EXPLORATION OF THE OLFACTORY SYSTEM AND AUTOMATIC MEMORY ENCODING

A Thesis

by

RENE WALLACE

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Chair of Committee,	Heather A. Labansat, PhD
Committee Members,	Thomas J. Faulkenberry, PhD
	Amber Harris Bozer, PhD
Head of Department,	Thomas J. Faulkenberry, PhD
Dean, College of Graduate Studies,	Credence Baker, PhD

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Abstract

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The concept that olfaction and memory influence each other has been explored for decades, however the idea that the odor could be an essential oil that students could use to improve test scores is a relatively novel area of research. The present study examined the process of encoding via the olfactory system into long-term memory by using essential oil as a retrieval cue. Participants (N = 112) were recruited and then split into three experimental conditions, Control, Essential Oil at Encoding and Retrieval, and Essential Oil at Encoding Only. Only the peppermint essential oil was manipulated among experimental conditions. First participants signed a consent form, took the PANAS, Session Evaluation Questionnaire, Need for Cognition, completed a 45-minute study session, had a 10-minute break, took a 15-minute free-recall exam, a 50-question multiple choice test, completed the Subjective Graphing Measure, then took the PANAS a second time and were debriefed. Results of the free recall and multiple-choice memory tests indicated that the essential oil did not show a significant increase in recall and recognition memory scores across conditions, however the essential oil did have a significant interaction with certain individual difference measures such as Need for Cognition and PANAS scores. Although Need for Cognition was a large predictor of how well an individual scored on a test of memory, there may be certain groups of people for

whom this encoding strategy may be effective for, and further research should be done in this area to determine future implications.

Keywords: olfactory system, long-term memory, essential oil, state-dependent learning, context- dependent learning

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CHAPTER I

Whether one is learning new material for academic purposes, occupational reasons, or for social interactions, sometimes the information a person thought they memorized seems to disappear which can leave people frustrated and discouraged. The problem of retrieving information is typically not a "memory" problem as people tend to assume but is instead an encoding problem. Extensive research demonstrates that one's ability to recall information is greatly influenced by the encoding process of that information (Smith, at al., 1978; Carter & Cassaday, 1998). Furthermore, researchers conclude that the encoding process can be improved if certain encoding strategies are used (Thompson & Tulving, 1970; Scullin et al., 2018). The focus of the present experiment is to explore if the olfactory system can be used to automatically improve encoding by adding implicit retrieval cues to the information.

When learning, information is coming to an individual through sensory input and the new information must be "encoded" in a way that makes sense for the memory system to store that new information. Encoding is the very first step where information is transformed (whether internal thoughts or external events) and changed into a form the brain can store. The storage location could be short or long-term memory based on how well the information is encoded. Thompson and Tulving (1970) state that encoding itself is the key to effective retrieval. The encoding process is a facet of a much larger system known as memory. The most widely accepted theory of how the memory system works is the Atkinson-Shiffrin model. Atkinson and Shiffrin (1968) state that memory is not one step but is a series of processes. Specifically, the Atkinson Shiffrin model states that memory is made up of three distinct processes. These processes are sensory memory, short-term memory which is also referred to as working memory, and long-term memory.

Encoding can happen in any of these processes, but it generally occurs in the transition from short-term to long-term memory (Atkinson and Shiffrin, 1968).

The two main methods through which individuals normally encode information are through controlled processing and automatic processing. Most encoding strategies used by students are within the controlled processes and are effortful, purposeful methods that attempt to encode information for later retrieval. Controlled processing is generally deliberate, elaborative, and takes strategic effort on the part of the learner (Scullin et al., 2018).

Alternatively, some memories are encoded quickly and implicitly with minimal cognitive effort from the learner and in some instances, the individual does not even pay conscious attention to the information at all for the memory to be successfully encoded (Scullin et al., 2018; Barzykowski et al., 2019). Known as automatic processing, it appears to happen for procedural and motor memories, and for classically conditioned behaviors (Tulving & Szpunar, 2009; Radvansky & Tamplin, 2012, Kirsch & Boucsein, 1997). Perhaps out of these, the greatest example of automatic processing is classical conditioning. Classical conditioning, where an unconditioned stimulus is paired with a naturally occurring stimulus and a connection is made (Schreurs, 1989) has been studied since Ivan Pavlov first explored the concept in 1902. However, the idea that an automatic connection could be used to encode information that is normally effortful has not been widely explored. When classical conditioning is looked at in light of a concept called biological preparedness, it is seen that most connections or associations have a biological explanation (DeSilva, 1988). Presumably because humans and animals have a predisposition to create associations between certain stimuli and responses out of a survival instinct (Davey, 1995). Two of the most common associations in biological preparedness in humans are taste and smell (LoLordo & Droungas, 1989).

Since it has been determined that external environmental factors and internal physiological factors can play a crucial role in memory formation and retrieval, the olfactory system is an exciting direction for researchers to continue to explore (Radulvic, at al., 2017; Godden & Baddeley, 1975). The phenomenon where one's own internal physiological condition affects memory retrieval is called state dependent learning, (SDL) whereas when the environment affects information encoding it is known as context dependent learning, (CDL) (Peters & McGee, 1982; Tulving, 1983, respectively).

SDL is explained as information storage and retrieval that is restricted to certain physiological states (Radulvic, et al., 2017). Meaning that the internal physical state an individual is in when the information is acquired would be the best state for recall (Peters & McGee, 1982). Examples of the SDL phenomenon have been found by Cane and Ross (1989), and Grant et al. (1989). Cane and Ross (1989) discovered that if the olfactory environment is the same during the initial learning setting and the retrieval setting, then memory performance is significantly better. Improved memory was also found to be true for sounds as Grant and colleagues (1989) found that auditory cues can better enable encoding when replicated from learning to testing environments. Grant and colleagues (1989) found that whether students learned information in a quiet setting or a noisy setting, they were best able to retrieve the information in the same level of auditory stimulation as the learning occurred.

In contrast, context-dependent memory looks at how external environmental cues affect memory retrieval (Godden & Baddeley, 1975; Smith, et al., 1978; Tulving, 1983). Godden and Baddeley (1975) conducted an experiment where they asked underwater divers to learn a list of words. Some divers learned the list on the shore and some underwater. When asked to perform a free recall of the word list some of the divers were tested in the same environment in which they learned the word list and others were tested

in the opposite environment. The divers who were able to recall the most words were in the same environment in which those words were learned (Goddard & Baddeley, 1975). Godden and Baddeley (1975) state the improved memory is proof of how environmental context can aid memory.

These context cues seem to be unconsciously and automatically encoded. Tulving (1983) states that optimal memory recall occurs when the conditions during recall are the same as when the initial memory was formed. Smith, and colleagues (1978) found that recall of information is best when participants are in the same room in which they learned the material, presumably because the students automatically encode the sensory information with the test information. The environment plays such a strong role in learning and how the body responds, that Seigel (2001) found whether or not a person overdoses on drugs is directly correlated to whether or not they are in an environment they normally use the substance in. Seigel (2001) states this is because the brain uses the same context cues in Classical Conditioning to prepare the body for the drugs that are about to be ingested.

Miles and Johnson (2007) conducted an experiment that involved context dependent memory and chewing gum. Participants were asked to memorize a word list in three different conditions. In one condition subjects had to chew gum while learning, in the second subjects were asked to chew gum during recall, in the third subjects chewed gum during both tasks. Miles and Johnson (2007) observed a significant relationship between chewing gum during learning and recall.

It should be noted that the literature sometimes seems to confuse the SDL and CDL and some researchers even use the terms interchangeably. For example, Radulvic and colleagues (2017) say that affective states, implicit and explicit motivations, and environmental interaction all come together to make all memories state dependent.

Another example of the literature confusion is when Carter and Cassaday (1998) refer to SDL as context that affects the determinant of retrieval.

Whether state dependent or context dependent, it is plausible to believe, based on the above stated research, that the olfactory system and odor association would fall into one, if not both learning phenomena. The present experiment will examine how sensory memory on its own may improve encoding. According to the American Psychological Association (2020) sensory cues are, by definition "a visual, tactual, olfactory, gustatory, or auditory stimulus that evokes a response or a behavior pattern." Researchers have suggested that external factors, such as ambient odors, can act as retrieval cues that aid the brain in recalling information relevant for non-related tasks such as during tests and quizzes (Smith, et al., 1992).

According to Herz (1997a) memory can be improved by pairing memories with odors at encoding and at retrieval in a context dependent learning environment. The encoding specificity principle states that when contextual stimuli are encoded with the target information and are then also present at retrieval, memory will be enhanced (Tulving 1983). Herz (1997a) states there is evidence to support the concept of memory being improved when an odor is present at encoding and retrieval and Smith and colleagues (1992) state that there are incidental elements in the environment that can be associated with learning stimuli directly such as odor.

Odor in the environment may play a critical hand in memory because of the proximity between the systems in the brain that heavily comprise the memory system. There are only two synapses that separate the olfactory nerve from the amygdala (Herz 1997b). Furthermore, short-term memory and long-term memory both transfer information as directed by the hippocampus which is only three synapses away from the olfactory nerve. Herz (1997b) states that because there is such a strong link between

emotion and memory and the olfactory system, odor-evoked memories have support as a logical concept based on proximity alone. Herz demonstrated the odor/memory effect when she paired 16 paintings that were highly emotionally evocative with eight odors and eight odor names. After 48 hours, participant's memories were tested, and the odor evoked memories proved to be more emotional than memories with just word associations.

The complicated system of human memory is one that researchers are still learning new information about as science progresses. It is believed that the amygdala and hippocampus are both areas of the brain that work together to help store and retrieve information as needed (Trevs & Rolls, 1994). These two areas have specific jobs as the amygdala is needed to experience emotion and the hippocampus to act as a mediator between learning and memory. Without these connections, an individual would not be able to form, experience, and later retrieve emotional, odor evoked memories (Aggleton & Mishkin, 1986; Eichenbaum, 1996; Herz, 1997b). An example of odor evoked memory is when researchers compared the smell, of an apple, the feel of an apple, and the sight of an apple to see which sensory system produced the most emotional memories and, again, found that olfactory associated memories were more significant (Herz, 1997b). Although it should be stated that the hippocampus and amygdala are not exclusively responsible for the memory process as there are many other areas of the brain at work during memory formation, these are just the two most explored structures.

When the amygdala and hippocampus are encoding an odor during memory formation, various stimuli could affect the quality of that memory pairing. The effectiveness of odor may be dependent upon how contextually appropriate that odor is or even how distinctive it is for the situation at hand (Herz, 1997a). When Smith and colleagues (1992) conducted an experiment with pleasant vs. offensive odors, they found

that relearning information can also be affected by odor cues. When subjects were able to relearn information they had previously learned, in the same odor environment as initial learning took place, their results were superior to the subjects who relearned in a new odor environment regardless of the type of odor- pleasant or offensive, (Smith, et al., 1992). Smith and colleagues (1992) presume the results are due to the fact that odor facilitates the retrieval process directly instead of just strengthening the trace of the memory. Eich (1978) found a strong effect of fragrance cues and verbal associations to those cues when he conducted an experiment where participants attempted to recall a word list that had been read to them finding that participants who were cued with a scent as opposed to a semantic cue better remembered the words.

Research demonstrates that there is a significant link between verbal associations of an odor and the stored items in memory as these odors can provide an extraordinarily strong, contextual cue that could last years and even decades (Smith, et al., 1992; Aggleton & Waskett, 1999). It is difficult to examine these claims of odor and memory in the context of real-world implications when an experiment simply has participants learning word lists or other various tasks that do not naturally occur in everyday life. To see if odor and memory could be paired for recall in a more real-world like environment, Aggleton and Waskett (1999) designed a unique experiment to test odor on memory. Participants toured a Viking museum in New York and were later divided into two groups. One group took a test on how much information they could remember from the museum while in a non-odor environment whereas the second group tested while smelling the same ambient odor that was in the museum. The condition group exposed to the odor remembered more information than the non-odor group which provides a real word example of how effective odor could be on memory.

Although the ambient odor of a Viking museum is logical when testing memories originally formed in a Viking museum, what odors should be chosen if trying to commit general information to memory in everyday situations? One type of popular odor category used in households across the United States is essential oils. Essential oils are made up of blends of volatile, incredibly complex, naturally derived compounds from plants usually retrieved from leaves, seeds, flowers, barks, and rhizomes and are usually made through cold pressing or hydro-distillation methods (Benny & Thomas, 2019). Over the past two decades extensive marketing efforts have made bold claims about the potential effects of essential oils. As essential oils have grown in popularity empirical studies have begun to look at essential oils and their effects. An area of research that has seen significant growth regarding essential oils is the realm of cognition and memory. For example, Moss and colleagues (2003) found that some essential oil odors did influence cognition, as did Benny and Thomas (2019) when they examined 23 essential oils and found positive results regarding certain essential oils and memory deficits in Alzheimer's patients as measured by items like pre and post cognition tests of participants. Benny and Thomas (2019) believe that essential oils show promising implications for future research regarding cognitive memory impairments and state that these bold claims are supported in part because of the properties found in specific essential oils and the ability of essential oils to cross the blood/brain barrier. Moss and colleagues conducted two other studies regarding essential oils and memory in 2008 and 2010 and found each time that the participants who are exposed to an essential oil outperform the control group on the trials that involved memory quality, and additionally found an effect on mood which supports SDL and CDL. These two studies also showed results that peppermint essential oil increased participants' memory and alertness. Finally, Moss and Oliver (2012) conducted a study where they found that rosemary essential oil affected participant's cognition and

that an individual's performance on cognitive tasks is causally related to the amount of the essential oil odor one is exposed to. They observed that the higher the concentration of essential oil smelled, the stronger the effect on cognition, speed, and accuracy. Degel and Koster (1999) also studied essential oil odors, specifically jasmine and lavender, and their effects on implicit memory, and found that lavender had a positive effect on test performance. Tyldesley and colleagues (2005) studied salvia essential oil and its effect on cognitive performance and mood in healthy adults and found that salvia essential oil had a significant, positive impact on cognition and memory. These examples are just a sprinkling of the many experiments that are emerging in the last two decades that explore essentials oils as automatic memory encoding aids.

The relatively new area of research data on essential oils provides enough affirmation to attempt to use essential oils as the odor in the present study. The present study aimed to explore how automatic encoding can be used to enhance memory retrieval in situations that typically lean on controlled processes. Specifically, the present study explores the concept that the olfactory system can be subconsciously paired with new material during student study sessions to improve memory. The main hypothesis is that subconscious pairing of a certain odor while learning information could produce a significant improvement in memory when that same odor is also present retrieval when compared with participants who did not have an odor present during encoding and retrieval. The present study operated under the belief that both SDL and CDL may play a role in olfactory encoded memories, and it is not known if those two concepts can be separated as they relate to odors. However, both SDL and CDL elements were attempted to be controlled as much as possible so that some clarity might be found in the confusion of the SDL and CDL grey area of the literature. The present study proposes that odor has the ability to assist free recall of information and recognition of information through

automatically encoding that information with retrieval cues and proposed the following hypotheses:

Hypothesis 1: Participants in the EOER (Essential Oil at Encoding and Retrieval) group will significantly outperform participants in the EOEO (Essential Oil at Encoding Only) and Control groups on free recall and recognition memory.

Hypothesis 2: Participants in the EOER and EOEO groups will significantly outperform the control group on recall and recognition memory.

Hypothesis 3: Participants in the EOER and EOEO groups will report more positive affect than participants in the control group.

Hypothesis 4: Participants in the EOER and EOEO groups will experience greater concentration and less anxiety than the control group as measured by the subjective graphing questionnaire.

Herz (1997a) states the more novel the odor smell, the higher probability it will act as a context cue that will subconsciously encode the memory of the participants. Therefore, peppermint oil was chosen because although it is not a novel scent in general, it is not an odor typically associated with a college classroom or studying. What makes the current concept exciting and purposeful to students and the general public alike is that the connection would be automatic and effortless on the part of the participant. The main hypothesis uses the automatic sensory cue of odor to enhance memory without extra effort on the part of the learner.

The present experiment is based on a unique design as to our knowledge, an essential oil has never been placed on a cotton ball and provided to participants. The rationale behind the new method is that previous research where odor was diffused in the environment or piped in through the vent system could not, with certain, assert that all participants received the same amount of odor. Another aspect of the design that has not

been previously attempted is cueing the participants in the EOER and EOEO groups to smell the cotton ball every five minutes when a bell is rung by the researcher. To add to the literature and to see if these specific changes would result in higher memory scores they were implement in the present study.

Another factor that made the present experiment unique is that most olfactory research consisted of studying word lists or similar tasks that are not usually encountered in everyday situations. To make the results of the experiment more applicable to real life events, actual study material that a student might need to learn for a typical college course was used. The study material was chosen to make the generalizability and transferability of the findings as high as possible. Although, it is true that students do not typically study in a classroom with other students, the ecological validity of the current study is greater than previous studies.

CHAPTER II

Method

Participants

Participants were students enrolled in classes at a south/central university in the United States and non-students from the general population. All participants were 18 years old or older ranging in age from 18 to 68 (M= 31.99, SD = 13.93) and consisted of 75 females, 36 males, and one individual who identified as non-conforming. Participants were recruited through announcements via personal university email accounts, SONA, various in person announcements in academic classes, and through social media. Participants were not compensated monetarily although some students were offered extra-credit as decided by their professors for participation. The participants (N= 112) were randomly assigned to one of three experimental conditions: Control (n=37), EOER (n=39), or EOEO (n=36).

Materials

Study Material

Study Article. Each participant studied an article previously published in Psychology Today, titled, "The Quest to Cure PTSD" (Sherman, C., 2019). The article examined new research surrounding Post Traumatic Stress Disorder. It spoke on research that is beginning to be able to pinpoint the source of PTSD symptoms and examined the future around PTSD. Along with research and cutting-edge therapy, it includes short stories from multiple real-life individuals who have been diagnosed with PTSD.

Essential Oil. Participants in both Experimental groups received a Ziplock baggie with a cotton ball that had been scented with one drop of 100% therapeutic grade peppermint essential oil produced by Young Living at 100% concentration. The scientific name for the essential oil used is *Mentha piperita* from the botanical family Lamiaceae.

Individual Difference Measures

Demographic Questionnaire. The demographic questionnaire acquired personal information such as age, gender, college grade, GPA, academic major, known allergies, and familiarity of essential oils.

The Need for Cognition Scale. Cacioppo et al., (1984). The Need for Cognition Scale is an 18-question assessment instrument that quantitatively measures "the tendency for an individual to engage in and enjoy thinking" (Cacioppo & Petty, 1982, p.116). The term "need" refers to the idea of a likelihood or tendency that someone possesses, rather than a biological need or drive. Since its creation, the need for cognition has been extensively studied in a variety of social contexts and descriptions of those high or low in need for cognition have been elaborated. Cacioppo and colleagues (1984) have demonstrated that although all people must make sense of their world, people who are high in need for cognition tend to seek, acquire, think, and reflect on information to make

sense of stimuli and events. Whereas individuals low in need for cognition are more likely to rely on others for understanding, use cognitive heuristics, and use social comparisons to acquire meaning (Cacioppo et al., 1984).

The Need for Cognition is scored by totaling up an individual's points for all of the questions. If an individual "very strongly agrees" with a question they are given four points or if an induvial "very strongly disagrees" they are given one point, unless the question is reversed scored. Out of the 18 statements on the Need for Cognition Scale, nine are reverse scored. The highest possible score an individual may receive on the Need for Cognition is 72 and the lowest possible score is -72.

Dependent Measures

Positive and Negative Affect Schedule (PANAS). Psychologists, David Watson, Lee Anna Clark, and Auke Tellegen developed the PANAS scale in 1988. The scale intends to measure someone's positive and negative affect and how a person is feeling at the moment. The PANAS measures both positive and negative feelings as individuals engage in everyday life. The PANAS measure can also be used as a tool for charting the immediate effects of therapy as well as any outcomes associated with positive psychological exercises, interventions, or activities. The scale is sensitive to momentary changes in affect when clients are directed to complete the form based on their affect at the present moment. The Positive and Negative Affect Schedule consists of 20 words pertaining to either positive or negative affect (Watson et al., 1988). Psychological literature demonstrates the reliability of the PANAS measure in both subscales, as measured by Cronbach's α, which has produced values of .86-.90 for the internal consistency of the positive affect subscale and .84-.87 for the internal consistency of the negative affect subscale (Watson et al., 1988). Also, test-retest reliability has been

reported with some studies reporting values around .79 for positive affect and .81 for negative affect (Watson et al., 1988).

Delayed Free Recall Exam. Participants were presented with 2 blank 8.5 X 11-inch sheets of paper for the free recall task. During the 15-minute free recall period, participants were given the following instructions, "Using the 2 pieces of paper provided, write down as much information as you can remember from the PTSD article that you studied earlier. You can write down ANYTHING you remember. Names, titles, bullet points, it doesn't have to be complete sentences. Whether it's a partial idea, theory, drug, anything. Nothing is off limits. Do not worry about spelling or punctuation." Free recall exams were scored by two blind graders giving one point for every one item, concept, name, or term remembered and written down from the article.

Multiple-Choice Examination. A 50-item multiple-choice exam was created that tested participant's recognition of main concepts and details they may have acquired after studying the article, "The Quest to Cure PTSD". One point was given for every correct answer.

Subjective Graphing Measure. In order to measure the influence of essential oils on learner affect and thought processes during the study sessions; after studying stimulus information, all participants were asked to recall their level of motivation, concentration, effectiveness, and anxiety across the study period. They then graphed each affect, indicating its level at the beginning, middle, and end of the study session. Identical subjective graphs were completed after the study session and were used as multiple dependent measures. The procedure and format used to collect affective ratings was based on the method of subjective graphing described by Hall and O'Donnell (1996) and Danseraue and Collegues (1995).

Session Evaluation Questionnaire. The purpose of the questionnaire is to measure participant ratings of the session (e.g., depth and smoothness) and personal emotional state after the conclusion of the session (e.g.; arousal and positivity) (SEQ; Stiles, 1980, Danseauraue, et al., 1995). A semantic differential scale is used to present 24 adjective pairs. The session qualities will be evaluated by the first set of 12-item pairs and the affective status of the participants will be assessed by the second set of 12- item pairs. The SEQ was filled out after the study session. The SEQ has a high level of internal consistency, for example .90 for Depth and .93 for Smoothness (Reynolds et al., 1996) when measured using coefficient alpha levels.

Procedures

College students signed up to participate in the study using their university's Sona system and/or their collegiate email accounts and non-students signed up via email, text, or social media. All participants were randomly assigned to a condition. At sign up, participants were asked if they were allergic to peppermint so that participants who were allergic could be excluded from participating. Participants were told where to show up, how long the session would last, and that all materials would be provided for them upon arrival. The experiment received IRB approval as a minimal risk study and all participants filled out an informed consent form.

Experiment

Upon arrival to the study each participant's temperature was taken and they were given a 3-ply disposable facemask. Participants were asked to sit in the room at a desk anywhere they saw a folder. The folder contained all materials needed to complete the study for one of the three conditions. The three experimental conditions were, Control (C), Essential Oils at Encoding and Retrieval (EOER), and Essential Oils at Encoding only, not at retrieval (EOEO). All sessions were held in the same room at two locations).

Experimental conditions were run one session at a time as to make sure scent was not cross contaminated. All sessions were performed using the same identical script minus the oil/odor instructions. Participants were asked to keep their folder closed until instructed to begin. The experimenter led participants through the study. Sessions began by having all participants turn off their cell phones. Next participants read and filled out the informed consent form (2 minutes). After providing consent, participants completed a demographics questionnaire (2 minutes) and the PANAS (5 minutes). Next all participants were informed they would be studying a Psychology Today article for 45 minutes over which they would be thoroughly tested. Participants in the Control Group (C) were asked to study as they usually do to learn new material that they know they will be tested over. Participants in the EOER and EOEO experiment groups received a Ziplock sealed baggie with one cotton ball that contained one drop of essential peppermint oil. These participants were also asked to study as they usually do to learn new material that they know they will be tested over, but additionally were instructed to smell the cotton ball without removing their facemasks, every five minutes when they heard the experimenter ring a bell. Every five minutes the experimenter rang the bell and stated, “please smell your cotton ball.” No other instructions were given during the study time. After the study session concluded, participants completed the Sessions Evaluation Questionnaire (5 minutes) and the Need for Cognition Scale (5 minutes). After the questionnaires were all completed, participants were asked to close their folders and were given a ten-minute break.

After the ten-minute break, all participants returned to the same room and sat back at their same seat with their folder. The experimenter then led participants to reopen their folders. The first task the experimenter instructed students to complete was the Free Recall Exam where participants were told “For the next 15 minutes, using the 2 pieces of

paper provided, write down as much information as you can remember from the PTSD article that you studied earlier. Names, titles, bullet points, it doesn't have to be complete sentences. Whether it's a partial idea, theory, drug, anything. Nothing is off limits. Do not worry about spelling or punctuation." Next, participants were instructed to complete a 50-question multiple-choice exam and record their answers on a scantron in pencil (30 minutes). Participants in the control group and EOEO group completed the exams as stated above with no further instruction. Participants in the EOER group were instructed to smell their sealed bag with the cotton ball before beginning each exam and every five minutes during the exam when they heard a bell ring. After the two exams were completed, all participants regardless of experimental condition, completed the Subjective Graphing Measures (5 minutes) and the PANAS scale again (5 minutes). Upon completion of these scales, all individual's folders were collected, and participants were thoroughly debriefed, thanked for their participation, and dismissed.

CHAPTER III

Results

Preliminary Analysis

Scoring

All data were transferred from physical paper copies to digital format and were then scored and reversed coded according to each specific measure's instructions. Participant's recall memory (free recall test) and recognition memory (multiple choice test) were evaluated using measures that had to be individually scored. Free recall tests were coded by two blind raters based on a key-words list where each rater gave one point for each correct item listed to find an overall recall memory score for each participant (M= 26, range of scores 6-60). An intraclass coefficient using absolute agreement was run to ensure reliability between the coders, results indicated an excellent intraclass

correlation of .947. The main researcher's scores were used for all subsequent analyses because the correlational coefficient was so large. The multiple-choice tests were scored using a Scantron key where each correct item received one point to find an overall recognition score for each participant (*M*= 32, range of scores= 20- 47).

A Pearson's bivariate correlation on Need for Cognition and recall memory scores (free recall test) and recognition memory scores (multiple choice test) was conducted to determine if there was a relationship between memory scores and Need for Cognition levels. Results indicated there was a significant, positive correlation between Need for Cognition and free recall memory scores ($r = .369$, $p < .01$) and Need for Cognition and recognition memory scores ($r = .372$, $p < .01$) (see Figures 1 and 2 respectively). Scores were then analyzed based on frequency statistics to determine median, mean, and mode so that groups could be divided according to their percentile ranking and placed into low, medium, and high groups (low < 58.67, medium = 58.68-69, high > 69.1). Splitting Need for Cognition scores into groups is part of the scale's scoring. There were exactly one-third of participants placed in each group and the median Need for Cognition score was 63.5.

Figure 1

Need for Cognition and Recall Memory Scores

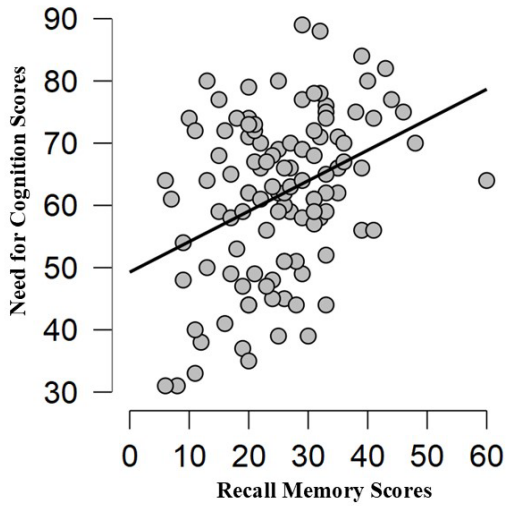
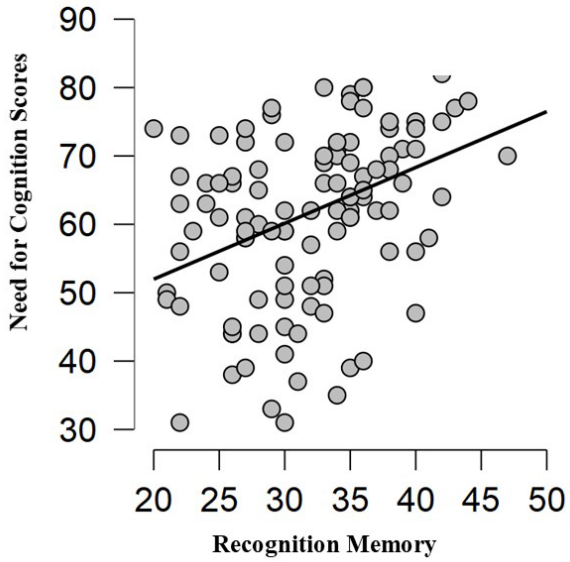


Figure 2

Need for Cognition and Recognition Memory Scores



Factor Analysis

A principal component analysis (PCA) was conducted on the Session Evaluation Questionnaire (SEQ) with varimax rotation to form composite scores to ensure all four factors loaded into our data set. All four factors of the questionnaire were present which replicated the same factors previously found by Danseraue et al. (1995) and Stiles and Snow (1984). By averaging the scores from the 24-item SEQ, four composite scores were found using unit weights. The four factors were (a) depth (e.g. “valuable”) (b) smoothness (e.g. “relaxed”) (c) positivity (e.g. “pleased”) and (d) arousal (e.g. “energetic”); see Table 1 for factors and loadings.

Table 1

Factor Loadings of Items from Session Evaluation Questionnaire

SEQ Item	Alpha	Item	Factor Loading
Depth	.81	Valuable/worthless	.78
		Shallow/Deep	.78
		Weak/Powerful	.76
		Full/Empty	.72
		Special/Ordinary	.60
Arousal	.-73	Involved/Detached	-.79
		Slow/Fast	.71
		Uncertain/Definite	.63
		Friendly/Unfriendly	.59
		Wakeful/Sleepy	-.52
Smoothness	.83	Rough/Smooth	.77
		Relaxed/Tense	.77
		Unpleasant/Pleasant	.77
		Uncomfortable/Comfortable	.69
Positivity	.80	Difficult/Easy	.78
		Happy/Sad	.72
		Angry/Pleased	.64
		Confident/Afraid	.57
		Bad/Good	.55

Primary Analyses

Recall and Recognition

A one-way analysis of variance was conducted on experimental conditions (Control, EOER, EOEO) on the recall and recognition memory scores. The results indicated no significant difference between the experimental conditions on free recall scores, F (2,111) = .374, p = .689, or on recognition scores, F (2,111) = .229, p = .795 (see table 2).

Table 2

Means, Standard Deviations, and One-Way Analysis of Variance in Recall and Recognition Memory and Experimental Conditions

Measure	Control		EOER		EOEO		F(2,111)	η^2
	M	SD	M	SD	M	SD		
Recall memory	24.76	10.43	24.59	9.16	26.72	9.83	.374	.007
Recognition memory	32.59	5.86	31.72	5.83	31.89	6.14	.229	.004

*p < .05 **p < .01

The free recall memory scores showed a Bayes factor of BF_{01}= 76.36 was found which means that the observed data are 76.36 times more likely to occur under the null hypothesis (there is no change in data based on experimental conditions) than the alternative hypothesis (experimental conditions affect free recall memory scores) with a posterior probability of 0.9871.

When the Bayesian ANOVA was run to analyze experimental conditions on recognition scores, a Bayes factor of BF_{01}= 88.56 was found which indicates that the observed data are 88.56 times more likely to occur under the null hypothesis (meaning there is no change in data based on experimental conditions) than the alternative hypothesis (experimental conditions affect recognition memory scores) with a posterior probability of 0.9888.

Need for Cognition

A MANCOVA was conducted to further explore Need for Cognition as a covariate based on preliminary correlational analyses. Need for Cognition scores were split into three groupings based on percentile ranks (low< 58.67, medium = 58.68- 69, high > 69.1). Across the three conditions (Control, EOER, EOEO), the main effect on free recall was not significant, F (2, 111) = .752, p = .47, nor was the main effect for recognition memory, F (2,111) = .068, p = .93. However, there was a main effect for Need for Cognition on free recall F (2, 111) = 9.621, p = .002, η^2=.082, and recognition scores, F (2,111) = 15.974, p >.001, η^2 =.129), indicating that those high in Need for Cognition scored significantly higher than individuals low in Need for Cognition regardless of experimental condition.

To further explore the effect that Need for Cognition may have on test scores, the Need for Cognition scores were split into three categories, high Need for Cognition, medium Need for Cognition, and low Need for Cognition as previously stated in the study. The split analysis was completed to explore the possibility that a specific grouping of the population may benefit from the essential oil which may not benefit other individuals lower or higher in Need for Cognition. Interestingly, when the one-way ANOVA was performed, it was found that there was a significant difference driven by Need for Cognition in both recognition and recall memory scores and that individuals in the medium Need for Cognition scoring group did appear to benefit from the intervention of essential oils, F (3,111) = 5.49, p<.001, (see Figures 3 and 4 respectively).

Figure 3

Need for Cognition Groups and Recall Memory Scores

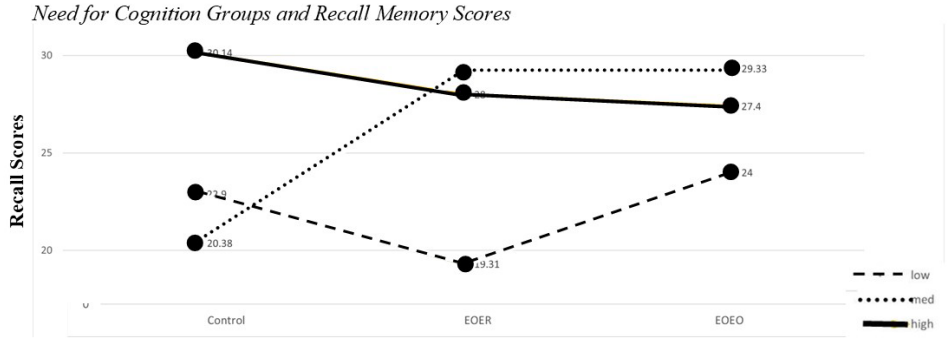
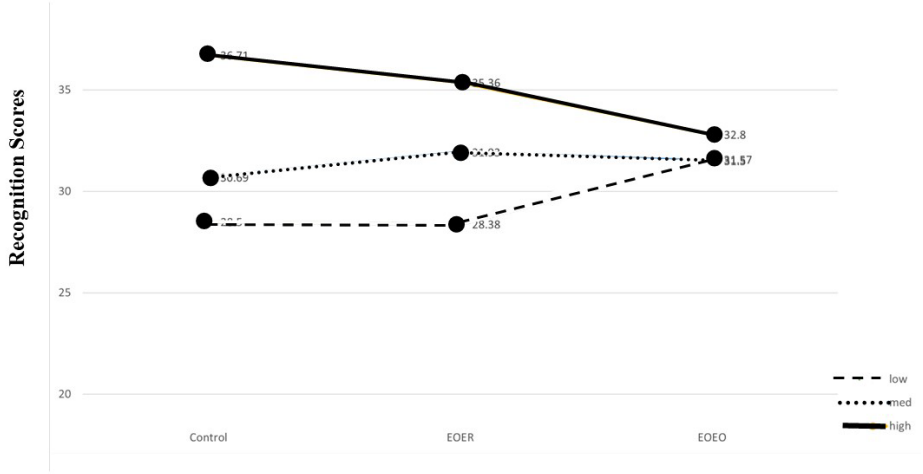


Figure 4

Need for Cognition Groups and Recognition Memory

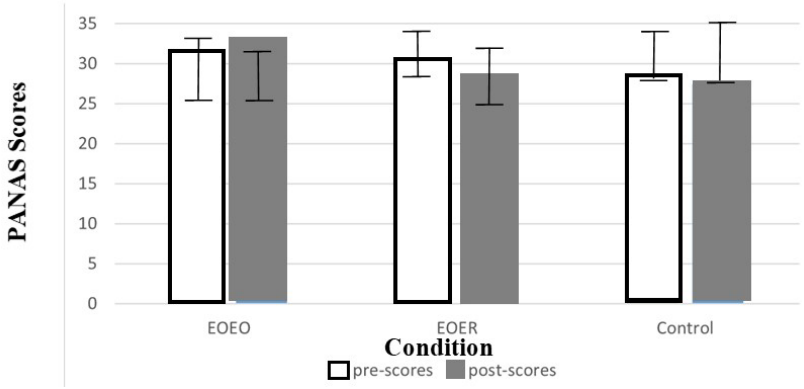


PANAS

A two-way analysis of variance examining condition by pre/post PANAS scores was conducted to see if experimental condition impacted participant's affect. Results indicated that participants in the EOEO condition reported significant increases in happiness from the beginning to the end of the experimental session (pre-PANAS, $M = 31.67$, $SD = 6.87$, post-PANAS $M = 33.31$, $SD = 8.67$) compared to the EOER condition (pre-PANAS, $M = 30.69$, $SD = 9.09$, post-PANAS $M = 28.31$, $SD = 8.51$) and the Control condition (pre-PANAS, $M = 28.28$, $SD = 7.92$, post-PANAS, $M = 27.46$, $SD = 8.67$) , $p = .009$ (see Figure 5). The interaction effect was found to be non-significant, pre-PANAS, $F(2, 108) = 1.70$, $p > .05$, post-PANAS, $F(2, 109) = 4.91$, $p > .05$.

Figure 5

Pre-and Post PANAS Scores Across Conditions

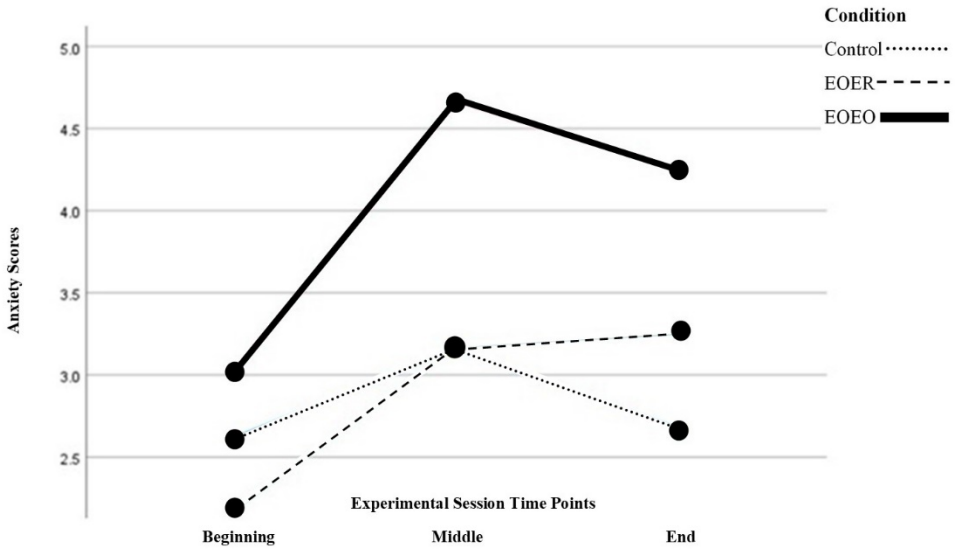


Subjective Graphing Measure

A repeated measures ANOVA was conducted to explore the hypothesis that anxiety was reduced in the EOER and EOEO groups as measured by the Subjective Graphing Measure. Results indicated that anxiety scores were not significant by condition F (2,109) = 3.84, p = .025) but there was a significant interaction effect F (1,109) = 283.25, p < .001 , η^2 =.722). It was discovered that the EOEO group reported higher anxiety scores (M = 4.25, SD = 3.12) than the EOER (M = 3.26, SD = 3.05) and Control group (M = 2.68, SD = 2.67) (see Figure 6), F(2,108) = 8.96, p < .001 , η^2 =.142).

Figure 6

Subjective Graphing Measure Anxiety Scores and Experimental Conditions



A repeated measures ANOVA was also conducted to evaluate if concentration scores were improved in the EOER and EOEO groups as measured by the Subjective Graphing Measure. Results indicated that the main effect for condition was not significant F (2, 109) = 3.06, p = .051 , η^2 =.053). Additionally, there was not a significant interaction effect between condition over time F (4,218) = *1.375, p* = 0.244*,* η^2 =..934) (Middle- M = 7.08, SD = 2.03, End- M = 5.87, SD = 2.50) than the EOER and Control groups (see Table 3 and Figure 7).

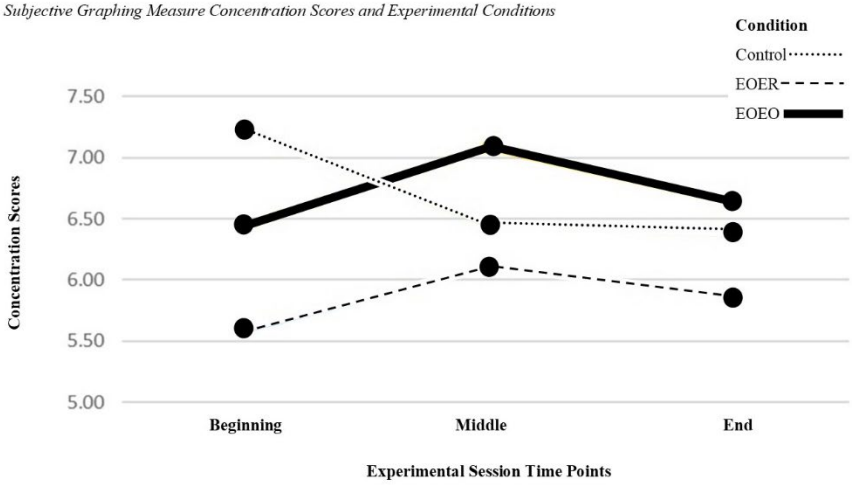
Table 3

Means, Standard Deviations of Subjective Graphing Measure Concentration and Experimental Conditions and Time

Factor	Control		EOER		EOEO	
	M	SD	M	SD	M	SD
Beginning	7.22	2.35	5.59	3.02	6.44	2.80
Middle	6.46	1.92	6.10	2.26	7.08	2.03
End	6.38	2.44	5.87	2.50	6.64	2.62

Figure 7

Subjective Graphing Measure Concentration Scores and Experimental Conditions



A multivariate analysis of variance was conducted to determine if the four factors in the Session Evaluation Questionnaire (depth, arousal, smoothness, and positivity) differed among experimental conditions. It was found that the EOER group significantly differed in depth when compared to the EOEO and control groups F (2, 110) = 11.88, p < .001 , η^2 =.182. It was also found that the EOER differed

(although not significantly) from the other conditions regarding smoothness and the EOER group reported feeling more aroused than the other conditions, see Table 4.

Table 4

Means, Standard Deviations, and Multivariate Analysis of Variance on SEQ Factors and Experimental Conditions

Factor	Control		EOER		EOEO		F(2,110)	η^2
	M	SD	M	SD	M	SD		
Depth	5.36*	.90	4.59**	1.17	5.69	.88	11.88	.18
Arousal	4.07	.52	3.78	.57	3.96	.62	2.51	.05
Smoothness	4.71	1.33	4.44	1.41	4.70	1.44	.44	.01
Positivity	4.81	.83	4.64	.82	4.61	.93	.59	.01

* $p < .001$

** $p < .05$

Discussion

The purpose of the present study was to connect the olfactory system and memory encoding in a way that did not cause extensive effort on the part of the learner. The results indicated that participants did not score higher in memory in the EOER and EOEO conditions over the Control condition in the present study. Results also suggest that peppermint essential oil did not serve as an effective encoding strategy since the results of the two main hypotheses (Hy 1: Participants in the EOER (Essential Oil at Encoding and Retrieval) group will significantly outperform participants in the EOEO (Essential Oil at Encoding Only) and Control groups on free recall and recognition memory and Hy 2: Participants in the EOER and EOEO groups will significantly outperform the control group on recall and recognition memory) were non-significant. Interestingly, the data for the EOEO condition does seem to be trending in such a way that suggests that the EOEO group fared better than the true

experimental EOER condition. Non-significance may have been found because too much cognitive load and mental effort may have been placed on participants in the EOER group by a bell sounding every five minutes during test taking. Cognitive load can be assessed by looking at the mental load an individual uses for a specific task-centered activity which takes into account the difficulty of the task at hand, whereas mental effort is measured by examining the amount of resources the individual is allocating to learn the specific task at hand (Choi, van Merriënboer and Paas, 2014). Choi, van Merriënboer and Paas (2014) state that if mental effort and cognitive load are examined together, the physical learning environment plays a role as a causal factor that interacts with the individual's characteristics, learning-task characteristics, or a combination of the two elements.

Perhaps the current study exhausted the availability of cognitive load and mental effort by having a bell ring every five minutes during test taking. Based on the trending data, cued essential oil smelling and bell ringing only during encoding may serve to refocus participants onto the study material. Having the essential oil at encoding only and not during retrieval may show a difference in scores in future research. Future studies could be conducted where the cotton ball with essential oil is placed on the desk, as in the present experiment, with participants being told to smell it every five minutes during encoding without a bell ringing and then are allowed to smell the cotton ball at will while test taking. Exploring the findings at hand could help to explain if attention is increased during studying because of the bell or because of the oil.

When Need for Cognition scores were analyzed to see how they correlated with memory scores, significant results were found which indicated that individual Need for Cognition levels appeared to be a larger contributor to memory score results than the experimental conditions themselves. The results obtained after splitting individuals that are high, medium, and low in their Need for Cognition scores is interesting because it speaks to the idea that individuals medium in Need for Cognition may be the ones who could benefit from the studying technique. The difference in scores may not have been seen in the previous analysis when the high, medium, and low Need for Cognition individuals were all grouped together because of the large standard deviations in the groupings. In the three-way split analysis those low in Need for Cognition were not affected, presumably because they did not find learning new information exciting or engaging, and those high in Need for Cognition presumably did not need the help of an encoding strategy so their scores remained relatively unchanged. However, the data suggests that individuals who are in the middle Need for Cognition group could benefit the most from essential oil encoding strategies because their memory test scores were improved. Individual who were medium in Need for Cognition saw significant increases in memory scores which shows us that the middle of the population might see a difference in their memory scores if peppermint essential oil is used during encoding. These results should be studied more thoroughly in future experiments to ensure the results can be replicated.

The PANAS scores indicated that the EOEO condition group was the only condition that had a significantly more positive affect when they left the experiment than when they got there. PANAS scores indicate that the group which received

essential oil during encoding were overall a little happier than the individuals in the other groups. The increase in positive affect could be explained by the EOEO group having the benefit of peppermint essential oil scent while studying, but not the frustration of interruptions while test taking. Whereas the control group did not encounter any stimulus that might change their affect and the EOER group may have not experienced an increase in affect because of the bell and interruptions while attempting to recall previously learned material. These results are not strong enough to encourage the general to use peppermint essential oil to increase their mood levels by large amount but perhaps the scent may make individuals a little happier while studying information for longer periods of time. The PANAS results provided an outcome for Hy 3: that "Participants in the EOER and EOEO groups will report more positive affect than participants in the control group."

To answer Hy 4: "Participants in the EOER and EOEO groups will experience greater concentration and less anxiety than the control group as measured by the subjective graphing questionnaire" a repeated measures ANOVA was conducted on the Subjective Graphing Measure. The repeated measures ANOVA showed that the EOEO condition reported significantly higher levels of anxiety as the experiment proceeded. The results may be because while encoding participants had the benefits of essential oil, but while test taking no longer had the scent of peppermint essential oil to help calm emotion. The same reasoning could be applied to results obtained for concentration as measured by the Subjective Graphing Measure since it showed significantly higher levels of concentration in the EOEO group as opposed to EOER and Control groups.

The Session Evaluation Questionnaire indicated that the factor labeled Depth was significantly higher for individuals in the EOER group over the EOEO and Control group. The SEQ results may be present because of the essential oil and bell ringing every five minutes during encoding and recalling information. Participants in the EOER group may have felt like the session had more depth and was less shallow that the experience of individuals in the other experimental conditions. The data also showed that the EOEO group evaluated the overall experiment as smoother than the other conditions. Although this result was not significant, the trending data suggest that because participants were interrupted less while attempting to remember previously learned information participants felt as though the session was smoother that their experimental counterparts.

Limitations

A major limitation of the present study that may have influenced the results is the COVID-19 pandemic. The experiment began in the middle of the pandemic and thus for safety measures, forced participants to wear a mask. No other experiment that examines smell has asked participants to wear a mask. The pandemic also affected the experiment model's design to be able to access long- term memory. Initially participants were to come for two different sessions over the course of one week. The first session was to answer intake documents and to study the article and then exactly one- week later participants were to come back to the same room at the same time and take the memory tests and questionnaires in the second half of the folder. The COVID-19 pandemic made a one-week break impossible and beginning and ending session had to be split not by one week, but by a 10-minute break instead. Although,

research states that after two-five minutes, information that can be recalled is stored in long-term memory it is possible that all participants regardless of condition remembered more than they would have one week later because extinction might have occurred more in those without essential oil at encoding. Also, researchers could not ask about participant's COVID status and if they had lost their smell because of COVID-19. Not knowing if participants could or could not smell may have had affected the present study.

Lastly, Experimenter Demand Effect may have played a role in the experiment as the Covid-19 pandemic made it difficult to recruit in-person volunteers. Therefore, the experimenter's family and friends made up approximately one-third of the sample for this study. Although they were all randomly assigned to different conditions, those individuals may have had a higher motivation for doing well on the memory tests because they personally knew the experimenter. Experimenter Demand Effect may be one reason the mean scores were so close across the experimental conditions.

Conclusion

Although there was no support for the main hypothesis, the present study has shown that data are trending in the right direction for certain individuals and that perhaps if rerun without a bell at testing and with a week in between encoding and retrieval, different results might be obtained. In addition, several more studies which examine different oil scents and methods of inhalation should be conducted to further explore the possibility of essential oils as automatic encoding tools for students and the general public alike. Significant results could prove to be helpful for campus

student resource centers as adding certain smells to a student's studying environment would be a relatively easy and cost-efficient way to help teach students a simple addition to their study habits that may enable them to retain more information without more effort.

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Appendix A

Informed Consent Form

Introduction
You are invited to participate in a research study conducted by Rene Wallace and Dr. Labansat from the Psychology Department at Tarleton State University. The purpose of this research is to explore different ways students' study for tests. Your participation is entirely voluntary.

This form includes detailed information on the research to help you decide whether to participate. Please read it carefully and ask any questions you have before you agree to participate.

Procedures
Your participation will involve studying material presented to you in the first session and taking a test over that material in the second. You will participate in two separate sessions over the course of 1 week, which should each take approximately an hour and a half. Your total participation in this project is expected to be 3 hours. We anticipate that 100 people will participate in this research study.

Before you read this form, you responded to some questions regarding *eligibility description* and demographic information. Researchers will maintain that data once you agree to enter the full study.

Risks
This is a minimal risk research study. That means that the risks of participating are no more likely or serious than those you encounter in everyday activities. The foreseeable risks or discomforts include possible exposure to adverse smells, anxious feelings connected with test taking, and loss of confidentiality. In order to minimize those risks and discomforts, the researchers will keep all identifying information from this experiment under lock and key in Tarleton's psychology department and remind you the test scores obtained have no effect on your personal grades or GPA..

Benefits
Participation in this study may directly benefit you by exposing you to a new study technique. We cannot guarantee that you will directly benefit from this study but it has been designed to learn more about successful studying. Some professors may have offered you extra credit to participate in this study. Make sure you obtain the necessary documentation to turn in to that professor for credit. Other benefits are being able to participate in a research experiment. You are contributing to scientific research that may be published in textbooks for future students to learn from.

Confidentiality
The researchers will make every effort to ensure that the information you provide as part of this study remains confidential. Your identity will not be revealed in any publications, presentations, or reports resulting from this research study. While we will ask all group members to keep the information they hear in this group confidential, we cannot guarantee that everyone will do so.

We will collect your information through email and in person documents. Online activities always carry a risk of a data breach, but we will use systems and processes that minimize breach opportunities. This digital data will be securely stored in an encrypted, cloud-based storage and the physical data in a locked drawer in a restricted-access office. Your identifying information will be kept for three years after the study is complete, and then it will be destroyed.

It is unlikely, but possible, that other state or federal officials may require us to share the information you give us from the study to ensure that the research was conducted safely and appropriately. We will only share your information if law or policy requires us to do so.

Voluntary Participation & Withdrawal
Your participation in this research is completely voluntary. If you agree to participate now and change your mind later, you may withdraw at any time by leaving the room. If you choose to withdraw after we have already collected information about you, your data will be destroyed. If you decide not to participate, the services you receive from the psychology department, if any, will not be affected in any way. The researchers may also choose to terminate your participation in this research study. You will be notified via email if this happens and will be told why you were excluded.

Findings
If the researchers learn anything new during the course of this research study that might affect your willingness to continue participation, you will be contacted about those findings. This might include changes in procedures, changes in the risks or benefits of participation, or any new alternatives to participation that the researchers learn about.

Identifiers may be removed from your information. These de-identified data may be used or distributed for future research without additional consent from you. If you do not wish for us to use your information in this way, please state so below.

Once the research study is complete, the researchers will email you the findings of the study.

IRB Review
The Institutional Review Board (IRB) for the protection of human research participants at Tarleton State University has reviewed and approved this study. If you have questions about the research study itself, please contact the Principal Investigator at rene.wallace@go.tarleton.edu . If you have questions about your rights or would simply like to speak with someone *other* than the research team about questions or concerns, please contact the IRB Chair at faulkenberry@tarleton.edu.

Informed Consent
By signing below, you agree to participate in this study. You indicate that you understand the risks and benefits of participation, and that you know what you will be asked to do. You also agree that you have asked any questions you might have, and are clear on how to stop your participation in the study if you choose to do so. Please be sure to retain a copy of this form for your records.

_____ _____

Participant's Signature Participant's Name, Printed

☐ I do **not** agree to allow my de-identified information to be used or shared for future research.

Date:_____

Appendix B

Demographics Questionnaire

Demographics Questionnaire

Gender_____

College Grade Level_____

Age_____

Do you use essential oils- Never_____ Seldomly_____ Regularly_____ Often_____ Very Often_____

Are you a psychology major _____

Current GPA (estimated) _____

Appendix C

PANAS

Positive and Negative Affect Schedule (PANAS-SF)

Indicate the extent to which you feel this way currently.		Very slightly or not at all	A little	Moderately	Quite a bit	Extremely
PANAS 1	Interested	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 2	Distressed	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 3	Excited	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 4	Upset	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 5	Strong	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 6	Guilty	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 7	Scared	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 8	Hostile	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 9	Enthusiastic	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 10	Proud	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 11	Irritable	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 12	Alert	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 13	Ashamed	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 14	Inspired	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 15	Nervous	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 16	Determined	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 17	Attentive	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 18	Jittery	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 19	Active	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 20	Afraid	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

Appendix D

Psychology Today Article Participants Studied

The Quest to Cure PTSD

For many with posttraumatic stress disorder, relief is elusive. But research pinpointing the source of symptoms is spurring new therapeutic approaches. It may even be possible to stop PTSD before it starts.

By Carl Sherman published October 14, 2019 - last reviewed on September 15, 2020

November 2019- The Power of Boundaries, Psychology Today

Russell Davies served two tours of duty, first with the Army's famed 101st Airborne Division, then leading an infantry squad in Afghanistan. He earned a Purple Heart and a Commendation Medal for valor when the truck he was driving hit an IED and, despite shrapnel wounds and open fire, he rescued the critically injured soldiers in the vehicle and got them helicoptered out. "It was definitely one of the biggest moments of my life," he recalls.
Photo: Jasper Gibson

As a 21-year-old tank commander in the Israel Defense Forces, Yuval Neria saw comrades and close friends badly hurt and killed in the 1973 Yom Kippur War. He himself suffered serious injury when his tank was hit, but that didn't keep him from taking command of other tanks, for which he received the Medal of Valor, Israel's highest combat award. He served again in 1983.

His experience on the Sinai front in 1973 vividly informs *Fire*, a war novel he wrote that captures the terror, courage, frustration, and confusion of battle. It also decreed his life's work.

“The Yom Kippur War taught me a lot about the devastating effect of severe combat,” says Neria. “I understood fear very well, extreme fear, fear for your life,” he says. “I knew a lot of people who eventually developed PTSD; I felt very connected to them, I wanted to be involved.” He became a clinical psychologist specializing in trauma, then a researcher probing its roots. In 2001, in the immediate wake of the World Trade Center attacks, New York’s Columbia University recruited him to head its Research and Treatment Program for PTSD.

He saw it as “an opportunity to follow what I’d felt was my destiny because of my experience in war.” Neria never had post-traumatic stress disorder, but “what I carry with me, in addition to the horror and the fear of war, is an understanding of what patients are going through and a commitment to their treatment.”

War, of course, is not the only experience that stamps the brain so powerfully that it remains constantly vigilant to threats, sees them where they may not exist, and fetches memories of fearful events so readily and vividly they overwhelm everyday activities. Nor is it the sole catastrophe that turns up the emotional torment at night, taunting sleep with the faces or cries of children, or spouses, or comrades who could not be saved from harm.

Fires, hurricanes, plane crashes, motor vehicle accidents, sexual abuse—any sudden, violent disruption, even a life-threatening illness like cancer—can leave a mark. And so Neria has conducted studies not only of veterans and prisoners of war and civilians under missile attack but also of earthquake survivors, those who’ve endured sexual assault, people who lost loved ones on 9/11, and those directly exposed to the 9/11 attacks in New York City.

At Columbia, Neria is focused largely on the neural mechanisms underlying PTSD. His work spotlights areas of the brain involved in identifying threats and storing memories of fearful events. Neria and colleagues have pinpointed abnormalities in how these areas look, how they work, and especially how they fail to work together.

From his ongoing studies, and those of many other researchers, effective treatments are emerging. They target specific biochemical processes and brain circuits.

Not all of the treatments are new. Exposure therapy, for example, has been around for decades, but combined with targeted biological treatments involving specific drugs and delivered in novel ways, it promises relief for the nearly 50 percent of sufferers left behind by current approaches, their whiplash reactivity driving them to withdraw from the world, or to navigate it with suspicion or anger, or to numb themselves with substances that exchange one kind of pain for another. There is also great new hope that there are ways to prevent PTSD from ever occurring.

Three Months, Three Years—or Forever

The existence of PTSD was formally recognized in 1980, when it was first included in psychiatry's *Diagnostic and Statistical Manual*, then in its third edition. The condition, however, has been around likely since the first hunter was mauled by a lion or the first temblor shook the earth.

PTSD is a response to experiencing or witnessing an event or series of events involving the threat of death or serious bodily harm. People with PTSD suffer from classic anxiety symptoms, like insomnia and worry, and are often hypervigilant—constantly alert to possible dangers. They characteristically have an exaggerated startle response: Unexpected sounds, movements, or contact can provoke a strong, even violent reaction.

PTSD is characterized by intrusive memories: The traumatic event(s) is recalled spontaneously in flashbacks with the same panic, dread, and terror it originally evoked. Distressing moods and thoughts persist. They can take the form of anger, guilt, shame, or a feeling of detachment from others. Thoughts like "Nothing good can happen to me" and "No one can be trusted" are common. To evade reminders of the trauma, sufferers may avoid leaving the house.

The disorder "is not merely fear based," stresses psychologist Paula Schnurr, executive director of the National Center for PTSD, a unit of the Veteran's Administration. It can show up as depression—complete with shame, guilt, and apathy—or as anger and aggression.

The Inside Story of PTSD

When sensory areas of the brain detect a potential threat, nerve impulses are immediately routed through the thalamus to the amygdala. Aroused, the amygdala generates the sensation of fear and signals the adrenal glands to secrete adrenalin, raising heart rate and blood pressure to mobilize the body for sudden action.

For more sustained mobilization, the hypothalamic-pituitary axis swings into gear, tripping off a cascade of hormones culminating in the release of cortisol, which extends the mobilization reaction. It also keeps the amygdala activated, maintaining the state of high alert. In such an aroused state, strong memories are readily formed, and they have staying power.

Under normal conditions, the thinking brain brakes amygdala activation, bringing mobilization to a halt when it concludes that danger is past, and the hippocampus puts the episode in the context of past experience. With PTSD, people remain hypervigilant, on the lookout for danger even in everyday circumstances. Fear memories are easily awakened—ordinary sounds, sights, or even thoughts trigger recollection of the traumatic event so vividly that it feels as if it's happening again.

Armand Cucciniello III was a diplomat at the U.S. Embassy in Baghdad during the Iraq War, living and working in the Green Zone, a compound secured by tall concrete walls topped by barbed wire. “But rockets and mortars lobbed or fired overhead had no problem penetrating it,” recalls Cucciniello. Attacks began during the troop surge of spring 2007, six months after he arrived. “My first exposure was the worst: I heard a woman die just meters away.”

There was no pattern to the attacks. “You never knew what would happen or when. After a year of off-and-on bombardment, I was very tense, highly emotional. I would well up as if I wanted to cry, for no reason,” Cucciniello recalls.

A psychiatrist told him he had PTSD and prescribed an antidepressant. The drug helped his emotional control, but even years later, “loud noises, doors slamming, anything like a boom would trigger me. Time would stop for a few seconds, and I’d be incapacitated,” he says. On a visit to family in New York City, the dull thump of a taxi going over an iron plate covering street construction—not loud, but “the exact pitch of a rocket exploding”—could provoke a flashback.

He had trouble sleeping for years, and even now, if he tries going off his medication, “everything comes back—the tense feeling, the welling up of tears.” Cucciniello has gone on with his life and is now an advisor to four-star Army General Robert Abrams, who heads the United Nations Command in South Korea.

There’s been a great surge of interest in biological markers that identify the changes caused by PTSD and that could be used to predict and diagnose the disorder, Schnurr reports. With brain-imaging tools like magnetic resonance imaging, researchers are getting a dynamic picture of the flashback memories, the fear, and other mood disturbances typical of the disorder. The National Center now also maintains a brain bank, a repository of postmortem tissue samples from PTSD sufferers, to facilitate investigation into the molecular machinery giving life to the symptoms.

“We see at least three regions involved,” Neria reports. They include the amygdala, which regulates emotion and is ground zero for processing fear; the hippocampus, where memories are processed for storage and retrieval; and areas of the prefrontal cortex, the planning and decision center of the brain, which normally has the capacity to dampen amygdala activity.

In the wake of a traumatic event, he says, circuits of communication among the three regions are disrupted, accounting for the toxic vitality of traumatic memory. “In PTSD, the amygdala is hyperactivated and the prefrontal cortex and hippocampus are underengaged, leaving patients overly anxious and haunted by their traumatic experiences, the memories appearing and reappearing involuntarily” with an intensity untouched by time.

“Trying to gain control over those memories and their related anxiety, nightmares, and flashbacks, we see a lot of avoidance—people avoid talking about their trauma, trying to control their anxiety level,” says Neria. They shun situations that might trigger recollection. “Numbing of emotion comes later—patients become more depressed than aroused.” Fifty percent of people with PTSD, in fact, also suffer from clinical depression.

Neurobiologist Benjamin Suarez-Jimenez, a member of Neria’s lab, employs virtual reality to explore the tendency to see danger where there is none. While in an MRI scanner, subjects video-walk through a meadow picking flowers. In some areas, they are stung by bees—represented by mild electric shocks. In others, they are not. “Healthy controls learn to distinguish between safe and dangerous locations, becoming hyperaroused only in areas where they were stung. People with PTSD overgeneralize; they don’t discriminate accurately between safe and threatening areas,” Suarez-Jimenez finds.

He is trying to pinpoint the brain areas responsible for the overgeneralization of threat. In earlier work, he identified the brain networks activated when healthy subjects make safe-dangerous distinctions, and is now collecting data on PTSD patients. “We want to compare brain activity, physiology, and self-ratings of anxiety in people who have never experienced severe trauma, those who have and developed PTSD, and those who were resilient.”

Although most brain-imaging work provides fundamental insights, some findings have direct clinical application. Several studies in his lab and elsewhere suggest that “the size of the hippocampus is a key to response to therapy,” says Neria. “We found that patients who have a larger hippocampus develop less PTSD over time and do better.” Tests revealing a small hippocampus might well signal the need for medication and psychotherapy aimed at reprocessing their memories.

Psychotherapy was instrumental for Philip Robinson. “Being a survivor is quite difficult,” says Robinson, who, 30 years ago last August, embarked on the steamer *Marchioness*, along with 130 others, most in their 20s, to celebrate the birthday of a London friend. He was below deck when a huge barge riding high in the Thames essentially ran over the boat and sent it down in seconds. “I was struck in the shoulder and hit by flying bottles. I just swam and swam. I’m a professional singer, and I kept hold of my breath. I got out through a broken window.” Fifty-one others didn’t.

In 1989, a birthday fest on the steamer Marchioness plying the Thames River ended the lives of 51 of the 131 people aboard when a barge ran over the vessel. Philip Robinson lost many friends. He attributes his own survival in part to his singing skills. “I have a reasonable amount of breath control.” His drive to “carry on” after the disaster gave way to a life re-evaluation; he took the risk of giving up work in finance to study music “to develop the gift I was given. My friends would have wanted that."
Photo: Jasper Gibson

And Robinson did well until, 11 years after the disaster, a public inquiry got underway. “We had to relive the accident. There were interviews, investigations. My relationship broke down. I was having trouble at work.” A visit to his GP led to a full psychiatric assessment. “I was suffering from depression. My normally robust coping mechanisms had been challenged and overwhelmed.” Two years of work with a therapist followed. He was encouraged to let go of the belief that “I was singing for dead friends.” He now sings for himself. “Singing is a way that my soul can talk to tragedy.”

Because Robinson is the first to acknowledge how fortuitously the elements of his life worked for him, he’s set up a charity to assist other victims of single-incident disasters get whatever help they are found to need. Every year his charity, the Antonio Vasconellos Fund, gives out 51 grants—each in the name of a *Marchioness* victim.

The Stricken and the Spared

Not everyone exposed to catastrophic or life-threatening events develops PTSD. Even among veterans of combat, which can deliver a barrage of disturbing events under conditions of high emotional arousal, rates of the disorder range from 10 to 30 percent.

Researchers have been dissecting exactly what constitutes resilience ever since the late sociologist Emmy Werner began tracking the development of every infant born on the island of Kauai in 1955 and discovered that only a minority of those delivered into highly adverse circumstances wound up troubled or in trouble. For the most part, says psychiatrist Adriana Feder of New York's Mt. Sinai Medical Center, resilience research has sought answers in psychosocial factors like family stability and social support, which foster emotional regulation. Only recently has it deepened to include biology.

Most research into exactly what goes awry in stress circuitry in PTSD looks at individuals who already have the disorder. But the most useful studies, Feder observes, would look at people before they experience trauma—such as military personnel pre-deployment and civilians beginning work in police and fire departments—and follow them.

A large national collaborative study named AURORA is doing the next best thing. Researchers are gathering data, including brain scans, on people seen in emergency rooms immediately after trauma exposure and seeking patterns of brain activity that predict how they fare over time. Feder herself is leading studies of police, construction workers, and others who responded to the World Trade Center attacks, comparing those who went on to develop PTSD with those who did not.

The 9/11 attacks, tragic as they were, are serving as a living laboratory illuminating the natural course of PTSD. Overall, studies show, among people exposed to the trauma, PTSD rates declined over the first few years.

Volunteer first responders were significantly more likely to develop PTSD than professionals, such as police and firefighters. Volunteers not affiliated with rescue organizations like the Red Cross were particularly hard hit, with PTSD rates of nearly 30 percent, vs 13 percent for the pros.

Those data confirm earlier findings: Individuals with a history of trauma exposure or mental difficulties and those with poor social support and recent or ongoing life stress are at high risk of PTSD. An important new finding was that physical impairment or job loss raised the risk of PTSD.

Psychotherapy, including exposure therapy employing virtual reality, was generally effective. New data found that children responded well to psychotherapy provided in school or the community.

IMAGEN is the acronym for a large European study tracking how a wide range of factors during adolescence influences brain development and adult mental health. One of the findings so far is that adolescents who are doing well despite the presence of major stressors in their life react in a distinctive way when shown pictures of fearful or angry faces, normally a stress-inducing scenario.

Notably, there is little activation of the amygdala. In addition, studies show that these youth have more grey matter in the prefrontal cortex. Circuitry involved in cognitive reappraisal—the ability to reinterpret an event's meaning—appears associated with more controlled, less excessive responses.

Can resilience be fostered? Stress-inoculation therapy, often a component of cognitive behavioral therapy, counts on it. It aims to fortify people in advance of difficult experiences by exposing them to a progression of challenging circumstances through imagery and video simulations. It seeks to help people develop coping skills; to maintain cognitive flexibility so that difficulties can be seen as challenges to be mastered and opportunities for growth; and to inculcate a sense of control, the realization that it's possible to shape the stress response by such perceptions. The therapy is often used with people who will be exposed to combat.

It may be that specific drugs given to people immediately before exposure to life-threatening conditions or immediately after can also forestall development of PTSD. Among the agents under study is neuropeptide Y (NPY), a chemical found throughout the nervous system and best known for promoting food intake.

In the brain, NPY is also associated with resilience to the harmful effects of stress, says neuroscientist Esther Sabban of New York Medical College. There is some evidence that NPY is an all-around inhibitor of nerve action, so that it takes a stronger dose of danger to overactivate stress-circuit neurons and dysregulate them. In the amygdala, its release mutes the response to stress.

Studies show that people with PTSD have lower blood levels of neuropeptide Y than those who don't develop PTSD. It is impossible to know yet whether the difference predates their response to trauma or is a result of it, although genetic studies suggest it's pre-existing.

In one of her own experiments, conducted on rats, Sabban and colleagues subjected animals to a strong and prolonged stressor—the rodent equivalent of trauma. Animals got NPY either 30 minutes before the stress exposure, immediately after it, or a week later, when severe stress effects had already set in. NPY given before or immediately

after exposure to stress completely blocked development of PTSD-like responses. It had no effect on full-blown symptoms.

Human studies with NPY are few. One small clinical trial found that the neuropeptide given intranasally (to go directly to the brain, averting unwanted effects on the body) reduced the anxiety symptoms of PTSD. Sabban and her colleagues are now conducting research that, she hopes, will lead to a clinical trial large enough to establish whether giving the drug within two days after trauma can forestall progression of distress to PTSD.

The Opposite of Stress

NPY is not the only chemical hope against PTSD. Compounds of interest include ketamine, an anesthetic that has a shady past as a club drug called Special K but which has recently been approved for use to treat severe, unremitting depression, especially when accompanied by thoughts of suicide. Delivered intravenously, it acts rapidly, within hours, although no one knows exactly how. After years of testing, esketamine (one of two nearly identical forms of ketamine) was FDA-approved for resistant depression early this year.

"A couple of patients we treated for depression had PTSD, and their symptoms seemed to get better as well," Adriana Feder reports. "This led to our first study, in 2014, with a single intravenous infusion of ketamine." Treatment resulted in improvement in all symptom groups of PTSD—re-experiencing the traumatic incident, avoidance, anhedonia, and hyperarousal—measured 24 hours later. Feder is now leading a clinical trial in which patients receive six doses of the drug over a two-week period, "to see whether we can replicate these initial findings and maintain the response."

There are strong indications that ketamine fundamentally alters nerve connectivity within the brain. "We published a neuroimaging study in depressed patients, which found increased connectivity in emotional regulation regions after ketamine administration," Feder reports. Her group is now conducting a similar study in patients with PTSD.

Neuroscientist Ronald Duman, professor of psychiatry and director of molecular psychiatry at Yale University, contends that PTSD is fundamentally a "synaptic deficit disorder"—blunting communication between individual neurons. "A lot of brain imaging work demonstrates decreased volume in brain regions implicated in PTSD. This led to the idea that a loss of synaptic connections could be involved."

A shortage of connections between nerve cells would compromise neuroplasticity, impeding learning and keeping those exposed to trauma stuck in their over-the-top response, with no neural escape route—no pathway for extinguishing the fear

response. Animal research has shown that synapses in the hippocampus and prefrontal cortex dwindle after chronic stress. But evidence that the same thing happens in PTSD has been elusive. “These are technically very difficult studies to do,” Duman observes.

There’s some indirect evidence of synaptic loss in humans with PTSD. In studies of tissue samples from the PTSD Center’s brain bank, researchers have found differences in genes regulating synapse formation between individuals with PTSD and those without.

The findings, if confirmed, could help explain how ketamine works—both in depression and PTSD. “Ketamine produces an effect opposite to stress: It increases synaptic connections in the prefrontal cortex, even after a single dose,” Duman says.

Synaptic plasticity—the growth of new inter-neuron connections—is the foundation of memory and learning. And, in its unraveling, it is the source of the memory-changing processes that go awry in PTSD.

Ordinarily, the link between a memory and the emotions associated with it can be extinguished; over time, the emotional response component weakens and dissipates. What’s more, scientists know that every time a memory is brought to mind, it can be modified and reframed, a process known as reconsolidation. That paves the way for talking about a bad experience with friends in pleasant surroundings to send the memory back into storage in less disturbing form.

But in PTSD, memories resist both kinds of change, making them nearly ineradicable. “The memory is always stored in its original form—they’re being raped again, with all the emotions of the original event,” explains clinical psychologist Ilan Harpaz-Rotem, also of Yale.

Prolonged exposure and cognitive reappraisal are known to be two of the most effective psychotherapies. They work by advancing memory modification—the very process crippled by PTSD. “Patients need a nudge, and enhanced neurogenesis after ketamine may open a window of reconsolidation,” says Harpaz-Rotem.

The Yale researcher is gearing up to provide that nudge, with a clinical trial that combines ketamine with prolonged exposure therapy. The combo could do in seven days what, under the best of circumstances, might otherwise take months. Before-and-after MRI studies will explore whether and how the treatment changes the way parts of the brain work together.

That’s one possibility—the rapid-acting way. If Ronald Duman is right, there are other ways to restore synaptic connectivity and psychological flexibility. Prime

among them is physical activity, which is known to directly stimulate the growth of new neuronal connections.

“Maybe a Door”

Paula Scnurr is excited about the use of ketamine to “potentiate and enhance the power of the most effective psychotherapy.” It’s an instance of taking something that works well and making it work even better. Another chemical agent that fits that bill is the psychedelic drug MDMA, aka Ecstasy. “It catalyzes the psychotherapeutic process,” says psychiatrist Michael Mithoefer, who has spearheaded two decades of research on MDMA. Intense interest in its potential has spurred the FDA to designate MDMA a “breakthrough” treatment for PTSD, and the agency is fast-tracking it toward approval. MDMA is already approved for use in Israel.

An international Phase III clinical trial—a big step toward approval—is already underway. An analysis of six small clinical trials showed that the agent brought about symptom improvement
double that of control groups. In the standard protocol, patients are given MDMA before each of three therapy sessions of eight hours or longer, conducted by two specially trained therapists and spaced a week apart.

“We don’t tell people to talk about trauma, but whatever comes up,” says Mithoefer. Unstructured as the sessions are, elements of standard trauma therapy—exposure to traumatic material and cognitive restructuring—are generally engaged. “We emphasize that MDMA is different from most psychiatric medications in that it is not designed to repress symptoms but to help process underlying causes; sometimes symptoms get worse before they get better.”

“I thought PTSD occurred only in those coming back from combat,” says Hayley Gripp. That was until 2014, when her car was hit broadside. Trapped and suffocating on the fumes, she passed out. She came to “consumed by gratitude” at being alive, despite injuries to her legs. “Everything was taken from me, including my livelihood, I could no longer stand on a set.” Two weeks later, “I heard a loud car horn, and I screamed. I was the girl attacked in a film. I knew how to scream. I thought I was going crazy.”
Photo: Jasper Gibson

As a neuroscientist researching trauma for three decades, psychologist Rachel Yehuda was skeptical of MDMA case reports. “Having been in the field for so long and having research experience with many treatments, I couldn’t fathom the claim that after one or two sessions people with chronic PTSD no longer had it,” says Yehuda, director of the Traumatic Stress Studies
Division at Mt. Sinai Medical Center.

That was before she went to Israel. “I began to understand this was an approach to trauma therapy that has to do with inducing a very safe and cocooned state for a person.” The drug, she says, “creates an open, warm feeling of self-compassion, and the therapist provides an environment for understanding the material that is coming up, making it safe to see from different angles.” It removes the barriers where people normally get stuck in psychotherapy—”where it hurts, the core where they don’t want to go.”

Yehuda herself underwent a session of treatment, which she says gave her an inside understanding of how the accelerated psychotherapeutic experience fosters accessing and processing the events of one’s life. “It’s like learning you can take a plane from New York to Los Angeles, rather than having to walk there.”

“Those of us who have tried to understand trauma have been looking for a window to help people,” Yehuda says. “This may be a floor-to-ceiling window, maybe a door.”

“We know MDMA decreases activity in the amygdala, and increases it in the prefrontal cortex, which fits really well with what we see clinically: People can suddenly talk about their trauma without being overcome by emotion.” Mithoefer says. “A vet who underwent treatment said, ‘Iraq changed my brain, and MDMA changed it back.’ There’s brain-imaging data to show that.”

Regaining Control of Their Own Brains

All the imaging studies exploring the neurobiology of PTSD have helped identify “which brain areas need to be turned up and which turned down,” says Paul Holtzheimer, deputy director for research at the National Center for PTSD. And that opens the way for highly targeted treatments, including neurofeedback.

“When you fear something, the amygdala becomes activated; in PTSD it’s activated more,” says Ilan Harpaz-Rotem. With neurofeedback, patients learn to reduce symptoms by dialing back brain activity by themselves. Especially after being at the mercy of unpredictable triggers anytime and anywhere, “it’s empowering for them to take control of their own brains,” he says.

Harpaz-Rotem is leading a clinical trial in which individuals with PTSD lie in an MRI scanner, watching a pointer that tracks blood flow—an indication of amygdala activity—while they are read a script and hear sounds evocative of the precipitating trauma. They are taught techniques to reduce fear and, by watching the pointer, can determine which ones dampen amygdala arousal.

The hope is that they will apply the techniques whenever they feel overwhelmed, “not to erase the memories but to learn to tolerate them,” he says. Before-and-after MRIs will reveal any altered connectivity between the amygdala, the hippocampus, and the prefrontal cortex and any correlations with symptom reduction.

Another promising treatment takes direct aim at the faulty circuitry of PTSD and gives it a reboot. Transcranial magnetic stimulation, which applies a shifting magnetic field to generate small electric currents in relevant spots, is already in use for drug-resistant depression and obsessive-compulsive disorder.

In PTSD, it targets a key neural node—the dorsolateral prefrontal cortex. The goal is to jack up cognitive control so the brain can better regulate emotion, decreasing the intensity of undesired experiences. “The effects may carry over to a number of symptoms—avoidance, even flashbacks,” says Holtzheimer.

Brain stimulation is being tested as a psychotherapy booster, too. Applied just prior to weekly sessions of cognitive reprocessing therapy, the treatment, Holtzheimer stresses, is still very much a work in progress. “If it follows the same timeline as that for depression, maybe in five years we’ll see a pivotal clinical trial that opens the door to broad availability.”

The ability to treat PTSD effectively is advancing in lockstep with new understanding of the disorder. Terrible events will continue to happen; even if war were to stop tomorrow, nature delivers its own random blows. Emotional aftershocks will inevitably reverberate in the minds and brains of those exposed. But while pain is inevitable, lasting suffering is not. Putting an end to it is no longer an impossible goal.

Appendix E

Session Evaluation Questionnaire

Directions: Please place an "x" on each line to show how you feel about this session.

This session was:

1. Bad	___ :	___ :	___ :	___ :	___ :	___ :	___	Good
2. Safe	___ :	___ :	___ :	___ :	___ :	___ :	___	Dangerous
3. Difficult	___ :	___ :	___ :	___ :	___ :	___ :	___	Easy
4. Valuable	___ :	___ :	___ :	___ :	___ :	___ :	___	Worthless
5. Shallow	___ :	___ :	___ :	___ :	___ :	___ :	___	Deep
6. Relaxed	___ :	___ :	___ :	___ :	___ :	___ :	___	Tense
7. Unpleasant	___ :	___ :	___ :	___ :	___ :	___ :	___	Pleasant
8. Full	___ :	___ :	___ :	___ :	___ :	___ :	___	Empty
9. Weak	___ :	___ :	___ :	___ :	___ :	___ :	___	Powerful
10. Special	___ :	___ :	___ :	___ :	___ :	___ :	___	Ordinary
11. Rough	___ :	___ :	___ :	___ :	___ :	___ :	___	Smooth
12. Comfortable	___ :	___ :	___ :	___ :	___ :	___ :	___	Uncomfortable

Right now I feel:

13. Happy	___ :	___ :	___ :	___ :	___ :	___ :	___	Sad
14. Angry	___ :	___ :	___ :	___ :	___ :	___ :	___	Pleased
15. Moving	___ :	___ :	___ :	___ :	___ :	___ :	___	Still
16. Uncertain	___ :	___ :	___ :	___ :	___ :	___ :	___	Definite
17. Calm	___ :	___	___	___	___	___	___	Excited

		:	:	:	:	:		
18. Confident	___ :	___	___	___	___	___	___	Afraid
		:	:	:	:	:		
19. Wakeful	___ :	___	___	___	___	___	___	Sleepy
		:	:	:	:	:		
20. Friendly	___ :	___	___	___	___	___	___	Unfriendly
		:	:	:	:	:		
21. Slow	___ :	___	___	___	___	___	___	Fast
		:	:	:	:	:		
22. Energetic	___ :	___	___	___	___	___	___	Peaceful
		:	:	:	:	:		
23. Involved	___ :	___	___	___	___	___	___	Detached
		:	:	:	:	:		
24. Quiet	___ :	___	___	___	___	___	___	Aroused
		:	:	:	:	:		

Appendix F

Need for Cognition

Need for Cognition Scale (from Cacioppo, Petty, & Kao, 1984)

For each of the statements below, please indicate whether or not the statement is characteristic of you or of what you believe. For example, if the statement is extremely uncharacteristic of you or of what you believe about yourself (not at all like you) please place a "1" on the line to the left of the statement. If the statement is extremely characteristic of you or of what you believe about yourself (very much like you) please place a "5" on the line to the left of the statement. You should use the following scale as you rate each of the statements below.

1	2	3	4	5
extremely uncharacteristic of me	somewhat uncharacteristic of me	uncertain	somewhat characteristic of me	extremely characteristic of me

1. _____	I prefer complex to simple problems.
2. _____	I like to have the responsibility of handling a situation that requires a lot of thinking.
3. _____	Thinking is not my idea of fun.**
4. _____	I would rather do something that requires little thought than something that is sure to challenge my thinking abilities.**
5. _____	I try to anticipate and avoid situations where there is a likely chance I will have to think in depth about something.**
6. _____	I find satisfaction in deliberating hard and for long hours.
7. _____	I only think as hard as I have to.**
8. _____	I prefer to think about small daily projects to long term ones.**
9. _____	I like tasks that require little thought once I've learned them.**
10. _____	The idea of relying on thought to make my way to the top appeals to me.
11. _____	I really enjoy a task that involves coming up with new solutions to problems.
12. _____	Learning new ways to think doesn't excite me very much.**
13. _____	I prefer my life to be filled with puzzles I must solve.
14. _____	The notion of thinking abstractly is appealing to me.
15. _____	I would prefer a task that is intellectual, difficult, and important to one that is somewhat important but does not require much thought.
16. _____	I feel relief rather than satisfaction after completing a task that requires a lot of mental effort.**
17. _____	It's enough for me that something gets the job done; I don't care how or why it works.**
18. _____	I usually end up deliberating about issues even when they do not affect me personally.

Note: **=reverse scored item.

Appendix G

Free Recall Test Instructions

On the sheet provided, please write down as much information you can remember from the PTSD article you studied last session.

Appendix H

Multiple Choice Exam

Please choose the correct answer and fill it in on your scantron.

1. What was the overall topic of this article?
a. Anxiety
b. Depression
c. PTSD
d. Eating Disorders

2. Neria was a commander in which county's military?
a. Iraq
b. Israel
c. France
d. Russia

3. A 21-year-old tank commander went on to write a novel about his experiences in war. This book was titled _____.
a. War
b. Fire
c. Raids
d. Valor of War

4. When Neria became a clinical psychologist, which catastrophic event led to his recruitment at Columbia University?
a. The attacks on the World Trade Center
b. Hurricane Katrina
c. Joplin MO tornadoes
d. War on Terror

5. While at Columbia, Neria focused on _____ underlying PTSD.
a. behavior abnormalities
b. neural mechanisms
c. traumatic dreams
d. general sleeping problems

6. In what year did the existence of PTSD become formally recognized?
a. 1970
b. 1975
c. 1980
d. 1985

7. Which edition of the Diagnostic and Statistical Manual first included PTSD?
a. Second
b. Third
c. Fourth
d. Fifth

8. Only individuals who experience an event can develop PTSD?
a. True
b. False

9. Which is not a symptom often associated with PTSD?
a. Hypervigilance
b. Insomnia
c. Worry
d. Compulsive Lying

10. When the brain detects potential threatening situations, nerve impulses route through the _____ to get to the amygdala?
a. Hippocampus
b. Thalamus
c. Pineal Gland
d. Prefrontal Cortex

11. Once the amygdala is aroused, it signals the adrenal glands to _____.
a. shut down
b. secrete adrenaline
c. begin sweating
d. store memories

12. When the hypothalamic-pituitary axis begins working, it sets off hormones which culminates in the release of _____.
a. Corticotrophin
b. Cortisol
c. Ghrelin
d. Leptin

13. Armand Cucciniello III was a diplomat at the U.S. embassy in which country during the Iraq War?
a. Benghazi
b. Afghanistan

c. Baghdad
d. Turkey

14. Attacks on the embassy at which Cucciniello was stationed began how many months after he arrived?
a. 2 months
b. 4 months
c. 6 months
d. 8 months

15. Cucciniello stated that because the attacks would occur without warning and with no perceivable pattern, he became _____.
a. angry
b. tense
c. depressed
d. lethargic

16. After Cucciniello spoke with a psychiatrist he was prescribed
a. antidepressants
b. sleeping Aids
c. no medication
d. high blood pressure medication

17. On a trip to visit with family in New York what provoked a flashback PTSD memory for Cucciniello?
a. A construction worker dropping a metal pipe
b. A taxi driving over an iron plate covering street construction
c. Fireworks at a concert
d. A dump truck disposing of a dumpster

18. Because of technology such as _____ , researchers are able to see a dynamic picture of flashback memories.
a. MRI
b. MRA
c. CT
d. XRAY

19. What area of the brain do researchers refer to as “ground zero” for fear processing?
a. Amygdala
b. Hippocampus
c. Prefrontal Cortex

d. Pituitary Gland

20. Individuals with PTSD experience an under engaged prefrontal cortex but experience an hyperactivated _____.
a. hippocampus
b. amygdala
c. adrenal gland
d. thalamus

21. Approximately what percentage of individuals diagnosed with PTSD are also diagnosed with clinical depression?
a. 35%
b. 50%
c. 75%
d. 85%

22. What technology does the Neurobiologist Benjamin Suarez-Jimenez use to explore an individual's tendency to see danger where there is not any?
a. Console video games
b. tablets
c. body scanners
d. virtual reality

23. Patients with a larger _____ were found to develop less PTSD as time goes on.
a. amygdala
b. thalamus
c. hippocampus
d. prefrontal cortex

24. Why was Philip Robinson on the steamer Marchioness?
a. Anniversary dinner
b. Friend's birthday
c. Vacation
d. Friend's wedding

25. After 9/11, researchers discovered that volunteer first responders were how likely to develop PTSD?
a. 20%
b. 30%
c. 40%

d. 50%

26. IMAGEN is the acronym for ____?
a. a European PTSD study
b. a PTSD research facility in Southern California,
c. a newly developed PTSD Therapy
d. a research grant funded by Stanford University

27. What is cognitive reappraisal?
a. one's ability to suppress PTSD symptoms
b. one's ability to reinterpret an event's meaning
c. one's ability to suppress traumatic memories
d. one's ability to catalyze psychotherapy processes

28. Esther Sabban is a neuroscientist from _____.
a. Harvard University
b. The Mayo Clinic
c. University of California Los Angeles
d. New York Medical College

29. Individuals who develop PTSD have lower levels of neuropeptide Y in their _____.
a. neurons
b. blood
c. muscles
d. skin cells

30. Dr. Sabban and her colleges tested NYP on rats exposed to stress that was the rodent equivalent of trauma and found that in which group of rats were PTSD-like responses completely blocked?
a. when NYP was given before stress
b. when NYP was given immediately after stress
c. neither groups failed to develop PTSD like responses
d. both groups failed to develop PTSD like responses

31. Special K is a chemical that is being used to treat depression. It has a shady past as a _____.
a. street drug
b. high school party drug
c. club drug
d. performance enhancing drug

32. The article states that a shortage of connections between nerve cells shows _____.

a. Nerodecline
b. Dementia
c. Neuroplasticity
d. Neurstasia

33. When a memory is brought to mind, it can be _____.
a. modified
b. extinguished
c. both
d. neither

34. When you talk about a traumatic memory with a friend in a pleasant surrounding you make an opportunity for the memory to be sent back in a less disturbing form. This process is known as _____.
a. reconciliation
b. reconnaissance
c. reconsolidation
d. resonance

35. A Yale researcher is conducting a clinical trial that combines Ketamine with _____.
a. cognitive reappraisal
b. memory enhancement procedure
c. prolonged exposure therapy
d. synaptic neurogenesis

36. Psychiatrist Michael Mithoefer said which drug "catalyzes the psychotherapeutic process"?
a. Ecstasy
b. Methamphetamine
c. Xanax
d. Adderall

37. Hayley Gripp developed PTSD after losing her legs in a _____.
a. skiing accident
b. car accident
c. biplane crash
d. helicopter crash

38. MDMA was stated to "create a cocooned state of safety and warm feeling of_____" for individuals with PTSD.
a. self-care,

b. self-love
c. self-compassion
d. self-determination

39. MDMA decreases activity in the amygdala while increasing activity in the _____.
a. cerebellum
b. occipital lobe
c. hypothalamus
d. prefrontal cortex

40. Which treatment generates small electric currents in relevant spots?
a. electro-occipital therapy
b. transcranial magnetic stimulation
c. pons-cranial therapy
d. stimulated current therapy

41. Brain stimulation is being tested as a psychotherapy booster. Currently it is applied _____.
a. right before CRT sessions
b. right after CRT sessions
c. concurrently with CRT sessions
d. 24 hours after CRT sessions

42. In one clinical trial, individuals diagnosed with PTSD lie down in a _____ while watching a pointer that tracks blood flow.
a. CT Scanner
b. MRI Scanner
c. MRA Scanner
d. TRA Scanner

43. Prior to her accident, Hayley Gripp was a/an _____.
a. artist
b. musician
c. actress
d. comedian

44. Most research into what goes awry in stress circuitry systems in individuals with PTSD looks at _____.
a. individuals who are survivors of the 9/11 attacks
b. individuals who already have the disorder
c. individuals who are first responders
d. individuals over the age of 50

45. Which therapy exposes individuals to a progression of challenging images and videos?
a. stress-inoculation therapy
b. stress-induction therapy
c. stress-cognition therapy
d. stress-behavioral therapy

46. Youth who reacted distinctively to fearful or angry faces were found to have _____than those who did not respond distinctively.
a. less gray matter
b. more gray matter
c. less neuron connectors
d. more neuron connectors

47. What factor has been shown to raise risks of PTSD?
a. beginning a new job
b. physical impairment
c. moving for occupational reasons
d. loss of a pet

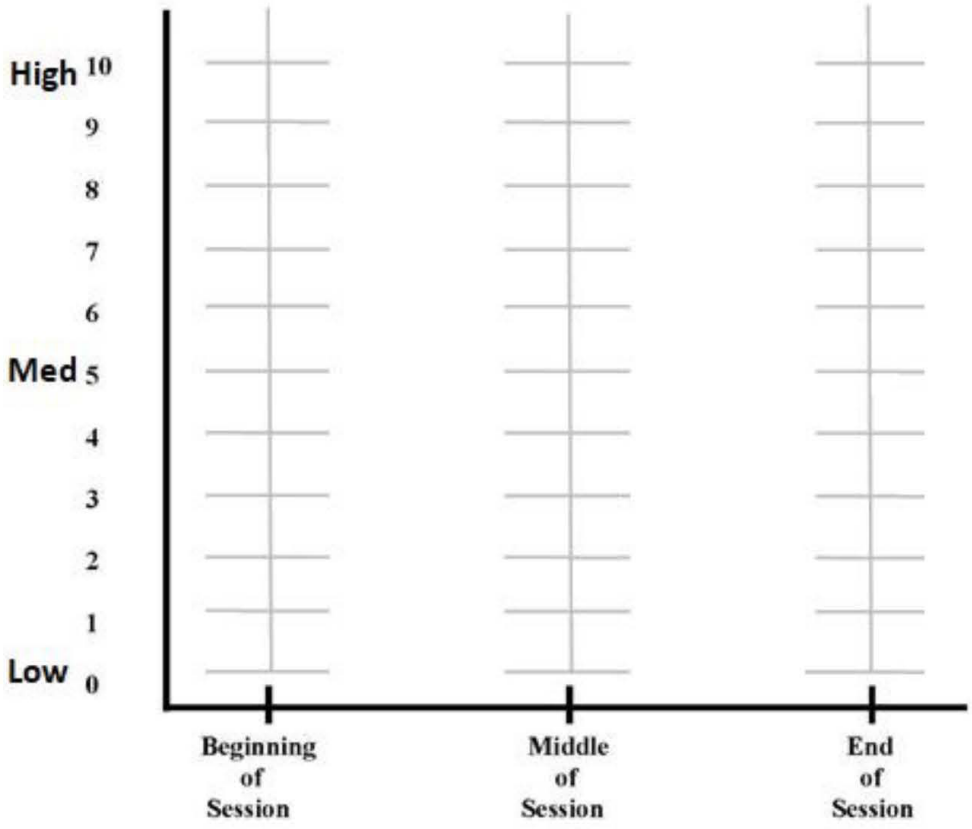
48. A study named _____ is gathering data across the country on people seen in the emergency room immediately after trauma exposure.
a. JASMINE
b. AURORA
c. BELLE
d. ARIEL

49. Researchers began looking into resilience after sociologist Emmy Werner began tracking development of every infant born on the island of Kauai in_____.
a. 1947
b. 1955
c. 1962
d. 1971

50. Phillip Robinson first began to experience PTSD symptoms _____ after surviving the Marchioness steamer accident.
a. 24 hours
b. 6 months
c. 7 years
d. 11 years

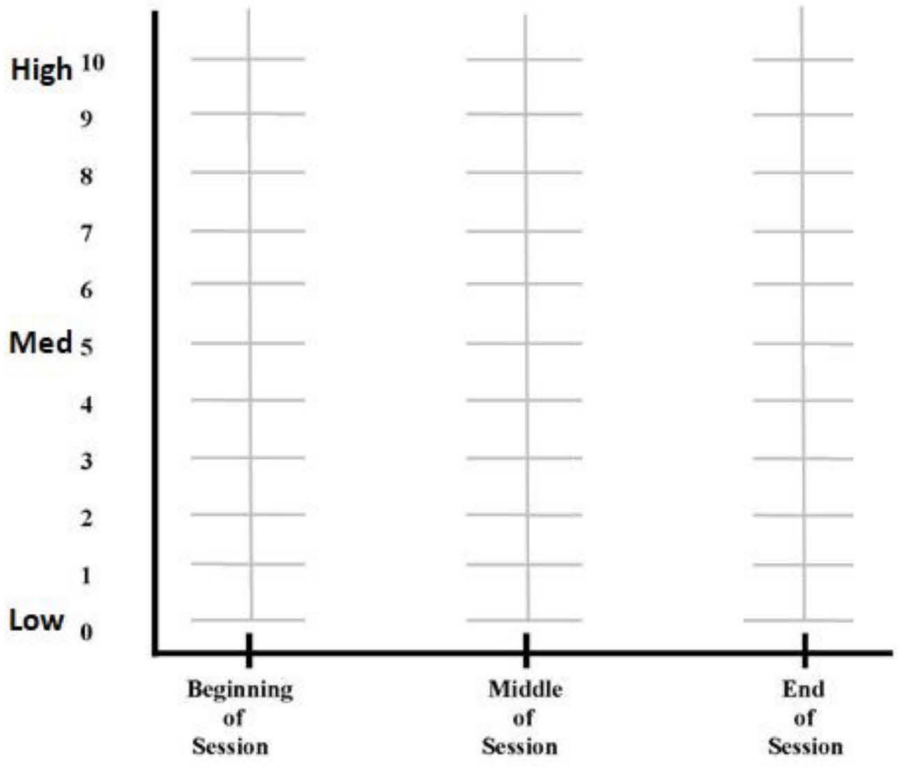
Motivation

For each point in time, indicate your level of motivation for studying during this session from 0-10.



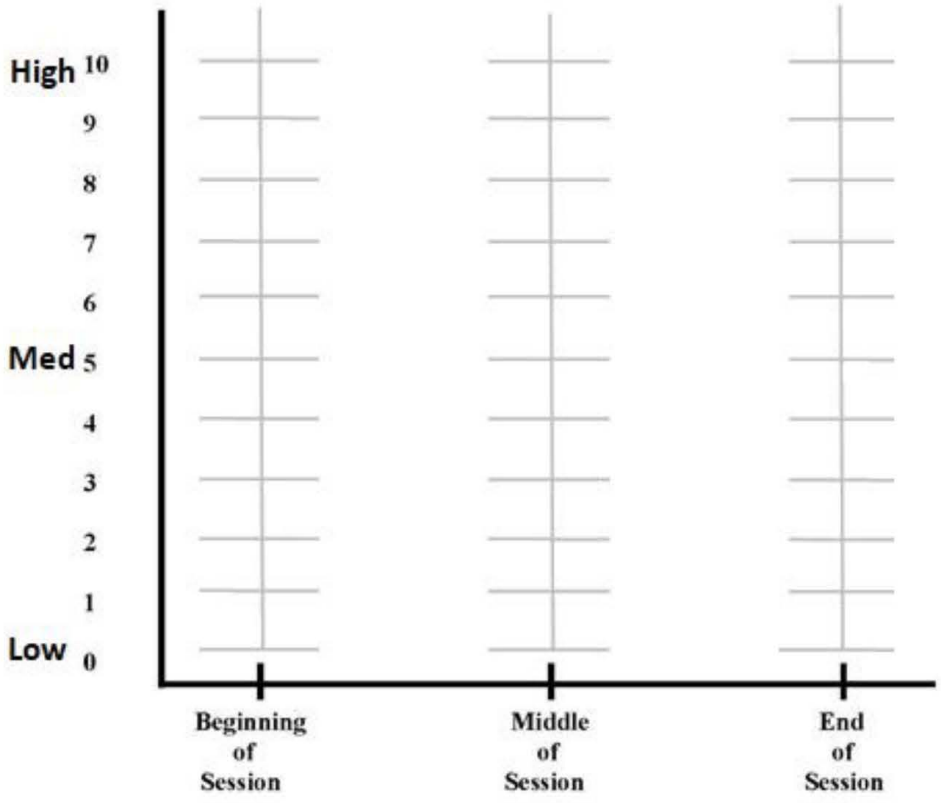
Concentration

For each point in time, indicate your level of concentration for studying during this session from 0-10.



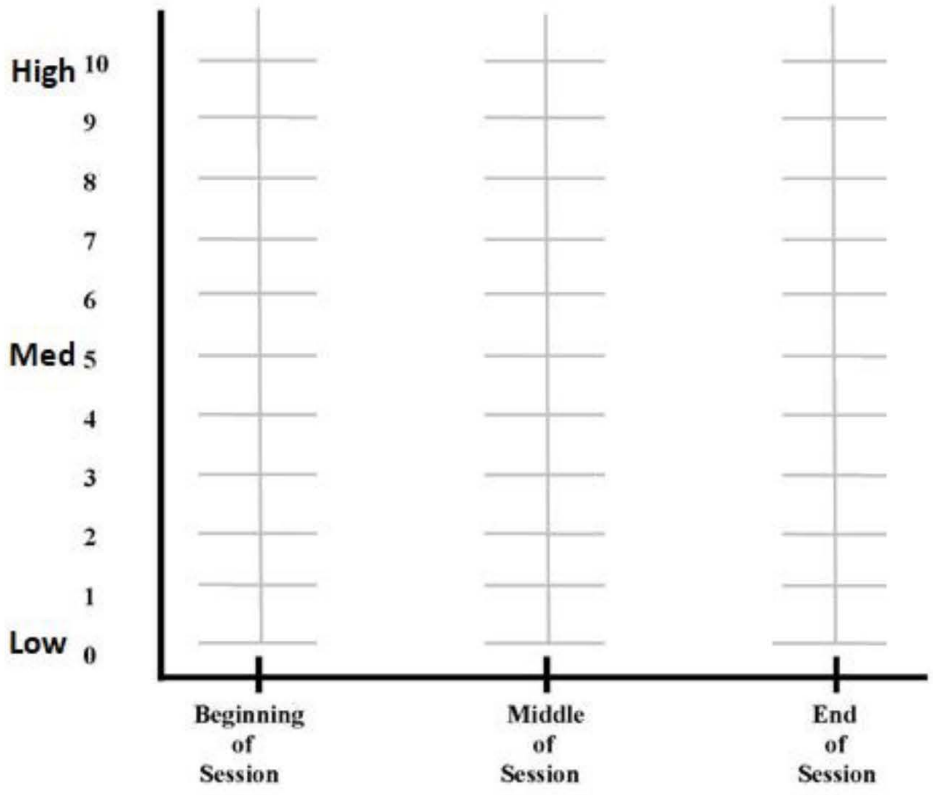
Effectiveness

For each point in time, indicate the effectiveness of your studying during this session from 0-10.



Anxiety

For each point in time, indicate your level of anxiety during this study session from 0-10.



Appendix J

Debriefing Statement

Thank you so much for participating in this research project. We are looking at how the olfactory system connects with memory in an effort to improve memory encoding. Specifically, we are exploring the possibility of essential oils serving as retrieval cues for students during test taking.

If you would like to know more about this research and what the results were when the study has been completed, please feel free to reach out to Dr. Heather Labansat or Rene Wallace. labansat@tarleton.edu rene.wallace@go.tarleton.edu