ ,  $p < .001$ ), as well as between post-induction and post-manipulation ( $M = 39.15$ ,  $SD = 9.98$ ,  $p = .004$ ). Moreover, we found a significant difference between baseline and post-manipulation ( $p < .001$ ), indicating that the manipulation reduced anxiety to a level lower than the baseline. Comparable results were obtained for positive affect,  $F(2,59) = 9.51$ ,  $p < .001$ ,  $\eta_p^2 = 0.14$  and negative affect  $F(2,59) = 27.68$ ,  $p < .001$ ,  $\eta_p^2 = 0.32$ . For closer investigation of the decrease in anxiety and negative affect after the manipulation and

the increase of positive affect, we conducted a univariate ANOVA. We calculated the difference  $\Delta$  in anxiety, negative and positive affect between post-manipulation and post-induction (Table 1). The  $\Delta$  scores of anxiety differ significantly between the groups,  $F(2,59) = 9.46$ ,  $p < .001$ ,  $\eta_p^2 = 0.24$ . Post hoc analysis revealed a significant difference between VR and desktop group ( $p = .012$ )

**Table 1.** Descriptive statistics  $M$  ( $SD$ ) of objective and subjective data for each condition.  $\Delta$  scores denote the difference between (post-)induction and (post-)manipulation measurements.

	Virtual Reality	Desktop	Control
$\Delta$ HRV (ms)	17.02 (11.82)	-9.45 (-2.34)	-2.61 (-3.08)
$\Delta$ Cortisol (nmol/l)	-8.11 (11.71)	-8.18 (9.67)	-5.24 (7.45)
$\Delta$ State Anxiety	-16.40 (9.27)	-8.76 (7.96)	-6.57 (6.19)
$\Delta$ Positive Affect	3.41 (4.79)	-2.35 (7.09)	-3.04 (5.17)
$\Delta$ Negative Affect	-5.90 (6.12)	-5.06 (3.40)	-3.35 (4.69)
Immersion	3.52 (0.67)	2.27 (0.91)	-
Presence	4.64 (0.90)	1.47 (1.66)	-

as well as between VR and control group ( $p < .001$ ), but no significant difference between control and desktop group ( $p > .999$ ). Hence, the VR group experienced the highest decrease of anxiety compared to desktop and control group.

We did not find significant results for the  $\Delta$  values of negative affect. However, the descriptive statistics indicate that the VR group experienced the highest decrease of negative affect, followed by desktop, and control group. The  $\Delta$  scores for positive affect, however, differ significantly,  $F(2,59) = 8.56$ ,  $p = .001$ ,  $\eta_p^2 = 0.23$ . Post hoc tests indicated a significant difference between the VR and both the control ( $p = .001$ ) and the desktop group ( $p = .007$ ). Differences between control and desktop group were non-significant ( $p > .999$ ). Hence, the VR group exhibited a higher increase of positive affect after the manipulation than the two other groups.

### 3.3 Immersion and Presence

A t-test for independent samples revealed a significant difference in perceived immersion,  $t(37) = 4.93$ ,  $p < .001$ ,  $d = -1.56$  between VR group and the desktop group (Table 1). Furthermore, a significant difference in the general feeling of being present,  $t(37) = 7.62$ ,  $p < .001$ ,  $d = -2.37$ , indicates that the VR group perceived higher levels of presence than the desktop group (Table 1). We observed significant correlations in the post-manipulation measurement between immersion and anxiety, Pearson's  $r(39) = -.53$ ,  $p = .001$ , as well as immersion and positive affect, Pearson's  $r(39) = .49$ ,  $p = .002$ . A linear regression analysis indicated immersion as a significant predictor of anxiety,  $R^2 = .276$ ,  $\beta = -.53$ ,  $t(38) = -3.75$ ,  $p = .001$ . Hence, high immersion results in less anxiety.

## 4 Discussion and Conclusion

Our results prove that the presentation of simulated natural environments is an effective method to provide relaxation and positive mood in acute stress situations. The reception of a computer-generated underwater scenario in VR reduces physiological stress, anxiety, and negative feelings effectively. Significantly higher HRV levels (i.e. less stress) during the exposition to the VE were measured in the VR group than in the desktop and control group. Additionally, we observed a medium-sized effect of immersion in the VE on the cortisol concentration. Since cortisol concentration is

determined by a multitude of factors (e.g. sex, age, daytime, chronic stress), we registered a high variability in our measurements, but did not find statistically relevant connections to our results.

With respect to the psychological data, the VR group exhibited lower anxiety levels than the desktop and the control group as well as less negative affect than the control group. Moreover, perceived immersion impacts anxiety directly. This finding indicates that VR can distract the user from acute distressing situations more effectively than less immersive media. The slight decline of HRV and positive affect in the non-VR groups supports this assumption. Hence, we follow the argumentation that immersion ties up cognitive resources, which then are not available for negative mental processes [17].

While the majority enjoyed the underwater scenario, a small number of subjects felt uncomfortable because of the “open water”. Others expected getting shocked or were afraid of certain animals (e.g. jellyfish). However, we did not find relations between the experience of unpleasantness of the VE and the observed measures. Moreover, one could argue that the mere novelty of VR causes fascination which masks the actual effect of the VE. Hence, we asked the participants whether they have used any VR technology before: 37 participants reported to have used VR before, 25 had no prior experience. With prior experience as a group variable, we did not find significant differences between any of the measures. Thus, the novelty effect as a confounding variable can be omitted.

Our findings highlight the role of immersion and presence as facilitators of relaxing and mood inducing effects of computer-generated natural VEs. VR technology can provide relief from emotional strain in acute stress situations and is a viable solution to enhance well-being of people who cannot benefit from the restorative effects of nature.

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## References

- [1] M.P. White, S. Pahl, K. Ashbulby, S. Herbert and M.H. Depledge, Feelings of restoration from recent nature visits, *Journal of Environmental Psychology* **35** (2013), 40-51.
- [2] S. Kaplan, The restorative benefits of nature: Toward an integrative framework, *Journal of Environmental Psychology* **15**(1995), 169-182.
- [3] R. Berto, The role of nature in coping with psycho-physiological stress: A literature review on restorativeness, *Behavioral sciences (Basel, Switzerland)* **4**(2014), 394-409.
- [4] A.P. Anderson, M.D. Mayer, A.M. Fellows, D.R. Cowan, M.T. Hegel and J.C. Buckey, Relaxation with Immersive Natural Scenes Presented Using Virtual Reality, *Aerospace medicine and human performance* **88** (2017), 520-526.
- [5] K. Tanja-Dijkstra, S. Pahl, M.P. White, J. Andrade, J. May, R.J. Stone, M. Bruce, I. Mills, M. Auvray, R. Gabe and D.R. Moles, Can virtual nature improve patient experiences and memories of dental treatment? A study protocol for a randomized controlled trial, *Trials* **15** (2014).
- [6] D. Valtchanov, K.R. Barton and C. Ellard, Restorative Effects of Virtual Nature Settings, *Cyberpsychology, Behavior, and Social Networking* **13** (2010), 503-512.
- [7] R. Herrero, A. García-Palacios, D. Castilla, G. Molinari and C. Botella, Virtual reality for the induction of positive emotions in the treatment of fibromyalgia: a pilot study over acceptability,

- satisfaction, and the effect of virtual reality on mood, *Cyberpsychol Behav Soc Netw* **17** (2014), 379-384.
- [8] R.M. Baños, V. Liñao, C. Botella, M. Alcañiz, B. Guerrero and B. Rey, Changing Induced Moods Via Virtual Reality, in: *Persuasive Technology*, W.A. Ijsselsteijn, Y. de Kort, C. Midden, B. Eggen and E. van den Hoven, Lecture Notes in Computer Science, Springer, Berlin and New York, 2006, 7-15.
- [9] G. Riva, F. Mantovani, C.S. Capideville, A. Preziosa, F. Morganti, D. Villani, A. Gaggioli, C. Botella and M. Alcañiz, Affective Interactions Using Virtual Reality: The Link between Presence and Emotions, *CyberPsychology & Behavior* **10** (2007), 45-56.
- [10] D. Villani, F. Riva and G. Riva, New technologies for relaxation: The role of presence, *International Journal of Stress Management* **14** (2007), 260-274.
- [11] C. Kirschbaum, K.-M. Pirke and D.H. Hellhammer, The 'Trier Social Stress Test': A Tool for Investigating Psychobiological Stress Responses in a Laboratory Setting, *Neuropsychobiology* **28** (1993), 76-81.
- [12] O. Kelly, K. Matheson, A. Martinez, Z. Merali and H. Anisman, Psychosocial stress evoked by a virtual audience: Relation to neuroendocrine activity, *CyberPsychology & Behavior* **10**(2007), 655-662.
- [13] C.D. Spielberger, R.L. Gorsuch and R.E. Lushene, Manual for the state-trait anxiety inventory, *Consulting Psychologists Press*, Palo Alto, CA, 1970.
- [14] D. Watson, L.A. Clark and A. Tellegen, Development and validation of brief measures of positive and negative affect: The PANAS scales, *J Pers Soc Psychol* **54** (1988), 1063-1070.
- [15] T.W. Schubert, F. Friedmann and H.T. Regenbrecht, Decomposing the sense of presence: Factor analytic insights, in: *2nd international workshop on presence*, Vol. 1999, 1999.
- [16] W.A. Ijsselsteijn, Y.A.W. de Kort and K. Poels, The Game Experience Questionnaire: Development of a self-report measure to assess the psychological impact of digital games. Manuscript., 2013.
- [17] H.G. Hoffman, J.N. Doctor, D.R. Patterson, G.J. Carrougher and T.A. Furness III, Virtual reality as an adjunctive pain control during burn wound care in adolescent patients, *Pain* **85** (2000), 305-309.

# Using the Virtual Multitasking Test to Assess the Realization of Intentions: A Preliminary Psychometric Study

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**Abstract.** Prospective Memory (PM) corresponds to the management of a set of cognitive functions responsible of our ability to remember to carry out an intended action at a specific time in the future. Some researchers have shown that elderly participants, particularly those with Alzheimer's disease (AD), have lower performance in PM tasks compared to control subjects. Therefore, PM is sensitive to aging and generally impaired in individuals with AD. Since many everyday life activities require good PM abilities, it is important to measure them in an ecological manner. For this, the virtual reality (VR) technology seems to reproduce adequately day-to-day living in a realistic way. **Objective:** The main aim of this study is to show the preliminary psychometric data obtained from the Virtual Multitasking Test (VMT) with sample healthy adults. **Method:** In this study, 63 participants were recruited on a voluntary basis. After having administered them a set of neuropsychological tests designed to assess PM in a traditional way, participants were immersed in the virtual environment to realize a set of ongoing and PM tasks. **Results:** The VMT appears to be a valid measure of PM. The PM tasks implanted in the VMT are interesting due to the presence of complex tasks that evaluate both PM and participants' adaptation during unexpected events. Unfortunately, the scale composed of three types of recall have to be developed again to be more consistent. **Conclusions:** In our previous work, we found that healthy elderly people, compared to younger, were slower, presented more cybersickness and did not navigate as well in the VE, especially when they wear a head-mounted display. Therefore, it will be essential to identify variables that are age specific and variables that are specific to the use of technology to have a really good ecological assessment of PM using a virtual environment.

**Keywords.** Virtual Reality, psychometrics, prospective memory, cognitive assessment

## 1.Introduction

Prospective memory (PM) is defined as the capacity to remember to perform an intended action in the future [1, 2]. To design a valid PM task in an ecological perspective, several theoretical considerations are required. First, it is very important that the individual be fully committed in another activity [3], named the ongoing task. In fact, the participant must have the possibility to forget or to put away the intention (PM component) to be concentrated on another activity, ideally an instrumental activity of daily living (iADL). If not, the intention is conserved into the working memory and

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then, it is impossible to assess PM. The ongoing task: a) should be adequately demanding, in terms of attentional resources, to influence the cognitive load, b) must be interrupted to realize the intention and c) resumed after that to continue the goal-oriented behaviour and finish the task. Concerning the PM task imbedded into the ongoing task, three types of recall have been previously described in the literature[4]: 1) the Event-based PM task assume that remembering an intention is based on a cue (event) present at the right time in the environment, for example, remembering to deliver a specific message the next time you see a friend; 2) the Time-based PM task is seen as more difficult because it consists of self-monitors the passage of time such as to remember to recall a friend at 4:30 PM exactly; 3) finally, Activity-based PM task, a less studied form of PM recall, is based on an activity and consists of recalling the intention while doing another task such as turning off the cooker after meal preparation.

PM is an important cognitive function in the neuropsychological field because it could be a good predictor of everyday abilities. It could also be useful to detect subtle cognitive change with aging [5]. Because of the importance of PM in the realization of iADL and because PM contributes to the security and the socialization of the person [6, 7, 8], it becomes very important to develop an ecological manner to assess PM with a verisimilar ecological approach. This is a way to be complementary to the traditional approaches of neuropsychological assessment. To reach this goal, virtual reality (VR) seems to be a very appropriate tool. Because VR can reproduce the everyday life in a laboratory condition (assuming standardization, constancy in data collection, etc.), some researchers begin to exploit new technologies for neuropsychological assessment.

The main goal of this study is to design and validate an ecological assessment tool for PM using a virtual apartment. The PM tasks were designed on a verisimilar approach (i.e. to reproduce instrumental activities of everyday life).

## 2.Method

### 2.1 Participants

Sixty-three participants were recruited from the University of Montreal and from the University of Angers. Participants were excluded: a) if they were less than 18-year-old; b) if they were depressive or anxious; c) if they had neurological impairment such as a traumatic brain injury, epileptic disease, mild cognitive impairment, etc. For this experiment, 35 women (55.6% of the sample) and 28 men (44.4% of the sample) participated in the experimental protocol. Participants were aged in means of 38 years old ( $\pm 21.97$ ) and had, on average, 15.22 years of education ( $\pm 3.12$ ).

### 2.2 Instruments

To assess PM and episodic memory (EM), 2 neuropsychological tests have been used. The Cambridge Prospective Memory Test (CAMPROMPT) was designed to assess PM and gave 3 types of scores: Time-based, Event-based and Total Score. The Rivermead Behavioural Memory Test (RBMT), third edition, was used to assess general memory. RBMT have been designed to screen PM and Episodic memory (EM) deficits on an everyday life perspective. The RBMT gave two types of scores: Episodic memory and Event-based PM score.

After being exposed to VR, three questionnaires were administered to control for the existence of cybersickness (temporary side effects associated with VR and occurring during or after immersion) [simulator sickness questionnaire], for the sense

of presence (impression to be really there in the VE) [iPQ presence questionnaire] and for a possible rise of cognitive load when interacting with VE [NASA Task Load Index].

### 2.3 Apparatus

The virtual environment (VE) used in this research is the third version of the Virtual Multitasking Test (VMT) [9]. The VMT is a tool where different scenarios are implemented into a 6 ½ room virtual apartment, each room includes at least one task except the bathroom. At the beginning of the test, participants are told that they are visiting their best friend. During the day, he is at work and they must live in his apartment. In the evening, they will go to a show with their best friend. However, during the day, they must perform several tasks alone based on daily life.

The necessary equipment for the study was a computer with an nVidia graphic card, a flat screen, a keyboard for movement and mouse for gripping objects and to control head movement.

### 2.4 Experimental protocol

At the beginning, the experimenter put the participant in context: He/she was visiting a good friend that planned to attend a show in the evening. During the day, 3 ongoing tasks must be performed (make the dinner, a roasted chicken; set the table for 2 persons; storing groceries). Before starting the task, the participant was trained to interact in the VE and he/she was invited to learn the environment and to manipulate some objects in the apartment. After 5-10 minutes of training, the participant learned the ingredients list for the recipe (n=9) and step for its realization (n=4). After that, participant started the task for about 30 minutes.

During the realization of the 3 ongoing tasks, 6 PM tasks must be performed. The Time-based PM tasks consisted to fax a document (3 times each 5 minutes) and let the marinade rest for 5 minutes. The Event-based PM tasks consisted of remembering to put off quoted ingredients for the marinade during the activity “storing groceries” and to take the shirt out of the dryer when it rings. The Activity-based PM tasks were to preheat the oven before beginning the marinade and programming the oven for 1h30 before putting the chicken in. These 2 last tasks were 2 steps of the recipe’s preparation. Table 1 presents the scoring system the 3 PM type of recall. Finally, during ongoing and PM tasks realization, it had 3 interruptions planned during the experimentation: 2 different phone calls, one asking to feed a fish and the other asking to look for the tickets put on a table and a storm requiring the closure of some windows.

**Table 1.** Scoring system for Time-based, Activity-based and Event-based PM tasks in the VMT-3

Time-Based	Activity-Based	Event-Based
The moment where the fax was done: 4 :50 (before) to 5 :10 (after) the target time = 4 points.	Made the PM task at less 10 sec. after the end of the action = 4 points. 11 to 20 sec. = 3 points 21 to 30 sec. = 2 points 31 to 60 sec. = 1 point After 60 sec. = 0 point	The number of ingredients put away for cooking the roasted chicken = 9 points When the shirt is put on the bed after the dryer was ringing = 1 point
4 :40 to 4 :49 or 5 :11 to 5 :20 = 3 points		
4 :30 to 4 :39 or 5 :21 to 5 :30 = 2 points		
4 :00 to 4 :29 or 5 :31 to 6 :00 = 1 point		

before 4 :00 or after 6 :00  
= 0 point

### 3.Results

All analyses were performed with SPSS software. The variances were homogeneous, and the data were normally distributed. We used Pearson’s correlation with a 0.5 significance level to measure the test validity and reliability.

#### 3.1 Reliability exploration: Is the scale working?

Table 2 shows the correlations between PM score after completing the VMT tasks. The alpha coefficient of internal consistency is very weak ( $\alpha=0.50$ ) probably because the number of items is too low. The preliminary analysis of the correlation matrix revealed that all items from the PM score seem to contribute to the total score (Time-base + Event-based + Activity-based). We can think each score contribute to the total score, but Event-based PM task seem to be more weakly linked maybe because the way to compute performance is different compared to the other. Another interesting thing is that the correlation coefficients for each pair of comparison are very low ( $>0.30$ ). We can interpret this as a lack of homogeneity between the measures.

**Table 2.** Correlation between the PM score after the VMT experimentation

	AB_PMT	TB_PMT	EB_PMT	PM_tot
AB_PMT	1	0.29**	0.25*	0.73***
TB_PMT		1	0.25*	0.81***
EB_PMT			1	0.56***

AB = Activity-based; TB = Time-based; EB = Event-based; PMT = Prospective Memory Task; tot = total. \* $p \geq 0.05$ ; \*\* $p \geq 0.01$ ; \*\*\* $p \geq 0.001$

#### 3.2 Criterion validity analysis

When we analyze the correlations existing between PM tasks from the VMT and traditional assessment, we can see some interesting data. The first thing observed is the absence of correlation between Activity-based PM tasks and all variables that come from the standard neuropsychological assessment. The second observation is a correct validity coefficient concerning Time-based PM tasks from the VMT compared to the CAMPROMT Time-based sub score ( $r(63)=0,26$ ;  $p \geq 0,05$ ). The third observation is the correct correlation between Event-based PM tasks from the VMT and three Event-based indices from the RBMT-3 (Appointment [ $r(63)=0,29$ ;  $p \geq 0,01$ ]; Message immediate recall [ $r(63)=0,26$ ;  $p \geq 0,05$ ]; Total PM score [ $r(63)=0,30$ ;  $p \geq 0,01$ ]). To finish, the total PM score from the VMT is correlated to the appointment item from the RBMT-3 [ $r(63)=0,27$ ;  $p \geq 0,05$ ] and the total score – immediate recall for EM tasks from RBMT-3 [ $r(63)=0,25$ ;  $p \geq 0,05$ ].

### 4.Discussion

The main goal of this study was to explore the psychometric properties of a new scoring system to assess PM using the Virtual Multitasking Test-3.

Table 2 showed the correlations between the PM scores from the VMT. Even if all items seem to contribute to the total score, the coefficient of correlation is below 0.7 for

Event-based PM task indicating that this item distinguishes itself from the others. We think that this could be because the scoring system is different (see Table 1) compared to the other way of scoring. On the other hand, the low correlations between PM items could be explained by the fact that Time-based, Event-based and Activity-based are very different types of recall difficult to be compared to each other. As we said in the introduction, Event-based and Time-based PM tasks seem to be very different: Time-based retrieval could be more difficult to realize because the recall is self-generate and the action is self-initiated. We could then suppose a greater implication of executive functions. Event-based PM tasks, on the other hand seem to request more attentional and memory processes to monitor if the targeted cue is not in the environment. Only when the cue is present, can the participant perform the intended action. Another explanation, in a psychometric point of view, could be that we don't have enough items that assess PM for each subscale.

This study sustained the validity of both Time-based and Event-based PM tasks realized in the VMT. Indeed, these 2 tasks assess the capacity to remember to perform an action in the future based on time cues and event cues present in the environment. Activity-based PM tasks do not seem to be a valid measure at first look. So, two alternative explanations can be given: 1) from a methodological point of view, neither RBMT nor CAMPROMT include Activity-based score in their scale; with this observation, it becomes difficult to judge what Activity-based score really measures. 2) The second explanation, more theoretical, is that some authors didn't consider Activity-based PM Tasks as a PM component because the cue for the recall is too "Striking" [4]. The face validity, the scoring system and the manner with which participant interpret the task, should be reviewed.

To try to understand our results concerning the psychometric data presented above, we lead another analysis a posteriori. The central questions to perform these analyses were: 1) What is the main difference between traditional and VR assessment? 2) Could we suppose that some unconsidered variables can explain the results?

To answer the first question, our analysis of the previous version of the VMT showed that VR generates a rise of cognitive load particularly when using Human-Machine Interfaces [9]. The main differences between traditional testing and VR-based testing could be synthesized using some interaction techniques, navigation protocols in the VE and by making the nature of the task itself closer to the activity of daily living than the tasks implemented using traditional assessment, such as the CAMPROMPT or the RBMT. For the second question, maybe the cognitive load generated by the VR tasks are a way of explaining the results obtained in our criterion validity process. To explore this question, we have performed a correlational analysis by exploring the relation between PM tasks from the VMT, the cognitive load assessed by the NASA Task load index (NASA-TLX) and the cybersickness that could be experienced in the VE. Table 3 shows the results obtained.

**Table 3.** Correlation between the PM task from the VMT and assessment of cognitive load and cybersickness.

	TLX physical	TLX temps	TLX effort	TLX Performance	TLX frustration	TLX TOT	Cybersickness nausea	Cybersickness Oculomotor	Cybersickness tot
AB	0.37	-0.05	-0.12	-0.11	-0.16	-0.22	-0.08	-0.19	-0.15
TB	-0.13	-0.24	-0.41**	-0.40**	-0.19	-0.35**	-0.28*	-0.46**	-0.42**
EB	-0.26*	-0.17	-0.29*	-0.33**	-0.23	-0.36**	-0.38**	-0.30*	-0.40**
TOT	-0.33**	-0.22	-0.39**	-0.39**	-0.26*	-0.42**	-0.32**	-0.46**	-0.44**

AB = Activity-based; TB = Time-based; EB = Event-based; tot = total. \* $p \geq 0.05$ ; \*\* $p \geq 0.01$ ; \*\*\* $p \geq 0.001$

Table 3 suggests that Time-based and Event-based PM tasks are more effortful than the Activity-based PM task supporting the idea that these types of tasks are very easy to realize [4]. On the other hand, the Time-based PM task is demanding in terms of mental or sensory efforts (thinking, calculating, remembering, deciding, looking, and searching); at the end of the experimentation, participants expressed the sensation that performance was important in the task realization. It seems that the realization of the Time-based PM Task in the VE influenced the total workload. The way to realize the task (move, navigation, manipulation) seems to be linked to cybersickness (higher cybersickness leads to lower performance). For the Event-based PM task, the cognitive load seems to be linked to physical demand (refer to the manipulation of the object, for example using the ingredients to realize the recipe). Same as for the Time-based PM Task, effort, performance and total workload are rising when the participant realizes the Event-based PM task in the VMT; a similar profile seems also to exist for the cybersickness: the performance in the VMT (for EB and TB tasks) is significantly and negatively correlated to the cybersickness.

In conclusion, to develop an ecological PM assessment tool which adopts a verisimilar approach using VR is not so simple. Interaction and navigation techniques in the VE could affect the performance. But at the same time, the score could be more representative of the real-life performance. For instance, we can affirm, regarding previous studies, that the PM task from the VMT presents a good face value. Nevertheless, the concurrent validity can be improved by integrating measurement that is adapted to the VR technology. In fact, one thing still missing in the analysis is the concurrent ecological validity of the VMT. Indeed, we can hypothesize that VR technology is probably better than existing assessment procedures because this is more verisimilar than traditional protocols. But, on the other hand, to demonstrate that fact requires reproduction of the same complex setting in a real situation to compare it with VR testing.

Some studies conducted in our lab show some difficulties in assessing older people using VR. We observed that the accumulation of tasks to perform in the VE is a greater challenge for the elderly in terms of requested cognitive resources. It was visible that the level of stress increased during the immersion, in most cases due to navigational and manipulation difficulties in the VE. With those results, it's easy to know that the assessment of pathological aging is impossible for now. The results suggest the need to fine-tune the scoring system to obtain a more sensitive and valid measure for PM, perhaps by including several aspects unique to the VR technologies.

## References

- [1] G. O. Einstein, & M.A. McDaniel, Normal aging and prospective memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, **16**(1990), 717.
- [2] J. Ellis. Prospective memory or the realization of delayed intentions: A conceptual framework for research. *Prospective memory: Theory and applications*, 1-22, 1996
- [3] M. A. McDaniel, & O. G. Einstein. Strategic and automatic processes in prospective memory retrieval: A multiprocess framework. *Applied Cognitive Psychology*, **14** (2000) S127-S144.
- [4] L. Kvavilashvili, & J. Ellis. Varieties of intention: Some distinctions and classifications. In M. Brandimonte, G. O. Einstein, & M. A. McDaniel (Eds.), *Prospective memory: Theory and applications*, (pp. 23-51). Mahwah, NJ: Lawrence Erlbaum Associates Publishers. 1996

- [5] L. Kvavilashvili, D. E. Kornbrot, V. Mash, J. Cockburn, & A. Milne. Differential effects of age on prospective and retrospective memory tasks in young, young-old, and old-old adults. *Memory*, **17**(2009), 180-196.
- [6] Costa, R. Perri, L. Serra, F. Barban, I. Gatto, S. Zabberoni, .. G. A.. Carlesimo. Prospective memory functioning in mild cognitive impairment. *Neuropsychology*, **24**(2010), 327.
- [7] G. Lecouvey, J. Gonneaud, F. Eustache, & B. Desgranges. Les apports de la réalité virtuelle en neuropsychologie : l'exemple de la mémoire prospective. *Revue de Neuropsychologie*, **4**(2012), 267-276.
- [8] M. A. McDaniel, O. G.Einstein, P. Rendell. The puzzle of inconsistent age-related declines in prospective memory: A multiprocess explanation. Kliegel- Matthias, ed. 141–160, 2008
- [9] F. Banville, J-F. Couture, J-F, E. Verhulst, J. Besnard, P. Richard, P. Allain. Using Virtual Reality to Assess the Elderly: The Impact of Human-Computer Interfaces on Cognition. HCI International 2017. Springer. 2017

# The Virtual Reality Working-Memory- Training Program (VR WORK M): Description of an Individualized, Integrated Program

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**Abstract.** Working memory (WM), which allows us to retain information in memory during a complex task, is a cognitive function that is crucial to daily life. It can be affected by several neurological conditions, such as traumatic brain injury or stroke. Numerous studies suggest that it is possible to resolve WM deficits using targeted rehabilitation programs. Virtual reality (VR) is an innovative technology that has proven to be valuable in the evaluation and rehabilitation of cognitive functions. It potentially optimizes cognitive stimulation in a safe environment and can help improve functional activities of daily living by replicating real-life scenarios. With that in mind, this article introduces the first VR-based WM rehabilitation program. The WM training program (Virtual Reality Working-Memory-Training program, VR-WORK-M) recreates a restaurant environment where participants must complete a WM task consisting in repeating a series of items heard via a headset. The goal is to train WM by simulating a business proposal presentation. The program contains several levels of difficulty resulting from the combination of four complexity factors: (1) the type of business concerned by the proposal (e.g., opening a bakery vs. opening a flower shop); (2) the number of items to repeat (4 vs. 5 vs. 6); (3) the number of subtasks to complete before the WM task (e.g., introducing oneself vs order a drink); and (4) the modality of distractors (e.g., an auditory distractor vs. a visual distractor). VR-WORK-M includes 54 levels of difficulty to be administered in a training program over a period of four weeks, with four or five sessions per week.

**Keywords.** Working memory, attentional control, training, virtual reality

## 1. Introduction

Virtual reality (VR) is an innovative technology that has proven to be a valuable tool in the evaluation and rehabilitation of cognitive functions, such as visual attention and short-term visuospatial memory [1]. Immersed in familiar environments that closely resemble real life, users are able to experience various sensory settings and perform different activities securely and measurably. VR has been used both to diagnose and treat cognitive impairment. VR technology is proposed as a new rehabilitation tool with possible added value over traditional cognitive approaches [2, 3, 4]. Advantages of VR use include the provision a safe and more ecological

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environment than paper-and-pencil test, while maintaining control over the stimuli presented [5]. In the case of rehabilitation following brain injury, VR can potentially

allow the creation of personalized, enriched environments that can stimulate neuroplasticity [6]. It potentially optimizes cognitive stimulation in a safe place and can help improve functional activities of daily living by replicating real-life scenarios [7, 8]. The use of VR in cognitive rehabilitation has been increasing, and several virtual environments reproducing situations of daily life have been developed for neuropsychological use (e.g., virtual apartments [9], supermarkets [10; 11; 12], or classrooms [13]) to stimulate cognitive function and improve certain cognitive disorders. Nonetheless, to our knowledge, there is currently no program specifically designed to investigate the use of VR-based rehabilitation targeting working memory (WM), that is, the capacity to temporarily hold information in memory while performing another activity. After reviewing the few studies that have dealt with WM training in a VR context, this article describes a new tool to improve WM: the virtual reality working-memory-training program.

## **2. Cognitive revalidation and working memory training**

The concept of WM assumes that a dedicated system maintains and stores information in the short term, and that this system underlies human thought processes. Current views of WM involve a central executive that mediates the flow of information to and from its two slave storage systems: the phonological loop and the visuospatial sketchpad [14; 15; 16]. The model also includes an episodic buffer that interfaces between the short-term memory and long-term memory subsystems. Traditionally, WM capacity had been viewed as an immutable attribute until recent studies showed that improvement could be achieved through flexible training delivered over an extended period of time. To measure changes that have taken place as a result of cognitive training, the degree to which performance on trained tasks transfers to external non-trained tasks is evaluated.

Several paradigms have been developed to assess WM abilities. The complex span paradigm is a well-established one. In this paradigm, the participant is asked to briefly remember a list of stimuli after a secondary task has been added. The paradigm combines short-term storage and processing, which is what defines WM [17]. This type of protocol allows one to train and improve not only WM but also inhibition, reading comprehension, and reasoning [18]. Such training has been found to result in changes to brain activity in the frontal and parietal cortices and the basal ganglia, as well as in dopamine receptor density [12,17]. When the effects of training are subsequently transferred to non-trained WM tasks, it can be said that training-induced plasticity has been induced in a common WM neural network. The positive effects that have been observed point to WM training as a potential rehabilitative intervention for people whose performance in daily life is negatively impacted by low WM capacity [19]. It seems that different training techniques will generate improvements in a wide range of cognitive abilities since they focus on domain-general WM mechanisms. The results of individual studies suggest a favorable outlook for WM training as a valuable tool in overall cognitive enhancement [20]. +

However, these protocols are not very ecological and do not really allow for the replication of challenging daily life situations faced by patients. For example, patients often complain of difficulty concentrating while driving, forgetting what is on the grocery list, difficulty concentrating at work, etc. To deal with the limited ecological validity of experimental protocols, VR technology is proposed as a rehabilitation tool with possible added value over traditional cognitive approaches [21, 22, 23]. It can potentially optimize cognitive stimulation in a safe environment and help improve functional activities of daily living by replicating real-life scenarios [24, 25, 26, 27].

### **3. The virtual reality working-memory-training program (VR-WORK-M): a new personalized intervention program**

The concept underlying VR intervention as a training method for cognitive dysfunctions such as impaired WM is to improve the brain's neuroplasticity by engaging participants in multisensory training. VR is increasingly used in the field of clinical neuroscience. After being applied to evaluate attention, executive function, and memory, VR has begun to be used in the rehabilitation of these cognitive functions.

We propose a new tool to improve working memory performance, the virtual reality working-memory-training program (VR-WORK-M). This program recreates a restaurant environment where participants complete a WM task, which consists in the repetition of a series of items heard through headphones (see Figure 1).



**Figure 1.** Virtual environment in VR-WORK-M

The scenario proposes that the participant is making a business pitch to another person in the restaurant. Although such a task may not apply to all ages and career profiles, it represents a practical and simple generic situation where the user has to share ideas with another person. The WM task in VR-WORK-M is based on the Brown-Peterson [28] and complex span paradigms, which involve both storing and processing information, unlike the free recall paradigm, which deals with storage only and is measured by simple span [29]. Specifically, the Brown-Peterson technique was designed to measure the effects of both interference and delay on short-term memory performance. Typically, participants are instructed to recall a few items after variable delays during which an interference task must be performed (e.g., mental addition, repetition of numbers, counting backward). The complex span paradigm involves introducing a delay before and/or after the presentation of each item to be recalled. During this delay, a processing task must be executed. VR-WORK-M is based on the stimulation and training of the phonological loop, which comprises a phonological

store that can retain mnemonic traces for a couple of seconds, and an articulatory rehearsal process that can preserve the traces longer. This cognitive subsystem’s capacity is limited because the articulatory process takes place in real time; thus, when the number of items to rehearse increases, the first item is forgotten before there is time to rehearse it. The information contained in this subsystem is both speech-based and acoustic. VR-WORK-M includes 18 training sessions over four weeks. During each session of immersive WM training, the participant must complete three levels of the program (see the schedule in Table 1). To advance in the program and proceed to the next level, the participant must complete between 75% and 85% of the WM task items.

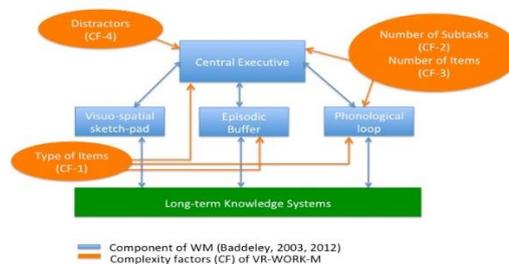
**Table 1.** Training schedule of VR-WORK-M program. Saturday and Sunday are rest days

	Day 1 Monday	Day 2 Tuesday	Day 3 Wednesday	Day 4 Thursday	Day 5 Friday
Week 1	<u>Neuropsychological Evaluation</u>	Training Session 1 (Levels 1, 2, 3)	Training Session 2 (Levels 4, 5, 6)	Training Session 3 (Levels 7, 8, 9)	Training Session 4 (Levels 10, 11, 12)
Week 2	Training Session 5 (Levels 13, 14, 15)	Training Session 6 (Levels 16, 17, 18)	Training Session 7 (Levels 19, 20, 21)	Training Session 8 (Levels 22, 23, 24)	Training Session 9 (Levels 25, 26, 27)
Week 3	Training Session 10 (Levels 28, 29, 30)	Training Session 11 (Levels 31, 32, 33)	Training Session 12 (Levels 34, 35, 36)	Training Session 13 (Levels 37, 38, 39)	Training Session 14 (Levels 40, 41, 42)
Week 4	Training Session 15 (Levels 43, 44, 45)	Training Session 16 (Levels 46, 47, 48)	Training Session 17 (Levels 49, 50, 51)	Training Session 18 (Levels 52, 53, 54)	<u>Neuropsychological Evaluation</u>

### 3.1 The program’s complexity factors (CF)

Four complexity factors were combined to create 54 levels for the WM task (see Table 2 for examples of the first six levels of the program).

**(CF-1) The type of item in the WM task:** Items may be frequent in the restaurant context (e.g., pie) or rare (e.g., petunia) or conceptual (e.g., time management). Word frequency was verified using the Lexique database [30]. Manipulating the difficulty of the items in the task allows WM to be stimulated and trained. Since the items become more complex, maintaining them in WM simultaneously challenges several components of WM (i.e., buffer, central executive and phonological loop; see Figure 2).



**Figure 2.** Modulation of the components of WM by the complexity factors of VR-WORK-M.

**(CF-2) The number of items in the WM task:** Participants may hear 4 items (e.g., (1) We want to open a bakery. (2) We want to offer the following items: (3) croissants and (4) chocolate croissants.) or 5 items (e.g., (1) We want to open a bakery. (2) We want to offer the following items: (3) croissants, (4) chocolate croissants and (5) cookies.) or 6 items (e.g., (1) We want to open a bakery. (2) We want to offer the following items: (3) croissants, (4) chocolate croissants, (5) cookies and (6) pies.). Increasing the number of items to repeat increases the cognitive load and challenges the phonological loop and central executive of WM.

**(CF-3) The number of subtasks before the business presentation is repeated:** In addition to the business proposal items to be repeated, participants may perform 2 subtasks (introduce oneself + thank the colleague) or 3 subtasks (introduce oneself + order a drink and a meal + thank the colleague). Increasing the number of subtasks between the time when participants hear the items to repeat and the point when they must repeat them allows WM to be trained by increasing the demand for attentional resources, challenging the phonological loop and central executive.

**(CF-4) The number of distractors before the business presentation is repeated:** The distractors are added to interfere with the maintenance of the items in WM. There are both auditory and visual distractors. Auditory distractors are a falling platter, a breaking glass, a closing door, a car accident and a nearby server singing Happy Birthday. The visual distractor is someone tripping and falling as he walks by the table. Increasing the number of distractions between the time when participants hear the items to repeat and the time when they must repeat them allows WM to be stimulated and trained by adding distractions that can interfere with the WM task. This will interfere with the participant's attention, which is important in WM. The central executive needs to distribute these resources and will therefore be stimulated.

**Table 2.** Examples of the first six levels of the program

<p><b>Level 1</b></p> <ul style="list-style-type: none"> <li>• Participant hears instructions (black screen)</li> <li>• Restaurant environment fades in</li> <li>• Phone rings/ participant hears business presentation/ caller hangs up</li> <li>• Colleague invites participant to start presentation</li> <li>• Participant repeats business presentation</li> <li>• Screen fades to black</li> </ul>	<p><b>Level 2</b></p> <ul style="list-style-type: none"> <li>• Participant hears instructions (black screen)</li> <li>• Restaurant environment fades in</li> <li>• Phone rings/ participant hears business presentation/ caller hangs up</li> <li>• Colleague invites participant to start presentation</li> <li>• Auditory distractor (door opens)</li> <li>• Participant repeats business presentation</li> <li>• Screen fades to black</li> </ul>
<p><b>Level 3</b></p> <ul style="list-style-type: none"> <li>• Participant hears instructions (black screen)</li> <li>• Restaurant environment fades in</li> </ul>	<p><b>Level 4</b></p> <ul style="list-style-type: none"> <li>• Participant hears instructions (black screen)</li> <li>• Restaurant environment fades in</li> </ul>

<ul style="list-style-type: none"> <li>• Phone rings/ participant hears business presentation/ caller hangs up</li> <li>• Subtask (participant presents himself/herself to colleague)</li> <li>• Auditory distractor (platter falls)</li> <li>• Colleague invites participant to start presentation</li> <li>• Participant repeats business presentation</li> <li>• Screen fades to black</li> </ul>	<ul style="list-style-type: none"> <li>• Phone rings/ participant hears business presentation/ caller hangs up</li> <li>• Auditory distractor (glass breaks)</li> <li>• Subtask (participant presents himself/herself to colleague)</li> <li>• Auditory distractor (door closes)</li> <li>• Colleague invites participant to start presentation</li> <li>• Participant repeats business presentation</li> <li>• Screen fades to black</li> </ul>
<p><b>Level 5</b></p> <ul style="list-style-type: none"> <li>• Participant hears instructions (black screen)</li> <li>• Restaurant environment fades in</li> <li>• Phone rings/ participant hears business presentation/ caller hangs up</li> <li>• Subtask (participant presents himself/herself to colleague)</li> <li>• Server arrives</li> <li>• Subtask (participant orders coffee)</li> <li>• Server leaves</li> <li>• Auditory distractor (car accident outside)</li> <li>• Colleague invites participant to start presentation</li> <li>• Participant repeats business presentation</li> <li>• Screen fades to black</li> </ul>	<p><b>Level 6</b></p> <ul style="list-style-type: none"> <li>• Participant hears instructions (black screen)</li> <li>• Restaurant environment fades in</li> <li>• Phone rings/ participant hears business presentation</li> <li>• While on phone, participant hears an extension to repeat</li> <li>• Subtask (participant repeats extension)</li> <li>• Caller hangs up</li> <li>• Auditory distractor (server sings Happy Birthday)</li> <li>• Subtask (participant presents himself/herself to colleague)</li> <li>• Visual distractor (person falls while passing table)</li> <li>• Colleague invites participant to start presentation</li> <li>• Participant repeats business presentation</li> <li>• Screen fades to black</li> </ul>

### 3.2 Variables that can be measured with the VR-WORK-M

Several measures are collected and three indexes can be calculated to test the impact of the complexity of the factor across the program. The participant success rate (PSR) can be calculated for the six levels that are the most representative of the program (levels 1, 11, 27, 34, 38 and 54). The PSR is the number of items correctly repeated converted into a percentage

$$\left( \frac{I_c}{I_t} * 100; I_c = \text{the number of correctly repeated items and } I_t = \text{the total number of items} \right)$$

). This will allow for the comparison of these levels. We expect PSR to decrease as the levels advance (PSRlevel 1 > PSRlevel 11 > PSRlevel 27 > PSRlevel 34 > PSRlevel 38 > PSRlevel 54). The level success index (LSI) measures the number of participants who succeed at each level ( $LSI = \sum n_R$ ;  $n_R$  = the number of participants who succeeded; e.g., for a certain level, if 6 participants succeed and 14 fail, the LSI for that level is 6). LSI is expected to decrease as the type of item in the WM task becomes more complex, as the number of items in the task increases, and as the numbers of subtasks and distractors increase. The index of difficulty (ID) measures the proportion of participants who succeed at each level ( $ID = \frac{\sum n_R}{n_t}$ ;  $n_t$  = total number of participants; e.g., if 20 participants try the level ( $n_t = 20$ ) and 19 succeed,  $ID = 19/20$ ). We expect ID to decrease across the 54 levels

#### 4. Conclusion and perspectives

This article describes a VR-based WM revalidation program. This program, which recreates a restaurant environment in which participants must complete a WM task by repeating the details of a business project, is designed to help individuals with WM disorders to return to work. Monitoring the impact of VR therapy using the VR-WORK-M with neuroimaging is the next promising step [31] that is underway in our lab, in addition to a formal validation of the tool. A practical approach to studying experience-dependent neuroplasticity in humans is to investigate longitudinal changes in brain structure or function following exposure to training. When combined with neuroimaging, VR training becomes a highly customizable experience that can be tailored to match its users' deficits or newly developed strengths. Sophisticated imaging techniques such as functional magnetic resonance imaging (fMRI) and functional near-infrared spectroscopy (fNIRS) not only permit precise mapping of activated brain regions but also allow for a detailed analysis of how activation levels change over the course of a VR training program. Whether VR is used to adapt the difficulty level in real time or to modulate training over a longer period, when it is combined with neuroimaging, a neurorehabilitation program can be individually optimized to reflect the naturally unique pattern in which each patient with a brain lesion is affected by the trauma

#### References

- [1] H. Shin, & K. Kim Virtual reality for cognitive rehabilitation after brain injury: a systematic review. *Journal of Physical Therapy Science*, **27**(2015), 2999-3002.
- [2] S. V. Adamovich, G. G. Fluet, E. Tunik, & A. S. Merians, (2009). Sensorimotor training in virtual reality: a review. *NeuroRehabilitation*, **25**(2009), 29-44.
- [3] M. Chrétien, I. Giroux, C. Jacques, S. & Bouchard. Using Virtual Reality to Elicit Dysfunctional Thoughts in Individuals With Gambling Disorder. *Journal of Gambling Issues*, **38** (2018)<http://dx.doi.org/10.4309/jgi.v0i38.3999>.
- [4] M. Chrétien, I. Giroux, A. Goulet, C. Jacques, S. Bouchard. Cognitive restructuring of gambling-related thoughts: A systematic review. *Addictive Behaviors*, **75** (2017) 108-121.
- [5] C. J. Bohil, B. Alicea, & F. A. Biocca. Virtual reality in neuroscience research and therapy. *Nature Reviews Neuroscience*, **12** (2011) 752-762.
- [6] M. F. Levin Can virtual reality offer enriched environments for rehabilitation? *Expert Review of Neurotherapeutics*, **11**(2011), 153-155.
- [7] S. Yeh, S. Lee, R. Chan, S. Chen, A. Rizzo. A virtual reality system integrated with robot-assisted haptics to simulate pinch-grip task: Motor ingredients for the assessment in chronic stroke. *NeuroRehabilitation*, **35**(2014), 435-449.
- [8] M. R. Kandalaf, N. Didehbani, D. C. Krawczyk, T.T. Allen, & S.B. Chapman. Virtual Reality SocialCognition Training for Young Adults with High-Functioning Autism. *Journal of Autism and Developmental Disorders*, **43**(2013), 34-44.
- [9] F. Banville, & P. Nolin. Using Virtual Reality to Assess Prospective Memory and Executive Functions After Traumatic Brain Injury. *Journal of CyberTherapy & Rehabilitation* **5**(2012), 45-55.
- [10] G. G. Fluet, & J. E. Deutsch. Virtual Reality for Sensorimotor Rehabilitation Post-Stroke: The Promise and Current State of the Field. *Current Physical Medicine and Rehabilitation Reports*, **1**(2013), 9-20.
- [11] É. Ouellet, B. Boller, N. Corriveau-Lecavalier, S. Cloutier, & S. Belleville. The Virtual Shop: A new immersive virtual reality environment and scenario for the assessment of everyday memory. *Journal of neuroscience methods*, **303** (2018), 126-135.
- [12] N. Corriveau Lecavalier, É. Ouellet, B. Boller, S. & Belleville. Use of immersive virtual reality to assess episodic memory: A validation study in older adults. *Neuropsychological rehabilitation*, (2018) 1-19.

- [13] S. Bioulac, S. Lallemand, A. Rizzo, P. Philip, C. Fabrigoule & M.P. Bouvard. Impact of time on task on ADHD patient's performances in a virtual classroom. *European Journal of Paediatric Neurology*, **16**(2012), 514-521.
- [14] A. D. Baddeley. Is working memory still working? *European Psychologist*, **7**(2002), 85.
- [15] A. D. Baddeley. Working Memory: Looking Back and Looking Forward. *Nature Reviews Neuroscience*, **4**(2003), 829.
- [16] A. D. Baddeley. Working Memory: Theories, Models, and Controversies. *Annual Review of Psychology*, **63** (2012) 1-29.
- [17] F. Schmiedek, A. Hilderbrandt, M. Lövdén, O. Wilhelm, U. Lindenberger. Complex span versus updating tasks of working memory: The gap is not that deep. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, **35**(2009), 1089-1096.
- [18] C. C. von Bastian, & K. Oberauer. Effects and mechanisms of working memory training: a review. *Psychological Research*, **78**(2014), 803-820.
- [19] T. Klingberg. Training and plasticity of working memory. *Trends in Cognitive Sciences*, **14**(2010), 317-324.
- [20] [20] A. B. Morrison, & J. M. Chein, (2011). Does working memory training work? The promise and challenges of enhancing cognition by training working memory. *Psychonomic Bulletin & Review*, **18**(2011), 46-60.
- [21] ] A. "S." Rizzo, S.T. Koenig (2017). Is clinical virtual reality ready for primetime? *Neuropsychology*, **31**(2017), 877-899.
- [22] U. Diaz-Orueta, B. Lizarazu, G. Climent, & F. Banterla. Virtual Reality for Neuropsychological Assessment. In Ma M., Jain L., Anderson P. (eds) *Virtual, Augmented Reality and Serious Games for Healthcare 1*. Intelligent Systems Reference Library, vol 68. Springer, Berlin, Heidelberg, 2014
- [23] L. R. Valmaggia, L. Latif, M.J. Kempton, & M. Rus-Calafell, (2016). Virtual reality in the psychological treatment for mental health problems: An systematic review of recent evidence. *Psychiatry Research*, **236** (2016) 189-195.
- [24] Corbetta, D., Imeri, F., & Gatti, R. (2015). Rehabilitation that incorporates virtual reality is more effective than standard rehabilitation for improving walking speed, balance and mobility after stroke: a systematic review. *Journal of Physiotherapy*, **61**(3), 117-124.
- [25] H. Coyle, V. Traynor, & N. Solowij, (2015). Computerized and Virtual Reality Cognitive Training for Individuals at High Risk of Cognitive Decline: Systematic Review of the Literature. *The American Journal of Geriatric Psychiatry*, **23**(2015), 335-359.
- [26] A. Darekar, B. J. McFayden, A. Lamontagne, & J. Fung, (2015). Efficacy of virtual reality-based intervention on balance and mobility disorders post-stroke: a scoping review. *Journal of NeuroEngineering and Rehabilitation*, **12**(2015). <https://doi.org/10.1186/s12984-015-0035-3>.
- [27] T. D. Parsons (2015). Virtual Reality for Enhanced Ecological Validity and Experimental Control in the Clinical. *Affective and Social Neurosciences. Frontiers in Human Neuroscience*, **9** (2015) 660.
- [28] J. Brown. Some tests of the decay theory of immediate memory. *Quarterly Journal of Experimental Psychology*, **10**(1958), 12-21.
- [29] G. Mora, Les mécanismes de maintien de l'information verbal en mémoire de travail. (Doctoral dissertation). Retrieved from Theses.fr (Accession No. 2011DIJOL002), 2011
- [30] B. New, C. Pallier, M. Brysbaert, & L. Ferrand (2004). Lexique 2: A new French lexical database. *Behavior Research Methods, Instruments, & Computers*, **36**(2004), 516-524.
- [31] W. P. Teo, M. Muthalib, S. Yamin, A.M. Hendy, K. Bramstedt, E. Kotsopoulos, ... & H. Ayaz (2016). Does a combination of virtual reality, neuromodulation and neuroimaging provide a comprehensive platform for neurerehabilitation? – A narrative review of the literature. *Frontiers in Human Neuroscience*, **10** (2016) 284.

## SECTION V

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### 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 un-pleasant 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*



# Embodiment in different size virtual bodies produces changes in women's body image distortion and dissatisfaction

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**Introduction:** Body image disturbance is considered a pervasive issue among women and is a core feature of eating disorders. Previous research provides evidence of the ability of body ownership illusions in virtual reality to produce changes in one's own body representation, especially in body size estimation. However, less information is available about changes in subjective body attitudes. This study assesses whether owning a female virtual avatar with different body sizes produces changes in body image distortion and body image dissatisfaction in women. **Method:** Forty female college students were exposed to an immersive virtual environment, in which they were sequentially embodied in three avatars using synchronous visuo-tactile stimulation. The first and third avatar had the same body size as the participant, but the second one had a larger body size. In the larger avatar condition, the group was divided into two: 20 participants owned a virtual body 20% larger and the other twenty a virtual body 40% larger. Body image distortion and body image dissatisfaction were assessed before and after embodiment in each of the three avatars using a silhouette test. **Results:** Mixed between-within analyses of variance showed a statistically significant effect of the variable Time (four assessment points) on body image distortion ( $F(3, 38) = 2.825$ ,  $p = .042$ ,  $\eta^2 = 0.069$ ) and body image dissatisfaction ( $F(3, 38) = 6.933$ ,  $p < .001$ ,  $\eta^2 = 0.154$ ). The effect of the variable Group (20% increase versus 40% increase in the larger body size avatar) and the interaction between time and group were not statistically significant. Overall, participants reported a reduction in the body image overestimation after owning the same-size avatar for the second time ( $M = 8.88$ ,  $SD = 12.48$ ) than at the other assessment points (at pre-test:  $M = 13.00$ ,  $SD = 17.09$ ; after owning the first same-size virtual body:  $M = 13.75$ ,  $SD = 11.14$ ; and the larger size avatar:  $M = 14.50$ ,  $SD = 15.18$ ). In regards to body image dissatisfaction, the highest levels were recorded at pre-test ( $M = 16.38$ ,  $SD = 18.54$ ) and after owning the larger size avatar ( $M = 15.50$ ,  $SD = 19.57$ ) and lowest levels

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after owning the same-size avatar for the second time ( $M=6.88$ ,  $SD=13.85$ ). More interestingly, the reduction in body dissatisfaction after owning the same-size avatar for the second time compared with pre-test was statistically significant ( $F(1, 38)=18.098$ ,  $p<.001$ ,  $\eta^2=0.323$ ). **Conclusion:** This study extends the evidence available about the ability of full virtual body ownership illusions to modify the mental representation of one's own body. Owning a virtual body with different body sizes produces changes not only in size overestimation but also in body dissatisfaction; and, most importantly, inducing the ownership illusion of a larger-size virtual body reduces body dissatisfaction when subjects return to the same-size avatar, probably due to a comparison effect.

**Keywords:** virtual reality, body ownership illusion, visuo-tactile synchronization, body image distortion, body image dissatisfaction

## 1. Introduction

Body image disturbance (BID), including both body image distortion and body image dissatisfaction, is considered a pervasive issue among women [1, 2] and is a core feature of eating disorders [3] (ED). Therefore, addressing BID is considered a critical aspect for the prevention and treatment of ED [4]. Previous research suggests that the mental representation of body image can be updated, based on incoming multisensory information [5, 6]. Indeed, several studies have used body ownership illusions of a virtual body to manipulate the perception of one's own body image [7-9]. Full body ownership illusion is defined as the subjective experience in which individuals feel an artificial body to be their own body [10] and is produced when different types of information (visual, proprioceptive, haptic, etc.) are combined into a multisensory representation [11].

Several studies have shown that full body ownership illusion-based interventions produce changes in the perception of one's own body size and shape [8, 9, 11, 12]. Preston and Ehrsson [8], for instance, induced full body ownership illusion of a mannequin in a group of individuals. This mannequin could be slimmer or larger than the individual's body size. They found a significant reduction in perceived body size and an increase in body satisfaction after owning the slimmer mannequin body. Similarly, Serino et al. [11] found a decrease in participants' perceived body size after they were embodied in a skinny belly avatar. Similar results have been found in clinical samples. Keizer and colleagues [13] found that owning a healthy-size virtual body significantly decreased perceived body size in patients with anorexia nervosa (AN) as well as in non-clinical participants, and that this perceived body size reduction persisted two hours later.

The main objective of this study was to assess the ability of the virtual body ownership illusion to produce changes in both perceptual and attitudinal aspects of body image in a non-clinical sample of women. Participants were expected to show higher levels of body image distortion and dissatisfaction after owning a virtual body that was larger than their own body than after owning a virtual body with the same body size. The distortion and dissatisfaction were also expected to be greater with larger virtual body sizes.

## 2. Methods

### 2.1 Participants

Forty female college students with an age range from 18 to 42 ( $M=22.55$ ,  $SD= 4.02$ ) and a body image index (BMI) range from 16.6 to 28.49 ( $M=21.65$ ,  $SD=0.40$ ) participated in the study. According to the World Health Organization [14], 33 participants (82.5%) had healthy weight ( $18.5 \leq \text{BMI} \leq 25$ ), three (7.5%) were underweight and four (10%) were overweight. Self-reported current ED diagnosis was considered an exclusion criterion.

### 2.2 Procedure

The current study was approved by the research Ethics Committee of the University of Barcelona. After signing the informed consent document, participants provided demographic data and completed the Figure Drawing Scales for Body Image Assessment (BIAS-BD) [2]. The BIAS-BD is a silhouette test that assesses body image dissatisfaction (BIAS-O) and body image distortion (BIAS-X). BIAS-O is assessed by comparing the discrepancy between the perceived body size and the desired body size, and BIAS-X by the discrepancy between the perceived body size and the real body size. Participants were also measured and weighed to calculate their BMI. After completing the test battery, a whole body photograph of the participant was taken and then used to create an avatar with a silhouette similar to that of the participant. Then, participants were sequentially embodied in three avatars using synchronous visuo-tactile stimulation. The stimulation consisted in a series of touches to the participants' arms (during 15 seconds each one), abdomen (during 30 seconds), and legs (during 15 seconds each one) by the experimenter using one of the HTC-VIVE controllers, while the participants looked at themselves (i.e., first-person perspective) in the virtual environment being touched by a 3D virtual HTC-VIVE controller (during 90 seconds) and, then, to the avatar reflected in a mirror in front of them (i.e., third-person perspective) during 90 seconds.

The first and third avatar had the same body size as the participant, but the second avatar had a larger body size. In the larger avatar condition, the group was divided into two: 20 participants owned a virtual body 20% larger than themselves, and the other twenty a virtual body 40% larger. Virtual body ownership illusion was assessed, using a visual analogue scale from 0 to 100, after owning the real-size virtual body for the first time ( $M=56.98$ ,  $SD=22.62$ ), after owning the larger-size virtual body ( $M=53.50$ ,  $SD=21.28$ ) and after owning the real-size virtual body for the second time ( $M=50.75$ ,  $SD=23.47$ ). No significant differences were found between the three measures ( $F_{1,7,66,9}=2.003$ ,  $p=.149$ ,  $\eta^2=.049$ ). Body image distortion and body image dissatisfaction were also assessed after embodiment in each of the three avatars using the BIAS-BD.

### 2.3 Virtual setting

The virtual environment was a room without any furniture but with a large mirror on the front wall, where the participants could see their virtual body. The environment was displayed using a head mounted HTC-VIVE display connected to a computer with enough graphic power to move virtual environments. The avatars were developed using Blender 2.78v, and Unity 3D 5.5.v was used to integrate all the elements within the virtual environment.

### 2.4 Statistical Analyses

Mixed between-within analyses of variance were conducted, introducing the within participants' variable Time (four assessment points: at pre-test, after owning the real-size virtual body, after owning the larger-size virtual body, and after owning the real-size virtual body again) and the between participants' variable Group (20% larger-size virtual body versus 40% larger-size virtual body). Post hoc tests comparing the four assessment points were also conducted. Normality (Kolmogorov-Smirnov's test  $p > .05$ ), sphericity (Mauchly's test  $p > .05$ ) and homogeneity (Levene's test  $p > .05$ ) assumptions were checked.

### 3. Results

Mixed between-within analyses of variance showed a statistically significant main effect of the variable Time (four assessment points) on body image distortion and body image dissatisfaction (Table 1), with low and medium effect sizes respectively. In contrast, the main effect of the variable Group (20% increase versus 40% increase in the larger-size virtual body) and the interaction between Time and Group were not statistically significant.

**Table 1.** Main effects and interaction between the variables Time and Group in body image distortion and body image dissatisfaction.

	BIAS-X			BIAS-O		
	<i>F</i> (1,38)	<i>p</i>	$\eta^2$	<i>F</i> (1,38)	<i>p</i>	$\eta^2$
Time	<b>2.825</b>	<b>.042</b>	<b>.069</b>	<b>6.933</b>	<b>&lt;.001</b>	<b>.154</b>
Group	.816	.372	.021	1.462	.234	.037
Time x Group	.798	.377	.021	.369	.547	.010

Note: BIAS-X (Body image distortion), BIAS-O (Body image dissatisfaction).

As table 2 shows, participants as a whole reported a reduction in body image overestimation after owning the real-size virtual body for the second time as compared with the other assessment points (at pre-test, after owning the real-size virtual body for the first time, and after owning the larger-size avatar). On the other hand, although overestimation after owning the larger-size virtual body was slightly greater in 40% size increase group than in the 20% size increase group (Table 2), the differences did not reach statistical significance ( $t_{(38)} = -1.369$ ,  $p > .05$ ). As regards body image dissatisfaction, the highest levels were recorded at pre-test and after owning the larger-size virtual body, while the lowest were reported after owning the same-size virtual body for the second time. Again, differences between groups after owning the larger-size virtual body did not reach significance ( $t_{(38)} = -1.135$ ,  $p > .05$ ).

**Table 2.** Mean body image distortion and body image dissatisfaction at pre-test and through embodiment to the real-size virtual body for the first time, the larger-size virtual body (20% or 40% larger) and the real-size virtual body for the second time in group 1 ( $n=20$ , participants who embodied the 20% larger-size virtual body), group 2 ( $n=20$ , participants who embodied the 40% larger-size virtual body), and the whole sample ( $N=40$ ).

	Pre-test		Real-size virtual body 1		Larger-size virtual body		Real-size virtual body 2	
	Group 1 <i>M (SD)</i>	Group 2 <i>M (SD)</i>						
BIAS-X	11.50 (16.63)	14.50 (17.84)	13.75 (10.75)	13.75 (11.80)	11.25 (15.80)	17.75 (14.19)	7.00 (11.74)	10.75 (13.21)
Total N=40	13.00 (17.09)		13.75 (11.14)		14.50 (15.18)		8.88 (12.48)	
BIAS-O	12.50 (18.39)	20.25 (18.32)	10.25 (15.08)	14.50 (18.98)	12.00 (21.36)	19.00 (17.44)	5.00 (16.22)	8.75 (11.11)
Total N=40	16.38 (18.54)		12.37 (17.06)		15.50 (19.57)		6.88 (13.85)	

Note: BIAS-X (Body image distortion), BIAS-O (Body image dissatisfaction), *M* (Mean), *SD* (Standard deviation).

Post hoc within-subject contrast tests for the variable time (Table 3) showed significantly lower levels of body image distortion and body image dissatisfaction after owning the real-size virtual body for the second time than after owning the larger-size virtual body and after owning the real-size virtual body for the first time. Most importantly, the reduction in body dissatisfaction after owning the same-size avatar for the second time compared with pre-test levels was also statistically significant, with a large effect size (Table 3).

**Table 3.** Within-subject contrast tests for the variable Time.

Time	BIAS-X			BIAS-O		
	<i>F</i> (1,38)	<i>p</i>	$\eta^2$	<i>F</i> (1,38)	<i>p</i>	$\eta^2$
Pre-test vs real-size avatar 1	.117	.735	.003	2.633	.113	.435
Pre-test vs larger-size avatar	.612	.439	.016	.163	.689	.004
Pre-test vs real-size avatar 2	3.03	.09	.014	<b>18.098</b>	<b>&lt;.001</b>	<b>.323</b>
Real-size avatar 1 vs larger-size avatar	.136	.715	.004	2.031	.162	.051
Real-size avatar 1 vs real-size avatar 2	<b>8.057</b>	<b>.007</b>	<b>.175</b>	<b>5.548</b>	<b>.024</b>	<b>.127</b>
Larger-size avatar vs real-size avatar 2	<b>5.636</b>	<b>.023</b>	<b>.129</b>	<b>12.572</b>	<b>.001</b>	<b>.249</b>

Note: BIAS-X (Body image distortion), BIAS-O (Body image dissatisfaction).

#### 4. Discussion and conclusions

The main aim of this study was to assess whether embodiment in different size virtual bodies produced changes in the level of body image distortion and body image dissatisfaction in a non-clinical sample of women. As expected, participants showed higher levels of body image distortion and body image dissatisfaction after owning the larger-size virtual body than after owning the real-size one for the second time. These results are in line with previous research showing that the mental representation of body image is malleable [8,9,13] and may change according to emotional and situational contexts [15].

On the other hand, no significant differences were found between groups with regard to owning the real-size avatar for the first time and owning the larger-size one. Two related factors may help to explain these results. First, most participants (90%) had a healthy weight or were underweight. Consequently, it may be that even an increase of 40% did not lead to a substantially overweight figure. Second, as participants were from a non-clinical sample, a weight increase of 20 or 40% probably did not induce such an intense response as expected.

However, the most interesting finding in this study is the notable reduction in body image distortion and dissatisfaction after owning the real-size avatar for the second

time compared with the results after owning the real-size avatar for the first time and, in the case of body dissatisfaction, at pre-test. According to Keizer and colleagues [13], the mental representation of the body depends on input from multiple sensory modalities and, therefore, full body ownership illusions could be useful for reducing the misestimation of body size in ED patients. These authors found that body image distortion fell in both anorexia patients and healthy controls after owning a healthy-size virtual body [13]. The fact that, in our study, the reduction was higher after owning the second real-size avatar than after owning the first one is probably due to a comparison effect, since prior to owning the second real-size avatar they had owned the larger-size avatar. This study has several limitations that should be also considered. First, the sample was recruited among female college students and, consequently, results cannot be generalized to other populations. Second, no structured interview or screening test was administered to assess the presence of an ED. Finally, body mass index was not considered in this study. Future research should take into account possible differences between overweight, normal-weight and underweight participants, as well as gender differences. Despite these limitations, however, the study adds to the currently available evidence on the ability of full virtual body ownership illusions to modify the mental representation of one's own body, and provides added support for its use in body image disturbance treatment in eating and weight-related disorders.

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## References

- [1] S. K. Bearman, K. Presnell, E. Martinez, E. Stice, The skinny on body dissatisfaction: A longitudinal study of adolescent girls and boys. *Journal of Youth and Adolescence* **35** (2006), 229-241.
- [2] R.M. Gardner, L.M. Jappe, L. Gardner, Development and validation of a new figural drawing scale for body image assessment: the BIAS-BD, *Journal of Clinical Psychology* **65**(1) (2009), 113-122.
- [3] R.M. Gardner, D.L. Brown, Body size estimation in anorexia nervosa: a brief review of findings from 2003 through 2013. *Psychiatry Research* **219**(3) (2014), 407-410.
- [4] C. Farrell, R. Shafran, M. Lee. Empirically evaluated treatments for body image disturbance: A review. *European Eating Disorders Review* **14**(5) (2006), 289-300.
- [5] D. Banakou, R. Groten, M. Slater, Illusory ownership of a virtual child body causes overestimation of object sizes and implicit attitude changes, *Proceedings of the National Academy of Sciences* **110**(31) (2013), 12846-12851.
- [6] C. Preston, R. Newport, How long is your arm? Using multisensory illusions to modify body image from the third person perspective, *Perception* **41** (2012), 247-249.
- [7] Keizer, A. van Elburg, R. Helms, C. Dijkerman, A virtual reality full body illusion improves body image disturbance in anorexia nervosa, *PLoS ONE* **11** (2016), e0163921.
- [8] Preston, H.H. Ehrsson, Illusory changes in body size modulate body satisfaction in a way that is related to non-clinical eating disorder psychopathology, *PLoS ONE* **9** (2014), e85773.
- [9] I.V. Piryankova, H.Y. Wong, S.A. Linkenauger, C. Stinson, M.R. Longo, H.H. Bühlhoff, B.J. Mohler, Owning an overweight or underweight body: distinguishing the physical, experienced and virtual body, *PLoS ONE* **9** (2014), e103428.
- [10] Maselli, M. Slater, The building blocks of the full body ownership illusion. *Frontiers in human neuroscience* **7** (2013), doi.org/10.3389/fnhum.2013.00083.

- [11] S. Serino, E. Pedroli, A. Keizer, S. Triberti, A. Dakanalis, F. Pallavicini, A. Chirico, G. Riva, Virtual reality body swapping: a tool for modifying the allocentric memory of the body, *Cyberpsychology, Behavior, and Social Networking* **19** (2016), 127-133.
- [12] Preston, B.J. Kuper-Smith, H.H. Ehrsson, Owning the body in the mirror: the effect of visual perspective and mirror view on the full-body illusion, *Scientific reports* **5** (2015), 18345.
- [13] Keizer, A. van Elburg, R. Helms, H.C. Dijkerman, A virtual reality full body illusion improves body image disturbance in anorexia nervosa. *PloS one* **11**(10) (2016), e0163921.
- [14] World Health Organization (WHO), Body mass index, retrieved from <http://www.euro.who.int/en/health-topics/disease-prevention/nutrition/a-healthy-lifestyle/body-mass-index-bmi>, (2017, Mars 12)
- [15] M. Ferrer-Garcia, J. Gutiérrez-Maldonado, A. Caqueo-Urizar, E. Moreno. Body Image in Eating Disorders: The Influence of Exposure to Virtual-Reality Environments, *Cyberpsychology, Behavior, and Social Networking* **13**(5) (2010), 521-531.

# Assessing presence in videoconference telepsychotherapies: A complementary qualitative study on breaks in telepresence and intersubjectivity co-construction processes

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**Abstract.** Assessing the efficacy of online psychotherapies is an important issue in eHealth. In the present research, we used an innovative approach to focus on the characteristics of breaks in interactions that impact the acceptance of the psychotherapy setting of a telepsychotherapy delivered in videoconference. We also tried to build a method to assess if the level of telepresence in online interactions would be influenced by the acceptance of the psychotherapy setting. Sessions of psychotherapy delivered in videoconference to two adults receiving CBT and two others receiving psychodynamic psychotherapy were analyzed to test the method. In this paper, we describe the methodology and illustrate preliminary results. An interactional grid was used to analyze verbal and non-verbal interactions, physical and social presence, and breaks in acceptance of the telepsychotherapy setting. This led to observe the interactional process of construction of enonciative co-presence, fundamental to allow people to experience intersubjectivity. This study is the first step towards a better understanding of the level of acceptance of the technological setting by patients and its influence on the interactions between them and psychologists.

**Keywords.** Intersubjectivity, videoconference telepsychotherapy, telepresence, acceptance of psychotherapy setting.

## 1. Introduction

Assessing the efficacy of online psychotherapies is an important issue in telepsychology. Addressing treatment mechanisms and interactional dynamics of patient-psychotherapist relationship also deserve attention. Previous researches show that telepresence predicts the strength of the therapeutic relationship [1] and suggest that telepresence should predict intersubjectivity [2]. Our approach in this matter rests on three assumptions: (a) a double re-definition of the concept of intersubjectivity was needed: on a general level (intersubjectivity as “the ability to create an interaction with

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another one and to recognize him as a subject. Consequently, the person is able to feel what the other one is feeling, in particular the other one's suffering" [3]) and on an operational level (intersubjectivity as a "unique combination of the interlocutors' subjectivities created in a specific context at a given time and the process of creating a shared world for the subjects to act in") [4]; (b) the necessity of an exploration of the processes of co-construction of intersubjectivity in telepsychotherapy, conceived as a complex reality resulting from a number of different interactional and reciprocal processes occurring among patient and therapist in a given setting; (c) the definition of a specific approach on the methodological plan should be accompanied by a profound reflection on its epistemological implications.

As far as the epistemological dimension is concerned, our study could be defined as pluri-disciplinary and complementary. Pluri-disciplinary is defined by the use of concepts, methods and techniques coming from different disciplines, but also by a common goal within a unique macro-disciplinary field [5]. We set for a pluri-disciplinary approach of interactional dynamics in video telepsychotherapy because of the needs and interests of approaching concepts, methods and techniques coming from different disciplines (clinical psychology, cyberpsychology, social psychology of cyberplaces, and interlocutory logic). Effort is oriented towards a common goal within a unique macro-disciplinary field, the field of cyber-interaction in telepsychotherapy. The approach is complementary (in the sense of Devereux [6]) regarding the methodology because the disciplinary perspectives mentioned above are applied to our object at different moments.

The current project stems from a desire to explore the efficacy of psychotherapies delivered in videoconference using two different theoretical frameworks: cognitive-behavioral therapy [7], and psychodynamic [8]. In the first phase of our endeavor, we started researching interactional dynamics of patient-psychotherapist relationship in telepsychology, trying to describe the process of "the integration of interlocutors' contributions to the interactional accomplishment of what could (have) be(en) defined as 'the therapeutic project'" [9]. Our principal aims were to: (a) compare the two above mentioned theoretical frameworks; and (b) focus on telepresence as an indicator of intersubjectivity co-constructed online [9]. On the basis of a deep analysis of previous results, the goal of the current study is *to assess acceptance of the technological setting* by patients and its influence on the interactions between patients and psychologists. We assume that a low level of acceptance of the technological setting by patients would be related to a low level of telepresence. The methodology chosen for this purpose has been therefore conceived to explore if breaks in acceptance of the telepsychotherapy setting could produce a low level of telepresence and intersubjectivity, potentially leading to the interruption of the treatment, and if there are "communicational regularities" underlying these breaks.

On the basis of these premises, the long term goal of this study is to explore two research questions: (a) what are the characteristics of breaks in interactions that impact the acceptance of the setting of a telepsychotherapy in videoconference (RQ1), on the relational level (observation, discourse analysis) (RQ1.1) and on the interlocutory level (interlocutory logic) (RQ1.2); and (b) can we consider that the level of telepresence in online interactions would influence the acceptance of the setting of telepsychotherapies in videoconference (RQ2)? The analysis is still in process and the current paper focuses only on describing the method, with an example of its application and the presentation of an original case selected from a sample of two adults receiving CBT and two others

receiving psychodynamic telepsychotherapies, and on which the current method has been tested for feasibility and sensitivity.

The problem is approached from the phenomenology of breaks in acceptance of the therapeutic setting (i.e., psychotherapy delivered by videoconference), which are easier to identify than overall acceptance of psychotherapy. Acceptance involves factors that can vary based on various reasons (psychotherapeutic method, mental state of the patient, etc), whereas breaks or ruptures in acceptance of the therapeutic setting can be measured in session and are most likely to be caused by events occurring during the session.

## 2.Methods

The sample consists of four adults receiving telepsychotherapy, who were not suffering of a psychotic disorder and displayed breaks in acceptance of the setting in videoconference telepsychotherapy, with two participants receiving CBT and the other two receiving psychodynamic telepsychotherapies. All therapy sessions were video recorded and coded.

To individuate—describe and assess the phenomenology of breaks in acceptance of the setting and intersubjectivity co-construction processes—the procedure follows an observational stance (see Figure 1 with the general structure of the method, with levels of interaction, corpus, technique, and outputs of the analysis).

LEVEL OF INTERACTION	CORPUS	TECHNIQUE	OUTPUT
[A] 'Basic' (general) interaction	[A1] Structural videorecorded and transcribed telepsych-therapeutic session	Interaction analysis Observation tool Interactional Grid analysis Haddouk (2017) 1. Looking/tuning of the look 2. Hooking/detuning of the look 3. Verbal significant events 4. Non-verbal significant events 5. Tuning behaviors' directed towards...the setting	Individuation of interactional (structural) hints in critical subsequences
	[A2] Functional X critical subsequences	Interaction analysis 5 functions: 1. Amplification of the effects of actions... 2. Filter/selection of intentions 3. Segmentation (physical time) 4. Opening on patient's intimate psych. space 5. Opening on intermediate space between the therapist and the patient	Individuation of interactional (functional) dynamics of critical subsequences
[B] 'Acceptance of setting' related interaction	[B1] Structural social presence Y critical subsequences (P&S)	Interaction analysis Observation tool (hetero-evaluation) Items from Telepresence Scale - Bouchard and Robillard (2018) 1. Conversation seems natural 2. As if physically in presence 3. Impression of being in the same room 4. Participants reacting to the presence of each other 5. Participants actively participating to the conversation	Individuation of structural clues of social presence perception Hypothesis on the influence of social presence perception on the acceptance of the setting (cognitive level)
	[B2] Functional intersubjectivity Z critical subsequences (Z&V)	Interaction analysis Observation tool Colinbert (2011) 1. Definition and recognition of subjectivities 2. Rules of interaction definition 3. Objects definition 4. Rules of discourse definition	Individuation of functional clues of social presence consequences Hypothesis on the embodiment of acceptance of the setting actions oriented to intersubjectivity construction (pragmatic level)

Figure 1. Schematic display of the grid used to analyze the verbal and non-verbal interactions in telepsychotherapy.

As shown in Figure 1, the analysis of the video recorded session is articulated in two phases ([A] 'Basic' interaction and [B] 'Acceptance of setting' interaction), each of one composed of two sub-phases performed by an external and independent coder, ([A1] Structural-interactions, and [A2] Functional-interactions; [B1] Structural-social presence and [B2] Functional-intersubjectivity). The goal of phase [A] is to individuate some critical subsequences featured by interactional cues and describe their dynamics to detect communicational regularities – independent of the psychotherapeutic approach – featuring breaks in acceptance of the setting [9]. Analyzing the

subsequences individuated in phase [A], phase [B] aims to individuate by structural cues of social presence perception to formulate a hypothesis on the influence of social presence perception on the acceptance of the therapy setting. The information is then analyzed in the context of the quantitative information collected with five items from the Telepresence Questionnaire [10], with scores on the items regrouped under four categories of telepresence: insignificant (scores from 0 to 25%), low (from 25 to 50%); medium (from 50 to 75%) or strong (from 75 to 100%). In the next step [B2], functional cues of social presence's consequences are searched for, with the objective to formulate a hypothesis on how traces of acceptance of the setting could be individuated in the process of constructing intersubjectivity [4]. The methodology is then to be applied to all therapy sessions and all participants to analyze emerging trends. In addition to the above phenomenological descriptions, understanding the processes associated with breaks in acceptance of the therapy setting requires a pragmatic analysis. The last step of the procedure is the analysis of relevant conversational sequences to grasp and describe the intersubjective processes resulting from activities exploiting the properties of the verbal interaction, which are intrinsically linked to any form of communication. Specific objects of this kind of analysis will be the formalization of interlocutory models describing the pragmatic functioning of the individuated breaks in acceptance of the setting [11].

### **3 Results: Example of the analysis of an original case**

C. is a 28 years old woman, mother of two children looking for a job and seeking CBT for generalized anxiety disorder. The treatment was interrupted after 4 sessions. The first 3 sessions were used for the analysis because there was sufficient material to assess breaks in telepresence and intersubjectivity co-construction processes. The following numbers in the analysis correlate with those of categories appearing in Figure 1.

#### *3.1 A-1 (N=3)*

1. In the first sessions, it seems that C. was looking for eye-contact with the psychologist and focusing on her words and guidelines.
2. In the following sessions, C. stopped looking for eye-to-eye contacts.
3. It has been noticed by the independent coder during the analysis that the psychologist used an informal form of verbal exchanges while the patient was using a formal form. Another important point was the irregularity of the verbal tuning, as the psychologist cut the patient off many times. This seemed to influence the patient's discourse, who took more time to start speaking during the following interviews.
4. C. wasn't smiling very much, and her face was a slightly frozen/rigid, whereas the psychologist was smiling.
5. Many silences were noticed in C.'s discourse, especially when both psychologist and patient were taking notes during the session. It has also been noticed in the analysis that C. forgot to bring her notes to a following session, even if the psychologist's guideline was to bring them.

### 3.2 .A-2 (X=6)

1. C. turned the volume higher, using a remote control, to hear the psychologist. The psychologist got closer to the camera to address C. after a disagreement about an issue discussed in the session.
2. Breaks in emotional tuning were also expressed by verbal comments about issues emerging during the session (sound volume) or observed by the independent coder (rhythm of the discourse).
3. The rhythm of the discourse is irregular, as the psychologist cut off the patient many times, despite agreed guidelines to raise hand before talking when the other is talking.
4. No relevant element was found.
5. No relevant element was found.

### 3.3 B-1 (Y=5)

Quantitative analyze of the subsequences was made in hetero evaluation of the scores from the Telepresence Questionnaire, with low results for Physical presence [Q#1- low (30 %), Q#2- low (30 %), Q#3- low (30 %)] and for Social presence as well [Q#4- low (40%), Q#5 – insignificant (25%)].

### 3.4 B-2 (Z=3)

1. Both patient and psychologist seemed to recognize each other's role in the first telepsychotherapy session. However, mutual recognition of subjectivities didn't seem to occur during the following interviews.
2. Conversational breakdowns were noticed, for example in the fact that following the cuts off, the patient seemed to talk less than before (cf. A1-3,4,5 ; A2-3).
3. The psychologist presented herself as a CBT and anxiety disorders specialist. C. presented a demand based on her symptoms. However, it seemed that beyond this general object's definition, the intersubjective encounter didn't occur.
4. General rules of discourse appeared in the psychotherapeutic framework but intersubjective dynamic wasn't established. For example, C. forgot to bring her notes (cf. A1-5).

As illustrated in the analysis of sessions, conversational breakdowns happened during first telepsychotherapy sessions (A1-2, 3, 4, 5; A2-1, 3). This may have influenced breaks in telepresence and intersubjectivity co-construction processes in the following two sessions (B1; B2-1, 2, 3, 4). Further analysis of *all* relevant conversational sequences over all three sessions need to be performed in order to grasp and describe the intersubjective processes, and then compared among all participants.

## 4 Conclusion

Examining the sense of presence in online interactions and the acceptance of the setting of telepsychotherapies in videoconference can be useful to enhance quality of

interactions with the media and the setting itself. The proposed methodology can help to understand the different levels of interactions between users (therapists and patients) and their links with telepresence. The preliminary results presented in this paper illustrate how the processes of co-construction of intersubjectivity in telepsychotherapy depend on a complex reality resulting from different interactional and reciprocal processes between therapist, patient and setting. The social interactions presented provide an example of the potential impact of breaks in acceptance of the therapy setting and telepresence in online interactions. The presentation of the coding method is the first step towards a better assessment of the level of acceptance of the technological setting by patients and its influence on the interactions between patients and psychologists. The complete analysis of all information will help guide projects on the co-creation of shared subjectivity in telepsychotherapy. The results might also be helpful to improve the quality of videoconference telepsychotherapies, for example in the creation of guidelines and quality standards.

We hope in the long term these results will be useful to individuate the ‘general’ rules (that is almost universal, i.e. independent from the theoretical framework of psychotherapies) underlying processes to videoconference telepsychotherapies efficacy. This could help to define some (general) guidelines in telepsychotherapy and establish the differences between videoconference telepsychotherapy and classical face to face psychotherapy, in terms of relationship. These future results could be useful to prepare training programs for psychotherapists, to enable them to spot signals useful to manage telepsychotherapies and to reduce the drop-out rate.

## References

- [1] M. Allard, S. Bouchard, A. Marchand, L.G. Cournoyer, I. Green-Demers, P. Renaud, L’efficacité de la psychothérapie pour le trouble panique en vidéoconférence: répliation et alliance thérapeutique, *Revue québécoise de psychologie*, **28** (2007), 43-64.
- [2] L. Haddouk, Intersubjectivity in Video Interview, In G. Riva, B. K. Wiederhold, & P. Cipresso (Eds.), *The Psychology of Social Networking: Communication, Presence, Identity and Relationships in online communities*. Versita, London, 2016.
- [3] J-P. Mugnier, Du diabolique au symbolique, dans quel monde vivons-nous?, *Cahiers critiques de thérapie familiale et de pratiques de réseaux*, **46** (2011), 33-45.
- [4] Galimberti, C., Brivio, E., Cantamesse, M., & Ibarra, F. C., Intersubjectivity as a Possible Way to Inhabit Future Cyberplaces. *Annual Review of Cybertherapy and Telemedicine*, **154** (2010), 9-13.
- [5] M. Cini, Oltre la disciplinarietà: le Humanities al confronto con le altre scienze, in M. Cini, (Ed), *Humanities e altre scienze*, Carocci Editore, Roma, 2017.
- [6] G. Devereux, *Ethnopsychanalysis: Psychoanalysis and anthropology as complementary frames of reference*. University of California Press, Berkeley, 1978.
- [7] S. Bouchard, V. Germain, A. Marchand, S. Guay, M.S. Drouin, Assessment of the Therapeutic Alliance in Face-to-Face or Videoconference Treatment for Posttraumatic Stress Disorder, *CyberPsychology and Behavior*, **13** (2010), 29-35.
- [8] L. Haddouk, Presence in Telepsychotherapy. Towards a Video-Interview Framework. *International Journal of Emergency Mental Health and Human Resilience*, Vol. 17, No.4, (2016), 712-713, ISSN 1522-4821.
- [9] L. Haddouk, S. Bouchard, E. Brivio, C. Galimberti, A. Trognon, Evaluating presence in telepsychotherapy. A complementary study on intersubjectivity co-construction processes. *Communication presented at the 22nd CyberPsychology, CyberTherapy and Social Networking Conference (CYPSY22)*, Wolverhampton, UK, 26th to 28th June 2017.
- [10] S. Bouchard, G. Robillard, Telepresence in videoconference scale, 2018.
- [11] Trognon, M. Batt, Interlocutory logic, in Interlocutory Logic. A unified framework for studying conversational interactions, In J. Streeck, (Ed), *New adventures in Language and interactions*, Benjamins, Amsterdam, (2010), 9-46.

# Virtual Reality Cue Exposure for Smoking Relapse Prevention: a Comparative Trial.

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**Abstract.** As a significant number of abstinent smokers tend to relapse over time, new challenges lie in preventing relapse with immersive technologies such as virtual reality. The effectiveness of virtual reality cue exposure (VRCE) with cognitive behavioural therapy is analysed through a comparative trial involving the first 61 participants. All the required Virtual Environments (VE) were created with an inexpensive Game Level Editor. Outcome measures supported the immersive and craving eliciting effect of the VEs. Results demonstrated that VRCE is at least as efficacious as traditional cognitive behavioural therapy in terms of maintenance of tobacco abstinence, craving reduction and decrease in nicotine dependence. Improvement in technologies and methodology for future research and applications are delineated.

**Keywords.** Virtual reality, cue exposure therapy, smoking relapse prevention virtual environments, therapy, game level editors.

## 1. Introduction

While intense debates focusing on drug legalization are frequent nowadays, and the use of psilocybin mushrooms or cannabis for therapeutic purposes is being discussed, a legal product - namely tobacco - is still involved in diverse chronic or lethal diseases among the smoking and non-smoking population. In 2010, a European health survey estimated a 28% prevalence of tobacco consumption among individuals over 15 years old, especially women compared to other continents [1].

Several tobacco quitting methods exist such as psychotherapy, nicotine replacement therapy (NRT) or electronic cigarettes. In several countries, using an electronic cigarette is even considered fashionable and generates recreational activities known as cloud chasing. Notwithstanding this recent trend, due to the hitherto high

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rates of relapse after smoking cessation programs (between 40% and 70%), the real challenge lies in the prevention of relapse [2]. Still, relapse prevention interventions, including Cognitive Behavioural Therapy (CBT), have been hampered by the frequent and unavoidable presence of social or non-social conditions associated with tobacco consumption in the daily life of abstinent smokers (e.g. drinking in bars with friends, drinking coffee during a break, waiting outside etc.) [3]. On the other hand, an alternative method known as Cue Exposure Therapy (CET) consists of repeatedly exposing patients to smoking related stimuli using objects (ashtrays), pictures or videos in order to help them deal with the strong and sudden consuming *impetus* known as craving. However, CET settings remain a passive procedure or are too disconnected from real situations [4]. These observations address *de facto* the need to implement new exposure strategies so as to help abstinent smokers to cope with smoking related situations in an active way. Consequently, virtual reality (VR), an immersive media allowing subjects to be exposed and interact in synthesized environments in real time, can help patients overcome their craving using virtual tobacco related cues. This method has been entitled Virtual Reality Cue Exposure (VRCE) and has been recently examined as a possible alternative instrument to traditional CBT. In VRCE, newly abstinent smokers are immersed in computer generated Virtual Environments (VE) representing risk situations for the patient in the context of tobacco craving and smoking relapse prevention. Even though previous researches have studied VRCE and demonstrated that artificial 3D situations can induce tobacco craving with success or lead to decrease in nicotine addiction [3, 5], the efficacy of VRCE on relapse prevention has yet to be analysed. Therefore, this study sought to investigate the effect of VRCE on smoking relapse prevention in the context of a comparative study involving VRCE and traditional CBT. The objectives are threefold. The primary objective of this study is to evaluate the effectiveness of VRCE compared to traditional CBT in the prevention of smoking relapse and the effect on dependence and craving. Secondly, to measure the impact of VRCE on emotional features, including depression, anxiety, self-esteem and quality of life. Thirdly, this trial aims to ensure that virtual environments constructed for the experiment produced craving and presence with limited cybersickness.

## 2. Methodology

The present trial was registered on ClinicalTrials.gov (Identifier: NCT02205060).

### 2.1 Sample

The first 61 participants (44 women, 17 men, mean age 49 years  $\pm$ 13.0) diagnosed with tobacco dependence and having an ongoing smoking abstinence of at least 7 days were recruited for the clinical trial. Diagnoses were established by the authors based on the DSM V criteria for tobacco dependence [6] and abstinence was verified by measuring the carbon monoxide (CO) exhaled. Mean pack-year for the sample before the abstinence period was 12.23  $\pm$ 5.72. The sample comprised a strong proportion of women and educated individuals (75.4% have undergone tertiary education) and more than half of them had never played video games or had stopped using them (42.6% never played, 23.3% stopped).

## 2.2 Assessments

*Presence Questionnaire* PQ v3.0 [7]. The PQ consists of 32 items rated on a 7-point scale, assessing the participant's perception of presence.

*Simulation Sickness Questionnaire* (SSQ) [8]. This 16-item instrument on a 4-point scale assesses the manifestation as well as the severity of motion sickness related symptoms exhibited in a simulation or virtual environment.

*Cigarette Dependence Scale* (CDS-12) [9], a 12-item self-report instrument measures the severity of cigarette dependence with scores ranging from 12 (no dependence) to 60 (high dependency).

*Tobacco Craving Questionnaire* (TCQ-12) [10], a 12-item self-report instrument rating the intensity of craving manifestation with scores ranging from 12 (no craving) to 84 (high craving).

*Analogue craving scale* is a 100 points scale that measures the perceived level of craving at a given time during the exposure to smoking related cues.

*State-Trait Anxiety Inventory* (STAI) Y-A (state) [11]. The STAI is a 20-item self-report instrument with scores ranging from 20 (absence of anxiety) to 80 (high anxiety).

*Beck Depression Inventory* (BDI) [12]. The BDI is a 21-item self-report instrument measuring mood and depressive symptoms.

*SF-12* [13]. Quality of life was assessed with this 12-item scale assessing physical function, physical pain, general health, vitality, social functioning and well-being.

*Rosenberg Self-esteem scale* (SES) [14]. This is a self-report questionnaire related to self-esteem and consisting of 10 items which produces a total score of 10 to 40.

*Carbon Monoxide* (CO). Tobacco abstinence is assessed using levels of CO exhaled in parts per million (ppm). A result superior to 6 ppm indicates a tobacco relapse [15].

## 2.3 Procedure

The participants were randomly assigned to 2 therapeutic groups: one group receiving traditional CBT and one group receiving VRCE. The protocol included 8 weekly sessions of 45 minutes each for both groups. All participants were taught addiction centred psychoeducation, craving management, relaxation, positive self-statements and cognitive restructuring as outlined by several works of reference [16, 17]. The only difference between the groups being the smoking related situations exposure procedure carried out from the 3<sup>rd</sup> to the 8<sup>th</sup> session. While participants in the CBT group were asked to visualize such conditions, the participants in the VRCE group were immersed in a computerized world using virtual reality equipment. The 6 sessions of VRCE comprised an exposure to 6 different context graded virtual environments related to tobacco consumption. Questionnaires and physiological measures detailed in the tables *infra* were registered before and after the treatment procedure with the exception of the analogue craving scale used repeatedly *per* procedure. Finally, in order to avoid any chemical influence on the therapeutic effect, participants from both groups were invited not to use any NRT or electronic cigarette until the clinical trial was duly completed.

## 2.4 Apparatus and Virtual Environments

The VR system includes a Sensics® zSight Head Mounted Display or HMD (1280x2024 stereoscopic OLED screen with 60° field of view), coupled with 3 degrees of freedom Virtual Realities® VirtualCube head tracker (angular resolution: 0,05°/s, latency 8ms). The steering wheel exploited for the driving VE is a Logitech® G27 with vibration and force feedback capabilities.

The software used to create and run the VEs is the commercially available game level editor (GLE) CryEngine's Sandbox of the video games series Crysis™ (Crytek GmbH) with the exception of the driving VE which runs with the City Car Driving simulation (Multisoft™). Prior to its full use for the trial, this was tested and compared to 6 other commercially available GLEs by considering several distinct criteria and requirements [18]. For smoking related cues to entail diverse situations, the first author exploited the aforementioned GLE to build 5 specific context graded VEs. The VEs constructed are validated smoking eliciting situations according to empirical works on tobacco consumption [16, 17], past studies [3, 5], and the criteria of the DSMV [6]: Having a drink with people smoking in a virtual beach bar, having dinner with avatars smoking on the terrace of a restaurant, being in a furnished living room with an ashtray and a lighted cigarette, waiting at a bus stop with avatars smoking, taking a break in the workplace with colleagues who are smokers and driving a virtual car on a road with traffic. All VEs were supplemented with events triggered by the experimenter (avatars proposing coffee or cigarettes) and interoceptive cues (heartbeat sounds, tunnel vision).



**Figure 1 & 2.** Screenshots of 2 VEs constructed for the present study. Note the smoking related cues (cigarette and packet, ashtray, alcohol) and the avatars' smoking attitudes (beach bar and bus stop).

## 3. Results

37 participants completed the program. Means, standard deviations and Analysis of Variance (ANOVA) F values listed in the table, evidenced a significant time effect for all subjective measures related to smoking dependence and tobacco craving. In contrast, no significant differences were found regarding the other scales. There was no significant interaction (time/group) for any of the scores. Upon finishing the protocol and according to the proportion of CO exhaled, 72% of the participants had maintained their tobacco abstinence. Mean PQ high scores and mean SSQ low scores indicated that

the patients felt immersed in the VEs without exhibiting cybersickness. Moreover, during the initial exposure session, the VRCE group exhibited a significantly higher craving  $t(61)=-2.34, p<.024, \eta^2=.11$ .

**Table 1.** Means, standard deviations of the dependent variables, results of two-way ANOVA Between Pre- and Post-test period (Time) and ANOVA for time x group comparison (Interaction).

Tests	Group	Pre-test	Post-test	ANOVA	Eta <sup>2</sup> Time	ANOVA	Eta <sup>2</sup> Interac.
		Mean (SD) n=61	Mean (SD) n=37	Time F (1,35)		interaction F (1,35)	
DSM	CBT	5.71 (1.65)	1.38 (1.43)	152.55***	0.82	2.26ns	0.06
	VRCE	6.27 (1.83)	2.20 (1.90)				
CDS	CBT	39.05 (11.64)	20.09 (8.62)	77.02***	0.69	0.42ns	0.01
	VRCE	40.50 (11.54)	22.44 (11.62)				
TCQ	CBT	35.76 (14.01)	21.76 (8.73)	36.39***	0.51	0.70ns	0.02
	VRCE	38.62 (15.89)	24.87 (12.18)				
Crav SS8	CBT	20.90 (20.7)	6.1 (14.90)	30.99***	0.46	2.10ns	0.05
	VRCE	40.0 (20.64)	13.20 (23.20)				
STAI	CBT	35.00 (8.79)	35.38 (9.45)	1.90ns	0.05	0.15ns	0.00
	VRCE	31.44 (10.58)	36.69 (14.10)				
BDI	CBT	16.52 (2.69)	15.47 (2.58)	1.41ns	0.04	2.28ns	0.06
	VRCE	17.81 (4.81)	17.62 (4.96)				
SFph	CBT	75.56 (2.15)	65.01 (2.37)	3.81ns	0.06	0.22ns	0.01
	VRCE	68.45 (2.24)	65.80 (2.21)				
SFme	CBT	70.35 (2.23)	63.46 (2.08)	2.41ns	0.06	0.66ns	0.02
	VRCE	63.46 (2.37)	59.72 (2.48)				
EES	CBT	32.52 (5.26)	31.86 (7.35)	0.04ns	0.00	0.38ns	0.01
	VRCE	30.69 (5.58)	31.50 (7.06)				
PQ			104.99 (27.39)				
SSQ			7.20 (7.41)				

VRCE: Virtual Reality Cue Exposure; CBT: Cognitive Behavioural Therapy; DSM: number of DSM criteria for tobacco dependence; CDS: Cigarette Dependence Scale; TCQ: Tobacco Craving Questionnaire; Crav S3 S8: mean craving level at the 3<sup>rd</sup> session (beginning of exposure session) and 8<sup>th</sup> session (post-test). STAI: State-Trait Anxiety Inventory; BDI: Beck Depressive Inventory. SFph/me: physical and mental factors of the SF12; EES: Rosenberg Self-esteem scale; PQ: Presence Questionnaire; SSQ: Simulation Sickness Questionnaire; \*\*\*  $p<0.001$ ; \*\*  $p<0.025$ ; \* $p<0.05$ ; ns: non- significant.

**Table 2.** Distribution of participants according the CO exhaled at post-test.

Post-test CO	<6ppm	<10ppm	<20ppm	>20ppm
% participants (n=37)	72.2%	13.9%	11.1%	2.8%

CO: Exhaled Carbone Monoxide; ppm: parts per million

#### 4. Conclusion

This ongoing research has demonstrated that these VEs, constructed with an inexpensive off-the-shelf game level editor, were able to generate presence and craving among this sample of abstinent smokers. Outcomes revealed a significant reduction of tobacco craving and dependence in both groups, and most of the participants who completed the protocol did not experience smoking relapse. In contrast, no significant differences were found regarding the other scales, even though an improvement in physical quality of life was observed but was not enough to reach statistical significance at this stage. Group comparison did not lead to any significant interactions between all variables, indicating that VRCE is at least as efficacious as traditional CBT in terms of smoking relapse prevention, the only exception being that participants of the VRCE group reported higher perceived craving in VEs. Although not statistically

significant, findings also show a trend towards a greater in-session craving decrease in the VRCE group. This continuing clinical trial with scheduled follow-up will verify if those tendencies are maintained and achieve significance. Interestingly, there was a high proportion of drop out (10 in CBT, 14 in VRCE). This may stem from the unprepared and unmonitored smoking cessation before recruitment, as well as the total absence of smoking substitute use (NRT etc.) during the protocol as required. An important corollary to these results is that future studies should focus on the additional clinical effect of combining VRCE with other means of smoking cessation and maintenance of abstinence (NRT and electronic cigarette). Finally, recent production of chemical banks generating artificial flavours including tobacco odour are commercially available, thus adding a sensory cue as crucial as olfaction to future smoking related VEs. This new immersive step is likely to enhance VRCE by fostering multi-sensorial integration [19] and as a result, enabling the participant to dive even more deeply in this temporary yet fascinating illusion of reality.

## References

- [1] World Health Organization. Global status report on non communicable diseases. Geneva, Switzerland: WHO, 2010.
- [2] D. K. Hatsukami, L. F. Stead and P. C. Gupta. Tobacco Addiction, *Lancet* **371** (2008), 2027-38.
- [3] I. Pericot-Valverde, R. Secades-Villa, J. Gutiérrez\_Maldonado, et al. Effects of Systematic Cue Exposure Through Virtual Reality on Cigarette Craving *Nicotine & Tobacco Research* **16** (2014), 1470-77.
- [4] J. Lee, Y. Lim, S. J. Graham, et al. Nicotine craving and cue exposure therapy using virtual environments, *Cyberpsychology and Behavior* (2004), 705-13.
- [5] B. Girard, V. Turcotte, S. Bouchard, et al. Crushing Virtual Cigarettes Reduces Tobacco Addiction and Treatment Discontinuation, *Cyberpsychology and Behavior* **12** (2009), 477-83.
- [6] American Psychiatric Association. *Diagnostic and statistical manual of mental disorders. 5<sup>th</sup> ed.*, American Psychiatric Association Washington, 2013.
- [7] B. G. Witmer, C. J. Jerome and M. J. Singer. The Factor Structure of the Presence Questionnaire, *Presence: Teleoperators and Virtual Environments* **14** (2005), 298-312.
- [8] R. S. Kennedy, N. E. Lane, K. S. Berbaum, et al. Simulator Sickness Questionnaire: An Enhanced Method for Quantifying Simulator Sickness, *International Journal of Aviation Psychology* **3** (1993), 203-220.
- [9] J. F. Etter, J. L. Houezec, P. Huguelet, et al. Testing the Cigarette Dependence Scale in 4 samples of daily smokers: psychiatric clinics, smoking cessation clinics, a smoking cessation website and in the general population psychiatric clinics, smoking cessation clinics, a smoking cessation website and in the general population, *Addictive Behaviors* **34** (2009), 446-5.
- [10] I. Berlin, E. G. Singleton and S. J. Heishman. Validity of the 12-item French version of the Tobacco Craving Questionnaire in treatment-seeking smokers, *Nicotine and Tobacco Research* **12** (2010), 500-7.
- [11] J. Gauthier and S. Bouchard. Adaptation canadienne-française de la forme révisée du State-Trait Anxiety Inventory de Spielberger, *Revue canadienne des sciences du comportement* **25** (1993).
- [12] L. Collet and J. Cottraux. The shortened Beck Depression Inventory: study of the concurrent validity with the Hamilton scale and Widlöcher's retardation scale, *Encephale* **12** (1986), 77-9.
- [13] J. E. Ware, M. Kosinski and D. M. Turner-Bowker. *User's manual for the SF-12v2<sup>TM</sup> Health Survey with a supplement documenting SF-12<sup>®</sup> Health Survey*, Quality Metric Incorporated, Lincoln, RI, 2002.
- [14] M. Rosenberg. *Society and The adolescent Self-Image*, NJ: Princeton University Press, Princeton, 1965.
- [15] S. E. Deveci, F. Deveci, Y. Acik, et al. The measurement of exhaled carbon monoxide in healthy smokers and non-smokers, *Respiratory Medicine* (2004), 551-6.
- [16] A. T. Beck, F. D. Wright, C. F. Newman, et al. *Cognitive Therapy of Substance Abuse*, Guilford Press, New York, 2001.

- [17] G. A. Marlatt and J. R. Gordon. *Relapse prevention : maintenance strategies in the treatment of addictive behaviors.*, Guilford press, New York, 1985.
- [18] E. Malbos, R. M. Rapee and M. Kavakli. The Use of Game Level Editors to Create Virtual Environments for the Treatment of Anxiety: Effects on Presence and Anxiety Levels, In Proceedings of the 13th Virtual Reality International Conference (VRIC 2011) April 6-8 2011, Laval, France, 2011.
- [19] B. E. Stein and M. A. Meredith. *The Merging of the Senses*, MIT press, Cambridge, UK, 1993.

# The Validation of a Telepresence Scale for Psychotherapy Delivered in Videoconference

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**Abstract.** The Telepresence in Videoconference Scale (TVS) was developed and tested over several years, but its psychometric properties have not been formally documented. The aim of this study was to examine the reliability and factor structure of the TVS. A total of 157 participants completed the scale following a videoconference session with a psychotherapist delivered over four clinical trials. The TVS was submitted to an exploratory factor analysis using the Principal Components method and a Varimax rotation. Three factors were found: "Physical Presence", "Interaction", and "Absorption". Inter-item correlations and Cronbach's alpha were conducted to measure the internal consistency of the scale. Discriminant validity and convergent validity were assessed with the Immersive Tendencies Questionnaire and the Distance Communication Comfort Scale. The results suggest that this revised version of the Telepresence in Videoconference Scale is a reliable and valid tool to measure clients' sense of presence during psychotherapy sessions delivered over videoconference technologies. Future research could examine whether this scale may be used in different contexts and with different populations.

**Keywords.** Cybertherapy, telepsychotherapy, telepresence, telepresence scale, videoconference.

## 1. Introduction

The use of video communications has become increasingly popular as technology has improved. In recent years, therapists have begun to offer telepsychotherapy via videoconference. Telepsychotherapy can be defined as "psychotherapy conducted by a therapist at a location different from the patient's through bidirectional communication technology supporting real-time interactivity in the audio, audiovisual, or text modalities" [1]. Studies have shown that therapy delivered in videoconference is as effective as cognitive-behavioural therapy (CBT) delivered face to face for disorders, such as posttraumatic stress disorder [2], panic disorder with agoraphobia [3], and obsessive-compulsive disorder [4].

However, very few scales have been developed to assess clients' sense of presence during psychotherapy delivered in videoconference or other means of remote

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synchronous communication. The Telepresence in Videoconference Scale (TVS) was developed by the Cyberpsychology Lab of Université du Québec en Outaouais (Canada). The original version was developed in both English and French. The scale has been used over the years (e.g., [2]), but its psychometric properties have not been formally documented. The aim of this study was to examine the reliability and factor structure of the TVS. Telepresence can be defined as the feeling of being *there*, with the psychotherapist, as opposed to being in a remote location receiving services delivered by a professional located somewhere else.

Convergent and discriminant validity were also examined. The Distance Communication Comfort Scale (DCCS) [5] was used to document if telepresence is distinct from actual comfort with distant communication. The construct measured by the TVS should be different from comfort measured by the two-way video communication subscale of the DCCS. They both inquire about participants' experience with videoconference during therapy. Comfort with distant two-way video communication can be defined as the degree to which people feel comfortable talking over video or on camera, enjoy talking in videoconference, don't have difficulties understanding the therapist, don't feel self-conscious in front of a camera, and can easily remain attentive, focused and undistracted in videoconference. Telepresence should be related more to the feeling of being together *in* therapy, in a shared location, and forgetting that the therapist or the patient is not in the same room. Telepresence should also be related yet distinct from trait-like tendencies to feel present [6]. Some people have a stronger tendency to feel involved in activities, to maintain focus on current activities and to play videogames. This tendency can make them more likely to feel present when reading a book, watching a movie, or being immersed in virtual reality [6]. However, feeling present and psychological proneness to react to immersive stimuli should represent distinct concepts. The Immersive Tendencies Questionnaire (ITQ) [6] was therefore administered to participants to document discriminant validity.

## 2. Method

### 2.1 Participants

Ethics approval was first obtained from the ethics committee of the Université du Québec en Outaouais (UQO). A total of 168 French-Canadian participants between the ages of 18 and 74 (126 women, 40 men; mean age of 36.28 years) were recruited to complete the three questionnaires, within the context of four independent studies. All of the participants signed a consent form before completing the questionnaires, which were completed following a one-hour cognitive-behavior therapy session with a psychotherapist. Due to missing data on several items (78.6%) for 11 participants, a final sample of 157 participants was used to analyze the TVS; 160 participants completed the Distance Communication Comfort Scale, and 113 participants completed the ITQ. Participants were all recruited from the UQO.

## 2.2 Measures

### 2.2.1 The Telepresence in Videoconference Scale (TVS)

The scale inquired about the participants' experience during the videoconference (e.g. their interactions with the therapist, whether they felt as if they were physically present and actively participating during the session, etc.). The final version of the scale has seven items (see section 3.1 and Figure 1) and is rated on a scale from 0% to 100% (0% – *completely disagree*, 50% – *moderately agree*, and 100% – *completely agree*).

#### TELEPRESENCE IN VIDEOCONFERENCE SCALE

Bouchard, S., & Robillard, G. (2018)

Cyberpsychology Lab of UQO

The following questions aim to assess how you felt during the last videoconference session. We will use the expression “the other person” to represent the main individual with whom you discussed, whether it is a male, a female, a therapist, a doctor, a lecturer, etc. For each question, please indicate how much you agree with the sentence using the percentage scale (0-100%) below.

(Completely disagree)	(Moderately agree)	(Completely agree)
0%    10    20    30	40    50    60    70	80    90    100%
<hr/>		
1. Our conversation via videoconference seemed natural..... %: ____		
2. I had the impression that our exchange through videoconference was happening as if I was physically in presence of the other person..... %: ____		
3. I got the feeling I was in the same room as the other person..... %: ____		
4. I felt that the other person reacted to my presence..... %: ____		
5. I had the impression that I was actively participating to the conversation with the other person ..... %: ____		
6. When the videoconference session ended, I felt like I was coming back to the “real world” ..... %: ____		
7. I lost track of time..... %: ____		

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#### **Scoring:**

- Mean of the 7 items
- “Physical Presence” subscale: Items 1, 2, 3
- “Social Presence” subscale: Items 4, 5
- “Absorption” subscale: Items 6, 7

**Figure 1.** Final version of the Telepresence in Videoconference Scale.

### 2.2.2 Distance Communication Comfort Scale [5]

This scale was used to assess participants' comfort with meeting with a psychotherapist or counselor via three different types of communication: videoconference (two-way video communication), telephone (two-way audio communication), and face to face [5]. The scale contains 27 items and is rated on a 7-point Likert-type scale (1 – *strongly disagree* and 7 – *strongly agree*).

### 2.2.3 The Immersive Tendencies Questionnaire (ITQ) [6]

This scale inquired about participants' tendency to feel absorbed when they do certain activities (e.g. watching a movie, playing a video game, playing sports, etc.) and how they feel at the present moment (e.g. how mentally alert they feel, how physically fit they feel). The questionnaire has 18 items with four subscales: focus, involvement, emotions, and games. It is rated on an 8-point Likert-type scale.

## 3 Results

### 3.1 Development of the Scale

Inspired by previous questionnaires designed to measure presence in virtual reality, our team of researchers proposed items for presence in videoconference-based therapy (i.e. telepresence). An initial pool of 24 items were initially suggested. These items were submitted to empirical criteria leading to the progressive reduction of the number of items [7,8,9]. Successive inter-item correlation analyses led to a progressive reduction in the number of items, from 24 to 10, to 8 and now 7.

### 3.2 Psychometric Properties

All data were analyzed using SPSS version 24. The TVS was first submitted to an exploratory factor analysis using the Principal Components method and a Varimax rotation. The KMO and Bartlett test confirmed the factorability of the database (KMO = .72,  $\chi^2 = 648.65$ ,  $p < .001$ ). The number of factors to extract was decided based on the convergence of three criteria: minimum eigenvalue of one criterion, scree-test, and interpretability of the factor structure. The scree-test plot was ambiguous and showed inflexions that would justify retaining either two or three factors. Three factors had eigenvalues over one. The interpretability of the factor structure confirmed the decision to retain three factors. Some items were removed in the process due to high inter-item correlations, to produce the final 7-item version of the TVS. The three factors found were: "Physical Presence" (items 1, 2, and 3), "Interaction" (items 4 and 5), and "Absorption" (items 6 and 7 of the final version of the scale). As shown in Table 1, all items loaded clearly ( $> .70$ ) on only one factor, with the final factor solution explaining 84.86% of the variance. Factor 1 ("Physical Presence") explained 33.54% of the variance. Factor 2 ("Interaction") explained 28.47% of the variance. Factor 3 ("Absorption") explained 22.86% of the variance. For scoring, a total TVS score can be obtained by calculating the mean of the seven items (value 0% to 100% each). In the current sample, the mean of the TVS was, 56.27% (SD = 21.43) for the total score, 60.97% (SD = 25.9) for the Physical presence subscale, 62.13% (SD = 27.72) for the

Interaction sub-scale, and 40.64% (SD = 29.97) for the Absorption subscale. The internal consistency analysis of the scale yielded a Cronbach's alpha of .80.

**Table 1.** Factor loading of the Telepresence in Videoconference Scale after a Varimax rotation.

Item number and Shortened description	Factor 1 "Physical Presence"	Factor 2 "Interaction"	Factor 3 "Absorption"
Item 1 Naturalness of conversation	.702		
Item 2 Physically present	.882		
Item 3 In the same room	.915		
Item 4 Other person reacted		.887	
Item 5 Actively participating		.866	
Item 6 Coming back to the "real world"			.901
Item 7 Losing track of time			.872

Note: Loadings below .70 are not reported.

Differences were found between genders only on the Absorption subscale, with males feeling more absorbed than females ( $t(153) = 2.67, p < .01$ ). Missing data about gender were excluded analysis by analysis. The correlation with age was non-significant ( $r = .15$ ). Missing data on age were excluded pairwise.

Discriminant validity and convergent validity were assessed with the ITQ ( $r = .0, ns$ ) and the Distance Communication Comfort Scale ( $r = -.25, p < .01$  for comfort with face to face communications,  $r = .17, p < .05$  for telephone communications, and  $r = .42, p < .01$  for videoconference communications). Missing data were excluded pairwise. The non-significant correlation between the ITQ and the TVS indicated discriminant validity, and that immersive tendencies and telepresence are distinct concepts. The significant correlation between the videoconference communications subscale of the DCCS and the TVS showed some convergent validity. However, they can still be considered distinct concepts since the correlation was moderate. Furthermore, the significant weak correlations between the other two subscales of the DCCS and the TVS indicated discriminant validity, and that comfort with using distant communication is distinct from telepresence.

#### 4 Conclusion

The TVS was developed to assess clients' sense of presence while communicating with a therapist via videoconference. The same items could be used to document the feeling of presence by therapists, but the TVS was not administered to therapists. The aim of this study was to examine the reliability and factor structure of the TVS as its psychometric properties had not been formally documented yet. A total of 157 participants completed the scale following psychotherapy sessions delivered in videoconference. An exploratory factor analysis lead to the characterization of a 7-item

version of the TVS. Three factors were found: “Physical Presence”, “Interaction”, and “Absorption”. Cronbach’s alpha and convergent validity and discriminant validity were acceptable.

The results suggest that this revised version of the TVS is a reliable and valid tool to measure clients’ sense of presence during a videoconference session with a therapist. The TVS may be used to explore the impact of telepresence on treatment outcome (e.g., [9]). One limitation of the study is that the data were collected with patients who received cognitive-behavioral therapy for anxiety disorders. Future research could examine the psychometric properties of the TVS in different contexts (e.g., school-based clinics), with patients suffering from other mental disorders (e.g., major depression, schizophrenia, adjustment disorders), and in other forms of psychotherapy (e.g., psychodynamic, inter-personal, emotion-focused). Predictors and moderators of telepresence in psychotherapy should also be studied.

## References

- [1] E.H. Kaplan, Telepsychotherapy: Psychotherapy by telephone, videotelephone, and computer videoconferencing, *Journal of Psychotherapy Practice & Research* **6** (1997), 227-237.
- [2] V. Germain, A. Marchand, S. Bouchard, M.-S. Drouin, & S. Guay, Effectiveness of Cognitive Behavioural Therapy Administered by Videoconference for Posttraumatic Stress Disorder, *Cognitive Behaviour Therapy* **38** (2009), 42-53.
- [3] S. Bouchard, B. Paquin, R. Payeur, M. Allard, V. Rivard, T. Fournier, P. Renaud, & J. Lapierre, Delivering Cognitive-Behavior Therapy for Panic Disorder with Agoraphobia in Videoconference, *Telemedicine Journal and e-Health* **10** (2004), 13-25.
- [4] J.A. Himle, D.J. Fischer, J.R. Muroff, M.L. Van Etten, L.M. Lokers, J.L. Abelson, & G.L. Hanna, Videoconferencing-based cognitive-behavioral therapy for obsessive-compulsive disorder, *Behaviour Research and Therapy* **44** (2006), 1821–1829.
- [5] P.L. Schneider, “A comparison of outcome variables in psychotherapy: Distance technology versus face-to-face”, Ph.D., University of Illinois at Urbana-Champaign, United States, 2000.
- [6] B.G. Witmer, & M.J. Singer, Measuring presence in virtual environments: A presence questionnaire, *Presence: Teleoperators and Virtual Environments* **7** (1998), 225-240.
- [7] S. Bouchard, & G. Robillard, *Validation de l'échelle de téléprésence en vidéoconférence. [Validation of the scale of telepresence in videoconference]*. Unpublished manuscript, Université du Québec à Hull. 2000.
- [8] S. Bouchard, How to create a therapeutic bond in telehealth: the contribution of telepresence and emotions. Oral presentation at the 7th annual meeting of the *Canadian Society of Telehealth*, Québec, October 3 – 5 2004.
- [9] T. Guitard, S. Bouchard, M. Allard, & G. Robillard, Establishing effective therapeutic alliance when delivering CBT in videoconference: The role of telepresence and the therapist’s behaviours. Poster presented at the 43th Annual convention of the *Association for Behavioral and Cognitive Therapy (ABCT)*, New York (NY), November 17-20, 2009.
- [10] C. Perpiñá, A. Ferrero, C. Carrió, M. Roncero, Normalization of the eating patterns in a patient with anorexia nervosa, purgative subtype, with the support of a virtual environment. A case study, *Annuary of Clinical and Health Psychology*, **8** (2012), 21-28



## SECTION VI

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### 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*



# Study Protocol for a randomized controlled trial of mindfulness training with immersive technology (virtual reality) to improve the quality of life of patients with multimorbidity in Primary Care: the Mindful-VR study.

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**Abstract.** In the last decades, the prevalence of patients with multimorbidity (MM) in Primary Care System (PCS) has increased significantly. Multimorbidity refers to the presence of multiple chronic conditions or diseases in a single person. One of the main consequences is the poor health-related quality of life. Mindfulness-based interventions (MBI) have shown to be an evidence-based approach to increase quality of life and promote mental health. In parallel, recently, the number of clinical centers that use immersive technology such as virtual reality (VR) has grown, aiming to improve their medical treatment efficacy. Our hypothesis is that MBI in association with VR may contribute to a better quality of life and mental health of patients with MM. Objective: Describing a protocol study which aims at verifying the feasibility and preliminary efficacy of the application of MBI enhanced by VR in order to improve the quality of life of patients with MM in PCS through two studies: Study 1- A pilot controlled and randomized study will validate a Mindfulness-based Health Promotion (MBHP) program delivered with VR (MBHP-VR) in a non-clinical population (college students recruited from the Universidade Federal de São Paulo); and Study 2- a randomized controlled clinical trial will evaluate the efficacy of MBHP-VR in patients with MM recruited from PCS facilities in São Paulo, Brazil; with 3 experimental groups: a) the treatment-as-usual (TAU) offered by the PCS, versus b) TAU plus MBHP-VR intervention, versus c) TAU plus MBHP traditionally delivered. As a primary outcome, quality of life will be assessed (SF-36), and as a secondary outcome depression and anxiety symptoms will be assessed (HADS). Mindfulness level will be considered as an explanatory variable. The relevance of this study is explained by the fact that MM is very common in the population notably in major adults

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and patients in PCS, with increasing costs and an absence of efficacious approaches for this complex public health challenge.

**Keywords:** Multimorbidity, Mindfulness, Primary Care System, Virtual Reality.

## **1.Introduction**

Multimorbidity (MM) is defined as the occurrence of two or more chronic diseases simultaneously in an individual [1]. In Brazil, 80% of individuals aged 60 years or older have at least two chronic diseases and the high occurrence of MM can be considered as a real epidemic, placing MM as the main focus and challenge of public health [2, 3]. The quality of life of patients with MM has been affected both in the physical and emotional sphere, as well as in the social sphere [4]. According to the systematic review there is an inverse correlation between MM and quality of life [4, 5].

Therefore, quality of life has been one of the main variables used to measure the impact of MM in the individual and in the populations [4-6]. A few years ago, Mindfulness-Based Interventions (MBI) proved to be an excellent intervention to increase the quality of life and promote mental health in patients with chronic diseases [7, 8]. The Brazilian Mindfulness intervention is called: “*Mindfulness Based Health Promotion*” (MBHP) and was based on the “*Mindfulness-based Stress Reduction*” (MBSR) program extensively studied in the literature [9-10]. MBHP was developed and validated for Brazilian population and showed similar results to MBSR in both: increased of quality of life and stress reduction [11-14].

In parallel, a few years ago, the number of clinical centers that use immersive technology, such as virtual reality (VR), has grown in order to help with their medical treatments and mental health [15, 16]. The use of new technologies such as VR has been shown to help to prolong the life expectancy of patients with multimorbidity, reducing stress and increasing resilience [14, 15].

Our main hypothesis is that mindfulness training enhanced by VR will contribute to a better quality of life in patients with multimorbidity. We expect that multimorbid patients who receive medical treatments at the Primary Care System will improve quality of life with mindfulness training enhanced by virtual reality. Specifically, the objective of this paper is to describe a study protocol aimed at verifying the feasibility and preliminary efficacy of the application of MBI enhanced by VR in order to improve the quality of life of patients with multimorbidity in Primary Care System in Brazil through two studies.

## **2.Method**

### **2.1. Study Design**

Two studies will be conducted:

The first, a pilot study, will be conducted in order to adapt and validate the MBHP protocol incorporated into VR system (MBHP-VR) and their capacity to produce mindfulness. This will be a control and randomized study with no clinical population. Two groups will be evaluated: 1) Mindfulness intervention MBHP with VR system (MBHP-VR), versus 2) traditionally delivered Mindfulness MBHP intervention (control group) (MBHP).

The second study will be the application of MBHP-VR in PCS for patients with MM. This will be a control and randomized study. Three groups will be compared in patients with MM: a) the treatment-as-usual offered by PCS (TAU), versus b) TAU plus MBHP-VR intervention, versus c) TAU plus MBHP traditionally delivered. The

research is approved (**Permit Number: 40727415.10000.5505**) by the Federal University of Sao Paulo Ethics Committee.

## *2.2. Study Procedure*

For the Pilot Study, participants will be college students recruited from the Universidade Federal de São Paulo. The study will be open to all college students, Portuguese-Speaking, men or women aged over 18 years in agreement with the informed consent terms of the research. The exclusion criteria will be: visual or auditory impairment, presence of cognitive or psychiatric disorders or risk of suicide [19, 20]. For the pilot study before starting the groups, participants will be asked to respond to a protocol of psychometric instruments, lasting approximately 15 minutes, in which we will measure the following dependent variables: mindfulness scale (MAAS), Viability of Technology Scale (VTS), The Mini-Mental State (MINI), and sociodemographic questionnaire (DEMO). Both studies will have the randomization performed by software [www.random.org](http://www.random.org) and post assessment 2 and 6 months after intervention.

For the study 2, participants will be recruited at the PCS São Paulo, Brazil. Patients with MM who are interested will be invited to attend a clinical screening. The screening will be performed by the medical team, evaluated according to the MM eligibility criteria [21, 22]. Inclusion criteria: Men or women with diagnosis of MM, Portuguese-Speaking, aged over 18 years in agreement with the informed consent term of the research. The exclusion criteria will be: visual or audition impairment, presence of cognitive or psychiatric disorders or risk of suicide [19, 20].

Participants who agree to sign the informed consent will be randomized into three groups: a) the treatment offered by the PCS (TAU) versus b) TAU plus MBHP-VR intervention, versus c) TAU plus MBHP traditionally delivered. After the randomization, the research team will instruct the groups, about the place, date and time. For the TAU plus MBHP+VR group, a twenty-minute meeting will be held to instruct participants on how to install the MBHP+VR application on their cell phones (Mobile VR) anywhere without leaving their own house. VR glasses (Gear VR) will be provided to patients from the Public Health System facilities after the patient's randomization into the study groups. For participants who could not stay for this meeting, an explanatory video will be provided by email. For the TAU plus MBHP traditionally delivered, the research team will instruct the group about data, time and place (PCS room). Before starting the groups, participants will be asked to respond to a protocol of psychometric instruments, lasting approximately 30 minutes, in which we will measure the following dependent variables: mindfulness scale (MAAS), quality of life scale (SF-36), self-compassion scale (SCS), depression and anxiety scale (HADS), Viability of Technology Scale (VTS), sociodemographic questionnaire (DEMO) besides the Qualitative Questionnaire about User Experience (QQUE). In the TAU plus MBHP+VR group this protocol of psychological instruments will be answered online via the SurveyMonkey platform (<https://pt.surveymonkey.com/>) which will be provided by email (access link). A mindfulness instructor certified by the *Centro Mente Aberta Brasil* (<https://www.mindfulnessbrasil.com>) will conduct the TAU plus MBHP+VR group and the TAU MBHP traditionally delivered. This is a blind study which the principal researcher will only have access to the data during its analysis in order to avoid any possible biases that may arise during its collection. At the end of the

study, after 8-week training, participants will receive by email a link to complete the post-assessment. After 6 months from the post assessment, participants will receive another link to complete the follow-up evaluation.

### 2.3. Mobile VR

The MBHP + VR will be developed for smartphone. To use the application the user will need VR glasses (Gear VR) and a headset (both available from the research team). To install the MBHP + VR application on the smartphone first the user will need to download the app (with Wi-Fi connection). It will be available by research team via email (by access link). After downloading the MBHP + VR application and positioning the smartphone on the VR Gear, the user will be able to use VR and to access the content of the mindfulness program on the smartphone.

### 2.4. Mindfulness-Based Health Promotion Program (MBHP) and MBHP- VR protocol (MBHP+VR)

The MBHP program uses shorter sessions than the MBSR model created at the University of Massachusetts (United States of America) by Jon Kabat-Zinn, at the end of 1970, aimed at patients with chronic clinical conditions [8, 9]. The purpose of The MBHP program is facilitating its implementation in the Primary Care System in Brazil [23]. The MBHP program is a structured and developed program for 8 weeks (8 sessions), where participants meet weekly for 2 hours to practice mindfulness. Each session is composed of formal practices of mindfulness, conceptual dynamics and imaginative scenarios [11-13, 24]. All formal practices of mindfulness are performed with closed eyes (with the exception of walking practice and movements); the dynamics and imaginative scenarios take place with open eyes. The main formal practices of mindfulness are: mindfulness of breathing, body scan (a technique similar to progressive muscle relaxation, but adapt to promote awareness), mindfulness of walking and movement [23].

The main imaginative scenarios are: (Bursting Balloons - imagining thoughts like balloons / The lake - imagining yourself at the edge of the lake, each thought consists of a boat, come and go, let them go / train station - imagine that the trains are thoughts, let them pass or enter the wagon / The mirror- Imagine that in front of you has a large mirror, which reflects the mind, pure and crystalline / Label thoughts - imagine labels in the thoughts, identify them / Elder - imagine you are 20 years old, 30 years old ... etc., the farewell, the funeral and the meaning of life).

In order to adapt the MBHP protocol to VR glasses, participants embody themselves inside a meditation room, where they can visualize their avatar (first person perspective), a colleague's avatar (third person perspective) and the mindfulness instructor avatar (third person perspective). The instructor will conduct the formal practice of mindfulness and synchronously the user will be able to choose between closing their eyes and keeping them open. During the imaginative scenarios (synchronous) the user could visualize himself, in the first person perspective, by looking down and around and seeing himself in a new virtual reality scenario. Approximately 10 different imaginative scenarios will be created. Each scenario will last approximately 5 to 10 minutes, to avoid visual fatigue due to excessive use of VR

glasses [20-25]. Synchronous sounds and movements with the virtual reality scenario will be used in order to enhance the experiencing of presence, immersion and embodiment of the present moment during mindfulness training [30-35]. The protocol and each MBHP+VR session are currently being developed by virtual reality engineers.

## 1. 2.5. Outcome Measures and Instruments

The questionnaires to be used and the timing of administration are shown in Table 1.

**Table 1.** Main dimensions, questionnaires and timing of administration of scales.

Questionnaire	Measurement	Assessment time		
		Pre	Post-2 months	follow-up 6 months
MAAS	Mindfulness [36]	X	X	X
SF-36	Quality of life [37]	X	X	X
SCS-SF	Self-Compassion [38]	X	X	X
HADS	HADS Anxiety and Depression [39]	X	X	X
DEMO	Sociodemographic	X		
VTS	Viability of Technology [40]		X	X
MINI	The Mini-Mental State [19]	X		
QQUE	Qualitative Questionnaire about User Experience		X	X

## 2.6. Statistical data analyses

As for study 1, we will compare the two groups via a *unilateral t-test* for the hypothesis of non-inferiority of the MBHP+VR group in relation to the MBHP (control group). If the normal distribution is not adequate for the data, we will make the comparison by generalized linear model [41], considering the distribution that best fits the data.

As for study 2, we will use a variance analysis model with a factor representing the intervention and control groups, assuming normal distributions and homogeneous variances for the data. Otherwise we will use generalized linear models for the comparisons. A similar approach will be used for the secondary outcomes of the study, such as depression and anxiety. The analyzes will be performed using the statistical package R [42] and consider a significance level of 5%.

## 2.7. Sample size estimation

As regarding study 1, we considered the comparison of two groups: the control group and the experimental group. It will be considered the Mindfulness score after the both training. Assuming that the mean and post-training standard deviation in the control group were similar to those observed in the Omidi and Zargar study [43] (53.8 and 15.5), considering a non-inferiority margin of 20% (i.e. 10.76 units in the mindfulness score), 80% of power and unilateral level of significance of 2.5% in a *t-*

*test*, we estimated that it will be necessary to collect data from 34 individuals in each group.

As regarding study 2, the comparison of quality of life measures after training in the two intervention groups and in the control group was considered. It was detected a minimum difference of 10 units as measured by the quality of life (SF 36) in the intervention groups in relation to the control group, considering a standard deviation of 17.8 units, similar to the study by C. De Aquino [44]. In addition, it was considered 90% of power and 5% bilateral level of significance, which leads to a minimum required sample size of 68 individuals per group. The calculations were performed with the aid of the PASS program PASS [45].

## **2. 3. Conclusion, limitations, and future directions**

This paper is aimed to describe the work-in-progress study about MBHP-VR protocol on MM patients from PCS in Brazil. First, this paper delineated the process of validating mindfulness training coupled with VR as an instrument able to produce levels of mindfulness equal or better than mindfulness training traditionally delivered in non-clinical sample. Secondly, it showed how a study of the applicability of mindfulness training coupled with MM in PCS in Brazil will be conducted. This study has some limitations, such as the lack of a physiological assessment to measure the participant's immersion and embodiment during training in mindfulness with VR. It is well known that a greater sense of immersion and embodiment contributes to a better experience in virtual reality [31, 46, 47].

The use of VR in mindfulness training has three main advantages. The first one is that MM patients could participate in mindfulness training from their homes. Since many patients with MM have difficulty to displace and also depend on relatives to take them to the care centers. The second advantage is a decrease in the costs for the Public Health System; since mindfulness intervention promotes quality of life, emotional regulation and stress reduction in MM patients, the recurrent demand for medical care and hospitalization in the Public Health system may decrease. The third advantage is that adherence in the self-treatment maintenance could increase motivation to follow them from their homes.

The description of this study may contribute to open frontiers for the discussion of new studies on the use of technology for the promotion of health. This descriptive study could serve as a basis for creating new studies using different clinical samples that may benefit from mindfulness training coupled with VR, such as people suffering from chronic pain [28, 43], obesity, eating disorders, depression, and so on [13, 48]. VR could help people who have difficulty getting out of their homes to practice mindfulness.

## **3. 4. Acknowledgments**

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## **References**

- [1] A. Doessing , V. Bureau, Care coordination of multimorbidity: a scoping study, *J. Comorbidity* **5** (2015) 15–28, 2015.
- [2] E. Wallace, C. Salisbury, B. Guthrie, C. Lewis, T. Fahey, and S. Sm, Multimorbilidade Em Cuidados De Saúde Primários : O Que Há De Novo ?, **31**(2015) pp. 230–232.
- [3] U. N. De Lisboa, Multimorbilidade – um desafio para a gestão nos Cuidados de Saúde Primários, 32–41, 2016.
- [4] M. Fortin, L. Lapointe, C. Hudon, A. Vanasse, A. L. Ntetu, and D. Maltais, Multimorbidity and quality of life in primary care: a systematic review, *Heal. Qual.Life Outcomes.*, **2** (2004) p. 51
- [5] E. Wallace, C. Salisbury, B. Guthrie, C. Lewis, T. Fahey, and S. M. Smith, Managing patients with multimorbidity in primary care, *BMJ (Online)* **350** (2015) h176
- [6] M. van den Akker, F. Buntinx, and J. A. Knottnerus, Comorbidity or multimorbidity: what’s in a name? A review of literature *Eur. J. Gen. Pract.*, **2**(1996) 65–70,
- [7] R. A. Gotink, P. Chu, J. J. V. Busschbach, H. Benson, G. L. Fricchione, and M. G. M. Hunink, Standardised mindfulness-based interventions in healthcare: An overview of systematic reviews and meta-analyses of RCTs, *PLoS One*, **10** (2015) pp. 1–17.
- [8] S. W. Mercer *et al.*, The CARE Plus study - a whole-system intervention to improve quality of life of primary care patients with multimorbidity in areas of high socioeconomic deprivation: Exploratory cluster randomised controlled trial and cost-utility analysis, *BMC Med.*, **14** (2016), 1–10.
- [9] M. M. P. Demarzo, Meditação aplicada à saúde, *Programa Atualização em Med. Família e Comunidade*, **6** (2011) 1–18
- [10] J. Kabat-Zinn, Mindfulness-based interventions in context: Past, present, and future, *Clinical Psychology: Science and Practice*, **10** (2003) 144–156
- [11] J. G.-C. Marcelo Marcos Piva Demarzo, Solange Andreoni, Nadia Sanches, Sergio Perez, Sandra Fortes, Mindfulness-based stress reduction (MBSR) in perceived stress and quality of life: an open, uncontrolled study in a Brazilian healthy sam- pleMBSR in a Brazilian healthy sample, *J. Ethnopharmacol.*, (2014).
- [12] M. Trombka *et al.*, Study protocol of a multicenter randomized controlled trial of mindfulness training to reduce burnout and promote quality of life in police officers: The POLICE study, *BMC Psychiatry*, **18** (2018) 1–9.
- [13] V. Salvo *et al.*, Mindfulness as a complementary intervention in the treatment of overweight and obesity in primary health care: Study protocol for a randomised controlled trial, *Trials*, **19** (2018) 1–14.
- [14] M. M. P. Demarzo, A. Cebolla, and J. Garcia-Campayo, The implementation of mindfulness in healthcare systems: A theoretical analysis, *Gen. Hosp. Psychiatry*, **37** (2015) 166–171.
- [15] D. Freeman *et al.*, Virtual reality in the assessment, understanding, and treatment of mental health disorders, *Psychol. Med.*, (2017) 1–8.
- [16] M. de Carvalho, T. Dias, M. Duchesne, A. Nardi, and J. Appolinario, Virtual Reality as a Promising Strategy in the Assessment and Treatment of Bulimia Nervosa and Binge Eating Disorder: A Systematic Review, *Behav. Sci. (Basel)*, **7** (2017) 43
- [17] M. Slater and M. V. Sanchez-Vives, Enhancing Our Lives with Immersive Virtual Reality *Front. Robot. AI*, **3**(2016)
- [18] USC, “Stress Resilience in Virtual Environments,” (2014) 90094.
- [19] M. F. Folstein, S. E. Folstein, and P. R. McHugh, Mini-mental state’. A practical method for grading the cognitive state of patients for the clinician, *J. Psychiatr. Res.*, **12** (1975) 189–198.
- [20] B. G. Shinn-Cunningham, Object-based auditory and visual attention, *Trends Cogn. Sci.*, **12** (2008) 182–186.
- [21] J. Y. Le Reste *et al.*, The European General Practice Research Network Presents a Comprehensive Definition of Multimorbidity in Family Medicine and Long Term Care, Following a Systematic Review of Relevant Literature,” *Journal of the American Medical Directors Association*, **14** (2013) 319–325, 2013.
- [22] C. Lewis, E. Wallace, L. Kyle, W. Cullen, and S. Smith, Training doctors to manage patients with multimorbidity: a systematic review, *J. Comorbidity* **2** (2016) 85–94.
- [23] M. M. P. Demarzo, A. Cebolla, and J. Garcia-Campayo The implementation of mindfulness in healthcare systems: A theoretical analysis, *Gen. Hosp. Psychiatry*, **37** (2015) 166–171.
- [24] M. M. P. Demarzo and J. Garcia-Campayo, Mindfulness Aplicado à Saúde *PROMEF - Programa Atualização em Med. Família e Comunidade*, May (2017) 125–164.
- [25] M. Navarro-Haro *et al.*, Meditation experts try Virtual Reality Mindfulness: A pilot study evaluation of the feasibility and acceptability of Virtual Reality to facilitate mindfulness practice in people attending a Mindfulness conference., *PlosOne*. (2017), 1–14.,.
- [26] I. Kosunen, M. Salminen, S. Järvelä, A. Ruonala, N. Ravaja, and G. Jacucci, *RelaWorld*:

- Neuroadaptive and Immersive Virtual Reality Meditation System, *Iui* (2016),. 208–217
- [27] M. V. Nararro-Haro *et al.*, The use of virtual reality to facilitate mindfulness skills training in dialectical behavioral therapy for borderline personality disorder: A case study, *Front. Psychol.*, **7** (2016) 1–9
- [28] D. Gromala, X. Tong, A. Choo, M. Karamnejad, and C. D. Shaw, “The Virtual Meditative Walk: Virtual Reality Therapy for Chronic Pain Management,” *Proc. ACM CHI’15 Conf. Hum. Factors Comput. Syst.*, **1** (2015) 521–524, 2015.
- [29] M. M. Alarcón, M. H. Sarto, and M. R. Maicas Garcia Campayo J, Utilidad de la realidad virtual en la enseñanza y práctica de mindfulness: una revisión The utility of the virtual reality in mindfulness teaching and practice: a review, 48–60, 2016.
- [30] F. De Vignemont, “Embodiment, ownership and disownership,” *Conscious. Cogn.*, **20** (2011), 82–93.
- [31] K. Kilteni, R. Groten, and M. Slater, The Sense of Embodiment in Virtual Reality, *Presence Teleoperators Virtual Environ.*, **21** (2012) 373–387, 2012.
- [32] S. Y. (Su) Kim, N. Prestopnik, and F. a. Biocca, “Body in the interactive game: How interface embodiment affects physical activity and health behavior change,” *Comput. Human Behav.*, **36** (2014) 376–384.
- [33] M. J. Giummarra, S. J. Gibson, N. Georgiou-Karistianis, and J. L. Bradshaw, “Mechanisms underlying embodiment, disembodiment and loss of embodiment,” *Neuroscience and Biobehavioral Reviews*, **32** (2008) 143–160,.
- [34] A. Luciani, J.-L. Florens, D. Couroussé, and J. Castet, Ergotic Sounds: A New Way to Improve Playability, Believability and Presence of Virtual Musical Instruments, *J. New Music Res.*, **38** (2009) 309–323
- [35] J. S. Roo, R. Gervais, J. Frey, and M. Hachet, Inner Garden: Connecting Inner States to a Mixed Reality Sandbox for Mindfulness, *CHI ’17 Proc. 2017 CHI Conf. Hum. Factors Comput. Syst.*, 1459–1470, 2017.
- [36] K. W. Brown and R. M. Ryan, Mindfulness Attention Awareness Scale (MAAS), *J. Pers.*, **84** (2009) 5–7.
- [37] J. E. Ware and C. D. Sherbourne, The MOS 36-item short-form health survey (SF-36). I. Conceptual framework and item selection., *Med. Care*, **30** (1992) 473–83.
- [38] K. D. Neff, The development and validation of a scale to measure self-compassion, *Self identity*, **2** (2003) 223–250.
- [39] a S. Zigmond and R. P. Snaith, The hospital anxiety and depression scale (HADS)., *Acta Psychiatr. Scand.*, **67** (1983) 361–370
- [40] T. Liang, C. Huang, Y. Yeh, and B. Lin, Adoption of mobile technology in business: a fit-viability model, *Ind. Manag. Data Syst.*, **107** (2007) . 1154–1169.
- [41] J. J. Faraway, Extending the linear model with R: generalized linear, mixed effects and nonparametric regression models, *Chapman Hall/CRC Texts Stat. Sci. Ser.*. 1–28, 2006.
- [42] R Core Team, *R: A Language and Environment for Statistical Computing*, vol. 1. 2015.
- [43] A. Omid and F. Zargar, Effect of mindfulness-based stress reduction on pain severity and mindful awareness in patients with tension headache: a randomized controlled clinical trial. *Nurs. midwifery Stud.*, **3** (2014) e21136, 2014.
- [44] C. De Aquino, V. Augustob, D. Moreirac, and S. Ribeirod, “Avaliação da qualidade de vida de indivíduos que utilizam o serviço de fisioterapia em unidades básicas de saúde,” *Fisioter. Mov.*, *Curitiba*, **22** (2009) 271–279, 2009.
- [45] P. L. Agreement, PASS 14 License Agreement,” pp. 1–2.
- [46] R. Llorens *et al.*, Body schema plasticity after stroke: Subjective and neurophysiological correlates of the rubber hand illusion, *Neuropsychologia*, **96** (2017).
- [47] A. Cebolla *et al.*, Embodiment and Body Awareness in Meditators, *Mindfulness (N. Y.)*, **7**, 2016.
- [48] T. Barnhofer *et al.*, Mindfulness-Based Cognitive Therapy ( MBCT ) Reduces the Association Between Depressive Symptoms and Suicidal Cognitions in Patients With a History of Suicidal Depression, **83** (2015) 1013–1020, 2015.

# The “Decoding of Social Interactions in Virtual Reality” Tasks for Autism Spectrum People: Development of an Intervention Protocol and Pilot Testing

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**Abstract.** Virtual reality (VR) could provide an opportunity to engage people with autism in complex social interactions and improve their social skills. Our team developed a psychoeducational program, named the Decoding Social Interaction Task in VR (DSITinVR), and this pilot study aims at exploring whether people with autism can improve their social cognition with DSITinVR as well as improving their social skills. Three AS adult males without intellectual disability were immersed in a 6-wall CAVE-Like system. Pre- and post-application of the program was assessed by the interviewer, participants and parents to document social decoding, social skills and social anxiety. Following exposition to DSITinVR, participants showed improvement in decoding social interactive situations. However, they showed less change in social skills and social anxiety. Based on the assessment of participants, parents and the interviewer, suggestions for modifying the program are proposed, including more situations dedicated to social-skills teaching, planned practice of skills between sessions, and reframing increase in awareness to avoid sensitization.

**Keywords.** Autism, Virtual reality, Social cognition, Perception, Strengths

## 1. Introduction

Autism spectrum (AS) encompasses a variety of symptoms and clinical features, including persistent deficits in social communication and social interaction. Deficits in social cognition may impact the capacity to engage in nuanced social behavior, to share emotions and interests, to have social-emotional-reciprocity, to adopt nonverbal communicative behaviors or to understand and develop relationships [1]. For example, lack of social understanding makes it difficult to decode mental and emotional states, while deficits in social motivation can reduce interest in engaging in social interactions and also negatively impact social communication [2]. In addition, Kenworthy et al. [3] demonstrated the role of executive dysfunction in social deficit in response to feedback and adherence to social rules. However, existing strengths in perception in autism [4]

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could compensate for difficulties encountered in the social domain and reduce associated anxiety.

Adults with autism are frequently unsatisfied with their employment, level of education, relationships and their prospects for the future [5,6]. Some of them have a limited social life and suffer from loneliness. All these elements may impact the well-being or the quality of life of adults with autism [7,8]. The capacity to properly decode social cues in multiple contexts could enhance responses to the environment [9]. Many intervention programs designed for people with AS include social skills training [10]. Despite the possible positive impact of these interventions, transferability of social skills in autism remains a major concern [11]. Using the potential of virtual environments could be an interesting avenue to help autistic persons have a better understanding of social cues and thus facilitate their social participation. Virtual reality (VR) has already shown promising results for appraising social environments in other populations who experience social anxiety [12,13]. More specifically, research has focused on using VR environments to assess reactions to immersion and to address social challenges among autistic children [14-16]. VR could provide an opportunity to engage with more realistic experiences and improve social decoding and social skills by working with a variety of everyday settings. Considering that autistic persons seem to react well to immersion in virtual reality [15,16], we used this innovative approach as a social learning experience for adult AS. The study had two objectives: 1) to explore whether AS people can improve their social cognition by using the Decoding Social Interaction Task in VR (DSITinVR), and 2) to explore if using the DSITinVR can have a measurable impact on AS persons' social skills.

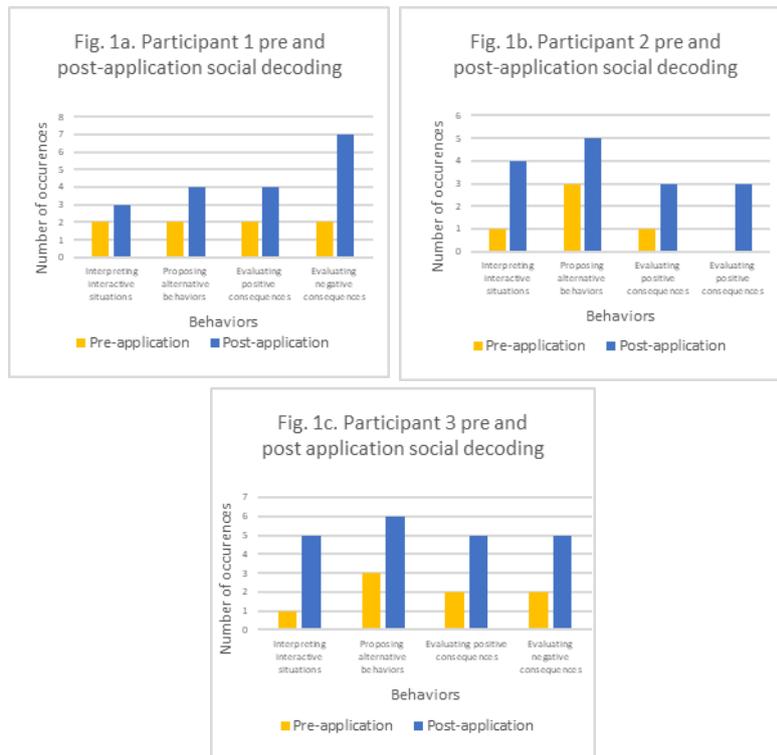
## 2. Methods

Three AS adult males with typical intelligence participated in this pilot study (for a more detailed description, see Cloutier [17]). The study was approved by the Université du Québec en Outaouais ethics committee and written consent was obtained for all participants. Building on people with AS's perception and information processing strengths, particularly those related to detection, identification and manipulation of visual information, the Decoding Social Interaction Task in VR (DSITinVR) was developed to immerse people with AS in complex social interactions [17]. One of the researchers (VC) who has clinical experience with AS persons accompanied the participants during the immersion. All tasks were conducted in Psyche, a fully immersive stereoscopic and wireless 6-wall CAVE-Like system where participants can move freely with a wand tracker. After trying VR for a few minutes to document the acceptability and potential of the DSITinVR for each participant, they were immersed in five social contexts. The first social interaction (a party) and the last (customers commenting on the physical appearance of a waitress in a bar) were used as opportunities to measure how AS people immersed in VR freely decode social interactions in a pretest and post-test design. The other three immersions (ordering food in a restaurant, dealing with an intrusive stranger in a bar, and at a bus stop) were used for social cognition training. Users were coached by VC in decoding the social interactions and their contexts, interpreting virtual humans' emotions and intentions, exploring a variety of possible actions, and deciding on which behavior and actions should be applied and practiced by the participant. As part of the experimental protocol during the VR training, notes were systematically written and drawn in a personal

logbook to help participants compile, organize and visualize all relevant information [17]. Pre- and post-application of the program was assessed by the interviewer, the participants and by the parents. They evaluated social decoding, social skills and social anxiety using two in-house tools and a questionnaire: the rating grid of behaviors involved detecting social cues (CPS), the perception of social decoding and social skills (CPI), and the Social Interaction Self-Statement (SISST) [18] assessing participants’ positive and negative thoughts about their social experiences.

### 3. Results

The rating grid showed that there was an overall improvement in participants’ ability to detect social cues as demonstrated in interpreting interactive situations, proposing alternative behaviors and evaluating positive or negative consequences of their actions (see Figures 1a, 1b, 1c). The questionnaire completed by parents reported improvement in social decoding for all participants and in social skills for 2/3 of participants. Two thirds of participants self-reported a reduction in maladaptive behaviors (see Table 1a and 1b). An increase in positive thoughts was observed for all participants, with a reduction of negative thoughts reported for only one participant, as measured by the SISST (see Table 1b).



Figures 1a, 1b, 1c. Pre-, post-application social decoding scores among participants.

**Table 1a.** Scores on the in-house questionnaire completed by parents

	Participant 1		Participant 2		Participant 3	
	Pre <sup>1</sup>	Post <sup>2</sup>	Pre	Post	Pre	Post
Social decoding*	13	6	9.5	8	10	7
CPS Scale**	24	10	17.5	14	13	13
CPI Scale***	18	14	15	15	14	20

**Table 1b.** Scores on the in-house questionnaire completed by participants

	Participant 1		Participant 2		Participant 3	
	Pre <sup>1</sup>	Post <sup>2</sup>	Pre	Post	Pre	Post
Social decoding*	8	9	6	9	7	7
CPS scale**	10	12	12	12	11	13
CPI Scale***	15	17	19	17	14	19
SISST-P****	46	47	55	57	26	33
SISST-N*****	44	47	35	38	36	33

\* Reduction in score represents an improvement in social decoding; \*\* Reduction in score represents an improvement in social skills; \*\*\* Increase in score represents a reduction of maladaptive behaviors; \*\*\*\*Increase in score represents an improvement in positive thoughts; \*\*\*\*\*Reduction in score represents a reduction in negative thoughts.

#### 4. Discussion

The innovative DSITinVR, combining virtual reality and the use of visual strengths in autism, shows promising results, although data collection needs to be extended to a larger number of participants. Based on the participants', parents' and the interviewer's assessments, suggestions for modifying the program were proposed, including more situations dedicated to social skills teaching, planned practice of skills between sessions, and reframing increase in awareness to avoid sensitization.

#### References

- [1] APA. *Diagnostic and statistical manual of mental disorders (DSM-5)*: American Psychiatric Association, 2013
- [2] B. F. d'Arc., F. Ramus, A. Lefebvre, D. Brottier, T. Zalla, S. Moukawane, . . . M-C. Mouren. Atypical social judgment and sensitivity to perceptual cues in autism spectrum disorders. *Journal of Autism and Developmental Disorders*, **46**(2016), 1574-1581.
- [3] L. Kenworthy, B. E. Yerys, L.G. Anthony, & G. L. Wallace. Understanding executive control in autism spectrum disorders in the lab and in the real world. *Neuropsychology review*, **18**(2008), 320-338.
- [4] L. Mottron, L. Bouvet, A. Bonnel, F. Samson, J.A. Burack., M. Dawson, & P. Heaton . Veridical mapping in the development of exceptional autistic abilities. *Neuroscience & Biobehavioral Reviews*, **37**(2013), 209-228.
- [5] J. L. Taylor, N. A. Henninger, & M.R. Mailick. Longitudinal patterns of employment and postsecondary education for adults with autism and average-range IQ. *Autism*, **19**(2015), 785-793.
- [6] J. L. Taylor, & M. R. Mailick. A longitudinal examination of 10-year change in vocational and educational activities for adults with autism spectrum disorders. *Developmental psychology*, **50**(2014), 699.
- [7] L.Bishop-Fitzpatrick, J. Hong, L.E. Smith, R. A. Makuch, J. S. Greenberg, & M. R. Mailick Characterizing objective quality of life and normative outcomes in adults with autism spectrum disorder: An exploratory latent class analysis. *Journal of Autism and Developmental Disorders*, **46**(2016), 2707-2719.

- [8] M. O. Mazurek. Loneliness, friendship, and well-being in adults with autism spectrum disorders. *Autism*, **18**(2014), 223-232.
- [9] F. Colver, H. Merrick, M. Deverill, A. Le Couteur, J. Parr, M.S. Pearce., . . .H. McConachie. Study protocol: longitudinal study of the transition of young people with complex health needs from child to adult health services. *BMC Public Health*, **13**(2014), 675
- [10] D. Spain, & S. H. Blainey. Group social skills interventions for adults with high-functioning autism spectrum disorders: A systematic review. *Autism*, **19**(2015), 874-886.
- [11] M. E. DeRosier, D. C. Swick, N. O. Davis, J. S. McMillen, & R. Matthews. The efficacy of a social skills group intervention for improving social behaviors in children with high functioning autism spectrum disorders. *Journal of Autism and Developmental Disorders*, **41**(2011), 1033-1043.
- [12] X. Pan, M. Gillies, C.Barker, D.M. Clark., & M. Slater . Socially anxious and confident men interact with a forward virtual woman: an experimental study. *PLoS one*, **7**(2012), e32931.
- [13] H. Park, J-J. Kim, H-J. Jang., C-J. Kim, Ku, I. Y. Kim, . . S.H. Park Characteristics of social anxiety from virtual interpersonal interactions in patients with schizophrenia. *Psychiatry*, **72**(2009), 79-93.
- [14] Y. Cheng, H-C. Chiang, J. Ye, & L.-H. Cheng . Enhancing empathy instruction using a collaborative virtual learning environment for children with autistic spectrum conditions. *Computers & Education*, **55**(2010), 1449-1458.
- [15] Y. Cheng, C-L. Huang, C. & Yang. Using a 3D immersive virtual environment system to enhance social understanding and social skills for children with autism spectrum disorders. *Focus on Autism and Other Developmental Disabilities*, **30**(2015), 222-236.
- [16] S. Wallace, S. Parsons, A. Westbury, K. White, K. White, A. & Bailey. Sense of presence and atypical social judgments in immersive virtual environments: Responses of adolescents with Autism Spectrum Disorders. *Autism*, **14**(2010), 199-213.
- [17] V. Cloutier. La réalité virtuelle au service du trouble du spectre de l'autisme: Une avenue possible pour favoriser l'intégration en améliorant les capacités de décodage social et les habiletés sociales. Master thesis conducted at the Université du Québec en Outaouais, 2017
- [18] C. R. Glass, T. V. Merluzzi, J. L., Biever, K. H. & Larsen. Cognitive assessment of social anxiety: Development and validation of a self-statement questionnaire. *Cognitive Therapy and Research*, **6**(1982), 37-55.

# The influence of expectations on usability and visual appeal in a web environment

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**Abstract.** The impact of verbal and textual influences that create expectations on the perceived and objective usability and visual appeal of a website was examined. A computer laboratory study, in the form of a user-based usability test, was done to determine the effect of textual and verbal expectations on visual appeal and usability. Results showed that the combination of textual and verbal expectations successfully influenced participants. When told that the website was going to be hard and ugly, participants were disinclined from using it, stating it was too hard to use, and struggled more when using it. Similarly, participants thought that the website was easier to use and prettier in the high expectations group than in the low expectations group. Results suggest that web developers and project managers should focus on investing in marketing and social media influencers as well as in the development of an attractive and usable website.

**Keywords.** Human-Computer Interaction, Usability, Visual Appeal, Expectations

## 1. Introduction

Many studies have been done on the relationship between usability and visual appeal, but the results vary vastly. There are many factors that influence the results, including website domain, the type of task, if incentive is given, and metrics used to get the usability and visual appeal measures. However, the impact of expectations on these two variables is understudied. Therefore, this paper examines the influence of expectations on usability and visual appeal, on an unfamiliar city council website [1], chosen to control for prior expectations. This work is an extension of previous work [1-3].

According to ISO 9241/11 [4], “usability is the extent to which a given product can be used by a specific group of users, to achieve specific goals with effectiveness, efficiency, and satisfaction in a specific context of use”. Effectiveness is how well users achieve specific goals, efficiency is the time to complete a given task, and satisfaction is the user’s experience of acceptability. The context of use is a predefined group of users, in a specific environment, who perform given tasks with the interface.

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Visual appeal is the cognitive judgment of an object's aesthetic appearance [5]. Expectations are beliefs on what is about to happen.

## 1. A Brief Background

In Human-Computer Interaction (HCI), “what is beautiful is usable” [6], since a relationship between a user's first impression of visual appeal and perceived usability was found, pre- and post- system use. However, more recent literature reveals different findings on the relationship between usability and visual appeal. For example, Katz [7] found significant correlations between perceived visual appeal and perceived usability *before* system use, but not after. Tuch et al. [8] found that usability affected perceived visual appeal after use, and not the other way around. Thus, the relationship between usability and visual appeal has not yet been properly understood.

Textual expectations, in the form of textual word-of-mouth (WOM), affect visual appeal and usability in an unfamiliar website type (i.e. city councils) [2]. However, the effect of expectations on visual appeal and usability was smaller than anticipated since subjective usability was not affected, and visual appeal was not affected on an attractive and easy to use website. Therefore, the purpose of this study was to reinforce expectations by implementing them verbally, to see if it would have a greater effect. The textual implantation of expectations used in an earlier study [2] mimicked textual online reviews. The verbal implementation of expectations used in this paper mimics in-person and video reviews, such as face-to-face communication between friends and online reviews such as those found in YouTube videos, respectively. To examine the impact of social media on the use and perception of websites, we examined both textual and verbal implementations of expectations in this paper.

## 2. Method

Five studies [1] were completed in order to get an easy and attractive website. Three levels of expectations were implemented: (a) easy and attractive (i.e. high expectations), (b) hard and ugly (i.e. low expectations), and (c) the control (i.e. no expectations). Expectations were implemented textually and/or verbally. As with an earlier study [2], textual expectations were nuanced task descriptions that participants read before they interacted with the website. The verbal expectations came from a confederate who acted like a participant and spoke to participants before the study began, giving them their ‘opinion’ of the website they supposedly just interacted with. This opinion was a rehearsed speech, similar to the task description (i.e. written expectation), reinforcing the expectations. The previous study [2] used only textual expectations. The present study used the same method from the earlier study [2] but added verbal expectations in an effort to strengthen the implementation, to see if more significant results could be obtained.

### a. Participants

In the present study, 20 (16 males, 4 females; 16 aged 18-30 years, 4 aged 31+) participants were recruited. All volunteered and were screened for 20/20 or corrected to

20/20 vision and colour blindness. Thirteen participants were not familiar with the purpose of city councils (the subject of our test websites), and seven were somewhat familiar. No one was very familiar with the purpose of a city council. Participants were individually tested, approximately one hour per session, ten participants per condition. In the analysis below, there are 30 participants which is the result of the addition of the control condition data from [2]. The control condition was identical to the other conditions but did not have any textual or verbal expectations associated with it.

### b. Materials

The System Usability Scale (SUS; [9]) and the Visual Appeal of Websites Inventory – Short version (VisAWI-S; [10]) scales were used for perceived measures of usability and visual appeal, pre- and post-use. Objective usability was acquired per task: the number of clicks, the number of hovers, task completion time in seconds with a maximum of three minutes, and success (pass if the answer is correct and within 3mins). Pre-use measures were based on a 6-second exposure to the website’s homepage, a page one click in, and a page two clicks in to the website (2sec/pg). Ten randomly ordered information retrieval tasks were given to participants. An example of a task is: “How many beaches are located in the Gold Coast?”



Figure 1. Section of the city council’s homepage.

### c. Procedure and Data Analysis

A confederate was in the experiment room, picking up their things and getting ready to leave as the participant entered the room. The experimenter asked the confederate if they were all done and the confederate responded that they were just leaving. The experimenter thanked them and told the participant to go ahead in and wait a minute while the experimenter left to set up the computers. The confederate then told them the usability and visual appeal expectations in the form of their experience with the website and left. The experimenter came back into the room.

The consent form was signed first. Then, the participant was given the written task descriptions according to the condition that they were randomly assigned to. The instructions were on the computer screen. Participants then briefly viewed the website slideshow and evaluated pre-use usability and visual appeal. Then, they were instructed to start each of the information-retrieval tasks from the homepage, told that the search bar would not work, to avoid using other websites or prior knowledge to answer the tasks, and asked to persist with a task until they got an answer or were told to move to the next one. The researcher then left the participant in the room alone. As soon as the researcher and participant were both ready in their separate rooms, the usability test

began. The participant and researcher were connected via a hands-free speaker. Participants then filled out the visual appeal and usability scales again. The researcher returned to the participant's room and asked the participant for feedback on usability, visual appeal, and if they believed and agreed with the confederate.

### 3. Results

#### a. Participant Feedback

None of the participants in the low expectations condition said anything positive about the usability, whereas 4/10 participants in the high expectations condition said that it was easy to use, consistent, and had a well-structured layout overall. Everyone in the low expectations condition was hostile about the website. For example, one said that he would fire the developer, while another said during the test, "can I just put 'no' without looking for it in the website? It's so bad."

Seven participants from the high expectations group said that the website looked great, had great colours, and that it looked "easy on the eyes". Only four participants from the low expectations condition said that it looked good but they were less confident in their opinions. For example, one said that the website "looks modern, I guess."

When asked if they believed the confederate, three people from the high expectations condition said that they did and four in the low expectations group said that they did. One participant in the high expectations group mentioned that he did have high expectations of this website when usually he did not have any of city council websites. One participant in the low expectations group said that he "tried not to be biased but subconsciously, I was." Therefore, it might be the case that people heard the confederate and tried to be neutral, but were indeed influenced.

One participant in the high expectations group agreed with the confederate saying that it was a great website, while three agreed with the confederate's description of the 'bad' website in the low expectations condition. Lastly, two participants in the high and three in the low expectations condition said that they did not remember what the confederate said. They never interacted with a city council website and had no expectations.

There was less disagreement with the confederate in this study than in disagreement with the textual expectations in [2], suggesting that the addition of the confederate influenced subjectively participants more so than just the written task description.

#### b. Statistical Testing

*Assumptions Testing.* The normality assumptions were not always met, success was binary, clicks and hovers were discrete, time was continuous, and sample size per condition was small ( $n=10$ ); Kruskal-Wallis and Fisher's Exact tests were used.

*Statistical Results.* Main effects were found in pre-use usability ( $H=11.553$ ,  $p<0.01$ ), post-use visual appeal ( $H=9.296$ ,  $p=.01$ ), and post-use usability ( $H=11.853$ ,  $p<0.01$ ). This means that a statistical difference was found amongst the high, low, and no expectation conditions. Paired comparisons showed that high and low expectation

conditions differed in pre-use usability ( $H = 88.5, p < .01$ ), post-use visual appeal ( $H = 89, p < .05$ ), and post-use usability ( $H = 94, p < .01$ ).

The average number of clicks per task ( $p < .05$ ) differed within the attractive website conditions. Pairwise comparisons showed that the number of clicks were different ( $p < .01$ ) between the high and low expectations conditions. Specifically, participants in the low condition, on average, clicked more often per task (3.82 clicks) than those in the high condition (2.8 clicks). Main effects were also found for task completion time ( $p < .01$ ) and the average number of passed tasks ( $p < .05$ ). Pairwise comparisons found that the difference in time ( $p < .01$ ) and passes ( $p < .05$ ) was between the high and low conditions. Participants took over half a minute longer to complete a task in the low condition (i.e. 108sec in low versus 71sec in high). The significance of the comparison of the average of passed tasks was confirmed ( $p < .01$ , one-tailed) with a Fisher's Exact test, where high had a better success rate (0.83) than the low group (0.58).

*Summary of statistical results.* High and low expectation groups differed in pre-use usability, post-use visual appeal, and post-use usability. In addition, the average number of clicks per task, average task completion time, and proportion of passes (success rate) differed between these two groups. Therefore, participants rated the same website as prettier and easier to use when they were told that it was going to be well made, attractive, and usable. Moreover, they struggled more with the website when completing the information retrieval tasks when told that the website was hard to use. *Expectations influenced both how participants viewed and interacted with the website.*

## 4. Discussion

### a. Results Summary

While the website presented to everyone was the same, the majority of participants in the high expectations condition thought that the website was attractive, whereas the majority of participants in the low expectations condition did not. People in the low expectations group were very critical of the usability and visual appeal levels. Yet, 8/10 in high expectation group said that they liked them.

Statistically, the low and high conditions differed in pre-use usability, post-use visual appeal, and post-use usability. This means that the same website was differently rated, depending on what the expectation was before the experiment. Specifically, participants rated the website better when they were told it was going to be easy and attractive, and they rated it as worse when they were told the opposite. In addition, the average number of clicks, completion time, and the success rates differed between the high and low conditions. The low expectation group made more clicks, took longer, and had a lower success rate while doing the same tasks and using the same website.

### b. Implications for Website Design

A bad reputation can turn people against your website, even if the reputation is not true. To overcome this, website operators might invest in marketing and social media influencers to give a website a more positive reputation right from the beginning. It will influence people before they use it and, according to the results of this study, last throughout use to influence their opinions after having used the website. In this study,

participants were forced to use it, whereas in real life there are thousands of websites to choose from and competition can be fierce. If you advertise, people will (1) know about it, (2) know something good about it, (3) be willing to check your website out, and (4) like it a bit more than they would otherwise.

### c. Limitations and Future Research

One limitation is the small sample size. However, we have significant results even with a small sample size which would only suggest that a larger sample would be even more successful in illustrating the influence of expectations. This study was done using a confederate who acted like a participant just finishing the usability test, and either praised or complained about the website. However, this may not be the best way to do so given the unfamiliarity, untrustworthiness, and minimal exposure to the confederate and the expectation. Yet, again, the results showed that expectations did influence usability and visual appeal, and indeed, more so than in the earlier study [2]. Given that expectations influence visual appeal and usability when both are either high or low, the next study should examine what happens with this relationship when the usability and visual appeal are incongruent with each other.

## 5. Conclusion

Visual appeal and perceived usability were rated as higher when the expectation was high, and lower when the expectation was low. Participant performance was also affected by expectations. Comparing to the previous study [2], the results suggest that verbally enforced expectations do impact the perception and use of a website, more so than just written task descriptions on their own. This suggests that while textual user reviews are effective, the combination of textual and verbal expectation setting is even more effective. Thus, marketing and social media influencers have the power to sway people towards and away from your website. It is important to give a website a more positive reputation right from the beginning. If you advertise, people will (1) know about it, (2) know something good about it, (3) be willing to check your website out, and (4) like it a bit more than they would otherwise.

## References

- [1] M. Stojmenović, C. Pilgrim, & G. Lindgaard, Perceived and Objective Usability and Visual Appeal in a Website Domain with a Less Developed Mental Model. OZCHI'14, Dec2-5, Sydney, Australia (2014), 316-323.
- [2] M. Stojmenović, J. Grundy, V. Farrell, R. Biddle & L. Hoon. Does Textual Word-of-Mouth Affect Look and Feel? OZCHI'16, Nov29-Dec2, Launceston, Australia (2016), 257-265.
- [3] M. Stojmenović, M., Biddle, R., Grundy, J., & Farrell, V. The influence of textual and verbal word-of-mouth on website usability and visual appeal. *The Journal of Supercomputing*, (2018).1-48.
- [4] ISO 9241/11. 1996. International Organization for Standardization. Retrieved June (2012).
- [5] J. Blijlevens, Typically the Best? Perceived Typicality and Aesthetic Appraisal of Product Appearances. PhD thesis, Delft University of Technology, The Netherlands, 2011.
- [6] N. Tractinsky, A.S. Katz, & D. Ikar. What is beautiful is usable. *Interacting with Computers*, **13**, (2000), 127-145.
- [7] Katz, Aesthetics, usefulness and performance in user-search-engine interaction. *Journal of Applied Quantitative Methods*, **5**, (2010), 424-445.

- [8] N. Tuch, S.P. Roth, K. Hornbaek, K. Opwis, & J. A. Bargas-Avila. Is beautiful really usable? Toward understanding the relation between usability, aesthetics, and affect in HCI. *Computers in Human Behavior*, **28**, (2012), 1596-1607.
- [9] J. Brooke. System Usability Scale (SUS). Digital Equipment Corporation, UK,1986.
- [10] M. Moshagen, & M. Thielsch. A short version of the visual aesthetics of websites inventory. *Behaviour and Information Technology* (2012), 1-7.

# The DataScapes Project: Using Letters, Proteins and Augmented Reality as Constituents for Landscape Art

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**Abstract.** The DataScapes Project is built on the fundamental aim of using the media theorist Harold Innis' writings on the Oral Tradition to support aesthetic innovation. Toward that end, it seeks to explore how Data Art and Sonic Art can be employed as constituents for Landscape Art displayed in the medium of Augmented Reality.

**Keywords.** DataScapes Project, Augmented Reality, Landscape Art, Sonic Art, Data Art, Algorithmic Art, Harold Innis, Media Theory, Toronto School of Communication, Oral Tradition

## 1. Introduction

Humans have been modifying their environs for a very, very long time. Some evolutionary biologists argue that our species has done so for functional reasons. Via *niche specification*, humans inscribe, construct and annotate landscapes to optimize their capacity for survival through food production, spatial orientation and habitation [1, 2]. Cultures past and present, however, have also used built form and modified topography for deeper purposes: to express their yearning for beauty; their conception of history; their power over space; and their belief that humans – in the end – live in a cosmos with intrinsic purposes that can be understood. “From the most immemorial Hindustan pagodas to the Cathedral of Cologne,” Victor Hugo writes, “architecture was the great script of the human race” [3]. When it comes to the human use of space for expression, however, there has been one common constant that has supported all scripts, be they prosaic or profound: the medium of expression has been material. The purpose of this paper is to suggest that the human use of surrounding space is now entering a new phase, one in which landscapes, seascapes and skyscapes are inscribed with expressive objects that are virtual. This innovation is being supported by new paradigms of computing – such as Ubiquitous Computing – and new media for expression, such as Augmented Reality, or AR. To provide a sense of how this latter

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medium potentially will impinge on human spatial expression, we present The DataScapes Project, an experiment in AR-supported landscape art.

### **1. Our Theoretical Ground: The Communication Writings of Harold Innis**

Our aspiration to construct an AR-landscape artwork suggested in turn the need to draw on some theoretical tradition to assist in the selection of its content and suggest how it might be constructed. It should not surprise that project members felt the need to draw on some structuring principle to help inform our efforts. Practitioners of new media routinely draw on precedent to guide their initial efforts. The first film-makers, for example, drew on theatre to structure their narratives. Multiple theoretical traditions were available, ranging from the cultural Marxism of Walter Benjamin to contemporary landscape theory and Michel de Certeau's writings on culture and space. However, given that we were endeavoring to generate an artwork in a new medium, we ultimately opted to approach our project from the standpoint of the media writings of Harold Adams Innis. For those unfamiliar with his work, Harold Innis was a political economist at the University of Toronto from 1920-1952. During the last decade of his life, Innis produced a series of works that explored the impact of novel communication technologies on the evolution of societies past and present. His writings were highly prized by Marshall McLuhan and are among the founding documents associated with the Toronto School of Communication. In his two most important anthologies – *Empire and Communications* and *The Bias of Communication* – Innis presented a set of concepts that were dedicated to explicating the physical and formal properties of communication technologies, and their cognitive effects [4, 5].

For our purposes, Innis' writings on the ancient method of communication known as the Oral Tradition proved to be the most relevant as they directly addressed the topic of expressive innovation. Innis' purpose in introducing the concept was to champion a communication discipline that prevented individuals, institutions and societies from setting into states of cognitive and cultural stasis. As he describes it, the Oral Tradition is not a method characterized by the use of human memory and voice. In fact, neither faculty was essential to the tradition's practice. Rather, Innis pressed for a definition in which communicants are committed to the use of formalisms characterized by rich internal complexity and hierarchy. Creativity is supported through user exploitation of a given formalism's internal complexity to arrange and then re-arrange its constituent parts. Such activities enable the user to explore new expressive possibilities and, through the separation, juxtaposition and translation of novel and different forms of content, new ways of looking at the world. The Oral Tradition further supports creativity by practicing what we would refer to today as an open-source ethic of content appropriation and re-creation. Formalisms, and the creative works that rests on them, are not inviolate things. In ancient Greece, new lays of poetry were routinely incorporated into extant works, and then modified to meet the needs of the larger whole [6]. In its essence, Innis' Oral Tradition presents an interesting frame of reference for creating digital, landscape art. In contemporary terms, his writings suggest a method that emphasizes formal complexity, the use of multi-topic and multi-modal content, content appropriation and information translation.

## 2. Our Formalisms

Once the terms for constructing the landscape were settled, the next step was to select a domain of art that lent itself to the content selection and re-purposing project members envisioned. Here, we were presented with an alternative that had obvious appeal: data art. In principle, it offered a ready source of copyright-free content. It further presented a means to create a formally-complex, multi-modal construct. Via this method, a data source could be used to generate one formalism via *visualization* and a second, complementary formalism via *sonification*. To generate our visualizations, project members selected the mode of algorithmic art, a domain characterized by complex topologies and mixtures of colour as well as static and dynamic images. For project sonifications, team members opted to employ methods from data-derived music, a mode of music composition that is the by-product of scientific efforts to locate significant patterns through sound. Multiple genres of music associated with different categories of data have emerged as a result, including DNA Music, Protein Music, Microbial Music, and even Astronomical Music [7-10].

## 3. Our Data and Methods

Once our formalisms were selected, the next priority was to find data that would, in poetic terms, enable them to live, move and have their being, by providing them with shape, sound, colour and motion. Here, our selections were determined as much by expedience as design. The expedience was determined by the need for software capable of translating raw data into music form. There is not a great deal of readily available proprietary or open-source software that is dedicated to that purpose. The design stemmed from project members' interest in producing at least one art work that reflected the concept of emergent change. Given this fusion of interest and circumstance, the project ultimately selected *MusicWonk* to translate its data, a decision that reduced the potential scientific data sets down to two: DNA and Protein [11].

*MusicWonk* operates by taking letter data, such as the letters A, G, T and C associated with DNA – and translating the same into numeric form, with A equaling 1, B equaling 2, Z equaling 26, and so on. Since we wanted our formalisms to express more than the four variations presented by DNA, we ultimately opted to use protein data, which, in the format presented by the U.S. National Institutes of Health, represents a given protein's constituent amino acids as a sequence of letters. Once *MusicWonk* has translated its source data into a numeric series, it then aligns it with a given music scale, producing a raw music string. From there, a composer can either use the method of music composition supported by *MusicWonk*, which follows a method akin to creating a computer algorithm or electric circuit, or he or she can export the raw music string to a .midi computer file, which can then be opened and modified using music composition software such as *Finale*. This is the method that our two project composers – Brock music students Erin Dempsey and Amy Brulé – used to complete the compositions associated with the project's two works. The ultimate result of our work with protein data was *The Five Senses*. As indicated in Table 1, the work contains five movements composed by Dempsey, each one derived from a protein associated with a given sense such as smell or taste.

Our second work, *Emergence*, was prompted by the capacities of *MusicWonk* and by the interest of project members in the phenomenon of self-organization studied by

the Science of Complexity. It was also prompted by the observation of scholars such as Werner Jaeger and Harold Innis that different domains of human activity – such as science, philosophy and theology – often produce constructs of change that are very similar [12]. It was finally prompted by the observation of John Bonnett that a number of parallels could be found between the core concepts of emergent change – such as positive feedback, the governance of formal cause, and the teleological governance of system attractors – and the philosophy of history found in the Christian Bible.

**Table 1.** Data sources for *The Five Senses*

<b>Movement</b>	<b>Protein</b>
Hear	TMC 1: Transmembrane cochlear-expressed protein 1
Sight	Medium Wave sensitive opsin 1 (Green cone photopigment)
Smell	Putative Olfactory Receptor 212
Taste	Sweet taste receptor TIR2
Touch	POU domain, class 4, transcription factor 2

Given our aim, we opted to use *Emergence* based on source text data taken from the Bible. Like *The Five Senses*, it again features five pieces, with each movement named after a constituent concept of self-organization such as “Attractor” “Differentiation” and “Selection.” Each work, in turn, rests on text data taken from the King James version of the Bible, as shown in Table 2, texts that pointed to processes analogous to positive feedback, formal cause, final cause, and so on. Once the source texts were identified, the same process as that used for *The Five Senses* was implemented: texts were translated into numbers, and then imported into *MusicWork*. Raw music strings were again generated, and then exported to *Finale*, where composer Amy Brulé used them as the basis for her final compositions.

**Table 2.** Data sources for *Emergence*

<b>Movement</b>	<b>Text Source</b>
Emergence	John 1: 1-18
Differentiation	Genesis 1:1-Genesis 2:3
Regulation	I Corinthians 12:12-31
Selection	Matthew 25:14-30
Attractor	Revelation 22:12-31

While drawing on the same numeric data as their accompanying musical scores, the visualizations for *The Five Senses* and *Emergence* were each realized via distinct methods. The graphics for *The Five Senses* were generated by mathematician and algorithmic artist Bill Ralph, who generates his own algorithms to create striking images characterized by their density, complex morphology and colour. His dynamic works are driven in two ways, first by the algorithm proceeding sequentially through the data, and secondly by locating relationships between different, non-proximate strings within the data [13, 14]. For *Emergence*, computer scientist Mark Anderson started with Screen Vector Graphic images that related conceptually with titles such as *Differentiation* and *Selection*. He then used the software *NodeBox* and project data to transform his images: to make them dynamic and prompt shifts in colour.

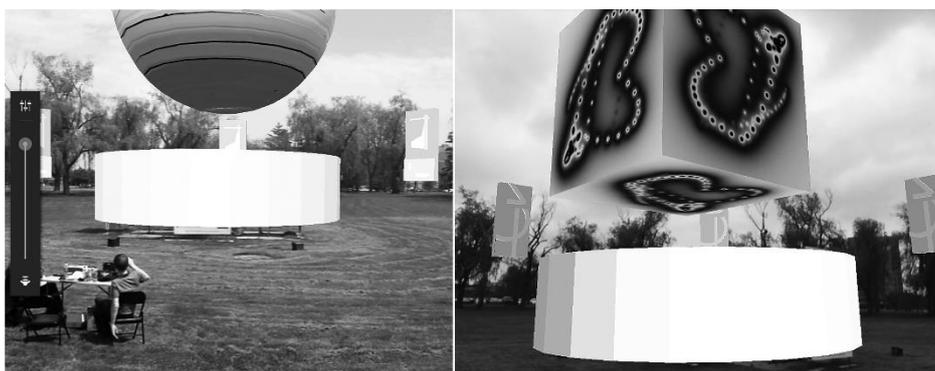
#### 4. Our Setting and App

With the content for the two works settled, the project's final two challenges were to locate a viable way to display the two works and to find a suitable setting in which to display them. For our initial version of *The Five Senses* and *Emergence*, we have opted to use a display system which relies on an app to activate the art works and a tablet computer to display them. To enable the app to properly register and stabilize the content during its first display, we mounted four QR code signs in the centre of our display setting. The setting for the first display was the southern traffic circle at Brock University, as shown in Figure 1.



**Figure 1.** Brock University Setting for *The DataScapes Project*.

In addition to the site, we overlaid a virtual set over the circle to assist in the display of each work. The set was comprised of a set of monoliths, which were situated on the periphery of the circle, and a cylindrical base, which was situated in the centre of the circle. Its purpose was to obscure the real-world statue situated in the circle's centre, and the accompanying scaffolding and QR Code signage. To display our visuals of each work, we used two objects, a cube for *The Four Senses* and a sphere for *Emergence*, as shown in Figure 2. The accompanying music for each piece activated automatically once the given user reached the prescribed distance from the central display space.



**Figure 2.** Display Set for *Emergence* and *The Five Senses*.

## 5. Conclusion

While AR is a rudimentary technology, its potential as a medium for the functional and aesthetic enhancement of human environs is both exciting and clear. Having completed the first stage of our project, our intent now is to further underline that potential by generating new artworks that will be set in seascapes and skyscapes located in Canada and the United Kingdom. We further intend to modify the app to enable future users to generate their own art by adding functions that will enable them to create their own sets, and integrate their own data, into displays supported by the *DataScapes* app. As forthcoming hardware and software from *Microsoft* and *Google* suggest, the next decade will likely see an explosion of Augmented Reality content. The potential AR will present for new forms of computer gaming, athletic gaming, art, education and narration are limitless. This is an exciting time to be in the digital humanities.

## References

- [1] J.E. Wuenscher, Niche specification and competition modeling, *Journal of Theoretical Biology* **25** (1969), 436-443.
- [2] T.A. Alley, Competition theory, evolution, and the concept of an ecological niche, *Acta Biotheoretica* **31**(1982): 165-179.
- [3] V. Hugo, Book 5, Chapter 2: This Will Kill That, *Notre-Dame de Paris*, Trans. John Sturrock, London, Penguin, 1978.
- [4] Harold Innis, *Empire and Communications*, Oxford, UK: The Clarendon Press, 1950.
- [5] Harold Innis, *The Bias of Communication*, Toronto: University of Toronto Press, 1952.
- [6] John Bonnett, *Emergence and Empire: Innis, Complexity and the Trajectory of History*, Montreal and Kingston: McGill-Queens University Press, 2013.
- [7] Peter Gena and Charles Strom. Musical Synthesis of DNA Sequences. *Sixth International Symposium on Electronic Art*, Montreal, 1995: 83-85.
- [8] J. Dunn and M. Clark, Life Music: The Sonification of Proteins, *Leonardo* **32**(1999):25-32.
- [9] P. Larsen and J. Gilbert, Microbial Bebop: Creating Music from Complex Dynamics in Microbial Ecology, *PLoS ONE* **8**(2013): e58119.
- [10] M. Ballora and G.S.Smoot, Sound: The Music of the Universe. *The Huffington Post*. Feb 23, 2013 [Accessed 2018 Mar 31]; [http://www.huffingtonpost.com/mark-ballora/sound-the-music-universe\\_b\\_2745188.html](http://www.huffingtonpost.com/mark-ballora/sound-the-music-universe_b_2745188.html).
- [11] Interactive Generative Creativity Software for Music, Visuals and Wordplay, *Algorithmic Arts*, 2015. [accessed 31 Mar 2018]; <http://algoart.com/>.
- [12] W. Jaeger, *The Theology of the Early Greek Philosophers: The Gifford Lectures, 1936*, Eugene, OR: Wipf and Stock, 2003.
- [13] C. Neufeld, B. Ross, and W. Ralph. The evolution of artistic filters. J. Romero and P. Machado. Eds., *The Art of Artificial Evolution*. Berlin: Springer-Verlag, .335–356. 2008
- [14] Bill Ralph's Art. 2018. St. Catharines, Ontario; [accessed 2018 Mar 30]; <http://billralph.com>.

# Simulating the inner voice: A study of sound parameters

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**Abstract. Introduction:** Inner voice is estimated to occur at least a quarter of people's conscious waking life. Much research work asserts that inner voice plays various important roles in cognitive functions, such as self-regulation, self-reflection, and so on. Virtual cognitions are a stream of simulated thoughts people can hear while emerged in a virtual reality environment that intend to mimic the inner voice and thus simulating the effect of an inner voice. Presenting and manipulating virtual cognitions in learning and training may be a useful intervention method to affect people's behavior and beliefs. Exposing people to virtual cognitions, presented as an inner voice, requires the simulation of such voice and therefore understanding of the underlying sound parameters. Many researchers believe that there is a relationship between people's inner and outer voice, even suggesting that people's inner voice resembles the features of their own outer voice. The work presented here, therefore, explored people's perception of their simulated inner voice by considering several core sound parameters of their outer voice. **Methods:** Using a specially developed audio recording and modification software tool, 15 participants (11 males, 4 females) set key sound parameters to match their own voice recording with their perception of either their own inner or their outer voice. After reading aloud nine sentences, they modified seven sound parameters of the recordings: pitch, speed, echo and volume of sound with the frequency band (20-320Hz, 320-1280Hz, 1280-5120Hz, and 5120-20480Hz). **Conclusion:** The result of the study indicates that people's sound perception is different between inner and outer voice. Also, individual variations were found for the perception of inner and outer voice differences. For developers who want to simulate inner voice in a virtual environment, these findings suggest that inner voice has its own distinct characteristics compared to an outer voice. The volume setting for the frequency band of 1280-5120Hz can be based on group perception, whereas for speed and echo settings it might require individualization.

**Keywords.** Virtual cognitions, Inner voice, Inner speech, Sound parameters

## 1. Introduction

Possibilities are, when you are reading this first sentence, you are hearing your own voice speaking in your head even if you are not saying anything out loud. This phenomenon is commonly called "inner voice", "inner speech" or referred to as "verbal stream of consciousness". Heavey and Hurlburt [1] found that in their sample, around a quarter of people's conscious waking life contains an inner voice. Much research work asserts that inner voice has a positive effect on many cognitive functions, such as self-regulation [2], self-reflection [3], and so on. Meanwhile, the stream of consciousness, already proposed by psychologist William James [4], refers to a continuous succession

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of thoughts in the conscious mind. It is also a narrative technique, intended to mirror people's internal psychological world and the way internal thoughts form in the mind. James Joyce's *Ulysses* [5] casts the thoughts and conscious experiences of characters in words in a first-person perspective, just as capturing the inner voice of characters. Based on these considerations, we propose creating virtual cognitions that work as a kind of inner voice or personalized voice-overs when people are in a virtual environment. Like virtual environment aims at replicating an environment by artificially creating sensory experiences, virtual cognitions aim at replicating thoughts by artificially creating cognitive experiences. Some replication successes have already been reported. However, these studies focus on replicating the physical body in virtual reality. For example, the rubber hand illusions or virtual body transfer illusions let people regard parts, or even their entire virtual human body as their own [6, 7]. It is interesting, therefore, to examine possible parallels for virtual cognitions to elicit an internalized mind illusion. Presenting and manipulating virtual cognitions may be a useful way to affect people's behavior and beliefs for training or therapeutic purposes.

Exposing people to virtual cognitions, presented as an inner voice, requires the simulation of such a voice and therefore understanding of the underlying sound parameters. Much research shows that there is a link between people's inner and outer voices. On one hand, taking a developmental perspective, Vygotsky et al. [2] argue that inner voice is the result of a gradual internalization process of outer voice, while Watson [8] claims that inner voice develops with the reduction of self-directed outer voice. On the other hand, taking a functional perspective, Hickok et al. [9] propose that when people speak, an internal copy of the sound of their voice is created simultaneously with the overt sound. Scott [10] goes a step further, putting forward and testing a theory that the internal copy of people's voice can also be generated without overt sound. He also believes that the mechanism the inner voice makes use of is the one mostly applied for processing outer voice. He sees the inner voice as the results of the internal prediction of the sound of one's own voice. Moreover, Filik and Barber's findings [11] suggest that people's inner voice resembles the features of their outer voice, even their regional accent. The work presented here, therefore, explores people's perception of their simulated inner voice by considering several core sound parameters of their outer voice. Although as described above, the inner voice seems to have a close relation, even similarities, with the outer voice, Brocklehurst and Martin [12] also found that stuttering people believed their inner voice was not stuttered, which means people's inner voice might hold different sound characteristics from outer voice. We, therefore, hypothesize that people's sound parameter settings are different depending on the type of voice – inner or outer voice.

## 2. Methods

To investigate the sound characteristic of the inner voice, an empirical study was conducted. The study was approved by University Human Research Ethics Committee (ID: 20).

### a. Participants

15 participants (11 males, 4 females) were recruited throughout the university campus via e-mail or approached personally. Their ages ranged from 23 to 36 ( $M = 26.1$ ,  $SD = 3.52$ ).

### b. Procedure

By using a specially developed audio recording and modification software tool, the participants first read aloud nine sentences while their voice was recorded. After that, the experimenter explained the concept of an inner voice to the participants and several examples of the inner voice phenomenon were given to help participants to have a clear understanding of this concept. Next, the participants had 2-3 minutes to recall their inner voice experience. After this, participants listened back to their previously recorded sentences and set key sound parameters to match their recording with their perception of either their own inner or outer voice. They modified seven basic audio effects and common digital audio-processing features [13] of the recordings: pitch, speed, echo and volume of sound with the frequency band (20-320Hz, 320-1280Hz, 1280-5120Hz, and 5120-20480Hz). The modification data of the parameter settings was collected as input for the statistical analysis.

### c. Data analysis

To analyze the participants' parameter setting data, multi-level models were used. Models were built in R version 3.4.2. All the experiment data, the R scripts, and output files can be found online.<sup>1</sup> Model 1 was the basic model that only included participants as a random intercept. Model 2 was built on Model 1 and added voice type as a fixed effect. Finally, Model 2 was extended by adding voice type as a random effect (Model 3). All models fitted assumed normal distribution, except models fitted on the echo settings. Here a Poisson distribution was assumed. The analysis compared the ability of the models to fit the data.

## 6. Results

To investigate the consistency of participants' parameter settings across sentences, Cronbach's alpha was calculated for all nine sentences for each parameter, and for both inner voice and outer voice. The results show consistency for the same parameter, and for participants' settings for each sentence both inner voice and outer voice. Coefficient alpha of inner voice ranged from 0.62 to 0.93 ( $M = 0.83$ ;  $SD = 0.10$ ). Coefficient alpha of outer voice ranged from 0.69 to 0.93 ( $M = 0.87$ ;  $SD = 0.09$ ).

Table 1 and Table 2 show the results of multi-level analysis. For parameter speed, Model 3 was the most appropriate ( $p < 0.01$ ), while for the sound volume of frequency band 1280-5120Hz, Model 2 was the most appropriate ( $p < 0.05$ ). Except for these two parameters, Model 1 was not outperformed by the extended model for other parameters. As the results show, none of 95% confidence intervals of the standard deviation for random intercept included zero, indicating that a significant variation between participants in setting the parameters in general.

1. **Table 1.** Multilevel analysis results of the parameters settings for Pitch, Speed, Volume of sound with frequency band (20-320Hz, 320-1280Hz, 1280-5120Hz, and 5120-20480Hz)

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<sup>1</sup> Files are stored at the 4TU.Research repository with a DOI: 10.4121/uuid:57d78b85-c9ae-4d9e-81f9-23d065913d52

	df	$\chi^2$	p-value	Lower 95%	mean	Upper 95%
<b>Parameter 1: Pitch</b>						
M1: Random Intercept				0.02	0.03	0.05
M2: Fixed VoiceType	1	0.30	0.59			
M3: Random VoiceType	2	4.93	0.08			
<b>Parameter 2: Speed</b>						
M1: Random Intercept				0.02	0.03	0.06
M2: Fixed VoiceType	1	0.97	0.33			
M3: Random VoiceType	2	11.80	0.003	0.03	0.06	0.10
<b>Parameter 4: Volume of sound with frequency band(20-320Hz)</b>						
M1: Random Intercept				0.10	0.14	0.21
M2: Fixed VoiceType	1	2.00	0.16			
M3: Random VoiceType	2	0.24	0.89			
<b>Parameter 5: Volume of sound with frequency band (320-1280Hz)</b>						
M1: Random Intercept				0.05	0.08	0.13
M2: Fixed VoiceType	1	3.01	0.08			
M3: Random VoiceType	2	1.21	0.55			
<b>Parameter 6: Volume of sound with frequency band (1280-5120Hz)</b>						
M1: Random Intercept				0.09	0.14	0.20
M2: Fixed VoiceType	1	7.02	0.01	0.01	0.05	0.09
M3: Random VoiceType	2	3.33	0.19			
<b>Parameter 7: Volume of sound with frequency band (5120-20480Hz)</b>						
M1: Random Intercept				0.11	0.16	0.23
M2: Fixed VoiceType	1	0.52	0.47			
M3: Random VoiceType	2	0.28	0.87			

2.

3. **Table 2.** Multilevel analysis results of the parameter settings for Echo

<b>Parameter 3: Echo</b>			Lower 95%	mean	Upper 95%
M3: Random voice type	Fixed effects	Intercept	-2.99	-1.91	-0.84
		voice type	-2.45	-0.97	0.51
	Random Effects	Intercept	1.23	1.93	3.04
		voice type	1.56	2.48	3.93

The results of multilevel analyses showed that participants set the speed, echo and the volume sound for the frequency band 1280-5120Hz differently when considering inner voice or outer voice. This suggests that people's sound parameters setting is different when it comes to the type of voice. Furthermore, the finding of a significant fixed effect indicates that the difference in volume perception for the frequency band 1280-5120Hz was consistent across participants. Here, participants set the volume higher for outer voice than inner voice. While for speed and echo the finding of a significant random effect suggests deviation across participants for setting inner and outer voices. It also suggests for speed and echo consistency on an individual level, i.e. an individual using the same speed and echo settings across his or her own nine voice recordings. For example, some participants consistently raised the speed for their inner voice and lowered it for their outer voice, while others consistently did this the other way around.

## 7. Conclusion and discussion

Although the phenomenon of "inner voice" has been studied for decades, controversies concerning the nature and function of inner voice persist. In this study, we employed a parameters modification experiment to gain a better understanding of (1) the relationship between inner and outer voices; (2) the sound characteristic of the inner voice; and (3) simulated internal thoughts in virtual reality to further enable the creation of virtual cognitions. This study has some weaknesses. First, the sample size of our experiment is limited, and the participants are all university students or employees. Second, the study is an indirect perception study, asking participants to replicate the sound of their voice to the best of their abilities. It assumes that people can replicate their voice by modifying these parameters. Third, although the findings give some insight into differences between the inner and outer voices, they do not tell much about the accuracy of the replication. Future work might therefore examine this by asking people for example to rate sound recordings on an analogue scale from not very accurate to very accurate. Still, of course, such examination remains difficult because of the intensely private nature of the inner voice.

Despite these limitations, the study provides some insight into the phenomena of the inner voice needed to create virtual cognitions. Based on the results of this study, some conclusions can be drawn. First, these findings indicate that people perceive their inner voice to sound different from their outer voice. Second, individualization in the perception is observed for the difference between inner and outer voices. For developers who want to simulate inner voice in a virtual environment, these findings suggest that inner voice must be modulated separately from outer voice. The volume setting for the frequency band of 1280-5120Hz can be based on group perception, whereas for speed and echo settings it might require individualization. Interesting is also the absence of systematic differences for various bandwidths, except the 1280-5120Hz band. The 1280-5120Hz band roughly overlaps with the 1000-5000Hz band where humans have been found to be most sensitive [14], and therefore most capable to distinguish between inner and outer voices.

Recently, Craig et al. [15, 16] propose using avatar therapy to let individuals talk with a computerized representation of their inner voice hallucination, aiming at reducing the frequency and severity of auditory hallucinations. It might be interesting to examine whether consistency can be found in the sound parameters settings of these recreated voices, and how they relate to people's own inner and outer voice perception. Moreover, as this study found individual differences how people perceive inner and outer voices, future work might focus on individual factors that could predict these variations as a next step in understanding how inner voice is shaped.

To conclude, this study opens up research into inner and outer voices perception and ways to simulate these voices. It has the potential of exposing people to thoughts and ideas, with applications in entertainment, education and health domains.

## Acknowledgements

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## References

- [1] C. L. Heavey and R. T. Hurlburt, The phenomena of inner experience *Consciousness and cognition* **17** (2008) 798-810.
- [2] L. S. Vygotskiĭ, E. Hanfmann, and G. Vakar, *Thought and language*. MIT press, 2012.
- [3] A. Morin and B. Hamper. Self-reflection and the inner voice: activation of the left inferior frontal gyrus during perceptual and conceptual self-referential thinking, *The open neuroimaging journal*, **6**, 2012.
- [4] W. James, *The principles of psychology*. Read Books Ltd, 2013.
- [5] J. Joyce, *Ulysses*. Editora Companhia das Letras, 2012.
- [6] M. Rohde, M. Di Luca, and M. O. Ernst, The rubber hand illusion: feeling of ownership and proprioceptive drift do not go hand in hand, *PloS one*, **6** (2011), e21659
- [7] M. Slater, B. Spanlang, M. V. Sanchez-Vives, and O. Blanke, First person experience of body transfer in virtual reality, *PloS one*, **5** (2010) e10564
- [8] J. B. Watson, Psychology as the behaviorist views it *Psychological review*, **20** (2013) 158
- [9] G. Hickok, J. Houde, and F. Rong, Sensorimotor integration in speech processing: computational basis and neural organization, *Neuron*, **69** (2011) 407-422.
- [10] M. Scott, Corollary discharge provides the sensory content of inner speech, *Psychological science* (2013) 0956797613478614
- [11] R. Filik and E. Barber, Inner speech during silent reading reflects the reader's regional accent *PloS one* **10** (2011) e25782
- [12] P. H. Brocklehurst and M. Corley Investigating the inner speech of people who stutter: Evidence for (and against) the Covert Repair Hypothesis *Journal of Communication Disorders* **44** (2011) 246-260
- [13] T. Holmes, *Electronic and experimental music: technology, music, and culture*. Routledge, 2012.
- [14] J. J. May Occupational hearing loss *American journal of industrial medicine* **37** (2000) 112-120
- [15] J. Leff, G. Williams, M. A. Huckvale, M. Arbuthnot, and A. P. Leff Computer-assisted therapy for medication-resistant auditory hallucinations: proof-of-concept study *The British Journal of Psychiatry*, **202** (2013) 428-433
- [16] T. K. Craig *et al.* AVATAR therapy for auditory verbal hallucinations in people with psychosis: a single-blind, randomised controlled trial *The Lancet Psychiatry* **5** (2018) 31-40



## SECTION VII

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### BRIEF COMMUNICATION



# Virtual Reality environments to reduce dental anxiety.

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**Abstract.** Dental procedural pain and anxiety are issues that affect a conspicuous part of the population, leading to a decrease of dental care frequency. The problem affects the patient as well as the dentist, who often has to face a certain resistance by the patients while doing the necessary procedures. The aim of the study is to demonstrate that is possible to reduce this anxiety through the use of Virtual Reality (VR). A group of 7 patients was immersed in a VR scenario during dental treatment in order to distract them from the feared procedure. The results are encouraging and show how VR is capable of insulating the subject from the surrounding annoying stimuli.

**Keywords.** Dental care, dental phobia, distraction, analgesia, virtual reality.

## 1. Introduction

Who does not know that subtle and uncomfortable anxiety that precedes a visit to the dentist? A conspicuous amount of people admit that they are afraid of the dentist, a fear that often finds its cause in childhood traumatic experiences and can manifest itself not only with heartbeat, sweating and retching during the treatment, but also with insomnia the night before the scheduled dental visit. Often, however, odontophobia is a form of unexplained primordial anguish. A recent study outlined how dental fear affects an impressive 58.8% of a sample [1], showing that fear was not affected by age or education level and that it was higher in women. In addition, people who visited the dentist more regularly and individuals without previous traumatic dental experiences were less

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anxious. Some odontologists use hypnosis to reduce anxiety and fear in the patients, but this process is highly complicated and, in order to achieve good results, it has to count on a very skilled professional and on a very motivated patient with high levels of hypnotizability (thus imagination). In line with previous studies carried out on the use of virtual reality (VR) as a distraction tool from anxiety and/or pain [2, 3], this study aimed to evaluate the validity and reliability of the VR intervention within this specific field by analyzing the response to the therapy by the patients who undergo dental care procedures.

## 2. Methods

A group of seven patients, composed of 4 males and 3 females, was recruited from a private dentist office in Palermo, Italy and they underwent dental procedures wearing a VR headset.

**Table 1:** Population characteristics

	<b>Experimental group</b>
	$n = 7$
Age (Mean $\pm$ SD)	$38.285 \pm 12.697$
(range)	$18 \pm 59$
Gender (M, F)	4, 3

The treatment consisted of a single exposure to VR, lasting the whole duration of the dental procedure. The VR scenarios used were “Castle” and “Cliff”, developed by The Virtual Reality Medical Center, San Diego, CA. These worlds help evoke relaxation and deep breathing [4]. VR scenarios were run in a Microsoft Surface, and the environments were visualized in a head-mounted display (Vuzix iWear video headphones), configuring an immersive VR experience. The movements through the environments were managed with the help of a joystick and the sound was reproduced by the same HMD, which was provided with insulating headphones.

Before the treatment we administered a questionnaire to detect sociodemographic variables and some aspects of the relationship with dentist, such as familiarity, visit frequency, satisfaction rate, past odontoiatric care, type of dental procedures, and use or no use of anesthesia. Furthermore, we assessed the grade of anxiety through the State-Trait Anxiety Inventory (STAI form Y-1 and Y-2), depression state through Beck Depression Inventory-II (BDI-II), and specific dental anxiety through the Dental Anxiety Scale of Corah (DAS) [5]. Before, during and after the treatment, we established the level of subjective anxiety through the Subjective Units of Distress Scale (SUDS) [6] and monitored the heart rate (HR) as physiological measure through a fingertip pulse monitor. Moreover, after the treatment, we measured the variations of state anxiety through the STAI-Y1.

## 3. Results

Wilcoxon test was used to compare values pre and post treatment. All analyses were carried on using SPSS v. 21.

As it refers to HR, there was no variation between the initial (HR1) and intermediate (HR2) values because the patients were under anesthesia. The results of the tests showed a significant reduction in the scores obtained in the State-Trait Anxiety Inventory Y-1, SUDS, and HR (table 1).

**Table 1.** Results at Wilcoxon test

Test-retest	Mean $\pm$ SD		Experimental	*
STAI Y-1	36.285 $\pm$ 10.617	29.571 $\pm$ 9.778	$z = -2.226$ , $p = 0.026^*$	Significant $p < 0.05$
HR	84.147 $\pm$ 20.489	81.000 $\pm$ 12.583	$z = -2.028$ , $p = 0.043^*$	
SUDS	4.428 $\pm$ 2.370	3.428 $\pm$ 3.101	$z = -2.410$ , $p = 0.016^*$	

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The results of the tests submitted before the treatment showed that the sample did not have excessive trait-anxiety (STAI-Y2<40) or excessive depression state (BDI-II<16). DAS scores showed a physiological anxiety for the dental context and odontoiatric procedures (7.571 $\pm$ 4.035).

Spearman correlation coefficients were used to examine the relationship between test/retest and variables of the questionnaire. Results indicated correlation tendency between low levels of instruction and high levels of trait anxiety ( $r = -.741$ ,  $p = .057$ ) and a significant correlation with depression ( $r = -0.808$ ,  $p = .028$ ); significant correlation between pretest state anxiety and previous dental care ( $r = -0.791$ ,  $p = .034$ ). Furthermore, DAS correlated with both previous dental care and frequency of odontoiatric chirurgic intervention ( $r = -0.798$ ,  $p = .032$ ). Therefore, we found that low levels of instruction, previous dental care and frequency of odontoiatric chirurgic interventions increases the level of state anxiety and stress related to dental procedures.

#### 4. Discussion and conclusion

Our results, in accordance with other studies [4], provide further support for the feasibility of using VR environments as tools to reduce anxiety and stress related to dental care, improve compliance with dentist and achieve non-disruptive behavior during the treatment. VR environments allow to patients relax and be distracted by navigating to another location while still physically remaining in the dental office, draining attention from the dental procedure. Therefore, it helps the patients better cope with the fear of the dentist and the odontoiatric procedures, and encourages the subject to achieve better dental health. The results obtained are encouraging even though the number of patients need to be increased, and a control group has to be added.

#### References

- [1] M. Saatchi, M. Abtahi, G. Mohammadi, M. Mirdamadi, E. S. Binandeh, The Prevalence of Dental Anxiety and Fear in Patients Referred to Isfahan Dental School, Iran, *Dental Research Journal* **12** (2015), 248-253.
- [2] D. Guarino, F. La Paglia, M. Daino, V. Maiorca, S. Zichichi, F. Guccione, A. Pintabona, M. D. Wiederhold, G. Riva, B.K. Wiederhold, D. La Barbera, Chronic pain treatment through virtual reality, *Annual Review of CyberTherapy and Telemedicine* **15** (2017), 181-184.
- [3] M. D. Wiederhold, K. Gao, B.K. Wiederhold, Clinical use of virtual reality distraction System to reduce anxiety and pain in dental procedures, *Cyberpsychology, Behaviour & Social Networking* **17** (2014), 359-365.

- [4] B. K. Wiederhold, K. Gao, C. Sulea, M. D. Wiederhold, Virtual reality as a distraction technique in chronic pain patients, *Cyberpsychology, Behaviour & Social Networking* **17** (2014), 346-352.
- [5] N. L. Corah, Development of a dental anxiety scale, *Journal of Dental Research* **48** (1969), 596.
- [6] J. Wolpe, A. L. Lazarus, *Behavior therapy techniques*, Pergamon Press, New York, 1966.

# Personalizing the Exergame Experience: A Personality Tailoring Approach

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**Abstract.** A sedentary lifestyle is a growing health concern. Many researchers and game designers are investigating the value of exergames for encouraging an active lifestyle. However, not all games are enjoyable for everyone and thus, players drop out. To provide a better understanding of how to create a more enjoyable experience and encourage continued play, we conducted an exploratory study to examine the effects of personality-based pairings on enjoyment in the context of two exergaming scenarios. Early results seem to show that player pairs who score high on conscientiousness and openness particularly enjoyed playing together in a cooperative game scenario, whereas player pairs who score high on extraversion and openness particularly enjoyed their interaction together in a competitive game scenario. This study serves as a good prototype to further validate the concept of personality-based pairings with a larger sample.

**Keywords.** Competition, cooperation, exergames, personality, personalization

## 1. Introduction

Exergames, which are a combination of exercise and video games [1], are enjoyable and effective at motivating initial exercise interest [2]. However, not all exergames are enjoyable for everyone. For example, research suggests that competitive exergames are enjoyable for highly competitive individuals, but not for non-competitive individuals [3]. There is also some research evidence suggesting that exergames may not be able to motivate exercise interest over the long-term [2]. To keep high-levels of enjoyment and increase retention rate, growing research suggest that it is important to personalize the gaming experience based on factors such as presentation of game content and player personality [4], as well as, a player's level of competitiveness and cooperativeness [5; 6]. Research shows that a training system that mimics the personality of an individual offers a highly motivating gaming experience [5]. Yet, how to personalize the game experience based on personality for the best possible exergaming experience is relatively under-researched. Although there is some research regarding how different personalities respond differently to pervasive strategies in health games [7] and how personality traits might influence player motivation in social network games [8], to the best of our knowledge, there has yet to be a study examining the effects of personality-based pairings in the context of exergames. Thus, the goal of this study was to better understand the effects of a player's personality profile for personalizing the exergame experience. We employed

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an Intraclass Correlation (ICC) to examine the level of agreement between player pairs, and a Wilcoxon Signed-Rank tests to investigate the effect of game scenarios on personality-based pairings. Preliminary results seem to show that personality and game scenarios do play a role on the level of enjoyment experienced between player pairs and recommend that future exergame design could tailor the game experience based on personality to increase player retention.

#### 4 Method

A within-participant design was used to explore the effects of personality-based pairings in two exergaming scenarios. 10 participants (7 males, 3 females; 5 pairs;  $M_{\text{age}} = 32$  years,  $SD_{\text{age}} = 4$  years) were recruited via convenience sampling to play virtual Bocce in a closed laboratory setting. Experimental sessions were approximately 1 hour long and were divided into three parts: a tutorial session to learn about the game followed by 2 play sessions. After playing both competitive (head-to-head) and cooperative (same team) game scenarios, participants completed the intrinsic motivation inventory (IMI) [9], the 10-item personality inventory (TIPI) [10], and a questionnaire consisting of seventeen customized items (7-point Likert scale 1 = strongly disagree to 7 = strongly agree) that evaluated game scenario enjoyment, as well as level of social influence one player had on the other.

#### 5 Results

From analysis of the TPI, a total of three different personality pairing categories were formed: 1) conscientiousness & openness (2 pairs), 2) extraversion & openness (2 pairs), and 3) neuroticism & openness (1 pair).

To determine which pairings enjoyed their interaction together most, an Intraclass Correlation (ICC) [11] was conducted on level of agreement between player's responses provided in the IMI. Results showed that there was a strong reliability between player pairs who scored high on extraversion and openness ( $ICC = 0.46$ ,  $p = 0.02$ )<sup>1</sup>, which seems to suggest that extraverts and explorers particularly enjoyed their interaction together. In contrast, results showed a weak reliability between player pairs who scored high on conscientiousness and openness ( $ICC = 0.46$ ,  $p = 0.10$ ), which seems to suggest that explorers and organizers may have not enjoyed their interaction together.

To examine the level of enjoyment and social interaction for each personality pairing category with respect to the two game scenarios (competitive vs. cooperative), two-tailed Wilcoxon Signed-Rank tests were conducted on the IMI and custom items that evaluated social influence. Although the results (Table 1) were not significant, which could be due to the small sample size and not from the absence of effect of personality traits, mean ranks ( $MR$ ) results seemed to show that player pairs who scored high on conscientiousness and openness particularly enjoyed playing a cooperative game ( $MR = 4.67$ ), whereas player pairs who scored high on extraversion and openness particularly enjoyed playing a competitive game ( $MR = 4.00$ ). With respect to social factors, results seemed to show that player pairs who scored high on

<sup>1</sup> All statistical tests were set at a p-value threshold of 0.05.

extraversion and openness experienced more positive social interactions in a competitive game ( $MR = 11.08$ ) than a cooperative game ( $MR = 7.86$ ).

**Table 1.** Two-tailed Wilcoxon Signed-Ranks tests on three personality pairing categories with respect to the level of enjoyment and social factors.

Measures	Personality Pairing Categories					
	Conscientiousness & Openness		Extraversion & Openness		Neuroticism & Openness	
	Z	p	Z	p	Z	p
Enjoyment	-1.14	0.16	-0.38	0.71	-1.00	0.32
Social Factors	-1.52	0.13	-0.49	0.63	-0.36	0.72

## 6 Conclusions

The results of this exploratory study seem to show that the level of enjoyment experienced between player pairs can be influenced by social factors, the personality of players, and game scenarios. Likewise, personality traits can also influence the gaming experience depending on how well the game mechanics are in line with the personality of player pairs. From a game design perspective, knowing the personality of players can help personalize the game experience by tailoring scenarios and other players which will more likely increase the level of enjoyment, social interaction and exercise adherence. For example, offering player pairs who score high on extraversion and openness game scenarios where they play against each other could encourage both players to be more engaged because, based on the results of this study, such pairings rated a competitive game to be more enjoyable compared to a cooperative game.

## References

- [1] T. C. N. Yim, Jeffrey, Graham, Using games to increase exercise motivation, *Future Play '07 Proc. 2007 Conf. Futur. Play*, (2007).
- [2] H. Sun, Impact of exergames on physical activity and motivation in elementary school students: A follow-up study, *Journal of Sport and Health Science*, **2** (2013), 138–145.
- [3] H. Song, J. Kim, K. E. Tenzek, and K. M. Lee, The effects of competition and competitiveness upon intrinsic motivation in exergames, *Computers in Human Behavior*, **29** (2013), 1702–1708.
- [4] R. Dias and C. Martinho, Adapting Content Presentation and Control to Player Personality in Videogames, *Proc. 8th Int. Conf. Adv. Comput. Entertain. Technol.*, (2011) 18:1–18:8.
- [5] L. A. Shaw, J. Buckley, P. M. Corballis, C. Lutteroth, and B. C. Wuensche, Competition and cooperation with virtual players in an exergame, *PeerJ Computer Science.*, **2** (2016), e92.
- [6] G. Chan, A. Whitehead, and A. Parush, An Evaluation of Personality Type Pairings to Improve Video Game Enjoyment, in *ACM SIGGRAPH 2014 Posters*, (2014), 16:1–16:1.
- [7] R. Orji, L. E. Nacke, and C. Di Marco, Towards Personality-driven Persuasive Health Games and Gamified Systems, *Proc. 2017 CHI Conf. Hum. Factors Comput. Syst. CHI '17*, 1015–1027, 2017.
- [8] M. V. Birk, D. Toker, R. L. Mandryk, and C. Conati, Modeling motivation in a social network game using player-centric traits and personality traits, *Lecture Notes in Computer Science (including Subser. Lect. Notes Artif. Intell. Lect. Notes Bioinformatics)*, **9146** (2015), 18–30.
- [9] R. M. Ryan, Control and Information in the Intrapersonal Sphere, *Journal of Personality and Social Psychology* **43** (1982), 450–461.
- [10] S. D. Gosling, P. J. Rentfrow, and W. B. Swann, A very brief measure of the Big-Five personality domains, *Journal of Research in Personality* **37** (2003), 504–528.
- [11] A. Donner, and M. Eliasziw. Sample size requirements for reliability studies. *Statistics in Medicine*, **6** (1987), 441–448.

# User Study of Emotional Visualization Dashboard for Educational Software: Description of the Study Protocol

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**Abstract.** This paper describes a user study plan for the MADE Teacher's Dashboard, our proposed data visualization dashboard that supports educators to inspect and reflect on the emotional states of students using web learning applications. Our goal was to support the system designer, and indirectly also teachers and students. Our dashboard follows affective learning models and monitors online learner emotions. It uses an open source library that supports tracking of facial features and detection of emotions in real time, identifying six different emotions. We present a user study plan to determine whether the data visualization graph can be interpreted properly.

**Keywords.** Education Software, Design, Affective Learning, Usability, User Testing

## 1. Introduction and Background

Our recent work has involved the design and evaluation of multimodal software for *affective* education, where the software supports emotional aspects of the learning process. We reviewed interaction design and evaluation methods, adapted them, and then conducted several case studies.

We introduced the Multimodal Affect for Design and Evaluation (MADE) framework; our proposed structure for designing and evaluating affective multimodal education systems [1]. Our approach involves the system designer working to create a system that supports the teacher's affective strategy, to further support their learning objectives for the students. Our design methods involved the emotional cycle in learning model identified by Kort et al. [2], to better support the teacher, as well as the student. In particular, we created the MADE Teacher's Dashboard [3] to help teachers understand the affective states of students as they worked through tasks.

As part of an iterative and user-centered design process, we wish to evaluate the Teacher's Dashboard. We aim at obtaining feedback on the design and function of the dashboard from participants who are instructors in our university. This paper presents our plan for evaluation of the Teacher's Dashboard.

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## 2. Teacher's Dashboard

The Teacher's Dashboard is shown in Figure 1. It displays data from student learning software augmented with video analysis algorithms to estimate student emotions in real-time. On the left is the student list; the instructor is able to select a specific student and the central graph then shows their emotions over time. Six different emotions are shown as colored lines. Emotions associated with positive valence (e.g. happy) are shown above the axis (0 to +1), and emotions associated with negative valence (e.g. sad) are shown below the axis (0 to -1). Vertical lines with "balloons" show specific learning events. When the teacher hovers their cursor on the balloon, a tooltip with descriptive text is shown. This allows the teacher to relate learning events to emotional states. For example, this would enable teachers to see when students struggle and become fearful that they are not succeeding.

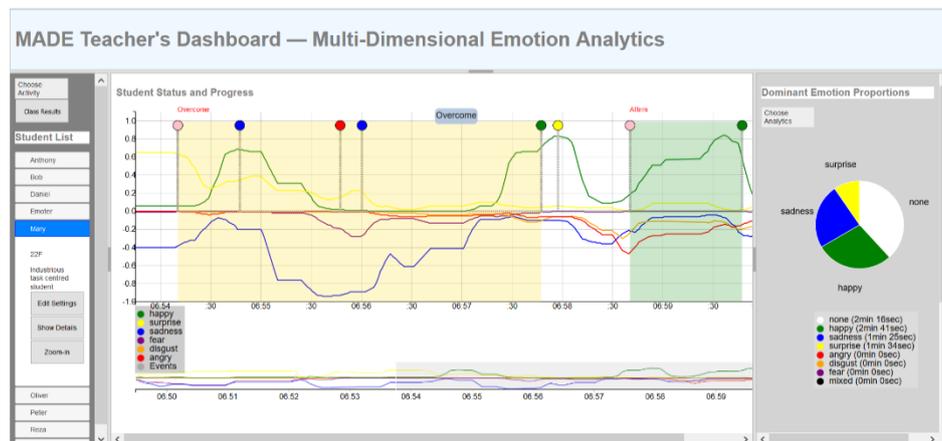


Figure 1. Data Emotion Visualization Dashboard.

## 3. User Testing

*Research Question:* Do teachers understand the graphs and indication of different affective learning phases on the dashboard?

To understand the utility of the dashboard, we propose two research hypotheses (below). For the first hypothesis, we would like to see if the participants can understand different affective learning phases. *H1: Participants can understand the affective learning phases on the dashboard and relate that to four phases of Kort et al.'s affective learning model.* For the second hypothesis, the participants will check on the dashboard if students' emotions are the same on the dashboard and the video recording of learners' facial expressions during different tasks. *H2: Participants perceive the same emotions on dashboard and the video.*

*Tasks:* After a briefing, a user will be given a list of tasks to be executed during the study. There will be a total of 4 tasks which will be given to all test participants to perform. These tasks are presented in Table 1. To evaluate the usability of the dashboard, we are considering learnability, efficiency, memorability, errors, and satisfaction [4].

4. **Table 1.** Task List and Measurements Facts.

Tasks	Derived Measure	Description
Is the student engaged with this task between 9AM to 10AM?	Learnability	How easy is it for users to accomplish basic tasks the first time they encounter the design?
Does the student receive affirmation feedback when the task is done?	Efficiency	Once users have learned the design, how quickly can they perform tasks?
Is selecting persona for a particular student helpful?	Memorability	When users return to the design after a period of not using it, how easily can they reestablish proficiency?
Is selecting the four affective learning phases useful?	Errors	How many errors do users make, how severe are these errors, and how easily can they recover from the errors?
	Satisfaction	How pleasant is it to use the design?

*Procedure:* The study will take thirty minutes for each participant. We will teach the participants how to interact with the system before the study, for five minutes. We will use a think aloud protocol and do audio recording. The procedure has four steps: *training session, tasks, usability questionnaire, and semi-structured interview.*

*Analysis Plan:* We will evaluate the hypotheses based on the performance of the participants performing the tasks. We will then evaluate the usability with the System Usability Scale (SUS) questionnaire [5]. The statistical analysis module will be implemented in R and will provide statistical techniques for hypothesis testing. To gain a deeper understating of the participants’ reflection on the dashboard and general issues of the affective education we will analyze our semi-structured interview using the Grounded Theory approach [6].

**4. Conclusions and Future work**

In this paper, a user study plan of our emotional educational dashboard is presented. The purpose of this dashboard is to help both teachers and students. We hope that this user study allows us to validate and help to improve the design, and ultimately help teachers understand the affective states of students.

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## References

- [1] R. GhasemAghaei, A. Arya and R. Biddle, The MADE framework: multimodal software for affective education, in: *EdMedia: World Conference on Educational Media and Technology*, 2015.
- [2] B. Kort, R. Reilly and R.W. Picard, An affective model of interplay between emotions and learning: Reengineering educational pedagogy-building a learning companion, in: *IEEE ICALT*, 2001.
- [3] R. GhasemAghaei, A. Arya and R. Biddle, A Dashboard for Affective E-learning: Data Visualization for Monitoring Online Learner Emotions, in: *EdMedia: World Conference on Educational Media and Technology*, 2016.
- [4] J. Nielsen, Usability 101: Introduction to usability, Nielsen Norman Group, 2012, <https://www.nngroup.com/articles/usability-101-introduction-to-usability/>.
- [5] J. Brooke, SUS-A quick and dirty usability scale, *Usability evaluation in industry*, 1996.
- [6] K. Charmaz and L. Belgrave, Qualitative interviewing and grounded theory analysis, *The SAGE handbook of interview research: The complexity of the craft*, 2012.

# Analysis of Binocular Imbalance Under Non-Immersive Virtual Reality Platform in Normal Population

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**Key words:** binocular imbalance, suppression, integrated binocular stimulation mode

## 1. Objective

To examine and analyze binocular imbalance in a group of randomly selected normal subjects with corrected visual acuity of 0.8 or more in both eyes who has no ocular diseases, by using non-immersive virtual reality devices, and to quantify the correlation between binocular imbalance in these normal subjects and various spatial-frequencies and temporal-frequencies in the integrated binocular stimulation mode.

## 2. Methods:

A retrospective study was carried out with data from 97 volunteers (51 males and 46 females). These volunteers were diagnosed with no eye diseases and had corrected binocular visual acuity of 0.8 or more. Their binocular visual function, Hirschberg Test refraction status, and binocular imbalance were assessed using the quantified visual perception stimulation mode in a non-immersive virtual reality platform and were subsequently analyzed by SPSS software.

## 3. Results

When normal subjects (with corrected binocular vision of 0.8 or more without ocular diseases) were assessed using the integrated binocular stimulation mode with different temporal and spatial frequencies, a gradual reduction of binocular imbalance was observed when spatial frequencies were increased. When contrast balance was adjusted, binocular imbalance was more prevalent in the horizontal state compared to in the vertical state; when stimulated by different temporal frequencies in the virtual reality stimulation mode, 17.53% and 29.90% of participants reached complete binocular fusion under low temporal frequency stimulation and high temporal

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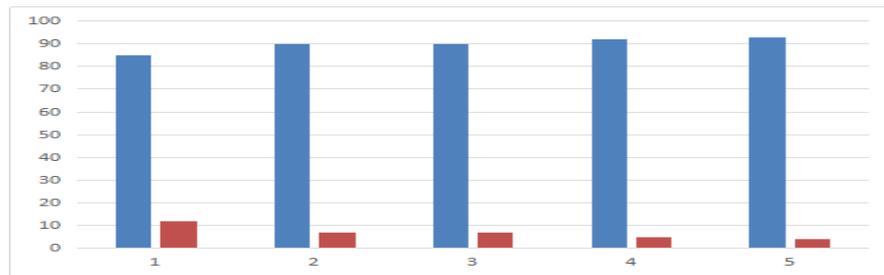
frequency stimulation respectively, while binocular imbalance was found in 65.9% and 62.89% of participants who were stimulated respectively by low temporal frequency and high temporal frequency. In addition, 16.5% and 7.21% experienced severe binocular imbalance under low temporal and high temporal frequency stimulation respectively. The integrated binocular stimulation mode under low temporal frequency was more sensitive in detecting binocular imbalance.

S0: balanced eyes, with full binocular fusion;

S1: Binocular imbalance. After monocular stimulation, there is a normal cycle of intermittent suppression in one eye which lasts about 2-3 seconds, followed by 2-3 seconds of binocular fusion. The cycle continues as 2-3 seconds of suppression takes place in the previously suppressed eye again, as described in Hussey's description of ICS

S2: severe binocular imbalance. Continuous suppression of one eye (clinical suppression)

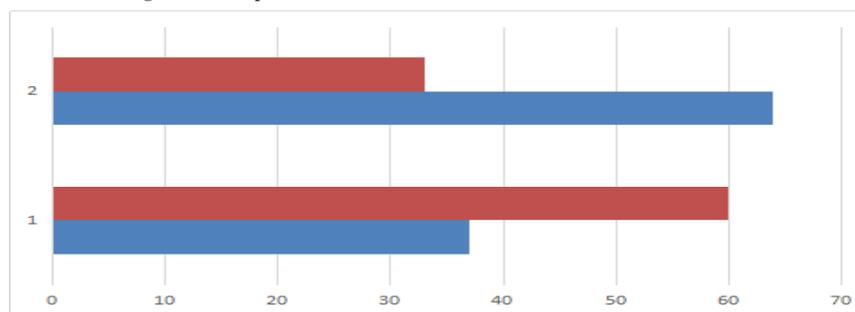
**Figure 1.** Spatial Frequencies.



**Legend:** Blue = S0+S1; red = S2.

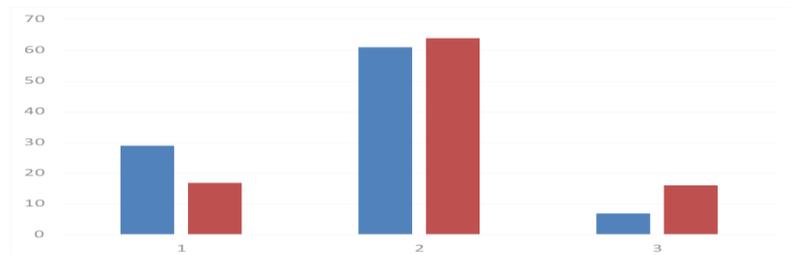
1=spatial frequency 1; 2=spatial frequency 2; 3=spatial frequency 3; 4=spatial frequency 4; 5=spatial frequency 5

**Figure 2:** Comparison between horizontal and vertical contrast balance.



**Legend:** Blue =S0+S1 Red = S2

1= horizontal contrast balance; 2= vertical contrast balance

**Figure 3:** Integrated binocular stimulation mode with different temporal frequencies.

**Legend:** Blue = high temporal-frequency group; Red = low temporal-frequency group 1 : S0 2 : S1 3 : S2

#### 4. Conclusion.

The status of binocular balance in normal subjects were not the same when stimulated by the non-immersive virtual reality platform, as many showed varying degrees of binocular imbalance. The results from our clinical study has demonstrated that integrated binocular stimulation with different spatial and temporal frequencies may enable a more sensitive detection of binocular imbalance, making it a powerful new tool for the diagnosis and analysis of clinical binocular abnormalities. In addition, since more than half of the normal subjects (without eye diseases who has corrected vision of 0.8 or more) exhibited binocular imbalance in our study, we believe this brief binocular imbalance is likely a transient physiological phenomenon which is not pathological to our visual acuity and function and should only be seen as pathological when binocular imbalance is prolonged, causing functional deficit such as reading impairment. There may be varying degrees of binocular imbalance existing between complete binocular fusion and prolonged monocular suppression, the binocular imbalance observed in this research study may only be one of the many possible intervals. In our future studies, we would like to explore into these varying degrees of binocular imbalance, in search for a definition of physiological binocular imbalance in terms of its duration, among those without eye diseases and with corrected vision of 0.8 or more.

#### References

- [1] G. K. Von Norden, B. Von Norden. *Visione binoculare e motilità oculare*. Palermo: MedicalBooks, 1985.
- [2] J. R. Griffin, J. D. Grisham. *Binocular anomalies. Diagnosis and vision therapy*. Woburn, MA: Butterworths-Heinemann 4th Ed., 2002.
- [3] Porac C, Coren S. Suppressive processes in binocular vision: ocular dominance and amblyopia. *Am J Optom Physiol Opt* 1975;52:651-57
- [4] E.S. Hussey. Intermittent central suppression: a missing link in reading problems? *JOptomVis Dev* 21(1990),11-6.
- [5] E. S. Hussey. Detect suppression with vectographs. *Rev Optom* 119 (1982), 49-52.
- [6] E. S. Hussey. Use of visual flicker in remediation of intermittent central suppression suggests regionalization of vision. *J BehavOptom* 10(1999),3-11.
- [7] M.J., Snowling, *Dyslexia*. Oxford: Blackwell, 2000.
- [8] B. J. W. Evans. *Dyslexia and Vision*. London and Philadelphia: Whurr Publishers, 2001.
- [9] B. C. Skottun, L. A. Parke. The possible relationship between visual deficits and Dyslexia: examination of a critical assumption. *J LearnDisabil* 32 (1999), 2-5.
- [10] L. Anapolle Vision skills survey of dyslexic students. *J Am Optom Assn* 38(1967),853-59.

- [11] P. Birnbaum, M.H. Birnbaum Binocular coordination as a factor in reading achievement. *JAm Optom Assn* **39**(1968),48-56.
- [12] J. F. Stein, A. J. Richardson, M. S. Fowler. Monocular occlusion can improve binocular control on reading in dyslexics. *Brain* **123** (2000), 164-70.
- [13] E. S. Hussey. Binocular visual sensation in reading: A unified theory. *J Behav Optom* **12**(2001), 119-26.
- [14] F. Zeri, M.De Luca, D. Spinelli, P. Zoccolotti. Intermittent Central Suppression-an evaluation of its presence using three instruments. *J Behav Optom* **16** (200), 59-62
- [15] J. M. Black, B.Thompson, G. Maehara, R. F. Hess. A compact clinical instrument for quantifying suppression. *Optom Vis Sci*, **88** (2011): E334-43.
- [16] E. S. Hussey Binocular visual sensation in reading II: Implications of A unified theory. *J Behav Optom* **13** (2002), 69-71.
- [17] H. Ostadimoghaddam, A. Fotouhi, H. Hashemi. et al. The prevalence of anisometropia in population base study. *Strabismus*, **20** (2012), 152-157.
- [18] R.F. Hess, B.Thompson Amblyopiaand thebinocularapproachto itstherapy. *Vision Res.* **114**(2015), 4-16.
- [19] M. J. Allen. Understanding suppression. *J Optom Vis Dev* **26** (1995)50-52.

# The Relationship between Amblyopia, Spatial Resolution and Binocular Visual Perception Eye Position in a Pediatric Population.

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**Abstract.** Types of amblyopia are usually classified according to visual resolution. Here we intended to study the relationship among the types of amblyopia, visual acuity interocular differences (vIODs), binocular perceptual eye position, and the spatial displacements to explore the deficits in binocular vision and the relevance with the deficits in fixation control ability, which can provide a novel basis and method for clinical diagnosis and therapy. **Methods:** We recruited 109 patients with amblyopia (age 4-17). Participants were asked to fix one eye on an optotype while the other eye fixed on another. We measure the offset when these two optotypes perceptually overlap. The performance of various visual functions was measured by the binocular perceptual eye position model and international standard eye chart. According to visual acuity, amblyopia can be classified into 2 types: moderate amblyopia (0.2-0.5) and mild amblyopia (above 0.6). According to offset, perceptual eye position can be classified into 3 types: type A (below 0.4 degrees), type B (0.4-2.0 degrees) and type C (above 2.0 degrees). **Results:** 60 patients were defined as moderate amblyopia and 49 patients were defined as mild amblyopia. There is no correlation between binocular vIODs and perceptual eye position offset in amblyopia ( $t = 0.620$ ). The offset of perceptual eye position in moderate and mild amblyopia showed no correlation. Type A accounted for 36.6% in moderate amblyopia, type B for 43.4% and type C for 20%. Type A accounted for 20.4% in mild amblyopia, type B for 65.3% and type C for 14.18%. The differences between distance and angles of spatial displacements in moderate and mild amblyopia were not statistically significant. The distance and angles of spatial displacements in the small circle in moderate amblyopia was  $26.89 \pm 27.02$ ,  $3.96 \pm 3.71$ , in the middle circle was  $27.20 \pm 21.47$ ,  $4.12 \pm 3.85$ , in the big circle was  $25.92 \pm 24.99$ ,  $2.79 \pm 2.72$ , and totally was  $26.95 \pm 24.12$ ,  $3.77 \pm 3.31$ . The distance and angles of spatial displacements in the small circle in mild amblyopia was  $20.25 \pm 14.16$ ,  $3.74 \pm 2.37$ , in the middle circle was  $19.26 \pm 13.55$ ,  $2.75 \pm 1.61$ , in the big circle was  $19.60 \pm 14.45$ ,  $2.36 \pm 1.75$ , and totally was  $19.70 \pm 13.92$ ,  $2.95 \pm 1.98$ . **Conclusion:** The offset of binocular perceptual eye position and spatial resolution in amblyopia have separate deficit patterns and there is no correlation between them. It appears to be abnormal perceptual eye position under the condition of various special resolution in amblyopia (normal value under 0.15deg). There is potential correlation among the offset and abnormality of perceptual eye position, binocular fixation instability and fixation eye abnormality. Therefore, neural deficits in the patients with amblyopia showed abnormality in binocular fixation and stability. The discovery of these amblyopia categories can provide a novel perspective and classification model for clinical diagnosis and treatment of amblyopia.

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**Abbreviations:** vIODs= visual acuity interocular differences; PEP= perceptual eye position, SD= spatial displacement; 3D=3 dimension

**Keywords:** Amblyopia; perceptual eye position; spatial displacement

## 1. Introduction

Amblyopia refers to unilateral or bilateral reduction in best corrected visual acuity, not directly attributed to structural abnormality of the eye or posterior visual pathways [1]. It is a developmental disorder of the entire visual system, including the extra-striate cortex. Amblyopia has a 1-3.6% prevalence, higher in the medically underserved [2-7]. It manifests mainly by impaired visual acuity in the amblyopic eye. The diagnosis of amblyopia must be confirmed prior to treatment. Confirmation is based on cycloplegic refraction, visual acuity measurement and orthoptic assessment. However, it is more complex than simply visual acuity loss.

Perceptual eye position (PEP) is a new concept describing binocular alignment raised by Zhao et al. in 2014 [8]. It is one of the indicators used to evaluate fixation disparity and binocular function measured by a computer-controlled perceptual examination evaluation system. Normal fixational eye movements, such as microsaccades, drift, and tremor, do not preclude binocular fusion [9].

Types of amblyopia are usually classified according to visual resolution. Here we intended to study the relationship among the types of amblyopia, visual acuity interocular differences (vIODs), binocular perceptual eye position (PEP) and the distance and angles of spatial displacements (SD) to explore the deficits in binocular vision and the relevance with the deficits in fixation control ability, which can provide a novel basis and method for clinical diagnosis and therapy.

## 2. Patients and methods

### 2.1 Patients

This study was approved by local Ethics Committee of Xi'an No.1 Hospital. A retrospective chart review of 109 patients with amblyopia who were confirmed through related inspections in the Department of Ophthalmology of Xi'an No.1 Hospital between November 2014 and November 2017. For all subjects, a detailed ophthalmic examination was given, including measurements of unaided and best-corrected visual acuity, a slit-lamp examination, a fundus examination, intraocular pressure, manifest and cycloplegic refractions, and ocular movement. All refraction procedures were performed with the same experienced optometrist. Patients were excluded if they had a history of obvious strabismus, nystagmus, severe trachoma, corneal disease, glaucoma, cataract, retinal or optic nerve disease, media opacities, ocular trauma, or mental retardation. Patients who underwent ocular surgeries or binocular vision therapies were also excluded. Children under 4 years were not enrolled in case they were unable to understand the procedure of the PEP measurement test.

Unilateral amblyopia was defined as an inter-ocular difference in best-corrected VA  $\geq 2$  lines. Bilateral amblyopia was defined as best-corrected visual acuity (BCVA) in each eye worse than 0.5 for 4- to 5-year-olds and worse than 0.6 for older than 6-year-olds<sup>[7, 10]</sup>. According to BCVA, amblyopia can be classified into 2 types: moderate amblyopia (0.2-0.5), mild amblyopia (above 0.6).

### 2.2 Measurement of perceptual eye position and spatial displacements

The devices used to measure PEP and SD included: Windows XP system PC host, LG 2343p polarized 3 dimension (3D) monitor with a resolution power of 1920 X 1080



In total, 109 patients were included in our study. 60 patients were defined as moderate amblyopia and 49 patients were defined as mild amblyopia (Table 1).

**Table 1:** Summary demographics of patients in the study

	Moderate amblyopia	Mild amblyopia	P
Patients	60	49	
Gender (male: female)	28:32	23:26	1.000 <sup>+</sup>
Age	10.83±2.21	9.50±2.81	0.210*

<sup>+</sup> From the  $\chi^2$  test

\* From One Way ANOVA.

### 3.2 Comparison of PEP between the groups

There is no correlation between binocular vIODs and PEP offset in amblyopia ( $t=0.620$ ). The offset of PEP in moderate and mild amblyopia showed no correlation. Type A accounted for 36.6% in moderate amblyopia, type B for 43.4% and type C for 20%. Type A accounted for 20.4% in mild amblyopia, type B for 65.3% and type C for 14.18% (Table 2).

**Table 2:** The comparison of PEP between groups.

	A	B	C	Total
Moderate amblyopia	22	26	12	60
Mild amblyopia	10	32	7	49

\* From the  $\chi^2$  test,  $P=0.068$ .

The distance and angles of SD in the small circle in moderate amblyopia was 26.89±27.02, 3.96±3.71, in the middle circle was 27.20±21.47, 4.12±3.85, in the big circle was 25.92±24.99, 2.79±2.72, and totally was 26.95±24.12, 3.77±3.31. The distance and angles of SD in the small circle in mild amblyopia was 20.25±14.16, 3.74±2.37, in the middle circle was 19.26±13.55, 2.75±1.61, in the big circle was 19.60±14.45, 2.36±1.75, and totally was 19.70±13.92, 2.95±1.98 (Table 3 and Table 4). The differences between distance and angles of SD in moderate and mild amblyopia were not statistically significant.

**Table 3:** The comparison of the distance of spatial displacements.

	Small circle	Middle circle	Big circle	Total
Moderate	26.89±27.02	27.20±21.47	25.92±24.99	26.95±24.12
Mild	20.25±14.16	19.26±13.55	19.60±14.45	19.70±13.92
t*	0.459	0.290	0.456	0.377

\* From the independent t test

**Table 4:** The comparison of the angles of spatial displacements

	Small circle	Middle circle	Big circle	Total
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Moderate	3.96±3.71	4.12±3.85	2.79±2.72	3.77±3.31
Mild	3.74±2.37	2.75±1.61	2.36±1.75	2.95±1.98
t*	0.872	0.267	0.650	0.470

\* From independent t test

#### 4. Discussion

Amblyopia is a unilateral or bilateral condition in which the best corrected visual acuity is below normal, in the absence of any obvious structural or pathologic anomalies but with one or more of the following conditions occurring during visual developmental: Amblyogenic anisometropia, constant unilateral strabismus, amblyogenic bilateral isoametropia, amblyogenic unilateral or bilateral astigmatism[11].

There have been many studies on amblyopia mostly focused on the visual acuity, however, many persons with amblyopia, particularly those with strabismus, also suffer from a large (sometimes complete) loss of stereoscopic depth perception. Recent reports of the dramatic effects of restored stereopsis have renewed interest in restoring stereopsis in affected adults. Nan, L.et al. found that, in amblyopic children, the deviation pixels of perception eye position and the gaze stability were abnormal in the amblyopic children with normal eye position. The more severe the degree of amblyopia, the more serious the abnormality. And they think that the treatment of amblyopia should focus on the improvement of the binocular vision [12]. It is believed that binocular function, especially stereopsis, responds to traditional amblyopia treatment, but how it works remains unclear. Xi J et al. found that 11 observers with anisometric or ametropic amblyopia after perceptual learning had improvements both in stereo vision and vision acuity [13]. All of this suggest that the most common deficit associated with amblyopia under ordinary (binocular) viewing conditions is impaired stereoscopic depth perception. Moreover, stereopsis is more degraded by monocular blur (or monocular contrast reduction) than by both eyes being blurred [14], amblyopic patients face similarly degraded conditions.

Perception, which is the result of sensation and thus different from it, represents not only the reflecting image, but also the integration of a variety of substances in the human brain after they act upon the sensory organs directly [15]. Therefore, in a broad sense, perception is the result of all of the coordinated activities synthesized by human brain [8]. The offset of binocular perceptual eye position and spatial resolution in amblyopia have separate deficit patterns and there is no correlation between them. It appears to be abnormal perceptual eye position under the condition of various special resolution in amblyopia (normal value under 0.15deg). There is potential correlation among the offset and abnormality of perceptual eye position, binocular fixation instability and fixation eye abnormality. Therefore, neural deficits in the patients with amblyopia showed abnormality in binocular fixation and stability. The discovery of these amblyopia categories can provide a novel perspective and classification model for clinical diagnosis and treatment of amblyopia.

## Reference

- [1] D. Desantis, Amblyopia. *Pediatric Clinics of North America*, 61(2014) 505-518.
- [2] K. Simons, Amblyopia Characterization, Treatment, and Prophylaxis. *Survey of Ophthalmology*, 50(2005)123-166.
- [3] P.D. Reese, and T.A. Weingeist, *Pars plana management of ectopia lentis in children*. *Archives of Ophthalmology*, 105(1987): 1202.
- [4] G. C. Lam., M.X. Repka and D.L. Guyton, Timing of amblyopia therapy relative to strabismus surgery. *Ophthalmology*, 100(1993): 1751-1756.
- [5] M. X. Repka, S.A. Cotter, R.W. Beck, et al., A randomized trial of atropine regimens for treatment of moderate amblyopia in children. *Arch Ophthalmol*, 111(2003). 603-611.
- [6] Group, P.E.D.I., The course of moderate amblyopia treated with patching in children: experience of the amblyopia treatment study. *American Journal of Ophthalmology*. 136(2003): 620-629.
- [7] Y.H. Aldebasi, Prevalence of amblyopia in primary school children in Qassim province, Kingdom of Saudi Arabia. *Middle East African Journal of Ophthalmology*, 22(2015): 86.
- [8] G. H. Zhao., L.U. Wei, Y. Li, et al., The study of perceptual eye position and gaze stability of the children with normal visual acuity. *Ophthalmology in China*, 23(2014): 312-315.
- [9] J. Otero-Millan, S.L. Macknik and S. Martinez-Conde, Fixational eye movements and binocular vision. *Frontiers in Integrative Neuroscience*. 8(2014): 52.
- [10] M. Pascual, J. Huang, M.G. Maguire, et al., Risk factors for amblyopia in the vision in preschoolers study. *Ophthalmology*, 121(2014): 622-629.e1.
- [11] M.E. Woodruff, , Amblyopia: Basic And Clinical AspectS. *Optometry & Vision Science*, 68(1991): 365-396.
- [12] L. Nan, L.U. Wei, A.L. Sun, et al., Perceptual eye position and gaze stability of the children with amblyopia. *Ophthalmology in China*, 23(2014): 417-419.
- [13] J. Xi, W.L. Jia, L.X. Feng, et al., Perceptual learning improves stereoacuity in amblyopia. *Invest Ophthalmol Vis Sci.*, 55(2014): p. 2384-2391.
- [14] G. E. Legge, and Y. Gu, Stereopsis and contrast. *Vision Research*. 29(1989): 989-1004.
- [15] J. Zeng, C. Yang, X. Yang, et al., Comparison of perceptual eye positions among patients with different degrees of anisometropia. *Acta Ophthalmologica*, 94(2016): p. n/a-n/a.

# Virtual Reality Graded Exposure Therapy for the Treatment of Combat- Related Posttraumatic Stress Disorder/Post Traumatic Stress: A Case Report 3 Years Post Combat Deployment

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**Abstract:** Department of Defense (DOD) and the Department of Veterans Affairs (DVA) have been encouraged to not only maintain the quality of care but also to increase the effectiveness of treatments for warriors diagnosed with Posttraumatic Stress Disorder (PTSD)/Post Traumatic Stress (PTS) secondary to their combat deployments to Iraq and/or Afghanistan. Virtual Reality Graded Exposure Therapy with Arousal Control (VR-GET) has demonstrated a positive treatment effectiveness resulting in significant reductions of PTSD/PTS symptom severity in combat veterans diagnosed with PTSD/PTS. In this report, we describe the outcome of VR-GET, for the treatment of combat-related PTSD/PTS in a warrior who experienced no treatment for his PTSD/PTS during the 3 years following his return from his last combat duty and who was first combat deployed, in support of Operation Iraqi Freedom, in February 2003.

**Keywords:** Virtual Reality Graded Exposure Therapy With Arousal Control, Veterans Administration, Department of Defense, Department of Veterans Affairs, Combat Deployment, Post-Traumatic Stress Disorder, Post-Traumatic Stress, Sentinel Events

## 1. Introduction

Posttraumatic Stress Disorder (PTSD) or Post Traumatic Stress (PTS) has been identified as the “Signature Injury” in active duty warriors returning from combat in Iraq and Afghanistan and also for combat veterans who have left the military [1-9] and “the prevalence of PTSD among U. S. service members serving in Afghanistan and Iraq has been reported at 13.8%” [10]. Additionally, according to McLay et al [11], chronic Insomnia is the most reported symptom of individuals diagnosed with combat-related PTSD/PTS. Reports have recommended that the Department of Defense (DoD) and the Veterans Administration (VA) should aggressively develop early intervention strategies and treatments for preventing and treating PTSD [1-9]. Hoge has also suggested that the VA adopt a number of strategies to improve the mental health care engagement and treatment for veterans needing services for PTSD [5].

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Virtual Reality Graded Exposure Therapy with arousal control (VR-GET) is a promising, patient centered “strategy” and intervention that has been evaluated in active-duty service members as an early intervention treatment for warriors, diagnosed with combat-related PTSD/PTS and having been successfully treated within months of having returned to the United States from the combat theater [12 – 15]. As an exposure therapy, VR-GET assists a patient in “learning” to manage fears and anxieties related to his or her combat-traumas (i.e., Sentinel Events) in a controlled, simulated environment which is generated using virtual reality (VR). VR-GET combines graded VR exposure with meditation and attention control (e.g., noticing distractions, letting them go and refocusing on the task at hand) in combination with autonomic nervous system control using the J & J Engineering Biofeedback system.



**Figure 1.** Three computer configuration for VR-GET with Biofeedback being calculated on the laptop computer. Simulated patient is holding a hand-held controller that he is using to “move” through the combat environment. A Head Mounted Display (HMD) and Headphones facilitate the immersion in the VR-GET simulated combat environment.

VR-GET has resulted in 70% of participants being able to reduce their PTSD severity by 30% or greater [15]. One VR-GET Case Study described a Second Class male Navy Corpsman successfully reducing his PCL-M score by 20% following 10 VR-GET Sessions [12]. Another VR-GET Case Study described a Second Class female Navy Seabee successfully reducing her PCL-M score by 65% following 20 VR-GET Sessions [13]. A third Case Study concluded that a senior Naval Officer successfully reduced his PCL-M score by 50% following 20 VR-GET “Hops” [16]. Recently, a male U.S. Army Officer, married and having four children, who was diagnosed with PTSD/PTS, was referred for VR-GET by a civilian Clinical Psychologist working at a U.S. Navy Branch Medical Clinic. In 2004, this Officer completed a two (2) month combat deployment to Turkey in support of Operation Iraqi Freedom. He subsequently was combat-deployed three additional times: (1) a five (5) month deployment to Iraq in 2004; (2) a twelve (12) month deployment to Iraq in 2008; and (3) a 6 month

deployment to Afghanistan in 2014. During his four combat deployments, this Officer was frequently, sometimes daily, participating in both mounted (e.g., in a vehicle) and dismounted (e.g., on foot) patrols. During his last two combat deployments, he was also a Senior Officer in Charge of convoys of military supplies. Following his having returned to the United States, at the conclusion of his 2004 combat deployment and reporting to his new U.S. Army Command, he reported to his Primary Care Physician (PCP) that he was experiencing symptoms consistent with PTSD/PTS. He was also beginning to experience profound difficulties with Initial Insomnia, Middle Insomnia and Terminal Insomnia. This Army Officer informed me that his PCP and his “Fellow Soldiers” had reassured him that his PTSD/PTS symptoms “would reduce and get better over time”. Hence, this Army Officer did not pursue a referral for treatment of his PTSD/PTS until 2017. Following is the report of the VR-GET, with physiological monitoring, with this Army Officer.

## 2. Method

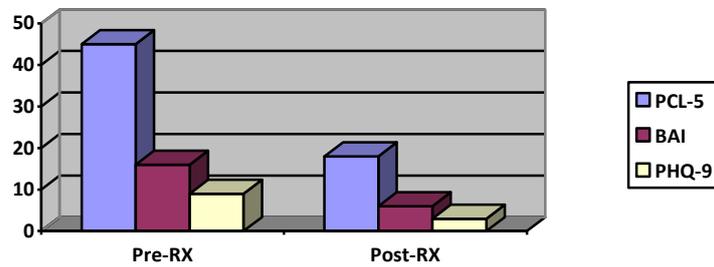
A 41 year old, male, U.S. Army Officer was referred to and volunteered for VR-GET. This participant met the DSM-5 [17] criteria for chronic PTSD/PTS with Chronic Insomnia. This participant’s co-morbid diagnoses included: Chronic Sinusitis, Chronic Low Back Pain, High Blood Pressure and Sleep Apnea. Prior to this participant’s referral for VR-GET, even though he had been diagnosed with Sleep Apnea and he was using a CPAP almost nightly, this Officer’s continued Chronic Insomnia had been untreated. This Officer has served 18 years in the Army and he has been married once and he and his wife have four children. Following this participant’s referral for VR-GET and in consultation with his PCP, the PCP prescribed Seroquil (25mg/qhs) to assist with improving the participant’s sleep quality and improving his mood. Shortly after starting to take Seroquil, this participant’s Chronic Insomnia resolved.



**Figure 2.** What the VR-GET patient sees while immersed in the VR-GET combat environment titled, “Fallujah”.

Prior to starting VR-GET, this participant completed a structured psychiatric interview, the PTSD Checklist for DSM-5 (PCL-5), the Beck Anxiety Inventory (BAI) and Patient Health Questionnaire-9 item (PHQ-9). This participant's VR-

GET followed the VR-GET guidelines previous described [12 - 15]. Importantly and in keeping with the VR-GET guidelines, the participant's Sentinel Events were incorporated into his VR-GET. Following 20 VR-GET sessions, the participant again completed the PCL-5, BAI and PHQ-9.



**Figure 3.** Results for PCL-5, BAI and PHQ-9 administered Pre VR-GET and Post VR-GET

#### **Sentential Events:**

1. "I was the Battalion Operations Officer in Iraq and I received a call from the Brigade Commander directing me to send a generator mechanic out to a Station near our Forward Operation Base (FOB) to repair a generator. I argued with my Commanding Officer that such an assignment was not safe and our generator mechanics were not trained to repair the Station generators. After arguing with my Commander for several minutes, I was ordered to send the inexperienced and unqualified generator mechanic to the Station to repair the generator. The generator mechanic traveled to the Station, began to repair the generator and was killed by an insurgent sniper. I was devastated and was unable to maintain my composure. The next few days were a blur culminating with the memorial ceremony for the mechanic".
2. "When just arriving at a large base in Iraq, with 20,000 U.S. personnel, we came under an indirect fire attack. These indirect fire attacks became a daily event and we gradually became immune to these attacks and would even sleep through the alarms signaling the attacks. One more, while asleep, the attack alarm went off, and the rocket came in very low. This rocket passed directly over our tent and landed across the street with a loud explosion. The blast shook me out of my rack and I ended up on the floor and our tent filled with dust, dirt and debris. I began to look around our tent for one of my tent mates and began calling his name and one of my other tent-mates came into the tent only to tell me that my missing tent mate was already at work. Just then, 4 more rockets flew through our tent area and impacted close by, with one rocket impacting onto a tent and wounding the personnel inside".
3. "Back in Iraq two years later, our FOB was under attack from mortar fire. I remember walking among my fellow officers in our barracks telling everyone that it was going to be ok. I was lying and terrified on the inside but felt the need to maintain some ridiculous John Wayne persona".

**Figure 4.** A few of the Sentential Events reported by the case study participant while combat deployed.

### **3. Results**

Following 20 VR-GET sessions, the participant's PTSD/PTS symptom severity decreased measurably. He is sleeping 8 hours a night, with 10 minutes or less sleep onset difficulties five to six nights a week.

### **4. Conclusions**

Virtual Reality Graded Exposure Therapy (VR-GET) led to measurable reductions in PTSD, anxiety and depression symptoms in our participant and our participant reported easily tolerating the VR-GET combat environments. These measurable reductions on PTSD, anxiety and depression were assisted with the prescription of

psychotropic medication. As with other VR-GET participants, our participant described becoming engaged in the graded exposures of the VR simulations/combat-environments and in spite of a busy and hectic active duty Army position, he was able to consistently keep his scheduled consultations. Of note, this Case Report is the second to describe the utilization of VR-GET more than 3 years post-combat deployment. Other reports describing VR-GET have documented treatment having occurred either proximal to return to the United States following a combat tour [12] or proximal to having returned to the United States following a most recent combat deployment, but with the participant's first combat deployment having been 4 years prior to VR-GET [13]. With our finding that Virtual Reality Therapy and VR-GET can assist with reducing combat-related PTSD symptom severity many years after a combat tour or combat tours, we recommend that VR-GET needs to be assessed more inclusively. Such an assessment may lead to the inclusion of Virtual Reality Therapy and VR-GET as being "evidenced-based therapy" that DOD and VA could adopt to improve the mental health care treatment options for veterans diagnosed with combat-related PTSD and requesting treatment.

## References

- [1] D. C. Arthur, S. MacDermid, K. C. Kiley, The achievable vision: report of the Department of Defense Task Force on Mental Health, June 2007. Defense Health Board, Falls Church, VA.
- [2] B. C. Kok, B. K. Herrell, J. L. Thomas, C. W. Hoge. Posttraumatic stress disorder associated with combat service in Iraq and Afghanistan, *Journal of Nervous and Mental Disease* **200** (2012), 444 – 450.
- [3] T. Tanielian, L. H. Jaycox. *Invisible wounds of war: Psychological and cognitive injuries, their consequences, and services to assist recovery*, Rand Corporation Monographs, 2008.
- [4] E. C. Ritchie, M. Owens. Military Issues, *Psychiatric Clinics of North America* **27** (2004), 459 – 471.
- [5] C. W. Hoge. Risks associated with untreated PTSD in veterans: implications for improving mental health care engagement and treatment, *Federal Practitioner* **30** (2013), Suppl. 3; 3S – 12S.
- [6] M. J. Roy, K. B. Highland, M. A. Costanzo. GETSmart: guided education and training via smart phones to promote resilience, *Studies In Health Technology and Informatics* **219** (2016), 123 – 128.
- [7] K. A. Hepner, E. M. Sloss, C. P. Roth, H. Krull. et. al., Quality of care for PTSD and Depression in the military health system, Rand Corporation, Santa Monica, CA, 2016; downloaded on May 2, 2016 from: [www.rand.org/topcs/post-traumatic-stress-disorder.html](http://www.rand.org/topcs/post-traumatic-stress-disorder.html).
- [8] R. Forsten, B. Schneider. Treatment of the stress casualty during Operation Iraqi Freedom One, *Psychiatric Quarterly* **76** (2005), 343 – 350.
- [9] M. D. Howard, R. P. Cox. Collaborative intervention: a model for coordinated treatment of mental health issues within a ground combat unit, *Military Medicine* **173** (2008), 339 – 348.
- [10] V. J. Rice, B. Liu, P. J. Schroeder. Impact of in-person and virtual world mindfulness training on symptoms of post-traumatic stress disorder and attention deficit and hyperactive disorder. In P. A. Kelly, T. L. Hendrickson (Guest Editors), Proceedings of the 2016 Military Health System Research Symposium, Kissimmee, FL, August 2016; *Military Medicine*, 183 (3/4 Supplement), March/April 2018., 413 – 420.
- [11] R. N. McLay, W. P. Klam, S. L. Volkert, Insomnia is the most common reported symptom and predicts other symptoms of Post-Traumatic Stress Disorder in U.S. service members returning

from military deployments, *Military Medicine*, **175** (2010), 759 – 762.

- [12] D. P. Wood, J. A. Webb- Murphy, K. Center, R. McLay, D. Reeves, et., al., Combat-related post-traumatic stress disorder: a case report using virtual reality exposure therapy with physiological monitoring, *Cyberpsychology & Behavior* **10** (2007), 309 – 315.
- [13] D. P. Wood, J. A. Webb- Murphy, K. Center, R. McLay, R. Koffman, S. Johnston, et. al., Combat-related post-traumatic stress disorder: a case report using virtual reality exposure therapy with physiological monitoring with a female seabee, *Military Medicine*, **174** (2009), 1215 – 1222.
- [14] D. P. Wood, J. A. Webb- Murphy, R. N. McLay, B. K. Wiederhold, J. L. Spira, S. L. Johnston, et., al., Reality graded exposure therapy with physiological monitoring for the treatment of combat related post-traumatic stress disorder. In J. D. Westwood et al. (Eds.), *Medicine Meets Virtual Reality 18 Proceedings 2011*, pp.696 – 702; IOS Press: Washington, D.C.
- [15] R. N. McLay, D. P. Wood, J. A. Webb-Murphy, J. L. Spira, M. D. Wiederhold, J. M. Pyne, B. W. Wiederhold, A randomized, controlled trial of virtual reality exposure therapy for post- traumatic stress disorder in active duty service members with combat-related PTSD, *CyberPsychology, Behavior and Social Networking* **14** (2011), 223– 229.
- [16] D. P. Wood, M. D. Wiederhold, J. M. Pyne, B. W. Wiederhold, J. L. Spira, Virtual reality therapy for the treatment of combat-related posttraumatic stress disorder: a case report 10 years post combat deployment. In B. K. Wiederhold, G. Riva, M. D. Wiederhold & G. Kirwan (Eds), *Annual Review of CyberTherapy & Telemedicine 2016*, pp. 161 – 166; IOS Press: Washington, D.C.
- [17] American Psychological Association: *Diagnostic and Statistical Manual of Mental Disorders (DSM-5)*, Washington, DC, American Psychiatric Association, 2013.

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