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Utility of virtual reality environments to examine physiological reactivity and subjective distress in adults who stutter

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ABSTRACT

Purpose: Virtual reality environments (VREs) allow for immersion in speaking environments that mimic real-life interactions while maintaining researcher control. VREs have been used successfully to engender arousal in other disorders. The purpose of this study was to investigate the utility of virtual reality environments to examine physiological reactivity and subjective ratings of distress in persons who stutter (PWS).
Method: Subjective and objective measures of arousal were collected from 10 PWS during four-minute speeches to a virtual audience and to a virtual empty room.
Results: Stuttering frequency and physiological measures (skin conductance level and heart rate) did not differ across speaking conditions, but subjective ratings of distress were significantly higher in the virtual audience condition compared to the virtual empty room.
Conclusion: VREs have utility in elevating subjective ratings of distress in PWS. VREs have the potential to be useful tools for practicing treatment targets in a safe, controlled, and systematic manner.

1. Introduction

1.1. Virtual reality environments

Virtual Reality Environments (VREs) have a long history of successful use in treating persons with disorders in which inappropriate arousal and/or anxiety is a component (Opris et al., 2012; Parsons & Rizzo, 2008; Powers & Emmelkamp, 2008). The success of VREs comes from their ability to provide safe, confidential, and controlled environments that mimic the real world. Many virtual environments exist, including virtual audiences. VREs are only useful in treatment if they engender reactions that are similar to those experienced in the real world, for example, increased heart rate in response to feared situations. In a variety of clinical populations VREs have proven to be useful tools in anxiety reduction treatment because they are capable of eliciting fear and arousal similar to that experienced in real world scenarios (Hadley et al., 2014; Hartanto et al., 2014; Jönsson et al., 2010). Importantly, a number of meta-analyses document the positive effects of VR-based exposure treatment to reduce fear and anxiety (Opris et al., 2012; Parsons & Rizzo, 2008; Powers & Emmelkamp, 2008), suggesting

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that VREs are 'real enough' to heighten arousal in order to subsequently reduce anxiety via virtual reality exposure therapy. The purpose of this study was to investigate the utility of virtual reality environments to induce physiological reactivity and increase subjective anxiety in persons who stutter (PWS).

1.2. Utility of virtual reality environments

Virtual reality environments (VREs) are computer-generated, 3-dimensional worlds in which clients can practice skills in environments that are safe, controlled, and repeatable. Another key feature of virtual environments is that clinicians can manipulate what occurs within them. Possible manipulations include varying the tasks that must be completed in the VRE or varying the reactions of avatars within the VRE. For example, clinicians can create hierarchies of tasks to be completed in the VRE, such as speaking to progressively larger virtual audiences as treatment progresses (Anderson et al., 2013). Clinicians can also manipulate the emotional valence of avatars and events encountered in VREs (Bekele et al., 2014). VREs provide standardization and they resemble real world situations, thus increasing their ecological validity for use in assessment and treatment.

In a variety of clinical populations VREs have proven to be useful tools in treatment because they are capable of eliciting fear and arousal, a necessary feature for successful exposure therapy (Foa & Kozak, 1986). Many of these studies involve speaking tasks. Jönsson and colleagues (2010) created a virtual version of the Trier Social Stress Test (TSST); the TSST requires participants to give speeches to a live audience that is trained to respond in certain ways. They documented increased reactivity in the virtual TSST, as measured by increased salivary cortisol and increased heart rate, in healthy adults (Jönsson et al., 2010). Recently, Fallon and colleagues (Fallon, Careaga, Sbarra, & O'Connor, 2016) replicated these findings, documenting increased cortisol and increased self-reported subjective arousal during their version of the virtual TSST. Heart rate and self-reported anxiety increased during dialogs with virtual blind dates and virtual job interviewers (Hartanto et al., 2014). Heart rate also increased from baseline during a virtual party scenario (Hadley et al., 2014). Taken together, these findings suggest that subjective self-reports of arousal/distress and physiological reactivity can be manipulated in VREs.

1.3. Autonomic nervous system and HPA axis

Physiological measures of arousal are obtained by monitoring autonomic nervous system (ANS) and hypothalamic pituitary axis (HPA) responses to stressful stimuli. The ANS is a part of the peripheral nervous system that controls vegetative functions of the body such as heart rate, constriction of the blood vessels, pupil dilation, blood pressure, sweat production, and digestion (Carlson, 2004). The ANS has two branches, the *sympathetic branch* and *parasympathetic branch*, each of which regulates bodily functions in aroused (sympathetic) or relaxed (parasympathetic) states. The main function of the sympathetic branch is to get the body ready to expend energy reserves (Carlson, 2004, p. 96), such as when stimuli are perceived as exciting or fearful. The parasympathetic branch functions to build the body's energy reserves, in preparation for times when the body must respond quickly to external stimuli. The sympathetic and parasympathetic branches often work in opposition, but they can be co-activated (Alm, 2004). Monitoring levels of ANS responses to stressful stimuli have long been used in the field of psychology as a way to measure stress response in humans and these measurements are valuable because they do not reflect subjective opinion (Lazarus & Opton, 1996; Weber & Smith, 1990).

The HPA axis includes the hypothalamus, pituitary gland, and the adrenal glands. Working together these structures also control and regulate the body's reaction to stress (Ice & James, 2007). The hippocampus and amygdala are also important structures in the stress-response system. The hippocampus exhibits inhibitory control over the HPA axis, providing negative feedback for the HPA axis, while the amygdala processes external stimuli that lead to behavioral and physiological responses. These responses include heart rate and blood pressure, and cortisol release (Carlson, 2004).

Commonly reported objective measures include changes in heart rate (HR), blood volume, electrodermal activity on the skin (e.g., skin conductance level or SCL), and salivary cortisol or alpha-amylase levels. Measuring how these physiological responses change in response to different situations allows researchers to indirectly examine the stress response (Ice & James, 2007), and VREs are particularly useful in systematically manipulating these different situations.

Arousal can also be measured subjectively by asking participants to rate their level of fear, distress, or arousal. The SUDS scale (SUDS; Wolpe, 1958) is a commonly used scale in psychology research (Benjamin et al., 2010) and has proven validity with depression and anxiety scales (Kim, Bae, & Park, 2008; Tanner, 2012). The scale has been used to measure clinically significant change treatment with anxious individuals (Benjamin et al., 2010) and has been used to measure subjective anxiety in VREs used to treat anxiety (Harris, Kemmerling, & North, 2002; Parrish, Oxhandler, Duron, Swank, & Bordnick, 2016). Use of the SUDS scale during fearful tasks can provide valuable "moment to moment" assessment of distress during treatment tasks, and together with objective measures can provide "a comprehensive understanding of [a client's] psychophysiology" (Thomas, Aldao, & De Los Reyes, 2012, p. 510).

It is important to monitor both objective and subjective measures of fear and arousal, because asynchronies between objective and subjective measures in response to stressful situations have been reported in numerous studies (Thomas, Aldao, & De Los Reyes, 2012). For example, treatment studies addressing various phobias (e.g., fear of spiders, heights, or contamination) have documented decreased self-reported fear with no change in HR post treatment (Lang & Craske, 2000; Rowe & Craske, 1998; Kircanski et al., 2012). Similar asynchronies and lack of positive correlations between objective and subjective measures have also been documented in socially anxious persons during speaking tasks. For example, when