Usability evaluation of an immersive virtual reality platform for self-attachment psychotherapy

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ABSTRACT

Virtual Reality (VR) is the state-of-the-art human-computer interface; it uses computer graphics to create a realistic-looking virtual world that the user can interact with in real-time. Recent advances in VR have shown promise in the pursuit of devising new techniques to combat mental disorder(s). Harnessing the power of VR, we have developed a customised immersive virtual reality platform to practise protocols of self-attachment psychotherapy. Consumer-level VR is a recent phenomenon; for wide scale adaptation of such platforms it is important that they are built taking into account usability engineering principles specific to virtual environments(VE).

In this work, we share our experience applying systematic heuristic and formative evaluations to our VR platform to make it more usable. The participants who evaluated our platform were asked (via a follow-up questionnaire) to rate their level-of-immersion, learn-ability and overall usability of the platform. Insights from our usability evaluation could help developers build better and more usable psycho-therapeutic VR platforms in the future.

ACM Classification Keywords

D.2.10 H.5.2: DesignUser Interfaces

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Virtual Reality, Virtual environment, Psychotherapy, Usability, Design

INTRODUCTION AND RELATED WORK

Immersive VR platforms, tools and technologies are now commonly used in a wide variety of sectors including military, healthcare, education, entertainment and gaming industries.

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The use of VR, in a wide range of fields, has increased substantially in the last decade. Tech giants have begun to mass market VR solutions. These include Facebook (Oculus), Google (Daydream, Cardboard and Jump), Sony PlayStation (PlayStationVR) and HTC (Vive). Advancements in VR hardware and software has enabled creation of visually rich and perceptually realistic environments, however, much needs to be done to improve the usability and 'interact-ability' of these Virtual environments. It is only through early incorporation of usability assessment into the design process that we can build highly-usable (and mass-consumable) applications which could effectively solve real-world problems.

To this end, Gabbard et al [11] details a taxonomy of usability guidelines for virtual environments; categorised into four main type of usability issues. In [2] Gabbard presents an overview of the usability evaluation methods for the virtual environments; the study provides an opportunity to compare and contrast major usability engineering approaches. Hix et al [12] explain usability methods which are adapted from GUI development and have been applied to the VE development. The study also shares usability experience of three different virtual environments.

Hix et al [13] discuss an iterative approach for user-centred design for VEs; the study also shares their experience applying user-centered design and evaluation approach to a real-world battle field visualisation virtual environment. Schultheis [15] examined the usability aspects of the VR driving rehabilitation platform; it was tested on the following groups 1) with traumatic brain injury(TBI) 2)with cerebral vascular accident (CVA) 3) health controls (HC). One of the main findings was that the TBIs and CVAs provided less favourable feedback - regarding the platform - than HCs. McComas et al [14] evaluated a desktop virtual reality platform to educate children to safely cross intersections; the main objective of the study was to see whether children can effectively learn and that are they able to effectively mimic their learning in the real-world setting. A significant change (positive) in performance was observed after the the VR intervention. Swartz et al [16] proposed a new two-phased usability engineering strategy and

also applied it on crumbs Cave application; they report on the usability methodology's effectiveness in detecting usability issues in crumb CAVE.

The remainder of this paper is organised as follows. In next Section we discuss self-attachment therapy(SAT) and the VR platform for SAT, and in Section 3 we detail a user study of VR platform for SAT we also report usability issues and follow-up questionnaire's summary. Conclusion and future work is discussed in Section 4.

VIRTUAL REALITY INTERVENTION

In this section we briefly explain self-attachment psychotherapy, its protocol and how these protocols were translated into functional specification for the virtual reality platform. We also share details of the tools and technologies used to build the VR platform.

Self-attachment therapy

Self-Attachment is a new psychotherapy - a set of protocols for re-training an individual's sub-optimal attachment schema [7][8][9]. It has shown success in pre-clinical trials, the therapy is rooted in the idea that many affect dysregulation disorders have their basis in early insecure attachment experiences [9][5], and it consists of a number of self-administrable protocols which aim to recreate the positive effects similar to that of an optimal infant-parent interaction(s). Under the Self-Attachment paradigm, the individual undergoing therapy has to role-play both as the inner-child and adult-self. The aim of the therapy is to create a secure attachment i.e. affectional bond between the adult-self and inner-child in order to enhance the capacity for emotion regulation. The different stages of the Self-attachment is supported by several computational models in the human brain and in associative artificial neural networks [10, 6, 4, 3]. There are four stages of SAT; a brief description of these stages are as follows[9, 10, 11]:

First stage: introduction to Self-Attachment - in this stage the individual is introduced to attachment theory, its scientific basis and the underlying hypotheses. The individual is familiarized with the basics of the neurobiology of attachment, love, bond making, emotion regulation, neuroplasticity and long term potentiation. The aim of this phase is to provide the initial motivation to the user for undertaking the therapy so that the individual can commit in terms of time and effort.

Second stage: connecting with the inner-child - in this stage the individual begins to create a relationship with the inner-child to establish empathy and ultimately compassion. The user provides a positive (happy) and negative (sad) photograph of their childhood. Several highly-structured protocols are then performed in order to conceptualise the inner-child as much as possible. These protocols include using the power of imagination (with closed eyes) to visualise that the child (that they were) is now present with them and that they can interact (touch/hold) with this child.

Third stage: building an affectional bond with the inner-child - during this stage of the therapy an affectional bond is created with the inner-child, which is subjectively experienced as falling in love with them. The adult-self adopts the inner-child and assures consistent love and support. It is after establishing this affectional bond that the individual can reprocess previously traumatic experiences and re-parent them towards a state in which they are able to self-regulate their emotion(s). In this protocol, the individual (adult-self) focuses on the images of the inner-child and attempts to bond with them, in order to create an attachment relationship. This bonding process is further enhanced with activities such as face-massaging (to mimic cuddling), singing and dancing directed towards the inner-child which are hypothesised to induce neural plasticity in key attachment-related neural circuitry.

Fourth Stage: developmental re-training and re-parenting of the inner-child - this stage consists of a number of re-parenting activities (sub-protocols) to emulate affectionate bond between the adult-self and the securely attached child; in order to minimise negative emotions and maximise positive affect. One example is a protocol that involves recalling a traumatic childhood episode and then imaginatively trying to re-experience it in as much detail as possible. Once this state has been recalled, the individual imagines that their adult-self quickly intervenes to embrace the child and to vocally (loudly) reassure them. The protocols (re-parenting activities) should be repeated and rehearsed so that the individual is able to integrate them into their routines.

Leveraging VR for SAT protocols

Technologist in collaboration with expert psychotherapists translated self-attachment protocols into functional specifications for the VR platform. In this section we will briefly discuss some of the major SAT to VR translations (mappings). As part of the protocol 1, an individual is familiarised with the scientific basis and the underlying hypotheses of SAT. In the VR this is achieved by displaying textual information in a customised virtual environment; user can also hear to the automated audio-recordings of this introductory textual-information (optional).

As part of the Happy/Sad child protocol an individual is required to recall and try to experience both happy and sad/traumatic memories - using their power of imagination - from their childhood by looking at their happy/sad childhood photos; from clinical trials of SAT it was established that a number of patients found it difficult to imagine this by just using their photos, therefore, we decided to include a customised avatar in the virtual environment. This avatar is especially customised to look like the child-self of the individual; more explanation of this facial-customisation feature is available in the upcoming section.

SAT protocols require individual to embrace/hug the inner-child (in imagination) and in response the inner-child should feel happy; we implemented this feature in VE by putting a collider-object around the child avatar; so when the individual attempt's to embrace or hug the child (while standing close to the child) its mood transition from sad to neutral and then from neutral to happy (using mood animations). Individual is additionally encouraged to iteratively conceptualise their secure attachment object in the form of a new and solid house which is incrementally constructed to replace a dark and derelict shelter (depicting the previous insecure attachment). VR platform

also has this feature to allow transition from a dark derelict shelter to a new solid house.

Tools and technologies

VR, the state of the art human-computer interface, is rapidly growing and along with it the development techniques and tools are also being updated swiftly. When we initially planned to develop the platform, it was suggested that we would use Oculus Utilities with Unity 5 to create the application for the self-attachment psychotherapy (SAT), but due to the updates in technology the actual development was done in Unity 2017.1.0 (With C# as the Scripting Language) and instead of relying on the Oculus Utilities we decided to use a different utility kit known as Virtual Reality Tool Kit (VRTK). With VRTK it was concluded that the application can be ported to other VR platforms with minimal amount of work, whereas if the development was done using Oculus Utilities we would have to develop a completely new application for each of the other platforms i.e. Google Daydream, HTC Vive, PlayStation VR etc. It is imperative to mention here that for VRTK to work the relevant platform Software Development Kits (SDK's) need to be installed and setup inside Unity which results in a bigger application file, but one that works on multiple platforms. The platform takes advantage of the itSeez3D Avatar SDK to generate the photorealistic 3D head for the child avatar. As with VRTK, itSeez3D Avatar SDK is also multi-platform out of the box therefore it replaced the initially suggested 3D morphable model (3dMM) proposed by James et al [1].

The platform has been designed with a minimalistic approach so as to not confuse the user. The target audience are people suffering from depression and mental health related issues, it is important for them to not get distracted during the therapy, therefore the application has a linear design and workflow. The user can very easily navigate from one screen to another with the tap of a button and return to the main menu from any screen without getting overwhelmed by the user interface (UI). We have also deliberately avoided adding background noises and colourful images which could potentially distract the user. Taking advantage of the Microsoft Speech Application Programming Interface (SAPI) we have successfully implemented Text to Speech in our application to help the user with better understanding the therapy and increase their level of immersion. SAPI has also been used to implement Audio commands, but as the technology is very new the results are not great as some times the application does not understand the voice input, mostly due to the accent of the user or high background noise.

The application has all the core features for the therapy and some additional features, but the development is far from over. As we obtain valuable feedback from the users, we will continue to make improvements to better enhance the experience. Feedback from user and psychotherapists will also be used to improve the implementation of the SAT protocols. We are also planning on developing an analytics layer for the application so we can gain valuable insights on the usage of the application. Figure 1 shows a participant performing assigned task using Facebook's Oculus.

Figure 1. a participant using SAT VR platform

USABILITY INSPECTION OF SAT VIRTUAL ENVIRONMENT

In this section we explain our usability inspection methodology; and how it helped us make our platform more usable and learnable. Employing usability methodology early in application development also helped us avoid known usability issues for VEs, thus, saving us a great deal of effort and time. Usability design guidelines by Gabbard et al [11] and Hix et al [12] provided a reasonable framework for the usability evaluation.

Heuristic Evaluation

Both first and second authors of this paper worked in group, as well as individually, to evaluate and improve design for the VE for SAT. We systematically iterated through the functionality of the VR platform. Anyone of us will lead the session; while navigating in the VE he would think out loud what he is trying to achieve by wearing the head-mounted display and whether he is experiencing any difficulty in performing (or learning about) any tasks; both of us will have have discussion over it; any of us would also discuss in case we notice any VE design guideline violation. Some of the major violations are as follows: 1)It was noticed that the navigation choices weren't consistent across different protocols 2) Ray-casting control through head mounted display position was not precise often it would make wrong selection 3) VE was unable to provide feedback on user's current state in the system and any indication as to what are the navigation possibilities from that state 4) There was no visual aid (just text description) to elaborate functionality of buttons for some scenarios.

For each violation, a recommendation (to update design) was made and accordingly application was modified so that the design guideline violation is fixed. Once the issue was fixed it application was tested for its correctness. Once all suggested changes were fixed we performed formative evaluation.

Formative Evaluation

Formative evaluation was performed by employing ten volunteers from diverse backgrounds, genders and expertise. A standard procedure to conduct formative evaluation was as follows: 1) the user was briefed about the experiments and psychotherapy 2) the user was given 5 minutes to explore/familiarise

Question	Average score
Overall how satisfied were you with the application?	3.25
How satisfied were you with the flow and controls of the application?	3.125
Rate the effectiveness of text to speech in increasing immersion and improving the understanding of self-attachment therapy?	3
Rate the effectiveness of the photorealistic avatar, did it make you feel like you were looking at your younger self?	4.25
Rate how easy or difficult was it to understand the various protocols of self-attachment therapy in the application?	2.25
How involved were you in the virtual environment experience?	4.37

Table 1. Follow-up questionnaire

with the Oculus VR equipment, controls and VE 3) the users were tasked to undergo SAT protocols in the VE. During the evaluation session we kept track of completion times for the task, frequent errors committed and their improvement suggestions/feedback(if any). Each session lasted between 30-45 minutes depending on the participants expertise/ proficiency with the VR technology.

The most common error (CE1) was in button-selection functionality i.e. participants found it difficult to caste a ray (by pressing thumb-stick button) and then simultaneously press trigger-button to select the desired option in the VE; another important constraint which further exacerbated this feature was that the participants also have to hold the Oculus controller (ray-cast) steady on the option. Second most common error (CE2) was not being able to embrace-the-child i.e. the user couldn't intuitively figure-out (on their own) that he/she has to move closer to the child before they could embrace/hug the child avatar (as part of the protocol). To address CE1, the button size was increased to make it easier for the users to cast a ray on it and also we decreased the sensitivity of the ray cast control so that it become easier for the users to make a selection. For CE2, we modified the protocol functionality to include a notification to notify the user to perform hug/embrace.

After participating in formative evaluation, the participants were required to fill a follow-up questionnaire. Results of the follow-up questionnaire are discussed in the following section.

Follow-up questionnaire

In this section we share results of the usability questionnaire; each participant who participated in formative evaluation was required to fill the questionnaire; each question could be marked on a scale of 1-5 (1 Strongly disagree to 5 strongly agree). As seen in Table 1, majority of the participants were able to effectively connect with the photo-realistic child avatar which indicates that the application will be effective in helping patients in creating a connection with their inner child. The scores for control and usability are all above average, which we believe is because of keeping them simple and having a minimal user interface. The score also indicates that the text explanations for the self-attachment protocols need to be improved and the placeholder text needs to be updated with proper elucidations. Another important observation is that the level of involvement score is 4.37 on a scale of 5 which means the users were immersed in the environment to a great extent.

CONCLUSION & FUTURE WORK

Virtual reality technology is the state of the art human-computer interface; visually rich and perceptual realistic VEs are enabling innovation across wide-range of fields. Commercial scale VR units are becoming cheaper and more accessible; and so is the demand to upgrade conventional solutions with more efficient/customised VR solutions. On the other hand, very little effort is being expended on usability aspects of the VR systems and as a result, VEs are poorly designed. It is important to employ an effective usability engineering methodology for all new (mass-consumable) VR systems.

In this study, we share our experience employing heuristic and formative usability evaluation methodologies to our VR platform. We believe that our findings can help developers build better and more usable psycho-therapeutic VR platforms in the future. We will be testing our platform in a clinical setting (soon) on real-world patients and we hope to learn more and share more insights from evaluating it in clinical setting.

REFERENCES

1. James Booth, Epameinondas Antonakos, Stylianos Ploumpis, George Trigeorgis, Yannis Panagakis, Stefanos Zafeiriou, and others. 2017. 3D face morphable models "in-the-wild". In *Proceedings of the IEEE Conference on ComputerVision and Pattern Recognition*.
2. Doug A Bowman, Joseph L Gabbard, and Deborah Hix. 2002. A survey of usability evaluation in virtual environments: classification and comparison of methods. *Presence: Teleoperators & Virtual Environments* 11, 4 (2002), 404–424.
3. David Cittern and Abbas Edalat. 2015. Towards a neural model of bonding in self-attachment. In *2015 International Joint Conference on Neural Networks, IJCNN 2015, Killarney, Ireland, July 12-17, 2015*. 1–8.
4. David Cittern and Abbas Edalat. 2017. A neural model of empathic states in attachment-based psychotherapy. *Computational Psychiatry* 1 (2017), 132–167.
5. David Cittern, Abbas Edalat, and Ibrahim Ghaznavi. 2017. An immersive virtual reality mobile platform for self-attachment. In *Artificial Intelligence and Simulation of Behaviour*.
6. Abbas Edalat. 2013a. Capacity of strong attractor patterns to model behavioural and cognitive prototypes. In

Advances in Neural Information Processing Systems (NIPS) 26, C.J.C. Burges, L. Bottou, M. Welling, Z. Ghahramani, and K.Q. Weinberger (Eds.). ACM.

7. Abbas Edalat. 2013b. Self-attachment: A new and integrative psychotherapy. `http://humandevelopment.doc.ic.ac.uk/papers/iop-talk.pdf`, *Talk at the Institute of Psychiarty, London* (2013).
8. Abbas Edalat. 2015. Introduction to self-attachment and its neural basis. *International Joint Conference on Neural Networks (IJCNN)* (2015), 1–8.
9. A. Edalat. 2017. Self-attachment: A holistic approach to Computational Psychiatry. In *Computational neurology and psychiatry*, M. Hanspeter (Ed.). Vol. 6. Springer, 273–314.
10. Abbas Edalat and Federico Mancinelli. 2013. Strong Attractors of Hopfield Neural Networks to Model Attachment Types and Behavioural Patterns. In *IJCNN 2013 Conference Proceedings*. IEEE.
11. Joseph L Gabbard. 1997. *A taxonomy of usability characteristics in virtual environments*. Ph.D. Dissertation. Virginia Tech.
12. Deborah Hix and Joseph L Gabbard. 2002. Usability engineering of virtual environments. *Handbook of virtual environments: Design, implementation and applications* 28 (2002).
13. Deborah Hix, J Edward Swan, Joseph L Gabbard, Mike McGee, Jim Durbin, and Tony King. 1999. User-centered design and evaluation of a real-time battlefield visualization virtual environment. In *Virtual Reality, 1999. Proceedings., IEEE*. IEEE, 96–103.
14. Joan McComas, Morag MacKay, and Jayne Pivik. 2002. Effectiveness of virtual reality for teaching pedestrian safety. *CyberPsychology & Behavior* 5, 3 (2002), 185–190.
15. Maria T Schultheis, Jose Rebimbas, Ronald Mourant, and Scott R Millis. 2007. Examining the usability of a virtual reality driving simulator. *Assistive Technology* 19, 1 (2007), 1–10.
16. Kent Swartz, Umesh Thakkar, Deborah Hix, and Rachael Brady. 1999. Evaluating the Usability of Crumbs: a Case Study of VE Usability Engineering. In *Proceedings of the 3rd International Immersive Projection Technologies Workshop*. Citeseer, 243–252.