

The Application of Serious Games in Virtual Reality as Intervention for Sugar Addiction

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Abstract. The escalating global health crisis of obesity, diabetes and heart conditions linked to disordered eating needs the implementation of effective interventions. Serious games, especially in Virtual Reality (VR), offer promising avenues for addressing these challenges through embodiment and emotional reactivity. Integrating gamification and mindfulness techniques, serious games can target addictive behaviours associated with sugar consumption. We propose to test the application of VR as a tool to address addictive sugar cravings in an 8-week serious games mindfulness based intervention. We hypothesise that the VR group will experience greater reductions in sugar addiction symptoms compared to the 2D computer-based group.

Keywords: Wellbeing, Serious Game, Sugar Addiction, Virtual Reality, Mindfulness, MBRP.

1 The Prevalence of Sugar Addiction

With the current health crisis, with more than 1 billion people in the world suffering from obesity and 43% of adults being overweight in 2022 [1], alongside the escalating prevalence of diabetes and heart conditions attributed to overweight problems, it is imperative to explore successful interventions to address these pressing challenges facing humanity.

According to the University of Michigan in 2023, about 1 in 8 Americans over 50 show signs of food addiction [2].

With the rise of processed and sugary food, this alarming number is predicted to only increase. Food addiction is characterised by individuals consuming larger amounts of certain foods than they intended, demonstrating an excessive preoccupation with specific foods, experiencing intense desires or urges for particular foods, and continuing to consume these foods despite being aware of their adverse consequences [3]. Mirroring other addiction forms, such as alcohol use disorder (AUD), a significant addiction craving feature as seen with AUD, are evident with food disorders [4]. While these two disorders seem different at first glance, similar pathophysiological mechanisms exist, including the experiences of craving [4]. Specifically, in food addiction, individuals experience a compelling urge to consume highly palatable and sugar focused foods, indicating a profound psychological and behavioural overlap with traditional substance dependencies.

Sugar addiction, a subset of food addiction, specifically focuses on the addictive properties of sugar-containing foods. These foods, often highly processed and rich in added sugars, can trigger neurological responses similar to those seen with substance abuse [5]. Consequently, consuming high levels of sugar can lead to cravings, loss of control, overeating behaviours, as well as severe withdrawal symptoms when sugar intake is reduced. Therefore, it is crucial to develop effective interventions to help reduce sugar addictive tendencies.

It has been previously argued that food and SUD cravings are elicited via repetitive behaviours and the positive emotional reinforcement that follows these actions. This process is elucidated by the behaviourist theory of Pavlovian classical conditioning [6], where repeated associations of an unconditioned stimulus with a previously neutral stimulus, combined with positive reinforcement, culminate in the pairing of an emotional response with the neutral stimulus. For instance, individuals might resort to chocolate and other types of sugar consumption, as well as processed foods during moments of high stress or anxiety as a means to cope and mitigate negative feelings, a behaviour commonly referred to as self-medicating [7]. As a result of continual exposure, the brain begins to link these food items with intrinsic rewards, engendering cravings and impulsive desires for consumption, alongside changes in the brain's reward circuitry [7]. One treatment avenue to reduce sugar cravings is the use of serious games.

2 Serious Games as a Treatment Method for Mental Health

Serious games have been used in therapeutic settings to support the management of various mental health disorders, including anxiety [8] [9], attention-deficit hyperactivity (ADHD) [10] [11] and alcohol use disorder [12] [13]. Results are promising, showing great improvement in the alleviation of symptoms, as well as the facilitation of deep learning [14] and behaviour change [15].

At the core of serious games lies a drive to modify behavioural patterns and a growing emphasis on education. Incorporating gaming elements into digital interventions offers numerous advantages, such as facilitating goal-driven, positive behavioural modifications and implementing reward systems [16]. Hence, serious games offer an incredible potential in developing successful interventions for mental health. This could result in the development of serious games centered around mindfulness techniques, which may include the adaptation of the Mindfulness-Based Relapse Prevention (MBRP) program to alleviate various mental health issues, including alcohol use disorder, internet gaming addiction and sugar addiction.

Mindfulness-based interventions offer promising avenues for treating mental health conditions, such as depression [17], obsessive compulsive disorder [18] and food addiction [19]. Methodologies behind mindfulness involve practices at fostering present moment awareness, acceptance and non-judgmental observations of one's thoughts, emotions and bodily sensations. By integrating a serious game approach and leveraging technology, especially virtual reality (VR), participants can experience a heightened sense of embodiment within the therapeutic environment. Ultimately, this immersive

experience has the potential to enhance engagement by fostering connectedness to the content. Thus, drop-out rates may decline as participants may feel more motivated to actively participate in the intervention thanks to the immersive and embodied experience VR offers.

3 Serious Games in Virtual Reality

VR offers immersive interactivity in virtual environments by stimulating various senses, including visual, auditory and in some cases even haptic [20] [21]. This approach of immersiveness increases user engagement and may therefore lead to greater therapeutic impact [22] [23].

At the forefront of VR is the ability to transport users into a wide range of virtual worlds. By focusing on high-definition displays and incredible sophisticated environmental designs, VR scenes can look highly realistic, mirroring real-world scenes. This is especially important when creating a sense of embodiment [24] and creating serious games focused on the treatment of mental health [25] [26].

Embodiment is referred to as a feeling of presence through different sensory signals arriving to the body, which the brain coherently interprets to create an accurate representation of the self [27]. Through integrating technology to applied neuroscience and psychology, especially through VR, subjects can experience embodiment in a virtual world. A study by Slater et al. [28] demonstrated that participants could experience a full-body transfer illusion in VR, where male participants were fully able to embody a virtual female bodily experience. Moreover, VR offers individuals the opportunity to experience the virtual world in a highly similar manner to the real world. González-Franco and colleagues [29] study highlighted identical brain responses in the motor cortex when moving their hand out of the way of a knife in VR compared to the same movement and neural responses in real life. Embodied simulations are especially crucial when designing effective psychological treatment methods for mental health disorders. Similar to the real world, VR experiences can predict sensory actions, concepts and emotions [30]. Thus, creating a similar physical and neural response within a virtual environment as one would encounter in the physical world.

A key consideration is whether engaging in mindfulness practices within a naturalistic VR environment would evoke stronger emotions and a more immersive full-body experience compared to practicing mindfulness in a traditional, non-VR setting, such as an indoor environment like an office. The immersive nature of VR, with its potential to create realistic and engaging nature environments, enhances sensory input and emotional engagement [31], making the mindfulness experience more vivid and impactful. This heightened level of immersion could amplify the emotional responses and physical sensations experienced during mindfulness practices, leading to more profound therapeutic outcomes. Previous studies on the application of VR in clinical populations with patients suffering from an eating disorders (ED), including anorexia nervosa (AN), bulimia nervosa (BN) and binge eating disorder (BED), have shown effective outcomes in helping patients reduce food cravings and anxiety responses to food [32]. Additionally, journal articles investigating the efficacy of VR on compassion and self-

compassion meditations have revealed that the use of virtual bodies can promote greater compassion and self-compassion, leading to a reduction of self-criticism [33].

Therapies like virtual exposure therapy or virtual social interactions heavily focus on the emotional reactions of the user when immersed in VR [34]. It may be possible that a similar emotional system is necessary in mindfulness VR interventions. Users experiencing a sense of presence when practicing mindfulness in VR may show greater changes compared to users practicing mindfulness in a 2D environment. Gall and colleagues [35] highlighted that virtual embodiment does affect emotional reactions to various stimuli. Hence, this supports our hypothesis that mindfulness VR interventions could be more efficient than mindfulness 2D environments, due to a sense of embodiment and emotional reactivity leading to greater significant therapeutic effects.

The immersive nature of VR shows great potential of application, especially for therapeutic purposes. Numerous studies using VR headsets, including exposure therapy for the treatment of post-traumatic stress disorders (PTSD) [36], cognitive-behavioural therapy (CBT) for the treatment of anxiety [37] and mindfulness for the treatment of alcohol abuse [38], have shown significant bettering of symptoms. For example, VR based interventions to treat PTSD are based on realistic environments that provoke fear or discomfort in a controlled environment, helping the user to successfully decrease their trauma.

By implementing VR in treatment methods for mental health, users have the possibility to alter their external and internal bodily experience, leading to a quicker and more significant reduction in sub-optimal mental health symptoms. Furthermore, patients might experience stronger emotions and more immersive full-body sensations through mindfulness practices in naturalistic VR environments than non-VR indoor environments like offices. Thus, this approach could potentially lead to enhanced therapeutic outcomes and deeper levels of relaxation and self-awareness, but also improved emotion regulation and stress management skills compared to the start of the intervention, while reducing stress responses over the course of the procedure.

4 Virtual Reality VS 2D Computer-Based Serious Game on Mindfulness to alleviate Sugar Addiction

This section aims to outline a proposed study, which is looking at reducing sugar cravings by implementing an 8-week serious game mindfulness-based intervention (MBRP) in virtual reality compared to an 8-week 2D computer-based intervention. The aim is to understand whether embodiment VR is more effective in eliciting emotions related to mindfulness, as well as addiction, and whether this emotional reaction reduces sugar cravings more significantly than the 2D mindfulness intervention.

Eligible participants will be administered at random to one of the following groups: virtual reality (treatment condition) or computer based (control condition). Note that the protocol for both groups is identical, with the only exception of the delivery method, i.e., the intervention will either be delivered in virtual reality or through a computer screen. Virtual environments for the serious game on mindfulness will differ, with 20

participants (virtual reality intervention = 10 participants, computer based = 10 participants) being administered to a naturalistic mountain view, 20 participants (virtual reality intervention = 10 participants, computer based = 10 participants) being advised to a Japanese forest, and 20 participants (virtual reality intervention = 10 participants, computer based = 10 participants) assigned to a beach (see figure 1).

There is little literature on mindfulness and naturalistic environment highlight the benefits of nature in reducing rumination [39] and anxiety [27], two important comorbidities of addiction [40] [41]. However, research is limited and does not highlight which specific naturalistic environment is more effective. Therefore, this proposed study also aims at understanding this critical matter by utilising three distinct nature based virtual environments with highly different components.

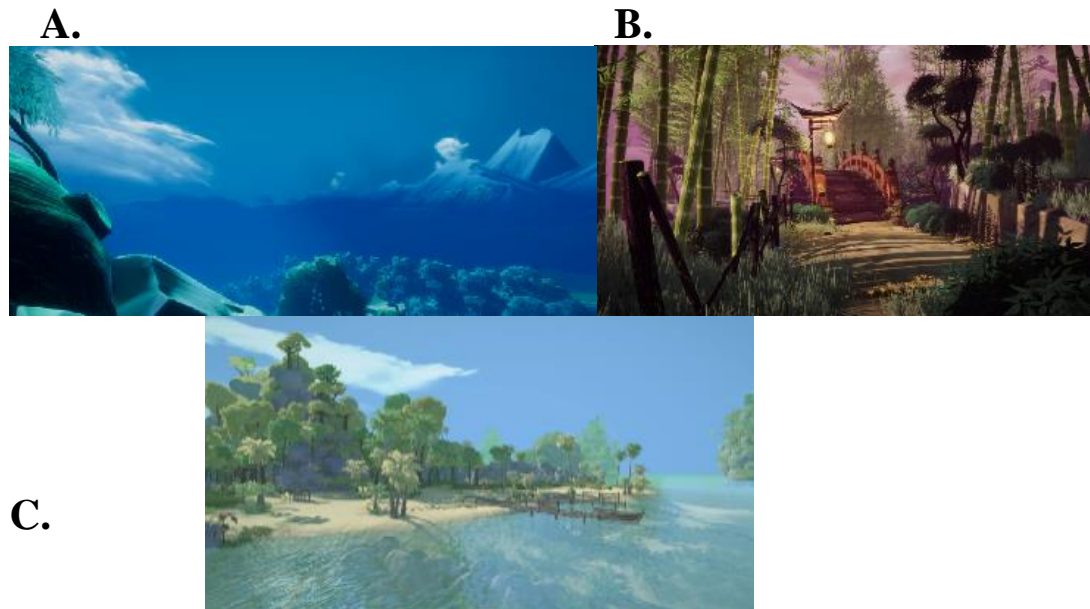


Fig. 1 Virtual environments participants will undergo the 8-week serious game Mindfulness-Based Relapse Prevention (MBRP) intervention. Environments are as followed: Naturalistic mountain view (A), Japanese forest (B) and Beach (C).

Both treatment conditions will undergo an 8-week serious game MBRP intervention adapted from Bowen et al. [42] to address symptoms of sugar addiction. The new build intervention will comprise 8 different sessions. Each session will last approximately 30 minutes and will have a central theme, based on meditation and mindfulness practices. Themes include, but are not limited to, being in auto-pilot, recognising thoughts and emotions when triggered, and the role of thoughts in relapse. The session on being on auto-pilot will focus on helping participants become aware of maladaptive habits and unconscious behaviours, while helping them to bring more intentionality into their daily actions. The session on recognitions thoughts and emotions when triggered, on

the other hand, is aimed at teaching participants to identify immediate reactions to stressors, while teaching them to respond more mindfully rather than impulsively. Additionally, the role of thoughts in relapse session will explore how certain thoughts can contribute to the risk of relapse, at the same time as providing participants with strategies for reframing these maladaptive thoughts to support long-term recovery. This 8-week intervention implements aspects of gaming by introducing an earning point and 'level-up' system where participants have the opportunity to score points and receive rewards by going to the next level, i.e., after completion of a session, participants automatically get a reward by collecting points which will propel them to the next level/session. Note that the reward only occurs by completing the session. Any dropouts or non-completion are not rewarded.

Overall, this study aims to evaluate the effects of the serious game MBRP in virtual reality compared to a computer-based intervention. We hypothesise that a greater reduction in sugar addiction will occur in the virtual reality group than the computer-based group. This immersive quality of VR is expected to make the mindfulness practices more effective, thereby leading to better treatment outcomes. Secondary outcomes include among others cravings improvement for sugar addiction, mindfulness and perceived stress. Additionally, we are curious to compare the effects of the different natural-based environments. By exploring various natural elements, such as forests, beaches and mountains, we aim to determine which specific natural elements are most effective in enhancing mindfulness embodiment and eliciting strong emotional responses by analysing participant's mindfulness scores before and after the various naturalistic intervention. These initial findings will give us some direction into which environment might be most suitable for reducing sugar addiction.

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