An Immersive Virtual Reality Mobile Platform for Self-Attachment

David Cittern   and   **Abbas Edalat**   and   **Ibrahim Ghaznavi** [1]

Abstract. Psychotherapy is among the most effective techniques for combating mental health issues, and virtual reality is beginning to be explored as a way to enhance the efficacy of various psychotherapeutic treatments. In this paper, we propose an immersive virtual reality mobile platform for Self-Attachment psychotherapy. Under the Self-Attachment therapeutic framework, the causes of disorders such as chronic anxiety and depression are traced back to the quality of the individual's attachment with their primary caregiver during childhood. Our proposed platform aims to assist the user in enhancing their capacities for self-regulation of emotion, by means of earning secure attachment through the experience of positive attachment interactions, missed in their childhood. In the virtual environment provided by the platform, the adult-self of the user learns to create and strengthen an affectional and supportive bond with the inner child. By long term potentiation and neuroplasticity, the user gradually develops new neural pathways and matures into an effective secure attachment object for the child, thereby enabling the self-regulation of emotions.

1 Introduction

Globally, Dysthymia (chronic depression) occurs in about 105 million people per year (or approximately 1.5% of the population) [28], and about 4% of people worldwide are affected by Generalized Anxiety Disorder (chronic anxiety) at some point during their life [7]. Self-Attachment is a new, self-administrable, attachment-based psychotherapy which starts from the premise that at the root of many affect dysregulation, mood and anxiety disorders is a suboptimal attachment experience during early childhood [20, 10, 11]. Showing success in initial preclinical trials, the therapy aims to naturally stimulate the release of oxytocin and dopamine in order to promote neural plasticity in key attachment related areas of the brain, in order to enhance the individual's capacities to self-regulate their emotion. This is achieved by the application of a number of attachment-based protocols involving, for example, the mental simulation of interactions with a good-enough caregiver. Application of these protocols supplies the individual with the unconditional affection and love that characterises secure forms of attachment, which provides scaffolding for the development of mental resilience and overall emotional well-being.

The purpose of this paper is to overview Self-Attachment therapy, and outline how recent advances in mobile Virtual Reality (VR) technology can be leveraged to assist in its undertaking (an idea first proposed in [9]). In particular, we will overview the features of an initial prototype mobile app and VR environment that has been developed to this end, before outlining our plans for the development of a new and immersive (sensorily-rich) VR environment to aid the user in undertaking the simulatory aspects of the therapy.

The remainder of this paper is organised as follows. In Section 2 we discuss related work on VR and other technological tools for mental health, and in Section 3 we detail Self-Attachment therapy along with neurobiological hypotheses with regards to its effects on brain regions involved in emotion regulation. An overview of the functionality of our VR mobile platform for Self-Attachment is detailed in Section 4. We conclude the paper in Section 5.

2 Related Work

Technological and web-based platforms have, for a number of years, been used to assist in the administration of various psychotherapeutic treatments (e.g. Beating the Blues, [22] and Living Life to the Fullest [29]). Recent advances in the field of VR have shown promise in the pursuit of devising new techniques for the treatment of a variety of psychological and medical conditions involving phobias, pain, anxiety and depression. Here we overview some key relevant platforms.

Rizzo et al. [24] developed Bravemind: an interactive VR-based exposure therapy tool which allows psychotherapists to immerse post-traumatic stress disorder patients into virtual environments in a controlled, stepwise fashion. This immersive VR platform enables the clinician to control multi-sensory emotional stimuli and monitor the intensity of the patients stress via brain imaging and psychophysiological assessment. Rizzo et al. [23] also developed the Stress Resilience in Virtual Environments (STRIVE) immersive VR platform for stress treatment. Veterans are first exposed to a virtual war-like environment in order to provoke physical, social and emotional stress, and after each war episode there is virtual mentor who explains the underlying causes and physiology of stress. Then in the second stage physical, social and cognitive exercises utilising Cognitive Behavioural Therapy (CBT) are undertaken.

Fernando et al. [14] uses VR technologies to treat anxiety and phobias, with customized virtual environments designed according to the specific type of phobia. The platform, dubbed Phobos, also has support for standard CBT treatment protocols. Freeman at al. [16] uses immersive VR technology to treat patients experiencing persecutory delusions by enabling them to test the threat predictions in virtual social environments. Results of the randomised controlled trail study of the proposed therapy revealed reductions in delusional conviction and real-world distress.

Hoffman at al. [18] makes use of VR to create a virtual environment containing snow and water, with the aim of relieving burn patients from their pain. The main idea is to immerse the patient in this virtual environment in order to drain their attention resources

---

[1] Algorithmic Human Development, Department of Computing, Imperial College London, SW7 2AZ, UK, email: {david.cittern10,a.edalat,s.ghaznavi16}@imperial.ac.uk. Authors listed in alphabetical order.

(which would otherwise be used to process pain signals). The team conducted fMRI brain scans which revealed a significant reduction in pain-related brain activity in response to using the application. Garrett et al. [17] propose Virtual Mediatative Walk (VMW), an immersive VR environment incorporating sensors and sound, which is intended to help chronic pain patients practice mindfulness-based stress reduction. Patients experiencing pain can see their mirrored version and using VMW they learn to control inner emotional states to reduce pain.

A concept closely related to Self-Attachment therapy is security priming [20], which involves temporarily activating mental representations relating to the availability of a secure attachment figure (using subliminal, visual or imagery techniques) in order to reduce distress and restore positive mood. Also closely related are recent studies that have experiment with virtual embodiment-switching within the context of mental health, which (as we will see in the next section) is a process undertaken during Self-Attachment therapy. Osimo et al. [21] uses virtual embodiment as a method for improving patient mood. In their experiments the individual was first embodied in a virtual body that closely resembled themselves, from which they described a personal problem to another virtual body representing Dr Sigmund Freud. Then, in the second part of the experiment, the individual was embodied in the virtual Freud, from which they offered their virtual self counselling. This virtual embodiment technique is proposed to result in sufficient detachment from conventional and habitual ways of thinking about problems, and can ultimately be used to create and retain positive cognitive changes. Falconer et al.[13] uses immersive VR to enable patients to practice self-compassion. First the individual is embodied in a virtual representation of themselves in order to deliver compassion towards a (generic) distressed virtual child. Then, the individual is embodied in the virtual child and experiences receiving compassion from their virtual self. Participants undertaking this procedure were found to decrease self-criticism and depressive symptoms, and increase self-compassion.

3   Self-Attachment Therapy

Self-Attachment is a new attachment-based psychotherapy that has recently been proposed as a method for re-training an individual's sub-optimal attachment schema [9, 10, 11]. Showing success in pre-clinical trials, the therapy is rooted in the idea that many affect dysregulation disorders have their basis in early insecure attachment experience [11]. It consists of a number of self-administrable protocols which aim to recreate the effects of positive infant-parent interactions using instead interactions that are fully internalised within the individual.

Under the Self-Attachment paradigm, the individual undergoing therapy is conceptualised as comprising both an inner-child and adult-self. The inner-child corresponds to the emotional self that becomes dominant under stress, whereas the adult-self relates to the more rational part of the self, dominant under times of calm and low perceived threat. The aim of the therapy is to create a secure attachment and affectional bond between the adult-self and inner-child, in order to enhance the capacity for emotion regulation within the individual.

3.1   Stages

The four stages of Self-Attachment are outlined below [10, 11, 12]:

1. Introduction to Self-Attachment therapy. In this preliminary stage the individual becomes familiar with the scientific basis and underlying hypotheses of the therapy. This includes a basic introduction to attachment theory; the basics of the (developmental) neurobiology of attachment, love, bond making and emotion regulation; and the mechanisms of neuroplasticity and long term potentiation. The aim of this preliminary phase is to provide the initial motivation for undertaking the therapy, which requires dedication and self-discipline in terms of time and commitment.

2. Connecting with the inner-child. In this second stage of the therapy, the individual begins to create a relationship with the inner-child with a view to establishing empathy and ultimately compassion with them. The individual selects both a positive photograph or their childhood (which elicits emotions and memories such as happiness or contentment) and a sad photograph (associated with negative affect). Several highly-structured exercises (termed protocols), focused towards these images, are then conducted in order to conceptualise the inner-child as concretely as possible. These protocols include (for example), with closed eyes, trying to visualise the two chosen childhood photos, and attempting to imagine that the child that they were is present and close to them and that they can touch and hold this child.

3. Building an affectional bond with the inner-child. During this stage of the therapy, an imaginative but passionate 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 vows to consistently support and love them, in order to reprocess previously traumatic experiences and re-parent them towards a state in which they are able to self-regulate their emotion. From the perspective of the adult-self, the individual focuses on the images of the inner-child and attempts to bond with them, in order to create an attachment relationship with them. This bonding process is enhanced with the use of activities such as self-massage, to simulate the act of cuddling the inner child, and (overt and/or imagined) song and dance directed towards the inner-child which (as we briefly outline below) are hypothesised to induce neural plasticity in key attachment-related neural circuitry.

4. Developmental re-training and re-parenting of the inner-child. The next stage of the therapy involves a number of protocols describing patterns of interactions between the adult-self and inner-child that emulate the function of a good enough parent interacting with a securely attached child, in order to minimise negative emotions and maximise positive affect. One example is a protocol that involves the reprocessing of painful and traumatic past events: first, the individual closes their eyes and recalls a traumatic childhood episode, remembering and re-experiencing in as much detail as possible the associated negative emotions (such as fear or helplessness). Once this state has been recalled, the individual imagines that their inner-adult quickly and competently intervenes in order to reduce distress in the inner-child, for example by embracing or vocally reassuring them. As for the bonding protocols, this can be enhanced with various activities: for example the individual can assist in imagining an embrace with the use of self massage. Other protocols aim to minimise negative, and maximise positive, affects. Other examples of protocols are those which use imagery techniques in order to minimise negative and maximise positive affects. The aim is for these protocols to become habituated with repetition, and so individuals are encouraged to integrate these protocols into their everyday activities, for example singing to the inner-child while walking or doing housework.

Notice that the therapy makes much use of visualisation and imagery techniques: this is because the early attachment type of a child

is formed in the pre-verbal years, during which the visual senses are relatively influential. Accordingly, the individual is additionally encouraged to gradually construct a visually potent picture of the creation of their secure attachment object as they progress through each stage of the therapy. This might be, for example, 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).

3.2 Hypotheses on Neurobiological Effects

Much of our work to date has focused on formulating and computationally simulating neurobiological hypotheses with respect to the underlying effects on the individual's brain of practising the protocols concerned with the creation of a bond between the adult-self and inner-child. The attachment schema has been theorised to be based in unconscious and implicit memories, rooted mainly in right-hemispheric brain regions centred on the Orbitofrontal Cortex (OFC), amygdala and hypothalamus [6]; areas known to be central to a range of social cognition and emotional processing functions. In the framework outlined by Rolls [25] (which we broadly follow in our work) the OFC is involved in emotion, (reinforcement) learning and decision making as a result of two primary functions. The first of these functions is its representation of the reward (anything that an individual will work to acquire) and punishment (anything that they will work to avoid) value of primarily reinforcing stimuli (e.g. food or pain, that are positively or negatively reinforcing, i.e. will increase or decrease the probability of repeating behaviours paired with them innately and without learning), with OFC activity representing many different types of primary reinforcer (including taste, pleasant and painful touch, and visual and auditory stimuli). The second function is the OFC's involvement in the learning and reversal of associations between previously neutral stimuli and primary reinforcers, such that these previously neutral stimuli become rewarding or punishing themselves. Rolls argues that emotions are states elicited by reinforcers, defined in terms of the withholding or administration of rewards and punishments (for example, non-delivery of an expected reward might lead to anger, while delivery of a punishment might elicit a state of fear).

Based on existing neurobiological data, we have previously hypothesised [5] that a main effect of the Self-Attachment bonding protocols (stage 3) is to associate broad classes of social stimuli that have previously been conditioned as being fearful or threatening in nature with representations of additional, naturally-induced reward (which result from the various interactions associated with the protocols, e.g. directed singing with inner-child imagery, that induce dopamine release). We proposed that these new associations in the OFC should increasingly facilitate endogenous oxytocin release (associated with a range of bonding and attachment-related behaviours) and restrain the release of corticotropin-releasing hormone (the precursor to cortisol, the stress hormone) via strengthening of an inhibitory pathway to the amygdala.

In [4] we considered how the formation of an empathic state with the inner-child (stage 2) might stimulate neural circuitry otherwise implicated in the onset of caregiving behaviour, in order to generate motivation for the application of these bonding protocols. Based on data concerning the strength of the empathic response with respect to the perceived innocence and closeness/relatedness of the other, we proposed that the particular representation used in Self-Attachment therapy for the target of this bonding (the inner-child) would assist in stimulating this motivational pathway.

4 An Immersive VR Mobile Platform for Self-Attachment

VR, the state of the art human-computer interface, uses computer graphics to create a realistic-looking virtual world that the user can interact with in real-time. Immersive VR platforms, tools and technologies are now commonly used in a wide variety of sectors including military, healthcare, education, entertainment and construction, as well as for scientific visualisation purposes. In recent years, tech giants including Facebook (Oculus), Google (Daydream, Cardboard and Jump), Sony Playstation (PlaystationVR) and HTC (Vive) have begun to provide powerful mass market VR solutions. Mobile phones are the most widely used technology worldwide; according to a United Nations telecom agency there are approximately 6 billion mobile-phone subscriptions across the globe. Thus, for reasons of accessibility, we have chosen to use the mobile-based Google Android platform (with Cardboard VR) to develop our Self-Attachment tool.

Our group has recently developed an initial prototype app and VR platform to assist the user in undertaking aspects of Self-Attachment therapy [27]: we overview the key features of this app here. Firstly, the app includes informational videos relating to appropriate and affectionate attachment behaviour between a child and primary caregiver, along with textual information relating to the theoretical aspects of the therapy. The mobile app includes functionality for managing the digital content (e.g. the happy/sad childhood photos, and designated favourite songs) utilised throughout the therapy, and after each exercise the user is prompted to write a diary entry to help them consolidate what they have experienced and learned (which includes speech-to-text functionality for dictation of entries). This digital content is stored in a 'memory bank', which the user can view in a style similar to flash cards (serving to induce active memory recall). The app allows the user to complete well-established self-report questionnaires on anxiety [26], depression [19] and attachment [15] (which are automatically scored), with resulting data presented visually to the user to communicate their progress. Launched from within this mobile app, our prototype VR platform allows the user to focus on their happy and sad childhood images within a virtual environment resembling a small garden, in order to complete the protocols in stages 2 and 3 involving these images.

A number of additional features are planned for the final app. Firstly, in order to assist in the first stage of the therapy, the app will include additional informational videos which introduce and overview the therapy, and provide motivational testimonials from participants who have experience improvement after undergoing Self-Attachment. We will additionally offer tutorial videos for the head, shoulder and neck massages involved in other stages, in case participants are not familiar with these techniques. The user will have the ability to print their happy childhood photos from within the app, since the third stage of the therapy requires that copies be placed in different areas of the living space. Playback of the self-designated happy songs will now include the option to display lyric subtitles in order to encourage engagement, and the app will automatically and periodically ask the user to complete the self-report questionnaires (rather than this being reliant on user initiative). Finally, pop-up Android notifications will be used to gently remind the individual to undertake the required exercises should they be neglecting their obligations.

We plan to expand on the functionality of the prototype VR environment to incorporate embodiment in adult-self and inner-child avatars, such that the user can carry out the protocols relating to

bonding and parenting. Some of these virtual interactions will be similar to the embodiment experiments conducted by [13] (described previously), although our implementation will involve an inner-child avatar that will be customised to have as close a resemblance to the user's own previous (childhood) self as possible (rather than with a generic child), in accordance with the theoretical underpinnings of Self-Attachment. We anticipate that relatively inexpensive add-on hardware (e.g. the shortly forthcoming VicoVR sensor [1]) can be used to optionally enhance the sense of immersion during these virtual bonding experiences, by means of tracking (and virtually replicating) the movements of the individual's own body.

Another potential feature that we are exploring is that of an internal dialogue: when the inner-child's attachment system is active, we envisage them opening a conversational dialogue with the adult-self. This would involve the inner-child first describing their current concerns and/or emotional state to the adult-self, followed by an appropriate (soothing) response from the adult-self, with a series of exchanges ensuing until the inner-child's regains emotional balance. From a technological perspective, this functionality might be implemented in the form of a conversational agent which has the ability to recognise the emotional and/or verbal content of the inner-child's dialogue at each stage, and to subsequently present an appropriate response aimed at soothing or calming them (see e.g. [2] which presents a real-time speech emotion and sentiment recognition module for an interactive dialogue system, and [3] for a survey of speech emotion recognition techniques). More ambitious solutions might involve dialogues with an animated adult-self avatar within the VR environment. Automated speech analysis techniques might additionally aid in determining the severity of depressive symptoms [8], in order to assist in tracking therapy progress.

5 Conclusion

Self-Attachment therapy is a new psychotherapeutic technique for re-training an individual's sub-optimal attachment schema, involving the regular practice of self-administrable protocols which aim to recreate the positive effects of affectionate infant-parent interactions. In this paper we briefly overviewed Self-Attachment along with our hypotheses regarding its effects on parts of the individual's brain involved in emotion regulation, and reviewed recent works that have successfully used VR for the treatment of various medical (including mental health) conditions. Based on this, we proposed a new immersive VR mobile platform to assist with administration of the protocols involved in Self-Attachment therapy and outlined its key functionality. Development of this platform is now underway, and our aim moving forwards is to conduct a randomised controlled trial in order to fully assess its efficacy in treating chronic anxiety and depression.

REFERENCES

[1] VicoVR. vicovr.com. Accessed: 13-01-2017.

[2] D Bertero, F Siddique, C Wu, et al., 'Real-time speech emotion and sentiment recognition for interactive dialogue systems', in *Proceedings of the 2016 Conference on Empirical Methods in Natural Language Processing*, pp. 1042–1047. Association for Computational Linguistics, (2016).

[3] P Chandrasekar, S Chapaneri, and D Jayaswal, 'Automatic speech emotion recognition: A survey', in *Circuits, Systems, Communication and Information Technology Applications (CSCITA), 2014 International Conference on*, pp. 341–346. IEEE, (2014).

[4] D Cittern and A Edalat, 'A neural model of empathic states in attachment-based psychotherapy', *Under-review, 2017*.

[5] D Cittern and A Edalat, 'Towards a neural model of bonding in self-attachment', in *2015 International Joint Conference on Neural Networks (IJCNN)*, pp. 1–8. IEEE, (2015).

[6] L Cozolino, *The Neuroscience of Human Relationships: Attachment and the Developing Social Brain (Norton Series on Interpersonal Neurobiology)*, WW Norton & Company, 2014.

[7] M Craske and M Stein, 'Anxiety', *The Lancet: Anxiety and Depression*, **388**(10063), 3048–3059, (2016).

[8] N Cummins, S Scherer, J Krajewski, et al., 'A review of depression and suicide risk assessment using speech analysis', *Speech Communication*, **71**, 10–49, (2015).

[9] A Edalat, 'Self-attachment: A new and integrative psychotherapy'. Talk presented at the Institute of Psychiatry, Kings College London on 02-05-2013, humandevelopment.doc.ic.ac.uk/papers/iop-talk.pdf. Accessed: 19-01-2017.

[10] A Edalat, 'Introduction to self-attachment and its neural basis', in *2015 International Joint Conference on Neural Networks (IJCNN)*, pp. 1–8. IEEE, (2015).

[11] A Edalat, 'Self-attachment: A holistic approach to computational psychiatry', in *Computational Neurology and Psychiatry*, ed., Amy Cochran Peter Erdi, Basabdatta Sen Bhattacharya, Springer series of Bio/Neuroinformatics, Springer, (2017).

[12] A Edalat, *Self-attachment: A self-administrable intervention for chronic anxiety and depression*, Technical report, Department of Computing, Imperial College London, 2017.

[13] C Falconer, A Rovira, J King, et al., 'Embodying self-compassion within virtual reality and its effects on patients with depression', *British Journal of Psychiatry Open*, **2**(1), 74–80, (2016).

[14] T Fernando. PHOBOS. psychologicaltechnologies.com. Accessed: 13-01-2017.

[15] R Fraley, N Waller, and K Brennan, 'An item response theory analysis of self-report measures of adult attachment.', *Journal of personality and social psychology*, **78**(2), 350, (2000).

[16] D Freeman, J Bradley, A Antley, et al., 'Virtual reality in the treatment of persecutory delusions: randomised controlled experimental study testing how to reduce delusional conviction', *The British Journal of Psychiatry*, **209**(1), 62–67, (2016).

[17] B Garrett, T Taverner, W Masinde, et al., 'A rapid evidence assessment of immersive virtual reality as an adjunct therapy in acute pain management in clinical practice', *The Clinical journal of pain*, **30**(12), 1089–1098, (2014).

[18] H Hoffman, G Chambers, W Meyer III, et al., 'Virtual reality as an adjunctive non-pharmacologic analgesic for acute burn pain during medical procedures', *Annals of Behavioral Medicine*, **41**(2), 183–191, (2011).

[19] K Kroenke, R Spitzer, and J Williams, 'The PHQ-9', *Journal of general internal medicine*, **16**(9), 606–613, (2001).

[20] M Mikulincer and P Shaver, 'An attachment perspective on psychopathology', *World Psychiatry*, **11**(1), 11–15, (2012).

[21] S Osimo, R Pizarro, B Spanlang, et al., 'Conversations between self and self as Sigmund Freud A virtual body ownership paradigm for self counselling', *Scientific reports*, **5**, (2015).

[22] J Proudfoot, S Swain, S Widmer, et al., 'The development and beta-test of a computer-therapy program for anxiety and depression: hurdles and lessons', *Computers in Human Behavior*, **19**(3), 277–289, (2003).

[23] A Rizzo, T Parsons, B Lange, et al., 'Virtual reality goes to war: A brief review of the future of military behavioral healthcare', *Journal of clinical psychology in medical settings*, **18**(2), 176–187, (2011).

[24] A Rizzo, G Reger, G Gahm, et al., 'Virtual reality exposure therapy for combat-related PTSD', in *Post-Traumatic Stress Disorder*, 375–399, Springer, (2009).

[25] E Rolls, *Emotion and decision making explained*, Oxford University Press, 2013.

[26] R Spitzer, K Kroenke, J Williams, et al., 'A brief measure for assessing generalized anxiety disorder: the GAD-7', *Archives of internal medicine*, **166**(10), 1092–1097, (2006).

[27] M Tirmizey, *Self-Attachment Therapy for Mobile Platforms*, Bachelor's thesis, Imperial College London, 2016.

[28] T Vos, A Flaxman, M Naghavi, et al., 'Years lived with disability (YLDs) for 1160 sequelae of 289 diseases and injuries 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010', *The Lancet*, **380**(9859), 2163–2196, (2013).

[29] C Williams. Living Life To The Fullest. www.llttf.com. Accessed: 20-01-2017.