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Environmental Enrichment: A Potential Treatment for PTSD and Alcohol Abuse

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A POTENTIAL TREATMENT FOR PTSD AND ALCOHOL ABUSE

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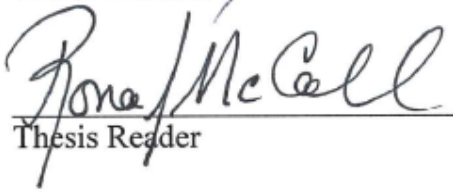

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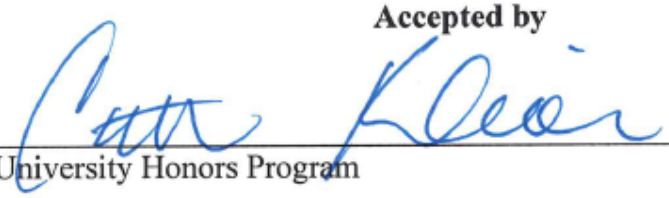

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TABLE OF CONTENTS

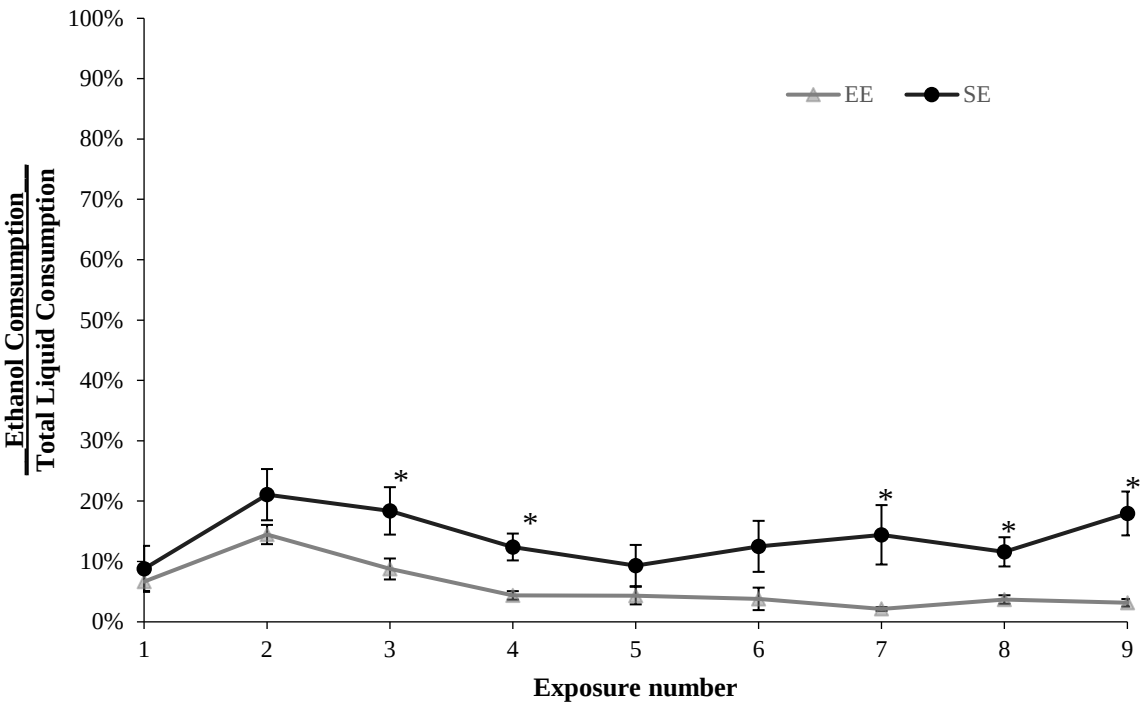

Figure 1. Ethanol consumption, as a percentage of total liquid consumption, across all nine ethanol exposures, by group. Error bars represent standard error. EE is enriched environment; SE is standard environment. * indicates $p < .05$ between groups.

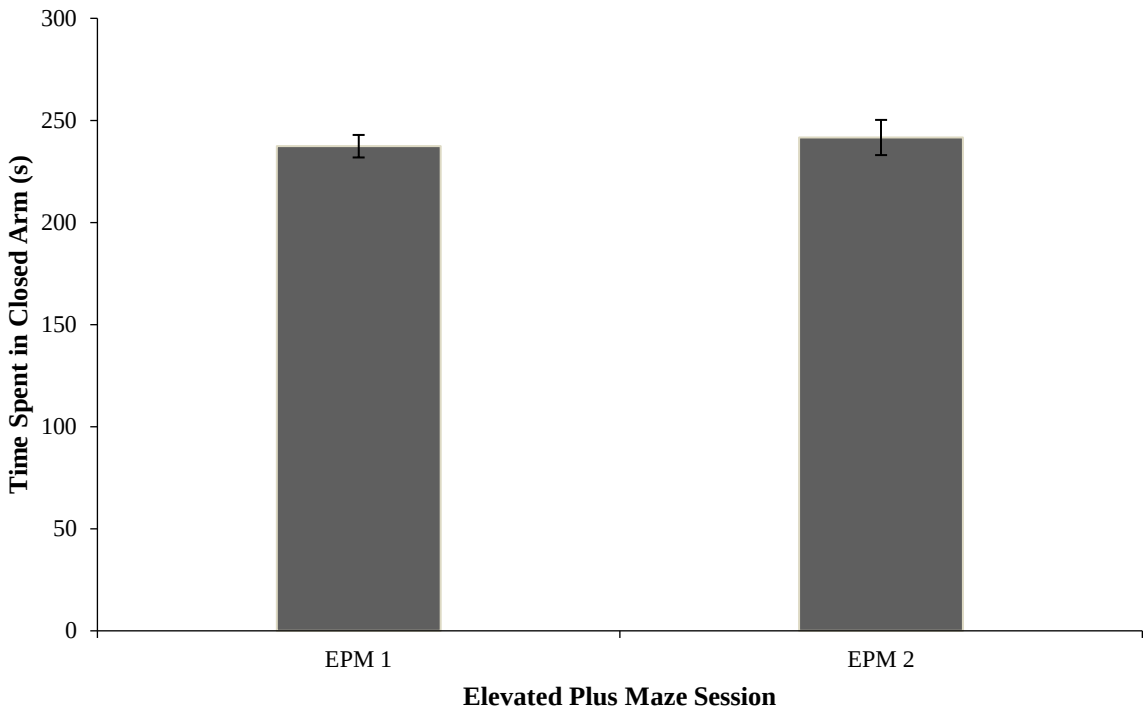

Figure 2. Mean time, in seconds, spent in closed arm of elevated plus maze (EMP) from the first to the second session, pre- versus post-stress. Rats spent 300 total seconds (5 minutes) on the maze per session. Error bars represent standard error.

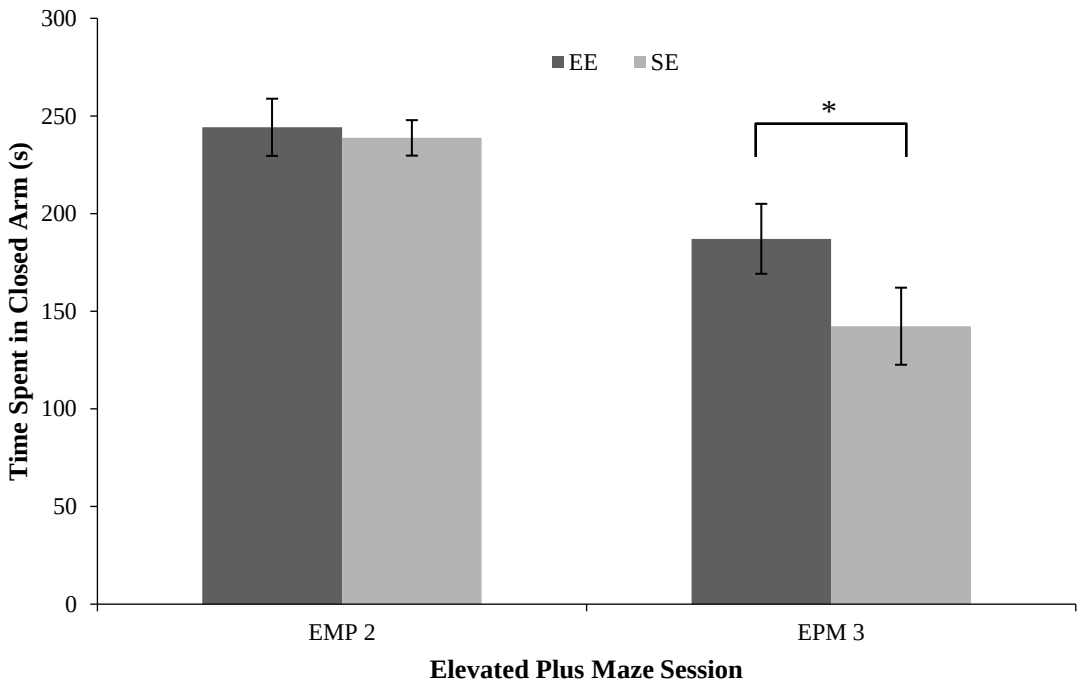

Figure 3. Mean time, in seconds, spent in closed arm of elevated plus maze (EMP) by group from the second to the third measurement, before versus after the three-week enrichment and ethanol exposure period. Rats spent 300 total seconds (5 minutes) on the maze per session. Error bars represent standard error. EE is enriched environment; SE is standard environment. * indicates $p < .05$ from session two.

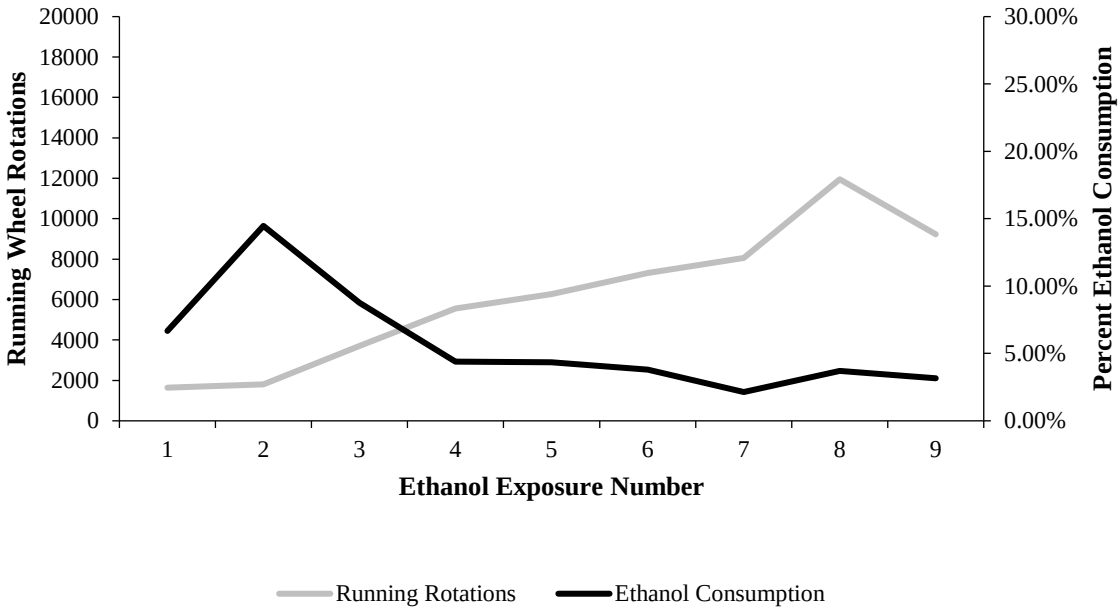

Figure 4. Correlation between ethanol consumption (as a percentage of total liquid consumption) and amount of running (number of wheel rotations).

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Abstract

Post-traumatic stress disorder (PTSD) will affect approximately eight out of every hundred individuals at some point in their lifetime. One major issue accompanying PTSD is alcohol abuse—estimated rates of alcohol abuse in persons with PTSD vary from 30-75 percent. Environmental enrichment (EE) has been shown to decrease voluntary alcohol consumption as well as decrease anxiety levels post-stress. As such, EE could be a potential treatment mechanism for co-morbid PTSD and alcohol abuse. Our independent research into the effectiveness of EE at attenuating post-stress alcohol consumption in male Sprague Dawley rats validates this idea. Rats were stressed and then given intermittent access to 20% ethanol via the 2-bottle-choice drinking paradigm for three weeks. Rats in EE consumed significantly less ethanol, relative to controls. Anecdotal evidence from survivors of trauma suggests that such findings could be translated into the human populations with PTSD, such as through travel, religion, and other forms of meaning making. Further, environmental enrichment surpasses other treatments as it seeks to "care for the whole person"—the Jesuit value of *cura personalis*—by attending to both their mind and body. This paper will discuss the explicit effects of PTSD, the specifics of our independent research, and the detailed implications of our results for the human population. As a caring and compassionate society, we have the responsibility to conduct further research to help to expand our knowledge of symptoms and vulnerabilities associated with PTSD and alcohol dependence, to harness valuable and effective treatment mechanisms.

Environmental Enrichment: A Potential Treatment for PTSD and Alcohol Abuse

FOREWORD

Imagine feeling constantly agitated and on edge, without any concrete cause or source of agitation. Imagine avoiding certain, common situations, because you know they will provoke you into an emotional break down and inhibit your ability to function properly; but still knowing that no matter how hard you work to avoid such situations, how careful and attentive you are at planning every moment of your day, they will still likely find you. Imagine being utterly exhausted at the end of every day, because every ounce of your energy is dedicated to the arduous task of being constantly vigilant and hyperaware; yet still being unable to go to sleep, afraid of the terror and nightmares that await you. This debilitating reality, or one with similar struggles and complexities, is the reality that post-traumatic stress disorder (PTSD) inflicts.

In today's society, PTSD is often dismissed as primarily a military problem. While it may be true that, due to the nature of their position, service members are more likely to experience trauma than civilians, putting them at an increased risk for developing PTSD, the reality is that over half of adults will experience at least one trauma at some point in their lives, military or not (United States Department of Veterans Affairs [USDVA], 2016). Due to such a high rate of trauma, PTSD is a reality that eight out of every one-hundred adults will face at some point in their lives (USDVA, 2016). Furthermore, while there remains a common stigma associating PTSD with weakness, the

truth is that anyone can be inflicted with this pervasive disorder, regardless of perceived mental, spiritual, or emotional strength.

In light of these truths, we, as caring individuals of a caring society, must attempt to understand the actualities of PTSD, in order to foster compassion and empathy, for the sake of mobilizing national interest into further treatment and resource development for those suffering from the disorder. This paper will aim to do just that. I will first attempt to exemplify the severe reality of PTSD through the lens of those who have experienced the disorder first hand. I will then discuss our current short comings, as a country, in lack of valid resources available to those with PTSD, with specific focus on the implications of high rates of alcohol abuse among those suffering from PTSD. Following, I will relate my own personal research into a potential treatment for comorbid PTSD and alcohol abuse, using male Sprague- Dawley rats as a model. I will go on to discuss the broader implications of the results of this research, particularly in light of the Regis Jesuit tradition, and make suggestions for future research and areas of improvements for treatment of PTSD.

Before I move on, I would like to recognize the individuals who have informed immeasurably on this paper, particularly the earlier portions, by choosing to disclose their own journeys with PTSD. These specific individuals include, in no particular order, Clint Van Winkle, Patricia Lawrence, and David J. Morris. Clint Van Winkle is a combat veteran of the marine corps. His vivid memoir provides insight into the struggle of PTSD through that lens, relating the horrors in Iraq that he had to learn to cope with upon

returning home (Van Winkle, 2009). Patricia Lawrence, on the other hand, is a survivor of gang rape; in her account, she relates her powerful journey of suffering from PTSD undiagnosed for almost 40 years**,** including the turmoil and shame she faced in being unable to "get over it," as many suggested she should (Lawrence, 2017). David J. Morris is also a veteran, but more notably was a war correspondent during the Iraq war, and experienced combat firsthand through that experience; his recollection is part autobiography, but mostly, to use his own words "a 'biography' of PTSD" itself (Morris, 2015, p. 20).

I am incredibly grateful for the courage of these individuals in choosing to disclose their struggles in equally poignant, compelling, and mindful fashions. They, along with the many others who choose to tell their own stories of PTSD, inspire deeper understanding, consideration, and empathy. They very clearly demonstrate the dramatic differences in the presentation of PTSD, emphasizing the fact that, while no two journeys are the same, each is just as precious and worthy of compassion. Admittedly, this paper does not illustrate the substantiality of PTSD to the same provoking capacity that the stories of those who have lived with the disorder do, nor should it. However, such individuals have enlightened this paper, and I hope that have I done their stories justice in my aims to inspire more thorough awareness and understanding of a disorder that permeates almost every corner of our society.

I. THE STARTLING REALITY OF PTSD

As its name implies, post-traumatic stress disorder (PTSD) is a devastating mental disorder that is induced by a traumatic, stressful event. As survivor David J. Morris (2015), an Iraq war correspondent, notes, "every survivor of trauma, whether or not they experience diagnosable post-traumatic stress, returns to the regular world and recognizes that things are not as they were" (p. 6). Morris's words adequately underline that, regardless of diagnosable PTSD, trauma is impactful and tends to change a person's perception and outlook on life. To be clear, this is not necessarily a negative outcome; humans' resilient ability to process and grow from trauma is indeed a very positive thing. The difference is that persons with diagnosable levels of PTSD are dramatically impacted by the trauma such that it begins to negatively infringe on their ability to function normally in daily life (United Stated Department of Veteran Affairs [USDVA], 2017).

In his bibliography, Morris provides a powerful description of the impact of trauma, which aptly highlights the capacity it has to debilitate:

> Like a bullet, [trauma] enters the body, angry, and with a surplus of power, eager to transmit it to whatever flesh it finds, doing its work, and then exiting, leaving the troubled body behind, dragging a comet's tail of memories, hope and innocence through the air, looking for another body to complicate. (Morris, 2015, pp. 42-43)

Morris effectively elucidates the devastating effect that trauma has. I would extend his metaphor to suggest that those with PTSD are those whom, for a variety of reasons, had

more trouble healing from the bullet of trauma. No one would suggest that a person who's suffered a bullet wound should be able to heal quickly and move on. Some may heal more easily, while others may need additional support and rehabilitation. Some might even need support for the rest of their life, if they suffered from chronic injury due to the bullet. But every method of healing and coping is perfectly valid, and society would generally agree that a person with a bullet wound should do whatever they need ensure the best possible outcomes following their injury. Indeed, the same is true for trauma, and the injuries, PTSD and otherwise, that it leaves behind.

The purpose of this chapter is to take a closer look at the symptomology of PTSD, through the realistic lens of people who have suffered through the disorder. Following, I will present the startling realities of the prevalence of PTSD and comorbid alcohol abuse and postulate some reasons as to why this may be the case.

Rates and Prevalence of PTSD

As stated previously, according to the United States Department of Veterans Affairs (2016), in the United States PTSD has a lifetime rate of approximately eight percent. This means that eight out of every hundred individuals will experience diagnosable levels of PTSD at some point in their life. Further, as many eight million adults suffer from PTSD in any given year. Lifetime rates of PTSD are higher for women than for men—ten percent of women will struggle with PTSD at some point in their lives, compared to four percent of men (USDVA, 2016). Given that approximately half of the US population will experience at least one trauma in their life (USDVA, 2016), this

statistic may not be quite as shocking. The types of trauma that men are likely to experience are different from the types of trauma that woman are likely to experience. Men are most likely to experience "accidents, physical assault, combat, disaster, or…witness [of] death or injury" (USDVA, 2016, para. 2). In contrast, women are most likely to experience sexual trauma in childhood or adulthood (USDVA, 2016). Because of the difference in the trauma that they experience, men and woman are likely to develop PTSD from different kinds of trauma.

Of those who experience trauma, approximately 30 percent or so will go on to develop PTSD (Perrin et al., 2014). One factor thought to influence the development of PTSD includes the degree to which an individual can control the trauma they experience—the more control the individual has, the less likely they are to develop PTSD (Volpicelli, Balaraman, Hahn, Wallace, & Bux, 1999). Note that in the traumas that are most likely to lead to PTSD, listed above, the individual has little or no control over the situation. Another factor in PTSD development includes the level of social support survivors receive after their trauma (Brewin, Andrews, & Valentine, 2000). Further, rates of development of PTSD also appear to be dependent on the type of trauma experienced; for example, rates of development for survivors of rape is approximately 50 percent (Perrin et al., 2014). In general, so called "man-made" trauma, such as rape, assault, and combat, tend to lead to higher rates of PTSD than "natural" trauma, such as natural disaster (Brewin et al., 2000). This is perhaps why PTSD is generally thought of as a military problem, because its members are more likely to be exposed to "man-made" (i.e.

combat) trauma than the civilian population. However, the high rates of experiences with man-made trauma even outside of the military prove this to be untrue. There are countless other factors, some understood and many others not, that influence the likelihood that an individual will develop PTSD—these factors intertwine with each other to craft an exceedingly complex narrative for every survivor of trauma. Regardless, given the high rates of trauma across all sectors of society, the pervasiveness of PTSD becomes almost comprehensible—PTSD can be, and is, anyone's problem.

Presentation of PTSD

According to the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5), a stressor that might precede PTSD includes exposure to actual or threat of death, serious injury, or sexual violence (American Psychological Association [APA], 2013). The exposure can be direct, having happened to the person's own self; indirect, having happened to a close friend or relative, and then relayed to the person; witnessed in person; or can consist of repeated indirect exposure to aversive details of trauma, such as that experienced by first responders (APA, 2013). After the traumatic event, PTSD presents in a number of symptoms; in diagnosable levels of PTSD, symptoms last for one month, and, as mentioned earlier, are severe enough to impede on normal, daily functioning (APA, 2013). To be more specific, PTSD symptoms impede on a person's life in four ways: re-experiencing of the traumatic event, avoidance of specific stimuli associated with the trauma, increased negative thoughts/feelings, and increased arousal and reactivity (APA, 2013). Understandably, all of these symptoms can present in a

number of fashions, and each individually has the capacity to devastate a person's daily functioning, let alone all four in combination.

Re-experiencing the Traumatic Event

The PTSD symptom of re-experiencing the traumatic event can present in a number of ways, such as through intrusive thoughts, nightmares, flashbacks, and emotional or physical reactivity to stimuli that serve as traumatic reminders (APA, 2013). Further, the re-experiencing is persistent and invasive, insofar as it is not wanted or intended by the individual. This is an important distinction, as reflecting on the trauma, on one's own terms, can indeed be an important process to healing.

The invasiveness of the re-experiencing of the traumatic event is clearly exemplified by both Patricia Lawrence (2017), a survivor of gang rape, and Clint Van Winkle (2009), an Iraq war veteran, throughout their respective memoirs. For example, Lawrence recalls an experience while at a bar with her coworker. Her coworker ignorantly ordered her rum-and-Coke—the drink that her rapists had tried to force her to consume. She recalls, "I sip my drink through a blur of memory of the last time I tasted this concoction…as monsters tried to make me drink it…The memory makes this attempt at a simple after-work drink more nightmare than happy hour" (pp. 102-103). Lawrence does not consciously invite these memories into her mind, but they nonetheless invade on her experience with her coworker. This re-experiencing, in the context of the traumatic reminder rum-and-Coke, makes Lawrence's time with her coworker nightmarish, when it should have been innocent and pleasurable.

Van Winkle (2009) similarly indicates his re-experiencing through constant, intrusive thoughts, stating “all I could think about was Iraq. There was no escaping it” (p. 111) and describing a “constant bombardment of war-related thoughts” (p. 161). Van Winkle speaks of his thoughts as something he was unable to escape, again emphasizing the unwelcomeness of such re-experiencing, as well at its persistence. In both Lawrence and Van Winkle’s experiences, it is made obvious that the symptom of re-experiencing in PTSD would indeed violate one’s ability to function normally in daily life. As Morris (2015) puts it, “life moves forward but one reencounters memories of one’s loss over and over again, finding its fingerprints in situations seemingly unconnected to the past” (p. 55). Those who suffer from PTSD are seemingly haunted by the memories of their trauma.

Avoidance of Stimuli Associated with the Trauma

Avoidance of specific stimuli associated with the trauma in PTSD includes avoiding trauma related thoughts or feelings, and trauma related reminders (APA, 2013). Given that such stimuli can often trigger a re-experiencing of the trauma itself, it is easy to see how these two symptoms might interact. Lawrence (2017) demonstrates this symptom when considering potentially returning to Utah, the state where her rape took place. She says, “I can’t imagine it. I don’t want to be breathe the same air or be lit by the same sun. I don’t want to see anyone in Utah” (Lawrence, 2017, p. 76). Lawrence’s apparent disdain toward this stimulus associated with her trauma, and her fervent desire to avoid it, clearly demonstrates the avoidance symptom of PTSD.

If the trauma of a person suffering from PTSD includes many stimuli closely associated with their daily life, avoidance can be even more debilitating. Another example from Lawrence (2017) is her tendency to avoid men. She says, “I am forever crossing aisles, changing directions, leaving rooms” (p. 81). This behavior persists even years after her attack. Lawrence (2017) relates an instance where she drops a class in college due to attention from a male professor, who appears to simply be impressed with her academic potential. Indeed, even years after her rape attention from men remains unbearable for Lawrence. In another instance, she relates an encounter with a male graduate student in the career counseling office at her university: “I am immediately hysterical... I cannot be in this tiny space with this stranger, this man. I am in so much danger I can’t believe the sun hasn’t blown up” (p. 125). Lawrence quickly leaves the situation, never learning of the results of the vocational and aptitude tests she had taken. Needless to say, in her effort to avoid men, Lawrence sacrifices many jobs and other opportunities (Lawrence, 2017).

To more clearly exemplify the degree to which avoidance can be crippling, consider a person whose PTSD was triggered by a car accident. After their accident, that individual may be inclined to avoid driving, or to avoid being in a car at all for that matter, causing them to miss necessary obligations and commitments. Particularly if that individual lives in a more suburban or rural environment, this avoidance would inhibit their ability to maintain work, go to the grocery store, or even seek out treatment. The avoidance in this person’s life clearly impedes severely on their ability to function

normally, and one can easily extrapolate other examples of daily stimuli that are virtually unavoidable if one desires to maintain normal functioning.

Increased Negative Thoughts and Feelings

Another key symptom of PTSD is the increase of negative thoughts or feelings that begins or is worsened following the trauma. This can be anything from negative mood and increased negative thoughts and feelings, to loss of interest in activities, to an inflated sense of blame towards self or others associated with the trauma, to feelings of isolation (APA, 2013).

Van Winkle (2009), Lawrence (2017) and Morris (2015) all exhibit anger as an indicator of negative affect, in hauntingly similar, yet simple, fashions. Morris (2015) notes "I was angry all the time" (p. 12); Van Winkle (2009) states "I wanted to be…less angry" (p. 161); and Lawrence "I'm angry all the time" (p. 92). The entangling of anger into all aspects of these individuals lives not only negatively impacted them, but also likely strained their relationships with others. Indeed, both Van Winkle (2009) and Morris (2015) describe strain in their romantic relationships post-trauma.

Lawrence (2017) provides additional powerful evidence for the debilitating effects of the depressed and disconsolate mood she experienced for years after her trauma. To provide just one of her many poignant examples:

> My real self is a murderous, hateful monster that I keep coiled neatly…in my belly. I pray for mass-extinction of our species. I want to be dead. I want everyone

else to be dead. This monster occasionally spews out venom and puts me in danger. I try to control her, but she lurks just under the surface. (p. 111)

Through her description of herself as a "monster," and her expression that she wishes for herself and everyone else to be dead, Lawrence clearly evidences negative thoughts and feelings. Further, it is made obvious through the intensity behind her words that such negative feelings would have the potential to cripple Lawrence's capacity to carry on with her life. Indeed, Lawrence (2017) relates many examples where she breaks down crying at seemingly inappropriate, and inopportune, times, forcing her to remove herself from many situations and often causing rigors demanded of her in everyday life to be nearly unmanageable.

Increased Arousal and Reactivity

As with the other symptoms, increased arousal and reactivity in PTSD can manifest in several different ways: hypervigilance, irritability or aggression, increased startle reaction, difficulty concentrating or sleeping, or engagement in risky behavior (APA, 2013). Put simply, individuals with PTSD have more reactive sympathetic nervous systems—the system responsible for the "flight-or-flight" response. As Van Winkle aptly (2009) puts it, when he finds out that he is suffering from panic attacks, "for some reason my mind had been putting my body into fight-or-flight mode when there wasn't any danger present" (p. 131).

Morris (2015) similarly describes his reactive symptoms: "I became irritable whenever someone walked behind me on the street, feeling their presence like heat on my

back… I watched rooftops without even meaning to and searched the roadway for IEDs" (p. 57). In this quote, Morris demonstrates increased irritability when he feels people are walking too close to him, as well as hypervigilance in his extreme alertness of threat, even when such threat is highly unlikely. Such behavior causes him to view benign, and even supposedly pleasant, environments through a threatening lens, likely inhibiting him from enjoying luxuries that so many take for granted, such as going on an evening walk.

Lawrence (2017) also struggles with the hyperarousal caused by PTSD, describing feelings of being overwhelmed when there are too many people around, of needing to have the perfect seat in the classroom with a good view of everyone else and of the exit. For example, in one instance, she describes "Suddenly I am overwhelmed by the noise and color, and without thought except escape, I set my loaded try down on the floor and leave" (p. 103). While this may not be as obvious an example of hypervigilance and increased arousal, it could still be classified as such. Indeed, feeling overwhelmed in a situation that would not be overwhelming to most, Lawrence demonstrates that she is aroused and startled more easily. This is also reflected in her need for an "escape" from an otherwise nonthreatening situation. Regardless of the presentation, it is clear by all of these individual accounts that hyperarousal impedes on their ability to engage with and/or enjoy activities that others take for granted.

PTSD and Alcohol Abuse

As with any psychological disorder, there are many other challenges that accompany PTSD. One major challenge facing those suffering from PTSD is substance

abuse: an estimated 40 percent of individuals in treatment for substance abuse also have PTSD (Dansky, Roitzsch, Brady, & Saladin, 1997 as cited in Volpicelli et al., 1999). While abuse rates are troublesome across substances, populations with PTSD have an alarmingly high rate of alcohol abuse in particular. According to the USDVA (2015), rates of alcohol abuse within populations with PTSD vary from approximately 30 percent to as much as 75 percent, depending on the type of trauma that the individual survived. Interestingly, of the three survivors with PTSD whose stories are presented throughout this paper, one of them, Clint Van Winkle, turned to alcohol as a means of coping. This statistic, one of three—or approximately 30 percent, perfectly parallels the more conservative estimates of comorbid PTSD and alcohol abuse. This micro statistic helps to reveal the truth to these estimates. While it may seem suspiciously convenient that only one of the three memoirs depict PTSD and alcohol abuse, I assure you that this was not a motivating factor when I selected which memoirs I would use for this paper.

To be more specific regarding the rates of concurrent PTSD and alcohol abuse, up to 75 percent of survivors of abuse or violent trauma, and up to 33 percent of survivors of accident, illness, or disaster struggle with alcohol-related problems (USDVA, 2015). Further, according to the USDVA, as many as 80 percent of Vietnam War veterans who are struggling with PTSD also struggle with alcohol-related problems, indicating a high rate of alcohol-related problems in those who suffer from PTSD as a result of trauma related to combat (USDVA, 2015). A national, epidemiological study conducted in 2011 suggested that, overall, 40 percent of individuals with PTSD also met criteria for alcohol

use disorder (Pietrzak, Goldstein, Southwick, Grant, 2011 as cited in Carter, Capone, & Short, 2011). Alcohol abuse is the number one most prevalent co-occurring disorder among men with PTSD; among women with PTSD, alcohol abuse follows depression and other anxiety disorders as the highest co-occurring disorder, with nonetheless high rates (Jacobsen, Southwick, & Kosten, 2001).

There are many proposed explanations for the high rates of alcohol abuse among individuals with PTSD, and it is likely that all are to some degree true and that they vary between individuals. Further, it is worth noting that there is certainly a "chicken-or-the-egg" issue with regards to PTSD and alcohol abuse. That is to say, alcohol use may increase an individual's risk for experiencing a traumatic event, and therefore increase their likelihood for developing PTSD, just as the presence of PTSD may increase instances of alcohol abuse (Jacobsen et al., 2001). Here, I will focus on the latter, and on some proposed explanations for why individuals with PTSD may also struggle with alcohol abuse, and even dependence. In general, the most widely accepted mechanism of comorbid PTSD and alcohol abuse is though to be one of "self-medicating," meaning individuals with PTSD rely on alcohol as a means to alleviate their symptoms (Carter et al., 2011; Jacobsen et al., 2001; Robinson, Sareen, Cox, & Bolton, 2009; USDVA, 2015).

Implication of GABA in PTSD and Alcohol Abuse

One symptom of PTSD that alcohol appears to "medicate" is hyperarousal (Jacobsen et al., 2001). Dysregulation of the main inhibitory neurotransmitter of the brain, gamma-aminobutyric acid (GABA), in the corticolimbic system is implicated in

PTSD (Bremner et al., 2000; Geuze et al., 2008; Lu et al., 2017; Vaiva et al., 2006). The inhibitory benefit of GABA helps to regulate anxiety, and thus a decrease in GABA would lead to dysregulation of anxiety, and anxious responses, suggesting a role of GABA in the hyperarousal of PTSD. Conversely, alcohol is, by nature, what is known as a "depressant," meaning that it slows down nervous system activity by increasing GABA levels (Valenzuela, 1997). This depressing effect of alcohol likely serves to counteract the elevated nervous system activity that is characteristic of PTSD (Jacobsen et al., 2001). This explanation appears to be partially true of Van Winkle (2017), who, upon learning he was experiencing panic attacks, notes "the attacks only came when I was sober. So I started to drink even more" (132). Although alcohol may be effective at providing acute relief of symptoms, withdrawal from alcohol can lead to a further increase in arousal, which may have an additive effect with the hyperarousal symptom experienced with PTSD, thus ultimately leading to an increase in symptomology (Jacobsen et al., 2001).

Implication of Endorphins in PTSD and Alcohol Abuse

Another plausible mechanism that contributes to the self-medicating effects of alcohol on PTSD involves the body's natural pain and stress response, endorphins. During prolonged trauma, the body releases endorphins; this release is responsible for the physical and emotional numbing that occurs during the trauma itself (Volpicelli et al., 1999). Volpicelli et al. (1999) propose that with prolonged, uncontrollable trauma, there can be a habituation to the endorphins, causing them to have less of an impact once the trauma is over, leading to endorphin deficit, and thus an endorphin withdrawal.

Conversely, alcohol use tends to increase endorphin levels (Valenzuela, 1997; Volpicelli et al. 1999). The numbing and euphoric effect often experienced with the consumption, and overconsumption, of alcohol can be attributed to endorphins. As such, the "endorphin compensation hypothesis" proposed by Volpicelli et al. (1999) suggests that persons suffering with PTSD may rely on alcohol is a means to compensate for their decreased endorphin activity, and alleviate the symptoms of PTSD. However, once the effects of this maladaptive coping wear off, an individual will experience rebound endorphin withdrawal, leading to further increase in the desire for alcohol and initiating a vicious cycle of alcohol abuse (Volpicelli et al., 1999).

Implication of Dopamine in PTSD and Alcohol Abuse

Alcohol additionally likely interacts with dopamine, one of the primary neurotransmitters that mediates the brain's reward system, to temporarily alleviate symptoms of PTSD. Given that dopamine is widely considered to be one of the main neurotransmitters implicated in the reinforcement of addiction (Berke & Hyman, 2000; Wise & Bozarth, 1987), it should not come as a surprise that it is also implicated in the increased alcohol consumption seen in individuals with PTSD. Namely, alcohol increases dopamine levels in the brain, contributing to the feelings of pleasure associated with alcohol consumption (Di Chiara, 1997; Valenzuela, 1997). According to Enman, Arthur, Ward, Perrine, and Unterwald (2015), decreased dopamine levels may be implicated in the negative affect associated with PTSD. Specifically, reduced dopamine levels could limit feelings of pleasure, accounting for a loss of interest in activities and an increase in

negative thoughts and feelings. As such, the increase of dopamine levels brought about by alcohol helps to alleviate the symptoms of PTSD that may be caused by a decrease of dopamine. However, prolonged alcohol consumption can lead to tolerance, requiring even more consumption to yield the same result. Such tolerance serves to reinforce the alcohol abuse, and to further alter dopamine levels when alcohol is not present, causing negative symptoms of PTSD to persist.

Need for further treatment development

GABA, endorphins, and dopamine are likely only a few of the mechanisms implicated in comorbid PTSD and alcohol dependence. Further, none of these systems work independently; rather, they all interact with one another to reinforce the cycle of addiction (Valenzuela, 1997). Nonetheless, given the examples above, one can clearly see how alcohol might serve as a temporary "band-aid" to dull the debilitating symptoms of PTSD. However, I want to reiterate that alcohol provides only a temporary relief, and in the long term likely actually increases the negative outcomes of PTSD and prolongs overall recovery, as clearly outlined by the long-term effects described above.

I would posit that the prominent levels of alcohol-related problems among the population of those with PTSD serves as concrete evidence of failure to provide sufficient resources to those suffering from the disorder. Due to lack of valid coping mechanisms, many persons with PTSD feel compelled to resort to maladaptive coping mechanisms—such as alcohol consumption. Any mental disorder comes with many other vulnerabilities and concerns, and PTSD is obviously no exception. However, it is plainly

unacceptable for the lower end of the estimated rates of alcohol-related issues to still be as high as almost one in three individuals (USDVA, 2015).

Despite the fact that there are some effective treatments of PTSD, high rates of alcohol abuse underline a clear need to further treatment development. While for many individuals with PTSD these treatments are effective and can be implemented successfully, there is clearly a large population with PTSD where such is not the case. For one reason or another, the most widely accepted treatments may not be accessible or realistic for many individuals. As a repercussion, these individuals may turn to alcohol as a maladaptive method to attempt to alleviate the symptoms of their PTSD, as evidenced by the alarmingly high comorbidity rates. Given that high alcohol intake can, and will, ultimately make symptoms of PTSD worse, treatment research should attend to the comorbidity of these two issues and attempt to develop treatments that address both disorders simultaneously (Carter et al., 2011). For this reason, the next chapter of this paper will discuss my own independent research into a potential treatment target for individuals struggling with PTSD and alcohol related issues. Further treatment development is necessary to provide more directed support that addresses both disorders simultaneously. My research is aimed towards all of the individuals, such as Clint Van Winkle, who are struggling to cope not only with PTSD, but also with alcohol dependence.

II. THE EFFECTS OF ENVIRONMENTAL ENRICHMENT ON ALCOHOL CONSUMPTION POST-TRAUMA IN MALE SPRAGUE-DAWLEY RATS

In the previous chapter, I aimed to exemplify that PTSD is a severe, impairing, and pervasive psychological disorder, using a lens of people who have lived with the disorder. As mentioned previously, PTSD comes with many other vulnerabilities and concerns; one major issue facing those suffering from PTSD is alcohol abuse—estimated rates of alcohol related issues in PTSD vary from 30-75 percent, depending on the type of trauma that the individual survived (USDVA, 2015). Given that alcohol dependence will ultimately make PTSD symptoms worse, this maladaptive coping mechanism should also be addressed in treatment development. In light of this call to action, I recognize that, as a responsible scientist and a compassionate human being, I am just as responsible for accepting this task as any other individual. Indeed, it would be rather hypocritical of me to demand that other scientists take the time to research something that I have not researched myself. As such, this chapter will relate the independent research that I conducted, focused on potential treatment mechanisms for comorbid PTSD and alcohol abuse.

One possible non-pharmacological treatment for PTSD that also addresses voluntary alcohol consumption is environmental enrichment (EE). EE has been shown to decrease anxious behavior in rat models of PTSD (Varman & Rajan, 2015; Hendriksen, Prins, Olivier, & Oosting, 2010). In addition, EE has been shown to decrease drug seeking behaviors (Galaj, Manuszak, & Ranaldi, 2016; Hajheidari, Miladi-Gorji, &

Bigdeli, 2015; Zhang et al., 2016). While the literature on environmental enrichment and ethanol is less established, there is evidence to suggest that the impact of EE on voluntary ethanol consumption is the same (Holgate, Garcia, Chatterjee, & Bartlett, 2017; Pang et al., 2013). Thusly, environmental enrichment is clearly a valuable mechanism, both as a protective factor and as a therapeutic technique.

Recall from the previous chapter that GABA, endorphins, and dopamine are some of the neurotransmitters implicated in the higher rates of alcohol abuse among individuals with PTSD, increasing these neurotransmitter activities in the brain to temporarily dull the effects of PTSD. As such, in order to help deter alcohol consumption and help alleviate the symptoms of PTSD, EE should act on these same mechanisms. Indeed, there is some research to suggest that it does act on these systems in a way that would attenuate alcohol consumption.

In terms of GABA, Mora-Gallegos et al. (2015) found that young rats had elevated hippocampal GABA levels after three months of EE, relative to controls, while Liu, He, and Yu (2012) found increased GABAergic synapses in the dentate gyrus of the hippocampus in early postnatal rats reared in EE. TThe hippocampus was one of the places that Gauze et. al (2008) found significantly lower concentrations of GABA receptor binding in veterans with PTSD, as well as Lu et. al (2017) in rats exposed to trauma. As such, the increase of GABA in this particular region may help to alleviate some of the symptoms of PTSD.

While there is little research on EE's effect on endorphins specifically, Lee et al. (2013) did find increased opioid signaling after two months of enrichment. Given that endorphins are one class that that binds to opioid receptors, this could indicate that EE increases endorphin activity, negating the desire for alcohol to do so. Furthermore, substantial research indicates that exercise increases the secretion of endorphins (Dinas, Koutedakis, & Flouris, 2011; Dishman & O'Connor, 2009). Given that voluntary exercise, via running wheel, is often a part of environmental enrichment, this may be a mechanism by which EE serves to augment endorphin activity. Nonetheless, more research is necessary to make definitive conclusions on the effect of EE, as a while, on endorphins specifically.

Dopamine systems are also likely influenced by EE, but in a slightly different fashion. In their study, Lee et al. (2013) found a significant increase of genes associated with dopamine receptors and a significant decrease of those associated with dopamine transporters. Darna, Beckmann, Gipson, Bardo, and Dwoskin (2015) additionally found decreased dopamine transporter function and increased extracellular dopamine levels with EE. Given that dopamine transporter is responsible for the reuptake which terminates dopamine activity, a decrease in this transporter, along with an increase in receptors and dopamine levels, may indicate increased dopamine binding, and thus increased activity (Lee et al., 2013; Beckmann et al., 2015); this mechanism is likely similar to that of selective-serotonin-reuptake-inhibitors (SSRIs), or anti-depressants. The prolonged effect of dopamine caused by decreased transporters and increased receptors

may decrease the desire to seek such dopamine stimulation from alternative, exogenous means such as alcohol. It is additionally worth noting that Lee et al. (2013) suggest that EE downregulates GABA transporter in a similar fashion.

Few studies to date have examined the effects of environmental enrichment on voluntary alcohol consumption post-traumatic stressor, and those studies that have tend to look at the effects of EE as a protective factor, rather than as a therapeutic technique (EE implemented pre- versus post- stressor). For example, Bahi (2017) observed that 15 consecutive days of EE, following their stress procedure, could attenuate subsequent alcohol consumption, relative to controls housed in a standard environment (SE). Given that EE was applied after their stress procedure, their results do indeed support the efficacy of EE as a therapeutic technique for reducing anxiety. Their results additionally suggest that it is a useful protective factor to preventing subsequent alcohol consumption; however, since EE was applied *before* alcohol consumption it does not explicitly support the use of EE as a therapeutic technique to reducing alcohol consumption (Bahi, 2017). As such, while some studies do suggest that EE reduces voluntary ethanol consumption as a protective or preventive factor (Bahi, 2017; Marianno, Abrahao, & Camarini, 2017), to garner a more wholistic understanding we must study EE's efficacy as a therapeutic technique, when applied specifically post-stress and concurrently with alcohol availability.

Studying EE from a therapeutic perspective is particularly important considering that it is something that an individual with concurrent PTSD and alcohol abuse can

control in the moment, as a form of treatment, rather than something that they can only hope to have experienced prior to the onset of the disorder. This purpose of this study was to do just that. In particular, this study aimed to assess the efficacy of EE as a means to attenuate alcohol consumption and stress levels, specifically post-single prolonged stress. We first tested the rats for baseline anxiety levels, and then subjected them to a single prolonged stressor followed by a week-long incubation period. After testing them again for anxiety levels, we divided the rats into two groups, matched for anxiety; one group was housed in EE for three weeks, while the others remained in a SE. During this three weeks, all rats were also given intermittent access to ethanol. Following this three-week period, rats were tested for a third and final time for anxiety levels. We hypothesized EE rats would consume significantly less alcohol and display significantly less anxious behavior, relative to SE rats. This study could have possible implications on the therapeutic value of environmental enrichment to those who suffer from PTSD and struggle with alcohol dependence.

Methods

All testing procedures were approved by the Institutional Animal Care and Use Committee of Regis University in Denver, Colorado. For a full study timeline, see Appendix A.

Subjects

We used 19 adult male Sprague-Dawley rats for this study. The rats were housed individually in standard cages with pine shaving bedding, on a reversed 12-hr light/dark cycle (9:00am lights off, 9:00pm lights on) with *ad libitum* access to food and water.

Single Prolonged Stressor (SPS)

While there is no standard accepted rat model for PTSD, the SPS paradigm is a well-validated model and is widely used (Eagle et al., 2012; Eagle & Perrine, 2013; Liberzon et al., 1997; Yamamoto et al., 2009; Schöner, Heinz, Endres, Gertz, & Kronenberg, 2017). Specifically, SPS emulates PTSD resulting from an acute and extreme traumatic stress, similar to PTSD in humans that stems from a single trauma, rather than a chronic traumatic environment (e.g. chronic childhood abuse).

Using the SPS protocol, we first restrained the rats for 2 hours in rodent restrainers. Each restrainer was made from a 5" long by 2" diameter PVC pipe, with a plug placed on either end and holes drilled into it (see Appendix B). The restraint hold was immediately followed by a 20-minute forced swim task in ~24°C water and a container deep enough that the rats were unable to support themselves with their tail. We then allowed the rats to rest for 15 minutes, after which time we placed them in an induction chamber with a metal grate on the floor. Under the metal grate were two open petri dishes filled with ~50ml of diethyl ether anhydrous. We exposed the rats to ether until they lost consciousness (~2 minutes). We then monitored the rats until they regained consciousness, returned them to their home cage and left them undisturbed for a 7 day "incubation" period.

Environmental enrichment

Prior to the SPS, all rats were housed in a traditional rat cage. Following SPS and the 7-day incubation period, rats were split into two housing groups: enriched environment (EE; N = 10) and standard environment (SE; N = 9). The methods for environmental enrichment were adapted from Nobre (2016) and Galaja, Manuszakb and Ranaldia (2016). Rats were matched for anxiety increase from pre- to post-stressor according to results of the elevated plus maze (described below) and split into groups such that the mean anxiety increase of one group was not statistically different from that of the other. Rats in the SE group continued to be housed in the traditional cage throughout the experiment. EE rats were housed in the traditional sized cage as well, with additional enriching qualities. EE cages each contained a running wheel, a small ball with a bell, and paper towel/toilet paper rolls (which were replaced as needed). In addition, the rats were exposed to two novel objects every day (excluding weekends). Objects were things such as a mug, a golf ball, glass objects of various shapes and sizes, PVC pipe, etc. See Appendix C for an example of an enriched cage. Upon completion of the study, each EE rat had been exposed to 30 novel objects. Objects were sterilized when moved to a new cage. In order to observe whether or not the animals were using the running wheels, and how much, we recorded the number of wheel rotations for every 24-hour period.

Two-Bottle-Choice Drinking Paradigm (TBC)

These methods are the same as those used by Simms et al. (2008). Following SPS, rats were given intermittent access to 20% ethanol without sweetener for three 24-hour

sessions per week (Monday, Wednesday, Friday), for a total of nine days of exposures (3 weeks total). During ethanol exposure, we gave the rats access to both a bottle of standard drinking water and a bottle of 20% ethanol, which were inserted on either side of the wire lid covering the cage; the left-right placement of the bottles was randomized to control for side preference. On days where ethanol was not present (Tuesday, Thursday, Saturday and Sunday), both bottles contained water. We changed the fluids within 15-60 minutes of the onset of the dark period of the reversed light/dark cycle. We measured all fluids (to the nearest gram) 24 hours after presentation (during the time of liquid change), in order to calculate total liquid intake and ratio of ethanol to total intake.

Elevated Plus Maze (EPM)

EMP is a well-validated model for measuring anxious behavior in rodent models (Sestakova, Puzserova, Kluknavsky, & Bernatova, 2013). The maze consists of four intersecting arms in the shape of a plus ("+"). Each arm is 30" long and 4" wide; two of the arms are open, and two have 4" high black walls lining the edges. The maze was suspended approximately 30" off the ground. The maze was cleaned and dried thoroughly between test subjects.

We performed three EPMs over the course of the study: one to establish baseline anxiety, one after SPS protocol, and one after the housing and TBC protocol. Rats began the EPM session at the center of the maze, where the arms cross. Activity on the EPM was recorded by overhead camera for 5 minutes. Later, we scored the rats for total amount of time spent in each type of arm (open, closed, and neutral) and total number of

arm crosses, from open to closed to neutral (as a measure of overall activity). To determine groups for enrichment, increase in anxiety from baseline was measured by subtracting the amount of time spent in the closed arm at baseline from that of post-stress (time spent in the closed arm is generally accepted to be an indicator of anxiety, such that more time in the closed arm indicates more anxiety).

Statistical Analysis

All statistical analyses were performed using JMP statistical software. To measure differences of alcohol consumption between groups, we computed a 2 x 9 Repeated Measures ANOVA of housing condition (EE vs. SE) by ethanol exposure (exposure one through nine). For our interaction, we performed a post-hoc 2-tailed t-test at each time point. To measure differences in anxiety before and after SPS, we completed a 2-tailed t-test between the first and second EPM for time spent in closed arm and overall line crosses. To measure differences in anxiety between the two housing conditions, we completed a 2 x 2 repeated measures ANOVA of housing condition (EE vs. SE) by EMP (two vs. three), for time spent in closed arm and overall line crosses.

Results

Ethanol Consumption

Water bottles that had obviously leaked, either totally or partially, were excluded from analyses. Ethanol consumption was measured as a percentage of total liquid consumption, to ensure that differences in ethanol consumption were not merely due to differences in overall liquid consumption. We found a main effect of housing on ethanol

consumption, such that the SE group consumed significantly more ethanol than the EE group, $F(1, 11) = 12.87$, $p = .0043$. Additionally, we found a main effect of time, such that overall ethanol consumption decreased over time, from the first to the ninth ethanol exposure, $F(8, 4) = 50.4732$, $p < .001$. However, it is important to note that post-hoc analysis showed that there was a significant increase in ethanol consumption from exposure one to two, $p < .001$. We found a significant interaction between housing and time, such that EE yielded a decline in ethanol consumption over time, whereas SE consumption remained consistent, $F(8,4) = 15.51$, $p = 0.0092$. Post-hoc analysis showed that there was no significant difference between the groups on the first and second exposure days, $p = .62$ and $p = .15$, respectively. However, by the third exposure, and again on the fourth exposure the EE groups consumption started to decrease and they had significantly less consumption than the SE group, $p = .033$ and $p = .0039$, respectively. There was no significant difference between groups on the fifth day of exposure, $p = .20$; the difference between the groups at the sixth exposure neared significance, $p = .06$. On the seventh, eighth, and ninth exposures, the differences between the groups were again significant, $p = .018$, $p = .0066$, and $p < .001$, respectively. For a depiction of main effects and interaction, see Figure 1.

Difference from First to Second EPM

There was no difference in time spent in closed arm from the first to the second EMP, before versus after SPS, $F(1, 18) = 0.38$, $p = .54$, Figure 2. Additionally, there was no difference in line crosses, $F(1, 18) = 0.087$, $p = .77$.

Difference from Second to Third EPM

An SE rat in the fell off of the maze during the third EPM and is thus excluded from this analysis; the rat was unharmed. There was a significant decrease in time spent in the closed arms from the second to the third EMP, before versus after housing conditions and ethanol exposure, $F(1, 16) = 22.13$, $p > .001$. There was no difference in time spent in the closed arms between the two housing conditions, $F(1, 16) = 1.03$, $p = .32$. There was also no interaction of EPM session and housing condition on time in closed arm, $F(1, 16) = 0.60$, $p = .45$. See Figure 3 for a depiction of time spent closed arm from EMP session two to three, by group.

There was additionally a significant increase in overall amount of line crosses from the second to the third EPM, $F(1, 16) = 10.95$, $p = .0044$. There was no difference in line crosses between the two housing conditions, $F(1, 16) = 1.22$, $p = .28$. There was also no interaction of EPM session and housing condition on line crosses, $F(1, 16) = 3.93$, $p = .065$.

Running

Recall that only rats in the EE condition had access to running wheels. We found that the amount of running (measured by number of wheel rotations) increased over time, $r^2 = .59$, $p < .001$. Further, we found a negative correlation between ethanol consumption and running, such that as running increased, ethanol consumption tended to decrease, $r^2 = .19$, $p < .001$. See Figure 4 for a depiction of running versus ethanol consumption over time.

Discussion

Environmental enrichment has been shown to decrease anxious behaviors (Varman & Rajan, 2015; Hendriksen et al., 2010), as well as reduce drug seeking behaviors (Galaj et al., 2016; Hajheidari et al., 2015; Zhang et al., 2016). For these reasons, in this experiment we looked at the efficacy of environmental enrichment as a treatment mechanism for concurrent PTSD and alcohol consumption. To do so, we subjected 19 rats to a single-prolonged-stressor, a well validated protocol for creating a rat model of PTSD (Eagle et al., 2012; Eagle & Perrine, 2013; Liberzon et al., 1997; Yamamoto et al., 2009; Schöner et al., 2017). Following, the rats were split into two housing conditions, standard environment and enriched environment, and exposed to alcohol for three days a week for three weeks, according to the two-bottle-choice drinking paradigm (Simms et al., 2008).

Effect of EE on Ethanol Consumption

In order to assess the effectiveness of EE for reducing alcohol consumption, we measured the animal's ethanol consumption as a percentage of the total liquid consumption and compared between the two groups. We hypothesized that animals housed in the EE condition would consume significantly less alcohol as compared to those in the SE condition. Unsurprisingly, there was no significant difference in ethanol consumption between the two groups early on in the housing condition (i.e. on the first and second ethanol exposure, or the first and third days of housing condition). However, by the third ethanol exposure, which was the fifth day of housing condition, EE rats

consumed significantly less ethanal than SE rats. This significant difference persisted on the fourth and the seventh through ninth ethanol exposures (eighth and eleventh through fifteenth days of housing, respectively). These interactive results between housing and time suggest that EE is indeed a valuable treatment in attenuating ethanol consumption, consistent with previous research on the effects of EE on ethanol consumption (Holgate et al., 2017; Pang et al., 2013). Interestingly, we observed that the SE rat's ethanol consumption remained more consistent across exposure, whereas EE rat's consumption tended to decrease more drastically over time. This result suggests that EE helps to actually reduce ethanol consumption over time, rather than just preventing it from increasing, further validating the efficacy of EE as a treatment for alcohol abuse.

Within our EE group, we observed a correlation between amount of running and ethanol consumption, such that as running increased, consumption decreased. These results are consistent with previous research on the effects of voluntary exercise on ethanal consumption (Darlington, McCarthy, Cox, & Ehringer, 2014; Gallego, Cox, Funk, Foster, & Ehringer, 2015). Indeed, according to Darlington et al. (2014), voluntary exercise likely activates the dopaminergic reward system, and thusly acts as a kind of substitution for ethanol. Given that we had no other dependent measures for EE, it is difficult to conclude whether or not our results are due to the effects of the running, or due to the EE as a whole. However, many studies have looked at the effects of EE without the presence of a running wheel and still found beneficial effects (Bahi, 2017; Hendrickson et al., 2010; Pang et al., 2013). For example, Bahi (2017) found that EE

blunted subsequent ethanol consumption, and their EE method did not involve a running wheel. Further, Hendrickson et al. (2010) looked at the effects of EE with running wheel versus without and concluded that the effect of EE on anxiety is not due solely to the effect of voluntary exercise *per se*. Studies such as these suggest that our results of the effects of EE on ethanol consumption are not due to voluntary exercise alone, but a combination of factors that EE provides. However, future studies of this kind should include one group of EE with a running wheel and one without, in order to help illuminate which factors of EE, if any, are the most beneficial.

Because we did not use any neurotransmitter agonists or antagonists or any immunohistochemical imaging methods, we cannot make any definitive conclusions as to which neurotransmitter systems might be implicated in the beneficial impact of EE on voluntary ethanol consumption, such as the GABA, dopamine, and endorphin systems speculated earlier in this paper. Future studies should include groups of animals treated with specific neurotransmitter agonists and/or antagonists, to help elucidate exactly which mechanisms are affected. For example, a study might have a group housed in SE conditions, but treated with a dopamine agonist to determine of the effects are similar to that of the EE condition.

Effect of EE on Anxiety

In order to assess the effectiveness of enrichment for attenuating anxiety, we used the elevated plus maze to measure anxiety levels before and after housing conditions. Based on previous research, we hypothesized that the rats in the EE condition would

exhibit less anxious behavior, reflected as less time spent in the closed arms of the EPM. Insignificant differences in anxiety levels between the two groups at the end of the three-week housing protocol is inconsistent with previous research showing that EE reduces the effects of post-stress anxiety (Bahi, 2017; Marianno et al., 2017; Varman & Rajan, 2015). However, most studies on the effect of EE on anxiety observe it as a protective factor, where animals are reared in EE and then exposed to stress, rather than a therapeutic factor, where animals are exposed to EE after they are exposed to stress. The fact that we did not see any difference in anxiety between the EE and the SE group seems to suggest that enrichment does not have a therapeutic effect on anxiety after stress. However, this does not mean that there is no benefit of EE, as it may help to attenuate other symptoms of PTSD

Most studies that do look at the therapeutic effects of EE on anxiety are interested specifically in these effects after stress—that is, EE is shown to reduce anxiety levels after anxiety levels have been increased due to stressor (Hendrickson et al., 2010). It is possible that EE only serves to decrease anxiety in the context of abnormal anxiety but has no effect on normal levels of anxiety. Indeed, Goes, Antunes, and Teixeira-Silva (2015), who studied the effects of EE on baseline anxiety levels (i.e. without any stress), only found an effect in rats who naturally expressed higher baseline anxiety, as compared to the other rats in the study. Given that we did not see an increased level of anxiety from baseline to post-SPS, all of our rats may have had normal levels of anxiety, therefore explaining why we saw no effect of EE.

In saying that, I should also note that we were surprised to find that the rats had the same levels of anxiety before and after SPS. SPS is a well validated model of PTSD, and we followed this protocol without modification to the best of our knowledge and ability. Due to limited resources in this study, we did not include a control group of unstressed rats. As such, it is impossible to make any definitive conclusions of the effects of the SPS, given that we have no unstressed group against which to compare. It is certainly possible that the anxiety levels exhibited by a control group would have been significantly lower than that of our animals subjected to SPS. Further, we may have observed an even greater decrease in anxiety over the course of the study in unstressed animals than we observed in our stressed animals. Future studies of this kind should include a control, unstressed group in order to accurately determine the effects of SPS. Indeed, many studies that do so find significant differences in measures of anxiety between the two groups (Schöner et al., 2017; Yamamoto et al., 2009). Further, there are uncontrollable individual differences in the likelihood of developing PTSD, such as slight genetic variation (Pitman et al., 2012; Brewin et al., 2000). As such, it is possible that while some of our rats did develop PTSD from SPS, others did not, diluting the observable results of those that did. In order to reduce this effect, we matched groups for anxiety; however, the number of rats with PTSD may have still been too greatly outnumbered by those without. Therefore, future studies with greater resources should separate rats that display PTSD-like symptoms from those that do not, as well as include a control group of rats that are not exposed to any stress at all.

Another possible explanation for why we saw no difference in anxiety levels between the two housing conditions or from pre- to post-stressor could be that our measurement for anxiety was invalid. Indeed, while EPM is a widely accepted measurement of anxiety (Sestakova et al., 2013), it may have been inappropriate for measuring the specific type of anxiety induced by our stressor and attenuated by EE. For example, Goes et al. (2015) found an effect of EE on anxiety measured by the free-exploratory paradigm (FEP), but none for that of the EPM. They suggest that EPM measures state anxiety, or anxiety that the subject experiences when facing a threat (i.e. the open arms of the maze), whereas FEP measures more stable baseline anxiety levels, where no threat is present (Goes et al., 2015). Hendrickson et al. (2010) used the open field test (OFT), but not EPM, as their behavioral measure of anxiety after inescapable foot shock. Further, auditory startle response is often used as a measurement of anxiety induced by SPS (Yamamoto et al., 2009). It is possible that we may have seen different results if we had used different measures of anxiety, such as FEP, OFT, or startle response. Futures studies of this kind should look at other behavioral measures of anxiety such as these and should use more than one measure.

One final explanation is that our results may have actually been an effect of repeated testing, given that there was an effect of EPM session on anxiety such that anxiety levels decreased from the second to the third EMP. That is, the rats may have become accustomed to the EPM and therefore increased time in the open arm of the maze is not due to decreased anxiety in general, but rather to a familiarity with the maze itself.

The effect of repeated testing may have also equalized the two groups, eliminating any differences between the two groups that we otherwise would have been able to observe; this could theoretically be true of any behavioral measure that is repeated over time. Additionally, some studies that do find significant biological difference between SPS and control groups still see no differences in behavioral measures on anxiety (Eagle et al., 2013). For these reasons, it is important that future studies look at more biological levels of anxiety, such as blood corticosterone levels (Eagle et al., 2013; Yamamoto et al., 2009).

Finally, it is entirely possible that EE helps to attenuate other symptoms of PTSD, such as invasive reexperiencing of the event, that is difficult to measure in a rat model. If this were the case, new measures need to be developed to help measure other PTSD symptomology in rat models. Overall, inconsistent results in the effects of EE on anxiety levels illuminate the need for more research to attempt to uncover exactly which aspects of EE are beneficial, in an effort to harness these factors into an effective treatment mechanism.

Limitations

As with any study, our study results should be considered in light of our limitations. The greatest limitation of this study already mentioned was small sample size and limitations in the number of groups (i.e. we did not have a control, non-stress group). Further, due to limited resources, we were also unable to utilize any neurotransmitter agonists/antagonists or perform any immunohistochemistry which would be necessary to

look at the brain and neurochemical mechanisms implicated in the effects of SPS and/or EE on ethanol consumption and/or anxiety levels. Another limitation was due to inadequate materials; namely, the bottles used to hold the ethanol and water were prone to spillage, causing a loss of data on several days. Finally, due to time constraints our housing condition and ethanal exposure only lasted for three weeks, whereas similar studies tend to last several more weeks. We have no way of knowing whether the differences we observed would have been greater or lesser given more time.

III. APPLICATION OF ENVIRONMENTAL ENRICHMENT IN HUMANS

The results of our independent research suggest that enrichment could be a very valuable mechanism as a treatment for alcohol abuse after stress. Lack of observable differences before versus after the stress makes it difficult to conclude with certainty that these results are true for PTSD. However, given that our animals were certainly stressed, it seems reasonable to assume that these results would have been consistent if we had observed measurable levels of PTSD symptomology. Given the results our study, it is likely that environmental enrichment could be a valuable treatment for preventing and treating alcohol abuse in persons struggling with PTSD.

Evidence of the Benefits of Enrichment in Humans

Unfortunately, there is limited empirical research into the effectiveness of environmental enrichment in human subjects. Because pharmacological treatments can be effective at treating PTSD, it would be unethical to ask persons with PTSD to withstand from such treatments, which could be helping them get better, for the sake of a randomized, controlled clinical trial. If there were a clinical trial into the effectiveness of environmental enrichment in the human population, it would likely need to be in concordance with pharmaceutical treatments. Nonetheless, anecdotal evidence provided by Morris, Lawrence, and Van Winkle, in addition to evidence in rat models, suggests that environmental enrichment would in fact be successful.

Before moving forward, I would like to acknowledge that I am aware that there may be some misconception regarding what I mean by “environmental enrichment.” To

be clear, “environmental enrichment” is not the same thing as a distraction or acute sensory stimulation. I am not suggesting the persons with comorbid PTSD and alcohol abuse should merely seek distraction in their life, and they’ll forget about their PTSD. I could see how this assumption might be made. On the contrary, enrichment entails something much more meaningful than a mere distraction. It entails novelty, engagement, intention. Certainly, finding enrichment as a successful attenuation of PTSD symptoms and alcohol consumption varies between individuals. What is enriching to one individual may not be to another.

One plausible example of environmental enrichment in the human population is presented by Morris (2015), when he describes how many persons with PTSD seek out travel as a form of coping. It seems likely that travel, experiencing new places and cultivating new memories outside of their trauma, could serve as a form of environmental enrichment. Morris (2015) claims, “the urge to reinvent one’s moral and physical universe through travel is so common that some students of trauma think it might be biological” (p. 75) Indeed, anyone who has traveled will likely agree that intentional and meaningful exploration of a new place would adequately qualify that place as an “enriching environment,” particularly if the traveler were to allow that place to have a positive and profound impact on their self. For example, Van Winkle (2009) moves with his wife to Wales for graduate school. He states, “it was time to move on, time to see a different part of the world, time to take control of my life” (p. 179). In listing these three things together, Van Winkle (2009) implies that they are all interrelated: seeing a

different part of the world will help him to move on and take control of his life. Indeed, Van Winkle (2009) does confirm upon returning that, while he still had some ways to go, Wales did help with his healing process. Surely individuals who rely on travel as a form of coping with PTSD, and, in the case of Van Winkle alcohol abuse, have tapped into environmental enrichment as a treatment mechanism.

While that's all well and good, the reality is that not many have the resources, financial or otherwise, needed to engage in the travel described by Morris (2015). He gives an example of an Iraq veteran who has moved almost every year since his return from Iraq; for most, particularly those with family obligations, this is simply out of the question. However, the components of environmental enrichment that are satisfied by travel can likely be satisfied by mechanisms that are more accessible to all. Lawrence (2017), for example, describes a period of time where she found peace in her dedication to Hinduism and to her own spirituality. To be clear, I am not suggesting that persons with PTSD merely need to move to a new country or convert to Hinduism to get better. Rather, what I am suggesting is that the pursuit of enrichment, of novelty and meaning, can be found through other, more accessible and commonplace, means, such as the exploration of literature, dedication to a new craft, commitment to specific field of study. As such, "environment" does not necessarily have to mean a physical, external environment, but could mean enriching the internal environment that any person is almost certainly surrounded with at all times—the mind. Certainly, the biographical authors cited in this paper, Morris, Lawrence, and Van Winkle, tapped into

environmental enrichment through the creative and meaningful process of relating their stories.

I would like to note that my intention is not to oversimplify PTSD. Undoubtedly the already tedious task of seeking successful environmental enrichment is made even more dauting in the midst of the debilitating disorder, let alone two when you also consider alcohol abuse. Further, environmental enrichment likely serves as a mechanism to attenuate symptoms; the elimination of symptoms likely requires complex and individualized treatment that goes beyond enrichment. These factors, combined with the ever-present individual variation, makes any certainty nearly impossible. Therefore, let me be clear: this is no simple issue. However, what I hope to have highlighted here is that environmental enrichment is a plausible treatment route for both alleviation of PTSD and attenuation of alcohol consumption. It is a treatment mechanism that has already been proven successful for rat models of PTSD (Varman & Rajan, 2015; Hendriksen, Prins, Olivier, & Oosting, 2010), and one that many with the disorder seem to have already successfully tapped into as a means to treat their symptoms. Therefore, even in the absence of empirical research, there is certainly no harm in clinicians suggesting that their patients seek out intentional enrichment in their daily lives—it would not make the symptoms any worse, and indeed may very well help them improve. Let us work to expand the population that is able to benefit from environmental enrichment as a treatment, such as to those with comorbid PTSD and alcohol abuse.

Cura Personalis in Environmental Enrichment

In its accessible and meaning making nature, environmental enrichment as a treatment mechanism encapsulates the Jesuit tradition *cura personalis,* Latin for "caring for the whole person" (Regis, 2018). The tradition of caring for the whole person entails caring for the mind, body, and spirit in promotion of their human dignity (Regis, 2018). Unfortunately, in our modern pharmacological world, one of the most widely used treatments for PTSD are antidepressants (Hendrickson et al., 2010; Pitman et al., 2012). While pharmacological treatments can be very valuable at treating the symptoms of a disorder, antidepressants alone do not provide wholistic treatment for PTSD. Mere pharmacological treatments are not aligned with *cura personalis*. While they may be helpful for attenuating some of the biological, or bodily, impact of by PTSD, they only address part of the problem.

Van Winkle (2009) says of the appointment where he was first diagnosed with PTSD: "And that was it: [The nurse] stood up and pointed me on my way. I left the clinic with a prescription of antidepressants I had no intention of taking and an appointment four weeks later for an initial consultation" (pp. 39-40). Due to the assumption that antidepressants are the catch all solution for PTSD, Van Winkle is clearly not being shown *cura personalis.* This is especially true considering Van Winkle was not even asked whether this was a treatment route that he wished to pursue—and it clearly wasn't. Admittedly, antidepressants may have been helpful to helping with some of Van Winkles symptoms of PTSD, such as his negative affect; however, he was given no options to

help cope with the other symptoms he was facing. Antidepressants alone cannot be the catch all solution for treating those with PTSD, as they clearly leave out care for the mind and the spirit of the person.

Environmental enrichment, on the other hand, is clearly attuned to *cura personalis*. The intentional seeking out of enriching and meaningful environments promotes engagement of the mind and the spirit. It necessarily requires that the person engaging in the enrichment consider what they would find meaningful and captivating as a form of meaning making. If such were not the case, it would not be enriching and therefore not be considered environmental enrichment—it would just be an environment. By realizing the intertwining of the non-physical mind with the physical body, the goal of enrichment is to better the persons psychological health, to in turn better their physical health.

Caring for the whole person with treatments such as environmental enrichment also serves to uphold the dignity of the person being treated because it acknowledges the complication and depth that each person holds, recognizing that everyone is on their own journey and needs personalized treatment to accommodate that. Conversely, pharmacological treatments only recognize a person as far as their biological mechanisms that can be influenced through medication, reducing humans to their materialistic selves without regard for the immense complexity that transcends tangible matter. Assuming that humans are only as complicated as the matter that makes them up is reductionistic and does not uphold dignity and respect. As such, pharmacological treatments alone are

unsubstantial, whereas treatments such as environmental enrichment capture all aspects of *cura personalis*. Continued research into such treatments that uphold the Jesuit tradition of *cura personalis* is important to providing wholistic and substantial care to persons with PTSD and other mental health disorders.

Final Thoughts

The goal of this paper was to illuminate the stark and pervasive societal issue of PTSD and comorbid alcohol abuse, as well as provide research for a potential treatment mechanism for the issue. By going into detail about the symptoms of PTSD, using examples of real people who have suffered from the disorder and boldly chosen to share their stories, I hope to evoke greater understanding and empathy for those facing a disorder which eight percent of the population will experience as some point in their life. My research suggests that an enriching environment could be a viable treatment to diminishing the alcohol issues with which so many with PTSD struggle.

Further research into the efficacy of EE as a treatment for comorbid alcoholism and PTSD, and other non-pharmacological treatments, are vital to improve support for this population—a population which, historically, has not been given nearly enough care. Research should aim to uncover exactly which factors of enrichment are the most valuable, in order to harness these mechanisms to create the most effective and substantial treatment possible. Unlike pharmacological therapy, forms of therapy such as this would be available at little to no cost, and, presumably, would not pose any threatening side effects, which are always a concern with medications. As a caring and

compassionate population, we have the responsibility to conduct further research to help to expand our knowledge of symptoms and vulnerabilities associated with PTSD and alcohol dependence. The expansion and continuation of such research, not only into PTSD but mental disorders as a whole, is important to ensure equal opportunity and care for all.

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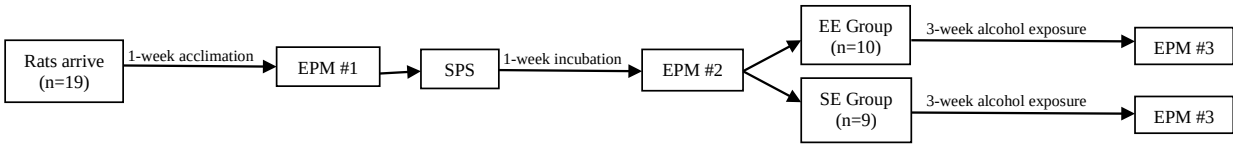
Appendix A: Study Timeline



Appendix B: Rodent Restrainers

These rodent restrainers were used for the 2-hour restraint hold during the single prolonged stress. Each restrainer was made from 5” L X 2” D PVC pipe, with a plug on either end. We drilled 0.5” holes into either end and the sides of the pipe, to allow both air flow and visibility.

Picture: Analyse DeSousa

Appendix C: Example of an Enriched Environment

EE boxes each contained a running wheel, a small ball with a bell, and paper towel/toilet paper rolls (which were replaced as needed). The rats were also exposed two novel objects every day (excluding weekends). Such objects included a mug, a golf ball, glass objects of various shapes and sizes, PVC pipe, etc. The novel objects in this particular example are the coffee mug and the colorful plastic toy.

Picture: Analyse DeSousa