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Do Olfactory Stimuli Increase Presence During Exposure Tasks: A Comparative Study

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DO OLFACTORY STIMULI INCREASE PRESENCE DURING EXPOSURE TASKS: A COMPARATIVE STUDY

by

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ABSTRACT

Exposure therapy (ET) is an extensively studied and supported treatment for anxiety and trauma-related disorders. ET works by exposing the patient to the feared object or situation without any danger in order to overcome the related anxiety. Over the past few years, various technologies including head-mounted displays (HMDs), scent machines, and headphones have been used to augment the exposure therapy process by presenting multi-sensory cues (e.g., sights, smells, sounds) to increase the patient's sense of presence. While studies have shown that scents can elicit emotionally charged memories, no prior research could be identified that examined the effect of olfactory stimuli upon the patient's sense of presence during exposure tasks. In this study, the effect of olfactory stimuli on subject's sense of presence was assessed via psychophysiological response (electrodermal activity), visual scanning, and self-report measures. Linear Mixed Modeling showed relationships between olfactory stimuli and presence ratings as well as self-reported anxiety levels, but not visual scanning or physiological arousal. Recommendations were made for continued research in the union of olfactory stimuli, presence, and exposure therapy.

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Cognitive behavioral therapy (CBT)
Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5)
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Event-related skin conductance responses (ER-SCR)
Exposure Therapy (ET)
Head-mounted display (HMD)
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Immersive Tendencies Questionnaire (ITQ)
Least squares means (LSM)
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CHAPTER ONE: INTRODUCTION

Anxiety disorders

Anxiety disorders share features of excessive fear, worry, and related behavioral disturbances (American Psychiatric Association, 2013) and are among the most common mental health problems seen in the medical community today. Estimates suggest that 19.5% - 28.8% of people within the United States have at least one anxiety disorder (Kessler *et al.*, 2005; Kroenke, Spitzer, Williams, Monahan, & Lowe, 2007) with lifetime prevalence estimates of 12.1% and 12.5%, for social phobia and specific phobia, respectively. Mean age of onset for anxiety disorders is 11 years old, which is earlier than age of onset of substance disorders (20) and mood disorders (30) (Kessler *et al.*, 2005). As such, anxiety disorders begin consuming resources far earlier than other types of mental disorders. The direct financial costs of anxiety disorders may take the form of counseling, hospitalization, and medications (Greenberg *et al.*, 1999). Indirect financial costs may include reduced productivity and absenteeism from work (Lepine, 2002). Direct and indirect costs combined, Greenberg estimated that anxiety disorders cost nearly $42.3 billion dollars during the 1990's (after adjusting for inflation, $75 billion in 2013 dollars). In addition to financial burdens, Greenberg and colleagues (1999) also specified impaired social functioning, increased likelihood of dropping out of school, teenage pregnancy, marital instability, poor career choices, and required caretaking by family and friends as costs associated with anxiety disorders. In addition, anxiety disorders are also associated with increased substance abuse and dependence, which likely increase direct and indirect costs (Leon, Portera, & Weissman, 1995).

Trauma and stressor-related disorders

Trauma- and stressor-related disorders are those in which exposure to a traumatic or very stressful event is explicitly included in the diagnostic criteria. This DSM-5 category includes posttraumatic stress disorder (PTSD) and acute stress disorder. Common types of traumatic events include assaultive violence, injury or shocking experiences, and even learning about trauma to others (Copeland, Keeler, Angold, & Costello, 2007). Trauma- and stressor-related disorders are closely related to anxiety disorders and until the publication of DSM-5, fell under the diagnostic umbrella of anxiety disorders (American Psychiatric Association, 2013). Whereas individuals with anxiety disorders often exhibit anxiety or fear-based symptoms, those with disorders associated with stress and trauma most often display anhedonic and dysphoric symptoms, externalized anger and aggressive symptoms, or dissociative symptoms in addition to anxiety and fear-related symptoms (American Psychiatric Association, 2013).

One common symptom shared by anxiety and a trauma-related disorder is behavioral avoidance. By preventing memories of the traumatic event from surfacing, those engaging in avoidant behavior can also prevent the negative and fearful thoughts and feelings associated with the traumatic memory thus protecting themselves from perceived danger and further harm. However, by avoiding those same thoughts and feelings, they prevent themselves from learning new and more appropriate response patterns (Foa, Huppert, & Cahill, 2006; Foa & Kozak, 1986). Ehlers and Clark (2000) describe avoidance as a maladaptive control strategy that short circuits disconfirmation of negative appraisals, which result in the maintenance of perceived current threat. This type of behavior has been documented in various populations with PTSD, including combat veterans (Pietrzak, Harpaz-Rotem, & Southwick, 2011), victims of sexual assault (Fleurkens,

Rinck, & van Minnen, 2014), and motor vehicle accident victims (Delahanty *et al.*, 1997). However, avoidance is also seen in many anxiety disorders, including social anxiety disorder, specific phobia, panic disorder, separation anxiety disorder, and agoraphobia (American Psychiatric Association, 2013). Preventing avoidant behavior and encouraging patients to face anxiety-provoking situations can correct incompatible and erroneous information with more appropriate behavioral responses that enable better daily functioning.

Exposure therapy

ET has been shown to be effective in the treatment of anxiety and trauma-related disorders (Butler, Chapman, Forman, & Beck, 2006). Exposure therapy is analogous in humans to fear extinction models used in animals (Myers & Davis, 2007) and is based upon the principles of classical conditioning discovered by Pavlov (1902) and later explored by Watson and Rayner (1920). An example of this might be conditioned taste aversion (Welzl, D'Adamo, & Lipp, 2001), where after eating a favorite food, the individual becomes severely ill and afterwards no longer desires the food that preceded becoming ill. With respect to anxiety disorders, an example of classical conditioning in PTSD might include avoidance of driving after coming into contact with a roadside bomb that detonated, threatening the life of the driver and/or passengers. In specific phobia, a child might develop an extreme fear response to dogs after being chased or bitten and subsequently avoids leaving the house due to fear of encountering a dog. Exposure therapy seeks to extinguish learned behaviors that are or have become maladaptive by exposing patients to the anxiety or fear-producing stimulus (or a facsimile of that stimulus) without exposing them to the danger, thus allowing new information and expectations to be learned.

ET is a highly researched and effective treatment for anxiety disorders (Powers, Halpern, Ferenschak, Gillihan, & Foa, 2010). ET has been included in several versions of cognitive behavioral therapy (CBT) that have proven to be effective for numerous different populations, including those who have been in motor vehicular accidents (Blanchard *et al.*, 2003) and victims of sexual assault (Foa, Rothbaum, Riggs, & Murdock, 1991; Resick, Nishith, Weaver, Astin, & Feuer, 2002; Resick, Williams, Suvak, Monson, & Gradus, 2012). There is also a wide body of literature supporting the effectiveness of ET in treating PTSD (Beidel, Frueh, Uhde, Wong, & Mentrikoski, 2011; Foa *et al.*, 2005; Foa, Keane, & Friedman, 2000; Frueh, Turner, & Beidel, 1995; Frueh, Turner, Beidel, Mirabella, & Jones, 1996; Powers *et al.*, 2010; Resick *et al.*, 2002; Rothbaum, Astin, & Marsteller, 2005). More recent treatments have incorporated virtual reality (VR) equipment and have been shown to be effective in populations that survived terrorist attacks (Difede & Hoffman, 2002) and those with combat-related PTSD (Rizzo *et al.*, 2008a; Rizzo *et al.*, 2010). There are a number of important benefits of using VR therapy; it is possible to expose patients to a greater number of situations and stimuli without leaving the therapists office, exposure stimuli can be precisely controlled, decreased time and expense formulating exposure sessions, and exposure with VR poses less risk of harm or embarrassment (Rothbaum, Hodges, Ready, Graap, & Alarcon, 2001). Additionally, Wiederhold *et al.* (2002) found that exposure therapy that included VR was more effective than imaginal exposure therapy in the treatment of fear of flying. VR was also shown to be at least as effective as in vivo in the treatment of acrophobia (Emmelkamp, Bruynzeel, Drost, & van der Mast, 2001).

One model that explains the mechanism behind exposure therapy is emotional processing theory (Foa & Kozak, 1985; Foa & Kozak, 1986). According to Foa and Kozak (1986), fear is

represented as a schema for escaping danger. When these schemas represent a realistic threat, it is considered an adaptive fear structure that facilitates effective reactions to that threat. However, when fear structures no longer represent an accurate reflection of the situation at hand, problems arise, including inappropriate associations between stimuli, physiological responses to harmless stimuli, and response elements that might interfere with adaptive behaviors (Foa & Kozak, 1986). According to these authors, in order to successfully modify a pathological fear structure, the fear structure must be activated and the patient must be presented with information that is incompatible with the existing fear structure.

The core components of exposure therapy include a) imagining the traumatic event, recanting the experience, and reprocessing the memory, and/or b) in-vivo exposure, in which situations and objects that may be associated with the trauma are confronted. In imaginal exposure the patient is asked to visualize the trauma as vividly as possible while the therapist provides information about all of the senses to increase an individual's ability to imagine the trauma. By adding actual sights, sounds, and smells, the individual may be better able to imagine the scene.

Olfaction Overview

Olfaction, or the ability to smell, is the result of responses by receptor cells to chemical stimuli. Chemosensory, as it is known, is found in nearly all animal species (Wilson & Stevenson, 2006). Chemosensory information is useful in the detection and identification of predators, food, mates, and many other daily functions. Odor perception begins with the olfactory epithelium (OE), a small area of specialized tissue located inside the nasal cavity. The OE is directly responsible for the detection of the volatile chemical compounds that comprise scents. From the OE, information is passed to the olfactory bulb (OB). The olfactory bulb is responsible for the filtration and

modification of sensory input. Sensory information is then passed along to the primary olfactory cortex (POC), which consists of six structures, (1) anterior olfactory nucleus; (2) olfactory tubercle; (3) piriform cortex; (4) anterior cortical nucleus of the amygdala; (5) periamygdaloid complex; and (6) the rostral entorhinal cortex. Information from the POC is then passed to the amygdala, thalamus, hippocampus, and hypothalamus.

It has been suggested that the amygdala is activated based on a combination of the valence and intensity properties of an odor (Winston, Gottfried, Kilner, & Dolan, 2005; Zald & Pardo, 1997). It is widely accepted that the hippocampus plays an important role in the formation of new memories about experienced events (Burgess, Maguire, & O'Keefe, 2002; Eichenbaum, 1993). Specifically, the hippocampus is linked to the ability to navigate an environment and recall the events that occur there (Burgess *et al.*, 2002), which becomes important when navigating a virtual environment. It has also been suggested that the amygdala and hippocampus act in unison when emotion and memory are connected. Phelps (2004) described the amygdala's ability to modulate the encoding and storage of hippocampal-dependent memories in addition to the hippocampus' influence on amygdala responses when emotional stimuli, such as those encountered during traumatic events, are presented.

It has long been suggested that smells are the best reminders of past experiences, a piece of folk wisdom first described in Swann's Way (Proust, 1925). In fact, research has shown olfactory stimuli to result in more emotionally potent memory recall than verbal and visual modalities (Chu & Downes, 2000; Chu & Downes, 2002; Herz, 1998; Herz & Cupchik, 1995; Herz & Engen, 1996). Olfactory stimuli have been utilized in exposure therapy with combat veterans to augment the sense of environment, and have included scents such as burning rubber,

cordite, garbage, body odor, gunpowder, and diesel fuel (Rizzo *et al.*, 2008c; Rizzo *et al.*, 2010). Kline and Rausch (1985) described the impact of olfactory stimuli as precipitants of flashbacks in Vietnam veterans. Vermetten and Bremner (2003) documented a particularly vivid example of the emotional impact olfactory stimuli can have when paired to traumatic events:

> *This morning, I noticed local firefighting equipment on the road just past my home. The fire police let me pass since our house is on the corner. Arriving home, I found my wife out on the back deck watching a fire that was about 300 feet away. This is when I noticed the smell of burning rubber, together with a faint smell of fuel oil or diesel oil. My wife stated she was worried about me because I was standing on the deck as if I was daydreaming for some minutes without responding to her. The smell brought to my mind the image of this burning Amtrak, again so vivid. The Amtrak was hit. The front door/ramp was open; both crew hatches were open and pouring out smoke and flame. Thick, black, acid smoke was boiling out of the troop compartment. There was an overpowering smell of burning rubber. I remember that smell and what it looked like that day vividly. There was nothing I could have done to save the people in the Amtrak. Fifteen Marines and 3 crewmembers died there that day. I felt the same hopelessness as I felt that day. I felt bad in my stomach, got a headache, and had a feeling of futility or finality when I thought about that incident.* (Page 203, paragraph 3).

Despite what appears to be general acceptance of the link between memory and olfaction, no identifiable research has focused on the role of olfaction in the treatment of anxiety disorders in general. Olfactory stimuli have been shown to increase presence in general virtual environments

(Dinh, Walker, Hodges, Song, & Kobayashi, 1999), but no research could be identified that sought to quantify olfaction's effect specifically with respect to simulated exposure tasks like those used in the treatment of anxiety and trauma-related disorders. If olfactory stimuli enhance the sense of presence in an environment during simulated exposure tasks, it seems logical that exposure therapy may be more effective when olfactory cues are added.

Introduction to presence

Presence has been conceptualized and defined in a number of different ways over the years. Hatada, Sakata, and Kusaka (1980) and Neuman (1990) examined presence as matter realism, or the degree to which a medium could produce representations of objects that "looked like the real thing." Another conceptualization is that of presence as transportation, or the transportation of the audience to another time and/or place through mechanisms such as writing, storytelling, television, or advertisements (Biocca & Levy, 1995; Gerrig, 1993; Minsky, 1980; Reeves, 1991; Rheingold, 1991; Slater & Usoh, 1993). Presence has also been conceptualized as a social actor within a medium (Horton & Wohl, 1956; Lombard, 1995). In this conceptualization, presence is said to exist when users respond to the medium as a social entity, rather than a machine or computer. Lastly, presence has been conceptualized as, and is often used synonymously with, the word immersion. The concept of presence as immersion focuses on the idea of perceptual and psychological immersion (Lombard & Ditton, 1997). Perceptual immersion has been defined by Biocca and Delaney (1995) as "the degree to which a virtual environment (VE) submerges the perceptual system of the user" and in fact, a VE is not even required. Theatres, simulator rides (such as those at amusement parks), and IMAX all have the potential to immerse their audience. Commercially, 5.1, and even 7.1 Surround Sound© audio/video receivers are advertised as putting

you “in the center of the action” (Dolby Labratories, 2014). However, perceptual immersion is only half of this concept of presence. The psychological component of presence takes effect when users feel involved (Palmer, 1995; Takatalo, Häkkinen, Komulainen, Särkelä, & Nyman, 2006) or absorbed (Quarrick, 1989) by a medium.

When discussed in the scientific literature, presence appears to be most often described from the transportation conceptualization (Schuemie, van der Straaten, Krijn, & van der Mast, 2001), that is to say, people are usually considered “present” when they feel as if they are actually in the virtual world. However, many different definitions have been proposed. Heeter (1992) suggested three different forms of presence including (1) personal presence, the extent to which a person feels like they are part of the environment, (2) social presence, how much other beings exist within the environment, and (3) environmental presence, how much the environment reacts to the user. Schloerb (1995) discussed two types of presence, which he identified as subjective presence and objective presence. Subjective presence referred to the degree to which the users view themselves as being physically present in the VE, whereas objective presence concerned the likelihood of successfully completing a task. Slater and Wilbur (1997) made a distinction between the terms presence and immersion. They contend that immersion refers to an objective description of the technical specifications of the system being used, such as resolution and field of view, where presence was the subjective sensation of being in a VE. It appears as if the word “immersion” and the word “presence” have to some degree been used with overlapping meanings. For the purposes of this study, Slater and Wilber’s 1997 definition of presence and immersion will be used unless otherwise stated.

Presence and Virtual Environments

One measure of increased presence is that upon recall, users recall the environment as a real place instead of a virtual and simulated location (Slater, Pertaub, & Steed, 1999). Similarly, virtual experiences may produce the same emotions and reactions as their real-world counterparts when the level of presence experienced by the user is sufficiently high. Hodges and colleagues (1994) found that participants with acrophobia reported increased anxiety when presented a VE that includes great heights. Another study found that VR increased anxiety in the treatment of patients with arachnophobia (Bouchard, Côté, St-Jacques, Robillard, & Renaud, 2006). This ability to evoke real emotions from artificial environments has presumably led to the use of VR for the treatment of numerous anxiety disorders (Parsons & Rizzo, 2008; Powers & Emmelkamp, 2008).

Measuring Presence

Due to overlapping definitions and conceptualizations, measurement of presence has proven challenging for researchers. Most instruments designed to measure presence are self-report measures, requiring respondents to rate different aspects of their respective experience. Having respondents rate their subjective experience has its benefits, as users can rate their personal reactions to whatever environment they experienced. While several presence questionnaires exist (Lombard, Ditton, & Weinstein, 2009; Schubert, Friedmann, & Regenbrecht, 2001; Witmer & Singer, 1998), they typically rely upon a simulator experience and are only quantifiable by the patient.

The measure developed by Usoh, Catena, Arman, and Slater (2000) focuses on the users' sense of "being there" and the degree to which the VE seems more realistic than the equivalent

everyday environment. Another metric used by these authors is the degree to which the environment was thought of as an actual location in the real world upon recall. Witmer and Singer (1998) identified four primary factors that affect presence: (1) control factors, or the amount of control the user had within the environment, (2) sensory factors, or the quality or size of displays, (3) distraction factors, or the degree to which real world stimuli detracted from the VE, and (4) realism factors, or how realistic the VE was to the participant. These four factors were later reduced to 3 factors, (1) involved/control, (2) naturalness, or how natural interactions in the VE felt, and (3) interface quality, the user's ability to focus on tasks.

Factor analysis supports earlier suggestions (Witmer & Singer, 1998) that presence, immersion, and interaction are distinct concepts (Schubert *et al.*, 2001). Knowing this, Schubert, Friedmann, and Regenbrecht (1999) developed the Igroup Presence Questionnaire (IPQ) by combining elements from the previous authors' questionnaires and previous research (Regenbrecht, Schubert, & Friedmann, 1998). The IPQ includes items that factor onto both presence (spatial presence, involvement, and realness) and immersion (quality of dimension, drama, interface awareness, exploration, and predictability), and correlates well with other existing measures of presence.

Objective measurement of presence has proven to be elusive due to the apparent subjective nature of the construct. Fortunately, more recent research has explored the utility of using physiological measures to assess presence indirectly by examining physiological reactions (heart rate variability and electrodermal response or skin conductance) with favorable results (Meehan, Razzaque, Insko, Whitton, & Brooks, 2005). Skin conductance levels are thought to serve as an indirect index of sympathetic activity or arousal that can be evoked by unexpected stimuli. Another

method proposed for assessing presence includes behavioral reactions to actions within the VE (Sheridan, 1992). Some examples of behavioral reactions might be attempting to dodge an object moving along a collision path with the user, or measuring how much time the user spends looking at objects within the VE. By quantifying behavioral responses, it has been suggested that presence can be objectively measured.

Increasing Presence

It is generally believed that the more senses are utilized by a medium, the greater its ability to generate a sense of presence (Anderson & Casey, 1997; Barfield, Zeltzer, Sheridan, & Slater, 1995; Bouchard *et al.*, 2006; Kim, 1996; Short, Williams, & Christie, 1976). Additionally, increasing the size of the screen used as a medium has been shown to increase presence (Freeman, Lessiter, Pugh, & Keogh, 2005; Hendrix & Barfield, 1996; IJsselsteijn, de Ridder, Freeman, Avons, & Bouwhuis, 2001; Welch, Blackmon, Liu, Mellers, & Stark, 1996). Serafin and Serafin (2004) also demonstrated that sound can create a sense of place. It was also found that multi-speaker systems increased presence (Short *et al.*, 1976). Tactile sensory presentation has been shown to increase presence, and has been used in the treatment of arachnophobia utilizing synthetic fur on rubber spiders while the patient viewed a virtual spider in the VE (Carlin, Hoffman, & Weghorst, 1997). It has also been suggested that olfactory delivery systems be introduced to VEs, but cited a lack of research in olfactory delivery methods and realistic scent concentrations as a barrier (Hoffman, Hollander, Schroder, Rousseau, & Furness, 1998). However, given the strong research supporting olfaction's ability to elicit strong emotional memory (Chu & Downes, 2000; Chu & Downes, 2002; Herz, 1998; Herz & Cupchik, 1995; Herz & Engen, 1996), it seems logical to explore olfaction's effect on presence during simulated exposure therapy tasks. If olfactory

stimuli increase presence during simulated exposure therapy tasks, it may also increase presence during exposure therapy where real-life autobiographical memories are related to the anxiety and trauma-related disorders.

Presence and Anxiety Disorders

It has been suggested that presence and emotion have a synergistic relationship. Robillard, Bouchard, Fournier, and Renaud (2003) indicated that anxiety might enhance sense of presence, and vice versa. Given the similar findings (Bouchard *et al.*, 2006; Regenbrecht *et al.*, 1998), it seems plausible that maximizing presence may assist the patient in "buying into" the exposure task during treatment. In addition, Price and Anderson (2007) reported that presence served as a mediator in the relationship between pretreatment anxiety and anxiety in-session, suggesting that presence served as a conduit enabling emotional responses to exposure to be experienced during treatment sessions. This proposed conduit has specific implications for the utilization of olfactory stimuli during exposure therapy as they may directly influence the ability of the patient to experience emotions during the treatment session.

CHAPTER TWO: METHODOLOGY

Participants

The objective of this study was to determine the effect of olfactory stimuli upon people's sense of presence when engaged in VE's similar to those used in exposure therapy. The linear mixed model was selected because it allowed us to examine hypothesized intra-individual (within-subjects) changes, as recommended in similar studies (Jones, Bowers, Washburn, Cortes, & Satya, 2004) that would not be captured by the other types of analyses, such as the results derived solely from group comparisons. GPower software version 3.1 (Faul, Erdfelder, Lang, & Buchner, 2007) was used to determine the sample size needed using an effect size (ES) of 0.40. Power was set to 0.80 as recommended by Cohen (1992). For a power $(1-\beta) = 0.80$, $\alpha = 0.05$, 60 total participants were needed to detect differences between the olfaction group and the control group utilizing a mixed model.

Measures

Quick Smell Identification Test (QSIT)

The Quick Smell Identification Test (QSIT; Sensonics, Inc., Haddon Heights, NJ) is a three-item multiple-choice test consisting of three microencapsulated odorant strips. Jackman and Doty (2005) found the Q-SIT to be highly reliable over time (r=0.87) and highly sensitive to identifying olfactory loss, particularly in those with severe olfactory deficits. In addition, they found that a score of two on the QSIT provided sensitivity (true positive) and specificity (true negative) of 99% and 43%, respectively. Positive predictive power and negative predictive power were found to be 91% and 42%, respectively.

State-Trait Anxiety Inventory (STAI)

The state-trait anxiety inventory (Spielberger, 1983) is a 40-item, self-report measure designed to measure both the transient state of arousal subjectively experienced as anxiety and the more chronic emotional presence of anxiety. It has excellent psychometric properties (Speilberger & Vagg, 1984) and has been adapted for use in over 40 languages. It has a 6th grade reading level, can be administered individually or in groups, and has a response burden of approximately ten minutes. The STAI assesses items based on a four-factor structure, which is comprised of two primary factors: state anxiety and trait anxiety. Both state and trait anxiety are further comprised of two additional factors, Anxiety Absent and Anxiety Present. Items on the STAI range from "I am Calm" (State Anxiety, Anxiety Absent) to "I worry too much over something that doesn't really matter (Trait Anxiety, Anxiety Present).

Igroup Presence Questionnaire (IPQ)

The Igroup Presence Questionnaire is a 14-item self-report questionnaire designed to measure presence utilizing a 7-point Likert scale (Schubert et al., 2001) that loads onto three subscales; spatial presence (the sense of physically being in the virtual environment), involvement (focus on the VE and involvement experienced), and experienced realism (subjective realism of the VE). Items range from "How aware were you of the real world while navigating in the virtual world?" to "How real did the virtual world seem to you?"

Immersive Tendencies Questionnaire (ITQ)

The Immersive Tendencies Questionnaire (Witmer & Singer, 1998) is a 29-item self-report measure designed to assess individual tendencies towards immersing in different mediums. The items in this questionnaire measure the participant's involvement in many different daily activities,

such as watching television, reading books, or enjoying movies. As involvement can result in more immersion, it is thought that those who become more involved will also have greater immersive tendencies.

Presence Visual-Analogue Scale (PVAS)

Participants will be asked to rate their level of immersion during the experiment to determine presence on a visual-analogue scale (VAS). Visual-analogue scales have been demonstrated to accurately index anxiety (Davey, Barratt, Butow, & Deeks, 2007). It has been shown that VASs have moderate to strong correlations with Likert based items (Hasson & Arnetz, 2005). The VAS response will be converted to units of measurement (millimeters) for data analysis purposes. VASs have superior metrical characteristic than discrete scales and can have a wider range of statistical methods applied to their measurements (Reips & Funke, 2008).

Presence Rating Scale (PRS)

Participants were asked at evoked events to rate their current level of presence during the exposure task. This rating was on a 7-point Likert scale to remain consistent with the Likert scale of the IPQ. The question, "How present do you feel?" was anchored at one (not at all) and seven (very much).

Simulator Sickness Questionnaire (SSQ)

The Simulator Sickness Questionnaire was developed by Kennedy, Lane, Berbaum, and Lilienthal (1993). It is a 16-item self-report scale used to rate common symptoms of simulator sickness on a 4-point scale. Such symptoms include general discomfort, headache, eyestrain, sweating, and vertigo. Information about the user's present state of health was solicited prior to

simulator use, as well as after simulator use. The SSQ was used for pre- and post-experimental assessment to assess symptoms commonly associated with VR use.

Skin Conductance (SC)

Electrodermal activity (EDA) measures the electrical conductance of the skin, which is made possible by sweat glands controlled by the sympathetic nervous system. Skin conductance was used as an objective measure of psychophysiological activity (Carlson, 2013). SC was assessed utilizing a Mindware MW3000A Bio-Potential and SC Monitor. Silver-chloride cup electrodes were placed on a medial site of the inner side of the foot, over the abductor hallucis muscle, adjacent to the foot sole, and midway between the proximal phalanx of the big to and a point directly beneath the ankle as determined by best practice (Boucsein, 2012; Edelberg, 1967; Rickles & Day, 1968). Data was collected with BioLab Acquisition Software and inspected visually during the experiment by either the principal investigator or a research assistant trained by the principal investigator. After the experiment, the signal was amplified 10x and processed through a 1 Hz Low Pass filter to remove artifacts caused by movement. All physiological data was then scored in EDA by the principal investigator.

Visual Scanning (VS)

Visual scanning, or head movement, was assessed as a behavioral index of presence as first hypothesized by Sheridan (1992). To assess visual scanning, colliders or "virtual triggers" were positioned uniformly around the participant within Unity3D that move with the participant as they navigate through the VE (Figure 1). When the participant looked around the VE by turning their head or turning their virtual body, a virtual beam swept across the trigger which resulted in a

numerical score that was used to assess differences between those in the smell condition and the no-smell conditions. This system was invisible to the participant.

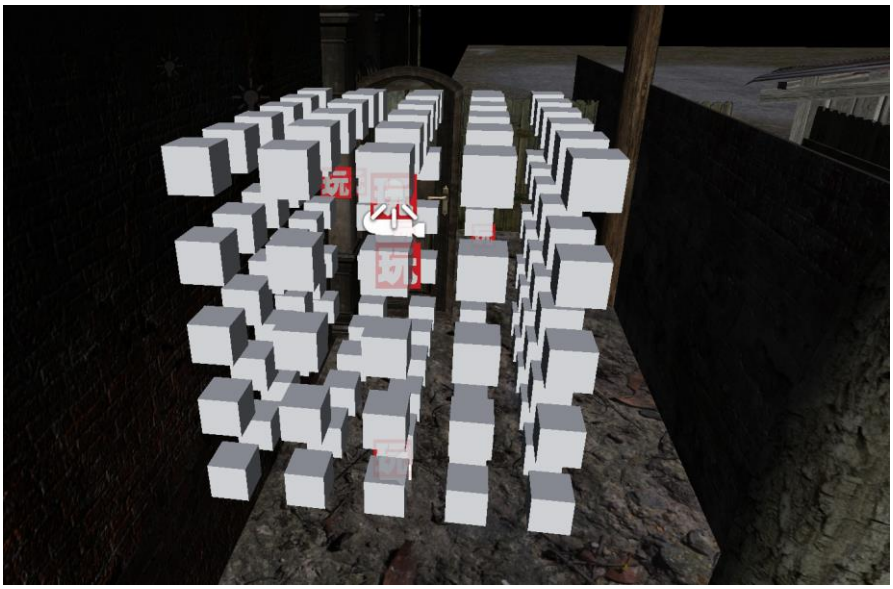

Figure 1: Colliders in the Visual Scanning system

Procedures

Prior to arriving to participate in the study, interested volunteers were asked to complete a brief online prescreen to exclude participants due to medication use or medical condition. Upon arrival, a member of the research team provided study information and informed consent. An introduction to the study and its purpose was provided, as well as a description of the experimental tasks that the participants were asked to complete. All participants were informed of audio/video recordings and their purpose at the UCF Psychology Clinic. Limits of confidentially were reviewed with participants prior to the participation. Participant rights, including the right to withdraw, were also discussed to ensure participant understanding. Participants were given ample time to ask questions and have them answered prior to participation.

Next, participants completed a demographic questionnaire and were screened for normal olfactory function as determined by the QSIT. Those with abnormal olfactory function (a score of less than 3) were allowed to complete participation, but were excluded from the final analyses. Participants who met inclusionary criteria completed the STAI, SSQ, and ITQ prior to being connected to the MW3000A physiological recorder. Two skin conductance leads were attached to the participant's right foot. Participants were then asked to remain stationary in a seated position for a 10-minute baseline acquisition period at the beginning of the collection phase once comfortably equipped with the VR equipment. Participants were then informed that they would be navigating through a virtual environment as directed by narrative, and given the following set of instructions:

> *We are going to begin. During the experiment, we are going to present you with a virtual reality scene. Please navigate your way through the scenario as we describe it to you. Elements of the environment will be described to you in detail. Your job is to imagine yourself in the environment exactly as it is presented. Please remain focused on the scene; particularly, do not imagine anything that would make you feel more comfortable or relaxed. At certain points, you will be asked to rate how much you feel you are immersed in the environment or in other words, how much you feel you are really there. We will use the 1 to 7 point scale where 1 is "not at all" and 7 is where you feel "completely" immersed. When you are asked for your rating, try to give me the rating as truthfully and as quickly as possible. Your rating is very important. Do you have any questions before we begin? You will be notified when the experiment is over, and given further instructions. Here we go…*

The VE was modeled in 3D and controlled with the Unity3D engine (Unity Technologies, San Francisco, CA) and represented an abandoned circus after dark. The VE was presented to the

subject using the Oculus Development Kit II HMD (Oculus VR, Irvine, CA) and high-fidelity stereo headphones (Audio Technica ATH-M50x; Audio Technica, Stow, Ohio). The participant had access to a virtual flashlight allowing them to explore any unlighted areas of the VE should they choose to examine the VE in greater depth. Participants were guided through the VE via location-based prerecorded narration. Congruent ambient sounds accompanied the 3D visuals of the VE. At various locations within the VE, scripted events (sights, sounds, or a combination of the two) were presented to add realism to the VE. For example, an audio sample of an unseen object bumping into a metal garbage was played as the participant passed a 3D garbage can along with the smell of a dumpster.

During Trial 1, Group A included scene-congruent olfactory stimuli (Popcorn, Cotton Candy, Garbage, and Smoke) throughout the scene, whereas Group B did not have olfactory stimuli present (see Figure 2). During the VE exposure, SC and PRS data were collected. After the subject completed the exposure task, they were removed from the VR equipment and asked to complete the state portion of the STAI, the IPQ, and a second PVAS. Once these measures were completed, half of both groups reversed conditions (smells versus no-smells) while the other half of each group remained constant through the second VE trial. Once Trial 2 was completed, the STAI, IPQ, PVAS, and SSQ were completed again. Upon completion of the final assessment measures, the subject's participation in the study ended.

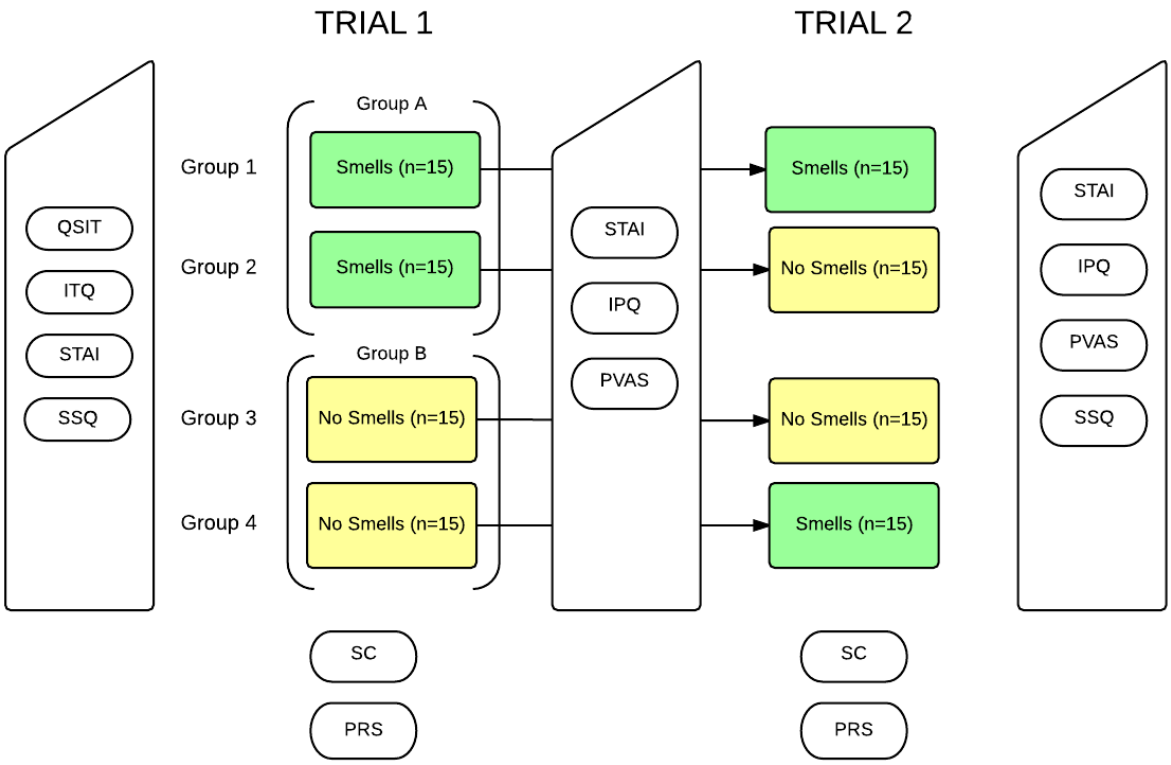

Figure 2: Research Design

CHAPTER THREE: RESULTS

Data screening

122 adults were recruited via community announcements and UCF's undergraduate research pool. Of these, 62 were not suitable for inclusion in the final analyses for various reasons, including simulator sickness and discontinuation (n = 18), scoring too low on the QSIT (n = 5), technical malfunctions (n = 38) and noncompliance with the experimental task (n = 1). Chi-squares and ANOVAs were conducted to determine if those excluded from the final sample were different proportionally to those included, but were found to be no significant differences were obtained with the exception of gender. Females were more likely to report their desire to discontinue or suffer from simulator sickness than males ($p = 0.012$).

The final sample consisted of 60 adult participants between the ages of 18 and 31 years of age (M = 20.48, SD = 3.13). The sample was 65% male (n = 39), while ethnicity varied within groups, which included 38 Caucasians, 11 Hispanics, 6 African Americans, 2 Asians, and 3 who identified as Other (e.g., of mixed ethnic background). Demographic information can be viewed in Table 1. To be included in the study, participants were required to achieve a passing score on the QSIT. A history of seizures, epilepsy, or current prescriptions for beta-blocking or anxiety medications excluded individual participants from participating.

Jackknife distance measures were calculated to identify multivariate outliers utilizing the critical value formula recommended in Penny (1996). Seven such outliers were found with critical values in excess of 5.50. All analyses were conducted with outliers both included and excluded to assess their influence on the mixed model. These analysis comparisons showed that

while outliers had a small impact upon significance *p*-values, they did not possess enough influence to alter the significance of any analyses. Thus, the outliers were included in the results as reported here.

Table 1: Demographic Information

	Group 1	Group 2	Group 3	Group 4
Mean Age (SD)	20.9 (3.45)	20.2 (2.00)	20.35 (4.12)	20.43 (2.96)
Gender				
Males	12	7	9	11
Females	3	8	5	5
Race/Ethnicity				
Caucasian	9	11	4	14
Hispanic/Latino	1	4	6	1
African American	3	0	2	0
Asian	1	0	1	0
Other/Mixed	1	0	1	1
Education				
H.S Diploma/GED	8	10	14	11
A.A	3	2	0	4
Bachelors	3	3	0	0
Masters	1	0	0	1
Marital Status				
Single	15	14	13	15
Married	0	1	1	0
Divorced	0	0	0	1

Participants who were recruited through UCF's research pool received research credit that was applied towards undergraduate courses that required research participation. Nine adults who were recruited by community announcement received a small gift card to a merchant of their choice.

Statistical analyses

All analyses were conducted on the final sample of 60 participants using JMP Pro 11.2.0 (SAS Institute Inc., Cary NC) after screening for data normalcy. All analyses defined significance utilizing a p-value of < 0.05 unless otherwise specified.

Trial 1 analyses

Presence ratings

One-way analyses of variance (ANOVAs) were used to assess differences between the olfactory group and the control group after Trial 1. Presence scores were compared between groups as measured by the IPQ, but were not significant ($F(1,59) = 2.709$, $p = .105$), despite the Scent group having slightly higher presence ratings ($M_S = 62.5$ & $M_{NS} = 58.8$). Presence as measured by the VAS was also compared. However, these differences also failed to achieve significance ($F(1,59) = 0.944$, $p = .335$). The pattern of scores reported on the VAS mirrored those and slightly favored the Scent group ($M_S = 74.71$ & $M_{NS} = 70.44$). The IPQ and visual-analogue scales were strongly correlated ($r(58) = .75$, $p < .0001$).

Behavioral measures

Visual scanning scores were also compared between those who received olfactory stimuli and controls. This analysis favored the No-Scent group ($M_S = 623.667$ & $M_{NS} = 686.567$), however, these differences were not statistically significant ($F(1,59) = 0.780$, $p = .38$). Trial 1

completion time was also examined. Completion time was, on average, shorter for the Scent group (M_S= 644.50 & M_{NS}=683.26), but did not reach significance ($F(1,59) = 2.468$, $p = .121$).

Anxiety ratings

Participants' scores on the STAI-Y1 (State) were compared to identify differences between those in the olfaction and control conditions. These differences approached significance ($F(1,59) = 3.475$, $p = .067$) and indicated that those in the scent group reported higher levels of state anxiety (M_S= 43.46 & M_{NS}=37.40).

Physiological measures

EDA was assessed for 10 minutes to determine each participant's tonic baseline of electrodermal activity. The mean of the final 60 seconds of this baseline period was then subtracted from EDA levels recorded during the experimental tasks to calculate a continuous variable to represent net EDA. Minor differences between groups were identified in the model (M_S= 0.964$_{\mu S}$ & M_{NS}=0.936$_{\mu S}$), though these differences did not achieve significance ($F(1,59) = 0.004$, $p = .948$). Comparisons were also made between groups for each of the three scripted startle events within the VE. EDA levels during the first scripted event, which consisted of a virtual garbage can rattling as the participant approached, did not vary significantly ($F(1,59) = .388$, $p = .535$), although those in the Scent group displayed higher levels of EDA for the 60 seconds post-event (M_S= 1.289$_{\mu S}$ & M_{NS}=.999$_{\mu S}$). The second scripted event involved a carnival ride crashing to the ground as the participant approached, which resulted in a virtual fire. The No

Scent group had slightly higher levels of EDA post-event (M_S= .853$_{\mu S}$ & M_{NS}=1.030$_{\mu S}$), but was not statistically significant (F(1,59) = .149, p = .700). The third and final event shut off the lights in the presence of a carnival character. As with the second event, those in the No Scent group had slightly higher post-event EDA levels (M_S= .978$_{\mu S}$ & M_{NS}=1.168$_{\mu S}$), but these too were not statistically significant (F(1,59) = .142, p = .707).

Mixed model analysis

Linear Mixed Model (LMM) analyses were utilized to assess change between trials for continuous outcome variables and within- and between-subject effects. Group membership and sex served as a between-subjects effect, while trial was assigned as the within-subject factor.

Presence ratings

IPQ scores were examined utilizing LMM predicted by sex, trial, gender, and group. A main effect for trial was significant (F(1,52) = 1.583 p = .0147. The group*trial interaction was also significant (F(3,52) = 6.625 p = .0007), which is plotted in Figure 3. These results indicate that participants felt significantly more present during Trial 1 (LSM_{T1}=61.68 & LSM_{T2}=59.26). Additionally, changes in IPQ scores varied across the group*trial combination, largely due to IPQ scores measured from the Scent-No Scent (S-NS) group. This group showed a disproportionate decrease in presence in Trial 2 compared to other groups. Control groups maintained relative stability across trials, as the Scent-Scent (S-S) group on average declined by just over a single point (1.37, LSM_{T1}=60.37 & LSM_{T2}=59.00) while the No Scent-No Scent (NS-NS) group declined less than a single point (.7, LSM_{T1}=57.44 & LSM_{T2}=56.74). Similarly, the

NS-S group increased from Trial 1 to Trial 2 as expected, though this increase in IPQ score was not as impressive as the reduction seen in the S-NS group.

Examination of the visual analogue scale showed significant main effects for trial ($F(1,52) = 7.955$ $p = .0068$) and the group*trial interaction ($F(3,52) = 5.382$ $p = .0027$). VAS scores echoed patterns seen in the IPQ scores, as the main effect for trial indicated participants felt more present during Trial 1 (LSM_{T1}=73.48 & LSM_{T2}=67.25). The group*trial interaction was also likely driven by responses from the S-NS group who reported a disproportionate decrease between Trial 1 and 2 (LSM_{T1}=79.43 & LSM_{T2}=61.32) compared to other groups, as well as the NS-S group, which saw a large gain in VAS score during Trial 2 (LSM_{T1}=74.81 & LSM_{T2}=79.74).

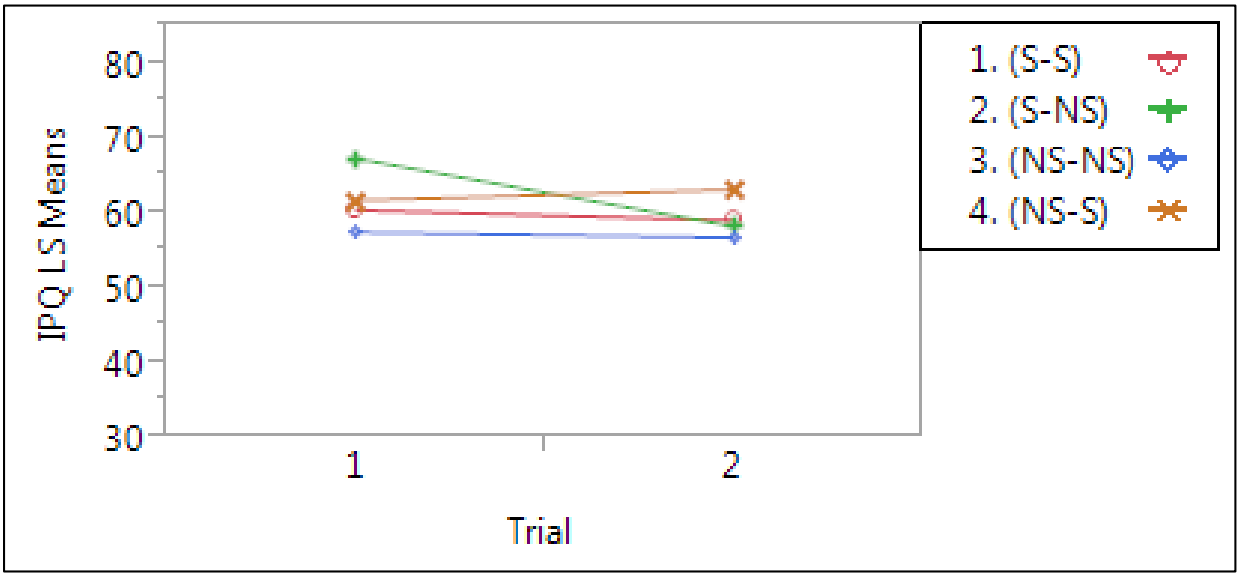

Figure 3: IPQ Score Interaction

Behavioral measures

LMM analysis of participant completion time showed a significant main effect for trial ($F(1,52) = 80.756$ $p < .0001$). This main effect showed that participants completed the second trial more quickly than the first trial ($LSM_{T1}=668.87_{sec}$ & $LSM_{T2}=571.71_{sec}$). LMM analysis of visual scanning showed main effects for sex ($F(1,52) = 13.872$ $p = .0005$), trial ($F(1,52) = 173.26$ $p < .0001$), and the sex*trial interaction ($F(1,52) = 7.725$ $p = .0076$). Males visually explored the VE more than their female counterparts ($LSM_M=556.47$ & $LSM_F=359.73$). Participants also visually explored the VE more in Trial 1 than in Trial 2 ($LSM_{T1}=622.82$ & $LSM_{T2}=293.38$). To further assess the interaction between sex and trial, Tukey's HSD was utilized and is displayed in Table 3. Male participant's VS scores in Trial 1 were significantly higher than all other VS scores in the model, and displayed a disproportionate decline in Trial 2 when compared to female VS scores. Female participant's VS scores also declined significantly in Trial 2.

Table 2: Sex*Trial Tukey HSD

Level	-Level	Difference	S. Error Diff	p-Value
Male,1	Female,2	526.18	58.45	<.0001
Male,1	Male,2	399.00	28.88	<.0001
Male,1	Female,1	266.31	58.45	0.0001
Female,1	Female,2	259.88	40.89	<.0001
Female,1	Male,2	132.70	58.45	0.1144
Male,2	Female,2	127.18	58.45	0.1395

Anxiety ratings

LMM analysis of participant's state anxiety scores showed a main effect for trial ($F(1,52) = 9.634$ $p < .0001$; Figure 4) after controlling for trait anxiety. Results showed participants felt most anxious during the first trial, and state anxiety in the first trial was significantly higher than

measurement at pre-exposure, but not significantly different from Trial 2 (LSM_{PRE}=28.08, LSM_{T1}=41.18, & LSM_{T2}=37.54).

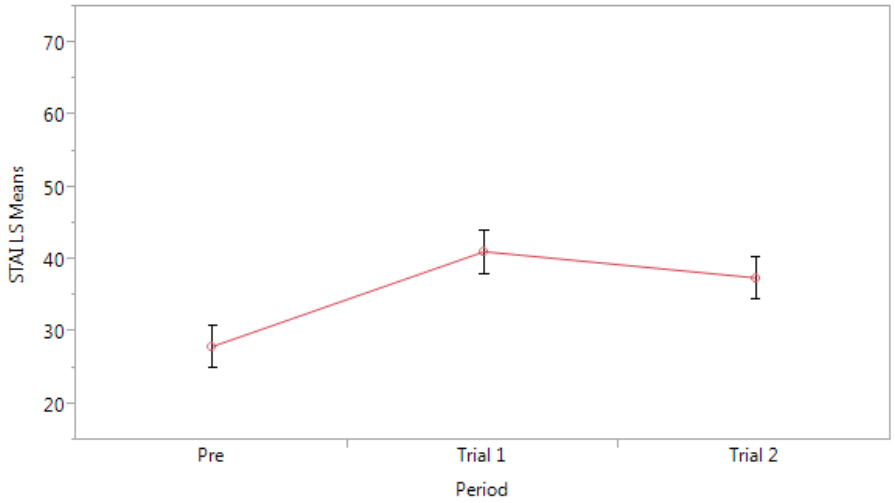

Figure 4: STAI Y1 Scores

A significant group*trial interaction was also observed ($F(6,58) = 3.368$ $p = .006$). The group*trial interaction showed that those who received olfactory stimuli in the first trial were significantly more anxious than those who did not. Moreover, the relative level of anxiety did not change during Trial 2 as illustrated in Figure 5. LMM analyses were also conducted to identify differences at the item level on the STAI Y1, which are illustrated in Table 3.

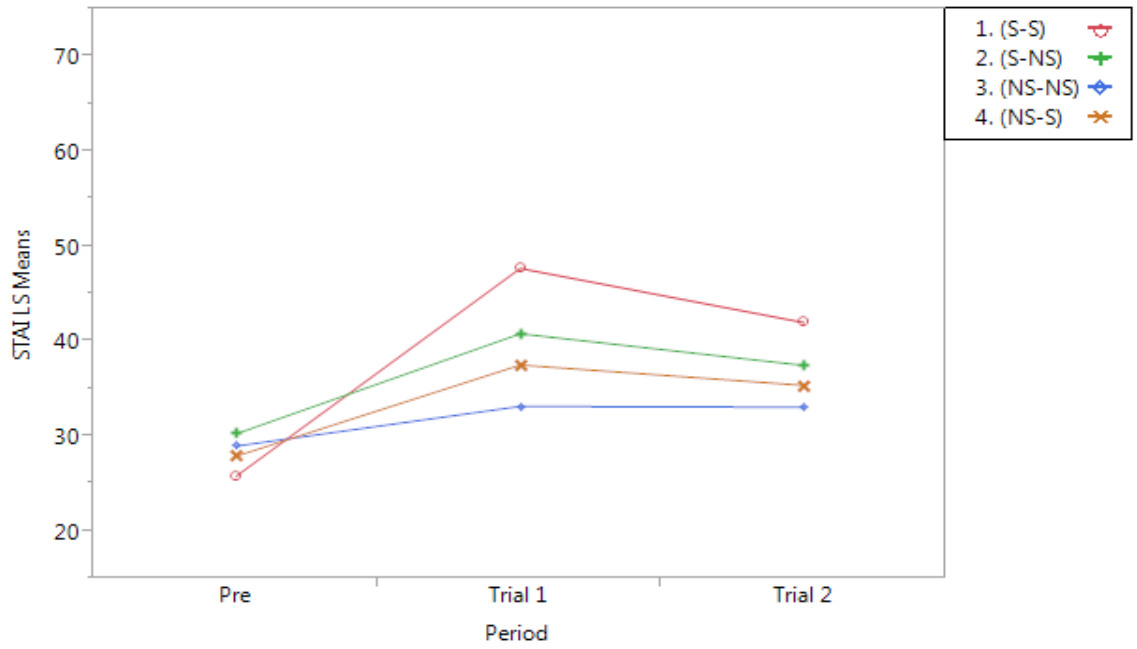

Figure 5: STAI Score by Group & Trial

Table 3: STAI Y1 Differences

STAI Y1	Main Effect	Sig.	LSM 1	LSM2	*Δ*
1. Calm	Trial	0.0001	2.48	2.94	-0.46
2. Secure	Trial	0.0431	2.81	3.02	-0.21
3. Tense	Trial	0.0003	2.43	1.89	0.54
9. Frightened	Trial	0.0051	1.77	1.43	0.34
11. Self-Confident	Sex	0.035	3.13	2.62	0.51
12. Nervous	Trial	0.0017	1.93	1.58	0.35
13. Jittery	Trial	0.0243	1.87	1.58	0.29
14. Indecisive	Trial	0.0095	1.46	1.27	0.19
STAI Y1	**Interaction**	**Sig.**			
4. Strained	Group*Trial	0.0331			

Effect	Description
1. Calm	Participants were calmer in Trial 2.
2. Secure	Participants were more secure in Trial 2.
3. Tense	Participants were less tense in Trial 2.
4. Strained	Females in Group 3 were disproportionately less strained after Trial 2.
9. Frightened	Participants were less frightened in Trial 2.
11. Self-Confident	Males were more confident during experiment.
12. Nervous	Participants were less nervous in Trial 2.
13. Jittery	Participants were less jittery in Trial 2.
14. Indecisive	Participants were more decisive in Trial 2.

Note: Items from the STAI Y1 that did not present any significant main effects or interactions are excluded from this table.

Physiological measures

A main effect for trial ($F(1,52) = 40.822$, $p < .0001$) was observed when analyzing net EDA within the LMM. A group*trial interaction approached significance ($F(3,52) = 2.600$, $p = .061$). The main effect for trial showed participants were more aroused during Trial 1 (LSM_{T1}=.985$_{\mu S}$ & LSM_{T2}=-.337 $_{\mu S}$). The group*trial interaction showed that the group that received olfactory stimuli in both trials had a significant reduction in arousal during the second trial (LSM_{G1T1}=1.093$_{\mu S}$ & LSM_{G1T2}=-1.099$_{\mu S}$). Similarly, those who received scents during Trial

1 but not Trial 2 demonstrated a disproportionate decrease in arousal during the second trial (LSM_{G2T1}=.947$_{\mu S}$ & LSM_{G2T2}=-.422$_{\mu S}$). These results can be seen in Figure 6.

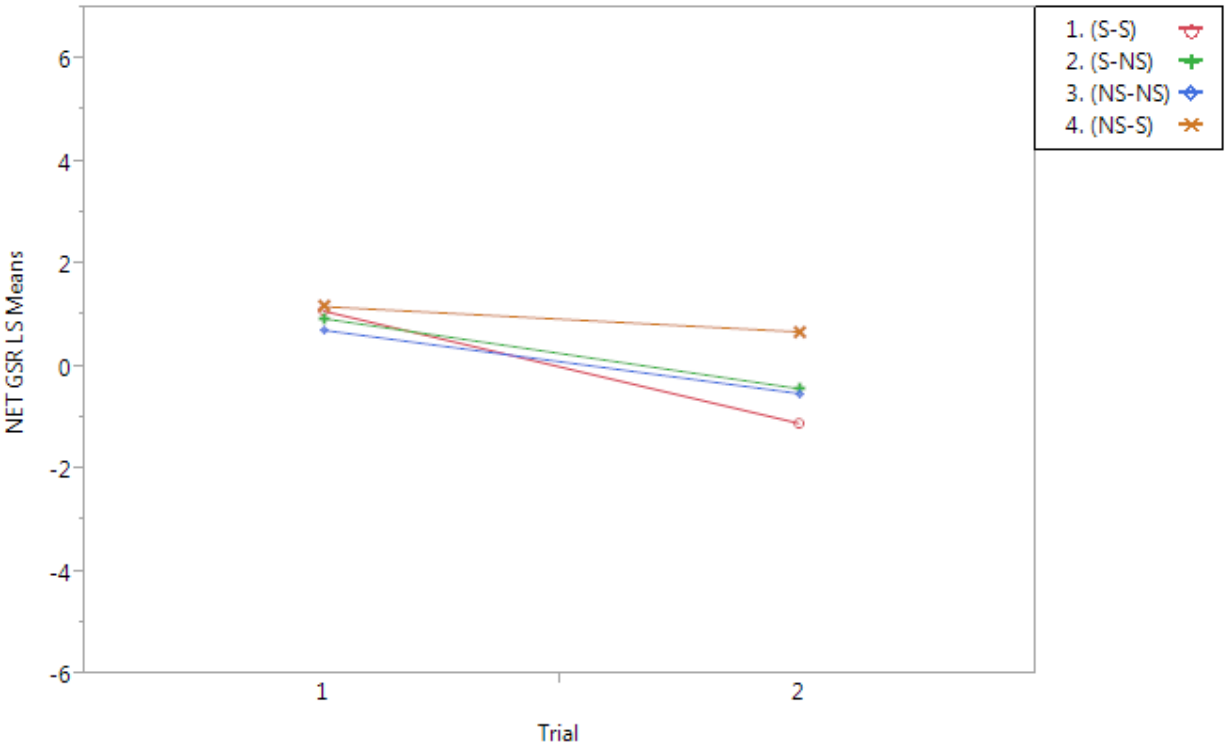

Figure 6: Group*Trial Interaction for EDA

Differences in event-related skin conductance responses (ER-SCR) and nonspecific SCRs (NS-SCR) was also examined through LMM. NS-SCRs were defined as a fluctuation greater than .05$_{\mu S}$, while ER-SCRs were defined as a fluctuation greater than .05$_{\mu S}$ that occurred within a 3 second window following a scripted event within the VE. LMM analyses of ER-SCR revealed a significant main effect for trial ($F(1,52) = 35.883$, $p < .0001$). Similarly, a significant main effect for trial was found for NS-SCRs ($F(1, 52) = 75.995$, $p < .0001$). Results indicated that participants were not as physiologically reactive to scripted events during Trial 2 (LSM_{T1}=2.734 & LSM_{T2}=1.84). Spontaneous reactions also decreased in Trial 2, indicating fewer spontaneous reactions during Trial 2 (LSM_{T1}=16.960 & LSM_{T2}=8.213).

Condition Identification

Another variable of interest was whether or not participants would be able to correctly identify the trial condition they had just received after each VE exposure. After each trial participants were asked if they received scents or smells during the trial they had just completed. This question was evaluated with three additional items, which assessed for similar sensory stimuli (tactile feedback, temperature changes, and visuals) that served as distractors. Agreement between the actual and perceived condition was assessed using Cohen's Kappa (Cohen, 1960) and cutoffs recommended by Viera and Garrett (2005). Across both trials, participants were able to correctly determine which condition they actually experienced with moderate success (K_{T1}=.53, K_{T2}=.62). Participants were able to correctly identify whether or not they had received scents with moderate success. In fact, a less-than-perfect agreement between perceived and actual condition is evidence of the validity of the collected IPQ scores. Had participants been able to correctly identify their condition, they may have then been able to accurately identify the research hypotheses and modify their responses accordingly.

CHAPTER FOUR: DISCUSSION

The results of our analyses were largely unexpected, but interesting nonetheless. Initial interpretation of the IPQ scores appears to trend in the hypothesized directions, with presence increasing or decreasing with the introduction or removal of olfactory stimuli, respectively. Responses on both the visual analogue scale and the IPQ indicated loss of presence when olfactory stimuli were withheld, and gains when olfactory stimuli were presented. Together, these patterns of scores supported the original hypotheses; though the difference in magnitude between the relative increase and decrease between the experimental groups was unexpected. It may be that the improvements of sensory fidelity (adding scents) are less impressive to participants than reductions in fidelity. From the presence perspective, the results suggest that a) the addition of scents may increase presence for some participants and b) the removal of scents, once presented, likely results in a large reduction of presence. The strong correlation between IPQ and VAS scores may indicate that simple scales can accurately assess presence, which may be beneficial for researchers who need less invasive ways to assess momentary presence, as interrupting tasks to assess presence can diminish presence.

Behavioral measures of presence appeared to demonstrate the expected order effects. Completion times were reduced during the second exposure to the VE. Initially, we hypothesized that olfaction would increase presence and lead to an increase in visual scanning. However, controls actually visually explored the environment more than their experimental counterparts. Visual exploration of the VE was also reduced during the second trial, with males exploring the VE to greater degrees than their female counterparts. Males also demonstrated a greater reduction in visual scanning across trials than females. This disproportionate drop in visual

scanning may be an artifact of experience; males reported playing arcade and video games at greater rates than females. Specifically, gender differences are known to exist with respect to spatial cognition (Baenninger & Newcombe, 1989). It may be possible that due to higher levels of spatial attention, males did not feel the need to explore during the second trial. It is unknown what pattern of visual scanning scores would have been observed after "training" the female participants, although experience has been shown to benefit spatial attention (Feng, Spence, & Pratt, 2007).

Interestingly, the effect of olfactory stimuli on participant's state anxiety was far less than hypothesized, with olfaction making little to no difference. Anxiety scores decreased regardless of whether or not the participants received scent, as evidenced by decreased reports of nervousness, uncertainty, and fright. However, a serendipitous finding was the fact that those who received olfactory stimuli in the first trial maintained higher levels of anxiety through Trial 2, regardless of Trial 2 condition. An ANOVA confirmed that differences between anxiety levels in those who received scents were significantly higher than their Trial 1, No-Scent peers. One possible explanation may be that the administration of scents during Trial 1 impressed participants, who were thus more engaged throughout the experiment. More research is required to adequately explain this finding.

Physiological measures also resulted in patterns different than hypothesized. As with state anxiety, physiological arousal was reduced in Trial 2, despite condition changes. It was noted by experimental staff during the data collection phase that many participants began to anticipate the scripted events in advance as evidenced by increasing EDA levels just prior to the event trigger being released. In these instances, most subjects experienced immediate reductions

in EDA, which did not meet the definition of event-related SCR responses (which required an increase post-event). One possible silver-lining may be that events were only predictable due to experimental design; events such as those used in clinical settings (for example, explosions for combat-related PTSD patients) are often under clinician control, who can monitor the patient for anticipatory behaviors and/or circumvent them. It is also important to note that participants in this experiment lacked autobiographical memories associated with the VE that would be present in those with disorders such as PTSD. Thus, autobiographical memory may moderate or mediate the effectiveness of olfactory stimuli used during ET.

Item level analyses of participant responses on the STAI Y1 provided some insight into participant anxiety levels throughout the experiment, and generally fell in line with both experimenter expectation and scores on the IPQ. Across groups, Trial 2 was perceived as less anxiety producing regardless of whether or not the participant reversed olfactory conditions. Males were more self-confident across trials, which may also be an artifact of arcade and video game experience, but not experience with computers in general.

Overall, this study demonstrates the potential of olfactory stimuli use in exposure therapy, and indicates that olfactory stimuli may be effective in increasing presence during exposure tasks similar to those used in ET. The score patterns for the reversal groups (S-NS & NS-S) trended in the hypothesized directions, although the NS-S increase was not as large as expected. If olfactory stimuli directly increase presence during individual sessions of ET, the effect on treatment outcome must also be examined. Given the escalating patient care costs of combat-related PTSD alone, the utilization of scents may positively impact treatment efficacy,

though the manifestation of this positive impact may take any of many different forms, such as increased patient acceptability or greater habituation in-session.

Another benefit may be increased generalization post-treatment. For example, the scent of smoke may be common to combat-related events and may serve as a specific trigger to a hypothetical patient. While ET may effectively reduce physiological symptomology to this patient's traumatic event, the inclusion of smoke during ET may allow broader generalization. Without the scents included, everyday activities like camping or cooking may remain avoided at greater frequency than if scents had been included during the treatment. Conversely, it may be that scents affect the therapeutic process by facilitating memory recall of otherwise difficult-to-remember situations.

Limitations

This study is not without limitations. As mentioned, participants did not possess autobiographical memories associated with the VE. If participants had had personal memories consistent with the narrative of the presented VE, a different pattern of presence and anxiety scores may have emerged. Future research in this domain may wish to utilize samples with common autobiographical memories. For example, military operations in OIF/OEF/OND frequently included convoys. Examining veterans with extensive convoy experience in a VE that approximated a convoy in Iraq or Afghanistan may better capture the influence of scents on presence and more closely resemble exposure therapy. This study does show that olfactory stimuli are not a detriment to presence and as such, the use of olfactory stimuli during ET for disorders like PTSD or specific phobias should not be ruled out. However, given the patterns within the data it appears that olfactory stimuli should not be removed once the user has

experienced them, as participants who lost olfactory stimuli in the second trial had significant reductions in experienced subjective presence. Additionally, olfactory stimuli may assist with treatment acceptability or in other words, patient “buy in” as anecdotal accounts of olfactory stimuli’s effectiveness has already been described in the memory literature.

APPENDIX A: NARRATIVE SCENE

You have lost your phone and keys while at the carnival. The carnival has closed but you are locked out of your car and you have no way of calling for help. Fortunately you have a flashlight. The main entrance is closed so you go around to the back to see if you can get in.

You see an abandoned alley that looks like a way in. Empty benches and boarded-up booths line the path. On the right, an empty hot dog stand sits forgotten in the dark. Old tires litter the ground, and you hear crackling in the background against gusts of wind overhead. Posters plaster the wood fences advertising the carnival attractions, and a large sign directs you towards the heart of the carnival grounds. You wonder where you could have left your keys...

The fences continue into the darkness. A water tower juts into the blackened sky overhead. The corridor turns to the right again, revealing more rotted out tires and a rusty chain link fence. A barrel behind the gate is labeled flammable. You see flames in the distance, reaching high into the darkness. You keep looking for a way in…

Something unseen stirs the metal garbage cans next to you as you continue your search. Your flashlight begins to flicker, and you wonder if it will last long enough to find your belongings. The stink of [**GARBAGE]** fills your nostrils. You're not sure what you'll do if you can't find your phone. You won't be able to call for a ride or unlock your car and home is miles away…

The path cuts to the right again and then left. Something metal strikes against metal somewhere nearby, but you cannot see or tell what happened, or who, or what, caused it. Another sign

directs you to continue to look for an entrance to the carnival. Are you alone? You wonder if there's a lost and found office that might have your things, but you have no idea where it might be.

Your path turns into an alley, and you feel pressed between the brick and cement walls. The roofing appears to have collapsed and it looks as though it might fall at any minute. If something happens to you, how will anyone know? A lone streetlight lights the path ahead of you and the alley reeks of garbage **[GARBAGE]**

Wind howls over your head as you double back into the shadow of a larger building. Signs point the way towards the heart of the carnival. The entire area is lifeless, dark, and cold. You have no idea what you're going to do if you can't find your keys to get out of here, and you haven't seen a phone anywhere. You move past two shuttered booths as your search continues. The area seems completely deserted. A light snaps on in front of you. You see another garbage can, and can smell the rotting food **[GARBAGE**] inside as you pass it.

You make your way through the campers wondering where everyone is. Vending machines and other junk are scattered about, and a Ferris wheel looms in the distance. Suddenly part of the Ferris wheel crashes down ahead of you with a metallic groan. The lights to a ride flash on and eerie sounds fill the air. You see something aflame ahead that wasn't there before… **(RATING)**

As you move around the wrecked ride, you hear the hiss of leaking gas and realize the fire is coming from a propane tank that could explode at any second.

Lights click on ahead of you, shattering through the noise of the wind. Though you cannot tell if someone is turning them on, of if it happened by chance…. You're not sure if this is the right way. In fact, this doesn't look familiar at all….

The light clunks off unexpectedly behind you, and an eerie laugh echoes nearby. Was that coincidence, or intentional? All you can see is the vending machines in the distance ahead of you. Darkness is everywhere, and you haven't seen any sign of your things. Did you lose them on a ride? Did they fall out of your pocket? You pass more empty booths, and carnival games, and finally arrive by some classic arcade games. The scent of **[POPCORN]** lingers here, but you cannot tell where it's coming from.

Lights from a carousel in front of you flash on revealing someone, or something directly in your path. The eerie laugh seems closer than before. You spot a large ride bathed in violet light. Someone, or something, is standing in front of it.

The lights die with a loud clank, blanketing the area in darkness. Where did he go? The lights return. The giant ride is abandoned and immobile. Going around it, you pass an empty hotdog stand and a rusty truck that looks like it hasn't run in years. You see what looks like the entrance to the carnival. The tattered curtain moves in the breeze…

You climb the stairs and enter, revealing a catwalk that passes through a colored tunnel. As you step onto the catwalk, the tunnel grinds into motion, rotating around you. You hear a loud

mechanical crash, and the tunnel crashes to a stop. The lights are cut out, and you cannot see anything! **(RATING)**

Emergency lights illuminate the exit ahead of you, and the door grinds open. Where are your keys? Are you ever going to get out of this place? As you exit the tunnel, you hear whistling! Someone is humming! Someone must be nearby!

You move through the metal fences. An empty ride is running ahead. You see more signs urging you forward. There must be an office here somewhere. You pass more garbage cans **[GARBAGE]**. The stink is awful. The wind howls overhead, making it difficult to tell where the man who is singing might be!

The maze opens into another area of the carnival. An empty carousel sits ahead of you as well as more empty booths. The wind roars overhead, and the man sounds very close….
The carousel lights up and begins playing music. Where did the whistling and humming go? Where are your keys? **(RATING)** You walk around the carousel, passing empty booths along the way. The smells of the circus drift on the night air **[POPCORN/COTTON CANDY]**. You pass by several old arcade games and smell the same stink **[GARBAGE]** that you smelled before. You see a light in the distance, and what looks like more trailers. Could that be the office? You're not sure... The wind howls overhead. The music begins to fade behind you...
[END]

APPENDIX B: UCF IRB LETTER

University of Central Florida Institutional Review Board
Office of Research & Commercialization
12201 Research Parkway, Suite 501
Orlando, Florida 32826-3246
Telephone: 407-823-2901 or 407-882-2276
www.research.ucf.edu/compliance/irb.html

Approval of Human Research

From: **UCF Institutional Review Board #1**
FWA00000351, IRB00001138

To: **Benson Munyan**

Date: **October 28, 2014**

Dear Researcher:

On 10/28/2014, the IRB approved the following human participant research until 10/27/2015 inclusive:

Type of Review:	UCF Initial Review Submission Form
Project Title:	Do Olfactory Stimuli Increase Presence During Exposure Tasks: A Comparative Study
Investigator:	Benson Munyan
IRB Number:	SBE-14-10650
Funding Agency:	
Grant Title:	
Research ID:	N/A

The scientific merit of the research was considered during the IRB review. The Continuing Review Application must be submitted 30days prior to the expiration date for studies that were previously expedited, and 60 days prior to the expiration date for research that was previously reviewed at a convened meeting. Do not make changes to the study (i.e., protocol, methodology, consent form, personnel, site, etc.) before obtaining IRB approval. A Modification Form **cannot** be used to extend the approval period of a study. All forms may be completed and submitted online at https://iris.research.ucf.edu .

If continuing review approval is not granted before the expiration date of 10/27/2015, approval of this research expires on that date. When you have completed your research, please submit a Study Closure request in iRIS so that IRB records will be accurate.

Use of the approved, stamped consent document(s) is required. The new form supersedes all previous versions, which are now invalid for further use. Only approved investigators (or other approved key study personnel) may solicit consent for research participation. Participants or their representatives must receive a copy of the consent form(s).

All data, including signed consent forms if applicable, must be retained and secured per protocol for a minimum of five years (six if HIPAA applies) past the completion of this research. Any links to the identification of participants should be maintained and secured per protocol. Additional requirements may be imposed by your funding agency, your department, or other entities. Access to data is limited to authorized individuals listed as key study personnel.

In the conduct of this research, you are responsible to follow the requirements of the Investigator Manual.

On behalf of Sophia Dziegielewski, Ph.D., L.C.S.W., UCF IRB Chair, this letter is signed by:

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