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Applications of virtual reality in individuals with alcohol misuse: A systematic review

Alexandra Ghiţă*, José Gutiérrez-Maldonado

University of Barcelona, Department of Clinical Psychology and Psychobiology, Spain

HIGHLIGHTS

- We review the literature on the applications of virtual reality in alcohol misuse.
- Virtual reality may enhance the effectiveness of cue-exposure techniques.
- Virtual Reality shows promise as an assessment and treatment tool.

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ABSTRACT

Background: Alcohol use and misuse have been intensively studied, due to their negative consequences in the general population. Evidence-based literature emphasizes that alcohol craving plays a crucial role in the development and maintenance of alcohol-drinking patterns. Many individuals develop Alcohol Use Disorders (AUD); significantly, after treatment many also experience relapses, in which alcohol craving has been repeatedly implicated. Cue-exposure therapy (CET) has been widely used in the treatment of alcohol misuse, but the results are inconsistent. Virtual reality (VR) can add effectiveness to cue-exposure techniques by providing multiple variables and inputs that enable personalized alcohol use assessment and treatment. The aim of this review was to examine the applications of virtual reality in individuals who misuse alcohol.

Method: We conducted an exhaustive literature search of the *Web of Science*, *Scopus*, *Embase*, *Google Scholar*, and *PsycInfo* databases, using as search items terms such as "alcohol" and its derivates, and virtual reality.

Results: We identified 13 studies on alcohol craving that implemented virtual reality as an assessment or treatment tool.

Conclusions: The studies that incorporate VR present clear limitations. First, no clinical trials were conducted to explore the efficacy of the VR as a treatment tool; nor were there any studies of the generalization of craving responses in the real world, or of the long-term effects of VR treatment. Despite these limitations, the studies included showed consistent results as regards eliciting and reducing alcohol craving. We suggest that VR shows promise as a tool for the assessment and treatment of craving among individuals with alcohol misuse. Further studies implementing VR in the field of alcohol consumption are now required.

1. Introduction

Craving is of great importance in the development and maintenance of alcohol-drinking behaviors (Ramirez et al., 2015). In alcohol use disorder (AUD), craving is heavily involved in drinking patterns, the severity of dependence, the maintenance of abstinence, and the risk of relapse (American Psychiatric Association, 2013; Wapp, Burren, Znoj, & Moggi, 2013). Alcohol craving is understood as a pathological appetite, a strong urge to drink alcohol, which induces neuro-psycho-physiological, emotional, behavioral, and cognitive changes in individuals with AUD (Addolorato, Leggio, Abenavoli, & Gasbarrini, 2001).

Long-term alcohol-drinking patterns determine automatic cognitive and emotional processing schema in individuals with AUD and promote compulsive drinking (Koob, 2013). Heavy drinking episodes alter the reward pathways through overstimulation of dopaminergic neurotransmission, a critical mechanism for eliciting hedonic and positive experiences. This reward mechanism strengthens alcohol drinking patterns, causing hypersensitivity to alcohol-related stimuli (Gardner, 2011; Robinson & Berridge, 1993). This chain of events leads to intense alcohol craving, relapse, and associated harmful behaviors even after many years of abstinence (Robinson & Berridge, 2008).

The treatment methods in alcohol misuse and AUD require a

* Corresponding author at: University of Barcelona, Department of Clinical Psychology and Psychobiology, Passeig de la Vall d'Hebron, 171, 08035 Barcelona, Spain.
E-mail address: alexandraghita@ub.edu (A. Ghiţă).

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multidisciplinary approach, including pharmacological, behavioral, and psycho-social interventions. However, despite complex treatment options, many individuals diagnosed with AUD experience several relapses after interventions and a decreased quality of life because of the chronic nature of these disorders (Litten et al., 2015). Therefore, there is an urgent need to conduct more research to expand assessment and treatment approaches. Virtual reality (VR) has recently attracted attention because of its potential utility for individuals with AUD. However, only a limited amount of research has been conducted to date regarding the effectiveness of VR-based approaches in extinguishing alcohol craving and thus preventing relapses. Nevertheless, several studies suggest that VR is a promising tool for a psychological approach to AUD treatment (Bordnick et al., 2008; Choi & Lee, 2015; Son et al., 2015).

1.1. Virtual reality cue-exposure therapy for AUD

Previous studies have emphasized that alcohol craving should be targeted in reduction of alcohol consumption and in AUD treatment (for example, see Zironi, Burattini, Aicardi, & Janak, 2006). Consistent with this assumption, cue-exposure therapy (CET) attempts to elicit both subjective and physiological craving in a controlled setting, with the goal of extinguishing alcohol urges. This cue-exposure paradigm is based on classical conditioning processes (Conklin & Tiffany, 2002; Weerts, Goodwin, Kaminski, & Hienz, 2006). From a classical conditioning perspective (Pavlov, 1927), alcohol-related cues elicit conditioned responses such as alcohol craving even when no alcohol stimuli are present. Hence, empirical research suggests that alcohol-related contexts and cues are of major importance in the development and maintenance of AUD (Bottlender & Soyka, 2004).

CET methods involve in vivo, imaginary techniques or simulated exposure to alcoholic beverages by presenting auditory, visual, or photographic cues (Monti et al., 2001). Nevertheless, in a meta-analysis, Conklin and Tiffany (2002) found that CET had only modest effectiveness with inconsistent results. The authors observed that in most cases, CET was conducted in a secure, safe room with only one cue presented at a time. However, alcohol addiction is a more complex condition and typically involves the interaction and processing of multiple variables at once. Thus, craving reduction is highly context-dependent, and cue presentation in a clinical setting can reasonably be expected to interfere with generalization of newly learned responses (Lee, Kwon, Choi, & Yang, 2007; Stasiewicz, Brandon, & Bradizza, 2007). Over the last decade, CET has evolved through the development of more exhaustive treatment approaches that may benefit from VR (Saladin, Brady, Graap, & Rothbaum, 2006).

VR technology simulates and enriches real-life situations by presenting a diverse range of stimuli to create a fully immersive experience. Multiple sensory inputs (auditory, olfactory, visual, and tactile) facilitate ecological validity and provide a better alternative to classical cue-exposure methods. Lee et al. (2007) suggested that VR technology adds effectiveness to CET because of its capacity to induce greater subjective and physiological craving, which in turn prompts the generalization of treatment effects to real world, daily life activities. VR-based assessment and treatment studies have provided benefits in many psychopathologies, particularly in anxiety disorders (Maples-Keller, Bunnell, Kim, & Rothbaum, 2017; Meyerbröker & Emmelkamp, 2010), post-traumatic stress disorder (Rothbaum et al., 2014) and fear of flying (Maples-Keller et al., 2017), as well as in eating disorders (Ferrer García & Gutiérrez Maldonado, 2012), pain management (Malloy & Milling, 2010), and drug addiction (Hone-Blanchet, Wensing, & Fecteau, 2014). In AUDs, VR has been used as: a) an assessment tool (to elicit craving); and b) a VR (exposure) therapy tool (to reduce craving), variously termed VR exposure [VRE], VR therapy [VRT], or VR exposure therapy [VRET]. VRETs have achieved good results for long-term effectiveness in other disorders: for example, a 12-month follow-up study of VRET in patients with fear of flying showed long-lasting benefits (Rothbaum, Hodges, Anderson, Price, & Smith, 2002). Another study indicated that the beneficial effects of VRET on fear of flying persisted over a 3-year follow-up period (Wiederhold & Wiederhold, 2003).

The aim of this review is to provide an insightful synthesis of published studies on the applications of VR as an assessment or treatment tool in individuals with alcohol misuse. Particular emphasis is placed on the value of VR in alcohol craving.

2. Method

We conducted an exhaustive literature search of the *Web of Science*, *Scopus*, *Embase*, *Google Scholar*, and *PsycInfo* databases. The following terms were entered to find the most relevant studies: “virtual reality”, “alcohol”, “drink”, “alcohol use”, “alcohol use disorder”, “alcoholism”, “alcohol dependence”, “alcohol addiction”, and “alcohol abuse”.

The inclusion criteria were: (a) studies containing empirical data on the application of VR in individuals with unhealthy alcohol use, (b) studies published since 1990 (when VR was first used in psychology), and (c) studies reported in English. The initial search yielded 107 articles. After a careful review of their abstracts and titles, 92 articles were excluded because they concerned different psychopathologies (e.g., fetal alcohol syndrome), drugs other than alcohol (e.g., tobacco, cocaine, heroin), or had aims that were incompatible with the purpose of the current review (e.g., alcohol-induced effects on driving). Therefore, 15 relevant studies were selected for further assessment. Of these, two were written in Korean, and were therefore excluded from this review.

3. Results

A total of 13 studies met the inclusion criteria. These studies are reported in Table 1. All studies implemented VR as an assessment or treatment tool.

3.1. Objectives of the studies

The very first study to explore the effectiveness of VRET in individuals with AUD was conducted by Kwon et al. (2006). This study aimed to demonstrate that VRET for AUDs could decrease alcohol craving. Six studies were centered on VR as an assessment tool in exploring alcohol cravings (Bordnick et al., 2008; Cho et al., 2008; Choi & Lee, 2015; Kim & Lee, 2015; Lee et al., 2008; Ryan et al., 2010). Two studies (Gatti et al., 2008; Spagnoli et al., 2014) used a similar research protocol to demonstrate the effectiveness of VR as a clinical assessment tool exploring social, personality, and behavioral features of patients with AUD. Five studies used VR as a VRET instrument in the treatment of AUD (Hyun et al., 2013; Kwon et al., 2006; Lee et al., 2007; Lee et al., 2009; Son et al., 2015).

3.2. Samples

A total number of 361 individuals participated in the 13 studies, with an age range of between 18 and 50 years old. Of these, 180 participants were diagnosed with AUD, 16 participants were members of Alcoholics Anonymous, 15 were college students with binge drinking habits, 38 were heavy social drinkers, another 38 participants were light drinkers, and 74 were healthy individuals with no history of AUD.

3.3. Instruments

As shown in Table 1, all studies involved some form of questionnaire assessment (e.g. Alcohol Urge Questionnaire, Obsessive-Compulsive Drinking Scale, Alcohol Use Disorder Identification Test, or Beck Depression Inventory). Several studies (Bordnick et al., 2008; Cho et al., 2008; Hyun et al., 2013; Lee et al., 2008, 2009; Ryan et al., 2010; Son et al., 2015) also reported using a *visual analog scale* (VAS) to assess