EXPLORING THE RELATIONSHIP BETWEEN PAIN AND PROSPECTIVE MEMORY

by

MAXINE KAYLEN GELTMEIER

DISSERTATION

Submitted in partial fulfillment of the requirements
for the degree of Doctor of Philosophy at
The University of Texas at Arlington
May, 2021

Arlington, Texas

Supervising Committee:

Dr. Perry Fuchs, Supervising Professor
Dr. Hunter Ball
Dr. Daniel Levine
Dr. Angela Liegey-Dougall
Dr. Matthew Robison

ACKNOWLEDGEMENTS

I would like to acknowledge Dr. Perry Fuchs for his continued support, advice, and encouragement. His guidance and reassurance gave me the confidence to be a more independent researcher. I am grateful to him for the life-changing opportunity he extended by providing his mentorship. I would also like to acknowledge the other impressive scholars on my dissertation committee. Their direction helped me to refine my work to a quality that I can be proud of. I would like to specifically acknowledge Dr. Angela Liegey-Dougall who has given me counsel multiple times throughout my graduate career. Her support and understanding helped to lift my spirits and motivate me during times where I was overwhelmed and uncertain. Lastly, I would like to acknowledge the outstanding staff and faculty of the psychology department. The culture of acceptance that everyone cultivates has made for an environment of growth and encouragement, of which I am truly thankful for.

DEDICATION

I would like to dedicate this work to my incredible family. To my parents for teaching me that hard work is rewarding and the perseverance takes patience. I always had confidence in myself because they had confidence in me. To my children, for motivating me to be the best example and role model possible. And to my husband, for inspiring me to go further than I ever dreamt. For always pushing me, supporting me, and encouraging me.

ABSTRACT

Exploring the Relationship between Pain and Prospective Memory

Maxine Kaylen Geltmeier, Ph.D. Candidate

The University of Texas at Arlington, 2021

Supervising Professor: Perry N. Fuchs

The relationship between pain and memory has been explored through multiple perspectives and approaches. One area that has been less defined is the impact of pain on prospective memory. While studies have found a negative relationship between pain and prospective memory, little is known about the potential mediators or moderators of this relationship. The purpose of the current study was to verify previous findings and to evaluate attention and emotional regulation as mediating variables. Data were collected from a university sample and a sample recruited based on recurrent pain and/or chronic pain. Measures included self-report and online cognitive tests. The use of subjective measures, objective measures, a university sample, and a reporting pain sample provided a more holistic evaluation of each factor and their interactions. Differing patterns were found between samples and between subjective and objective measures. Attention and emotion regulation did not significantly mediate the relationship between pain and prospective memory. Further elucidation of pain and memory interactions could be particularly beneficial to those with chronic pain conditions and cognitive decline.

Keywords: Pain, Prospective Memory, Attention, Emotion Regulation

TABLE OF CONTENTS

CHAPTER 1

INTRODUCTION

Pain is a debilitating condition, and the incapacitating nature of pain is often attributed to injury, financial burden, and emotional distress (Berryman, Stanton, Bowering, Tabor, McFarlane, & Moseley, 2014; Lumley et al., 2011). However, pain can also be impactful through more subtle means. The impact of pain goes beyond salient outcomes, such as the tissue damage itself, resulting in less apparent outcomes, such as cognitive disruption (Dick, & Rashiq, 2007; Ishizuka, Hillier, & Beversdorf, 2007). Cognitive impairments and disruptions have been linked to pain for processes such as attention, emotional regulation, and memory.

Pain and Memory

While cognitive outcomes of pain are less conspicuous than physical outcomes, decades of research have been dedicated to elucidating and interpreting these indirect impairments. Early observations of patients with chronic pain revealed that memory complaints are commonly present in those with persistent pain conditions (Jamison, Sbrocco, & Parris, 1989). The notion that chronic pain impacts memory has been consistently supported over the past few decades (Schnurr, & MacDonald, 1995; Rode, Salkovskis, & Jack, 2001; Whitlock et al., 2017). A recent review has highlighted the negative outcomes of chronic pain on both working memory and long-term memory (Mazza, Frot, & Rey, 2018).

Similar to chronic pain, acute pain also negatively impacts memory. Ishizuka et al. (2007) found that participants under a cold pain stimulus performed more poorly on a recall task than under a control condition. Likewise, heat pain stimuli have been shown to impair recognition memory, even when pain is cued and expected (Forkmann, Schmidt, Schultz, Sommer, & Bingel, 2016). Beyond thermal pain, other pain modalities can impact memory. Norton et al.

(2020) recently found that painful electric shock following presentation of auditory words can impair recollection of the word on the following day. These findings, taken together, indicate that pain interacts closely with cognition, specifically memory, irrespective of pain duration or pain modality.

In addition to human evaluations, preclinical research has been conducted to understand the mechanisms involved in the interaction between pain and memory. Much of this research focuses on the impact that pain has on attentional resources, where pain is theorized to monopolize attention and interrupt processing for learning and memory (Lötsch et al., 2012; Albuquerque, Häussler, Vannoni, Wolfer, & Tegeder, 2013). Several biological markers have been identified for cognitive and memory impairments for pain in rodents, such as tumor necrosis factor-α (TNF-α), and other inflammatory mechanisms (Ren et al., 2011; Grégoire, Michaud, Chapuy, Eschalier, & Ardid, 2012). Furthermore, there is some evidence to suggest that neurotransmitter activity, altered by persistent pain, is involved in memory deficits (Kodama, Ono, & Tanabe, 2011). The interaction between pain and memory is complex; an abundance of research has resulted in several reviews produced to outline these complexities (Seminowicz, & Davis, 2007; Moriarty, McGuire, & Finn, 2011; Low, 2013).

Prospective Memory

While research regarding the interaction between pain and memory is prolific and wide reaching, there are still aspects of the relationship which have yet to be fully explored. For example, the vast majority of research in the field has focused on retrospective memory. Retrospective memory is memory of past experiences and information (Tulving, 1993). However, fewer studies have evaluated the impact of pain on prospective memory. Prospective memory is our ability to remember to complete certain actions or behaviors in the future

(Baddeley, 1976). Prospective memory has been interpreted within a Multiprocess Framework, where retrieval processes can be automatic or controlled (McDaniel & Einstein, 2000). Automatic or spontaneous retrieval occurs with less demand on cognitive resources (focal prospective memory) and controlled monitoring occurs with higher demand on cognitive resources or attention (non-focal prospective memory). Prospective memory has been shown to have unique qualities, such that prospective tasks and retrospective tasks are not always related (Einstein, & McDaniel, 1990). These basic differences suggest that processing of prospective memory may be impacted by pain differently than what is seen for retrospective memory.

Health. Deficits in prospective memory could have profound consequences for individuals experiencing pain, particularly for those recovering from surgery or individuals diagnosed with chronic pain. If prospective memory is impacted by pain, these patients may be particularly vulnerable to forgetfulness for prospective tasks, such as taking pain medication, practicing/attending physical therapy, or remembering future medical appointments (Zogg, Woods, Sauceda, Wiebe, & Simoni, 2012). As a result, these individuals may mistakenly over-medicate, under-medicate, prolong the healing process of an injury, or potentiate their condition.

Furthermore, some pain medications can also negatively impact general cognitive functioning (Moriarty et al., 2011). Therefore, individuals suffering from chronic pain are susceptible to cognitive impairment due to both pain itself, and the medication they have been prescribed to manage their pain, resulting in a compounding effect (Schiltenwolf et al., 2014). It has yet to be determined if the same compounding effect extends specifically to prospective memory. However, this may be the case since findings have shown that pain medications can impact prospective memory similar to other cognitive processes (Richards et al., 2018). These

concerns emphasize the importance of evaluating the interaction between pain and prospective memory.

Previous Research. Assessments regarding the influence of pain on prospective memory have indicated that there is a significant impact; such that, those suffering from a pain condition incur impairments on prospective memory (Miller, Basso, Candilis, Combs, & Woods, 2014). Those with chronic pain tend to score more poorly on tasks involving short term prospective memory (Ling, Campbell, Heffernan, & Greenough, 2007). Furthermore, those experiencing an acute pain stimulus have been shown to have impairments on prospective memory performance when tasks demanded higher resources on executive function (Pitães, Blais, Karoly, Okun, & Brewer, 2018). Such findings are supported by the Multiprocess Framework. Only one study has failed to find a significant impact of pain on prospective memory (Gatzounis, Schrooten, Crombez, & Vlaeyen, 2018). While these initial evaluations indicate a link between pain and prospective memory, there are still many unknown variables and slight contradictions in the limited amount of research that has been conducted, such as the null findings from Gatzounis et al. (2018).

Further exploration of the relationship between pain and prospective memory could elucidate potential strategies for managing negative outcomes. Specifically, techniques to improve prospective memory could be more easily identified if the mediators for this relationship were known. Thus, further exploration to identify unknown mediating and moderating variables would allow for future research to target those factors in order to disrupt the effect that pain has on prospective memory.

Attention and Emotion Regulation

Cognitive and emotional processes can alter pain perception, indicating that specific functions of cognition and emotion could be potential mediators or moderators for prospective memory. Many researchers have speculated that attention plays a particular role in pain perception (Eccleston, 1994; Eccleston, & Crombez, 1999; Pincus, & Morley, 2001). This is particularly evident in cases of distraction analgesia, where pain perception can be reduced by focusing on alternative stimuli (Bukola, & Paula, 2017). Reciprocally, attentional mechanisms for certain tasks can be disrupted by pain stimuli (Kuhajda, Thorn, Klinger, & Rubin, 2002; Moore, Keogh, & Eccleston, 2012). In addition, functional imaging studies have shown use of closely related areas of the brain for pain and attention mechanisms, specifically in the anterior cingulate cortex (Davis, Taylor, Crawley, Wood, & Mikulis, 1997).

These findings strongly support the notion that attention is likely involved in either mediating or moderating the relationship between pain and prospective memory. Results by Grisart, Van der Linden, and Bastin (2007) and Oosterman, Derksen, van Wijck, Veldhuijzen, and Kessels (2011) provide further evidence, where both studies found that, memory impairment could be partially explained by attentional decline or redirection in chronic pain patients. Lastly, the Multiprocess Framework previously described suggests that there would be specific consequences on controlled monitoring, where attentional disruptions would be detrimental to prospective memory.

Mood and affect can also influence perceived intensity of a pain stimulus (Rainville, 2002). For example, negative emotions or cognitions, such as depression, can increase perceived intensity of pain (Keefe, Lumley, Anderson, Lynch, & Carson, 2001; Berna et al., 2010). Conversely, inhibiting or regulating negative emotions can reduce pain perception (Paquet,

Kergoat, & Dubé, 2005). More recent findings reveal there is a complex interaction between cognitive processing, such as attention, and affective processing, such as emotional control, in relation to pain (Baker, Gibson, Georgiou-Karistianis, Roth, & Giummarra, 2016). Therefore, to further explore the relationship between pain and prospective memory, attention and emotional regulation are viable factors to measure for mediation and moderation.

Upon initial investigation, the neural correlates of pain and memory that are most often discussed do not suggest much overlap between the areas that are responsible for these processes. For example, typical areas cited for pain processing consist of the thalamus, somatosensory cortex, insula and cingulate cortex (Peyron, Laurent, & Garcia-Larrea, 2000). Typical areas discussed relating to memory processing most consistently involve the hippocampus, amygdala, and cerebellum (Thompson & Kim, 1996). These superficial distinctions imply that there may not be much overlap between pain and memory processing. However, evaluation of areas that modulate pain and memory suggest that processing is not independent between these two constructs (Rowe, Toni, Josephs, Frackowiak, & Passingham, 2000; Metz, Yau, Centeno, Apkarian, & Martina, 2009). Likely, areas such as the prefrontal cortex, which are responsible for multiple functions, allow for interaction between pain and memory through adjacent mechanisms, such as attention or emotional regulation. In fact, the medial prefrontal cortex of the brain has been implicated in modulation of pain as well as memory and attentional mechanisms (Ochsner et al., 2006; Euston, Gruber, & McNaughton, 2012). The current study aimed to identify whether mediation is driven by constructs that overlap pain and memory, such as attention and emotional regulation.

Purpose and Importance

To reiterate, the purpose of the current investigation is to explore the interaction between pain and prospective memory. Further exploration into this interaction is important because of the negative outcomes relating to health as a consequence of prospective memory impairment, such as over-medicating or under-medicating. Some of the most notable health issues would likely be seen in chronic pain populations. These populations are especially vulnerable to prospective memory deficits due to the negative impact of pain, as well as, the negative impact of analgesic medications and chronic pain comorbidities. Furthermore, many individuals with chronic pain are elderly and suffer from natural impairments to cognition as a result of aging (Verhaeghen, & Salthouse, 1997). These factors have all been shown to negatively impact memory independently, but together they could compound to produce more prevalent vulnerabilities and impairments. The current investigation will aim to validate previous findings in a college age group, expand on such findings with additional measures, and assess translation to chronic pain patients.

In order to better understand the impact of pain on prospective memory the two additional variables that have been proposed for measurement are attention and emotional regulation. Executive control may also have been a viable factor to explore (Buhle, & Wager, 2010). However, in a study conducted by Cook, Ball, and Brewer (2014), manipulations of executive control had no impact on prospective memory. Such contradiction in the literature indicates that inclusion of executive control as a factor may be premature until better understanding is achieved. Therefore, the current investigation will employ several methods to evaluate pain and prospective memory in concurrence with attention and emotional regulation.

There were two parts to the investigation. Part one involved gathering self-report data and objective measures of pain and prospective memory in a university sample. Part two involved gathering self-report data and objective measures of pain and prospective memory in a sample reporting issues with recurrent pain and/or chronic pain. Gathering data from these two samples will give an indication of translational ability between these types of designs/populations for future research. If results are highly similar between the designs, future research may be able to generalize with more confidence in cases where one method is available over the other or one sample is more easily assessed over the other. Alternatively, if results are inconsistent then future generalization will need to be made with caution.

It was hypothesized that there would be a relationship between reports of pain and reports of prospective memory, emotion regulation, and attention. Specifically, it was predicted that the relationship would be present for subjective repots of memory and objective measures of prospective memory for non-focal cues. It was also hypothesized that inclusion of emotional regulation and attention into a mediation analysis would reveal significant mediation (see Figure 1). Lastly, it was hypothesized that the sex of the participants would interact with pain measures and emotion regulation, where females would have more memory errors (Fillingim, King, Ribeiro-Dasilva, Rahim-Williams, & Riley III, 2009; Ricarte, Bravo, Latorre, Ros, & Watkins, 2016; Fillingim, 2017).

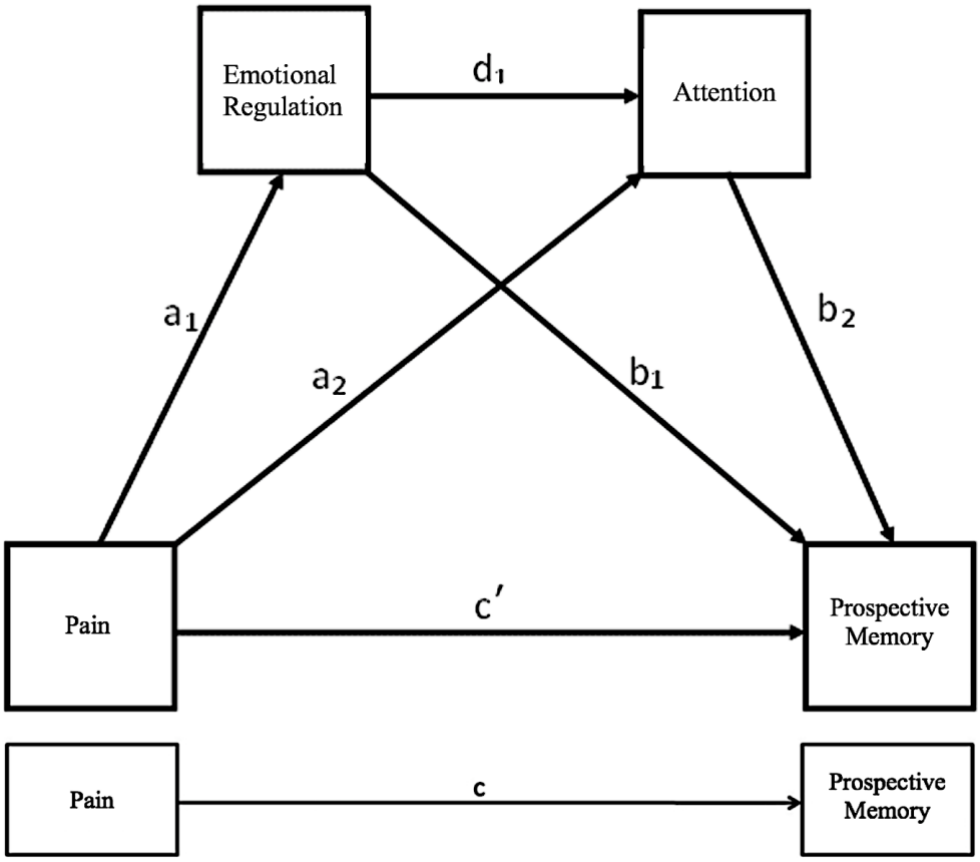


Figure 1. Hypothesized model given that a significant relationship is present between pain and prospective memory.

CHAPTER TWO

METHODS

To thoroughly evaluate the relationship between pain and prospective memory a two-part study was conducted. The initial investigation was designed as a three-part study. However, due to unfortunate data loss the design was modified. The first part of the study was conducted by evaluating university students' self-report measures on a variety of items, such as pain prevalence, emotional regulation, attention, and memory. In addition, objective measures for memory and attention were also collected. The second part of the investigation evaluated the same self-report and objective measures with paid participants who were reported to have

reoccurring or chronic pain symptoms. The combined results between the two parts of the study were assessed for similarities and inconsistencies between the samples.

Part One

Participants. Participants were recruited through The University of Texas at Arlington (UTA) SONA system. All aspects of this evaluation were in compliance with, and were approved and reviewed by UTA's institutional review board (IRB). By signing up for and completing the questionnaire participants acknowledged their consent, which was written into the procedure (see Appendix A). Participants were given the right to withdraw at any time. The study aimed to recruit 200 participants based on power analysis via pwrSEM (Wang & Rhemtulla, 2020), where parameter estimation was conducted through structural equation modeling (SEM). Paths were estimated at .25 for each regression based on findings from Pitaes et al. (2018) where correlations ranged from .22 to .45. Residual variances of prospective memory, emotional regulation, and attention were set at .70, .84, and .94, respectively. See Appendix B for model specification and exact power estimates per path.

Procedures. This evaluation consisted of an online questionnaire (see Appendix C) administered through QuestionPro, which participants were asked to complete to their best ability. Questions were drawn from relevant questionnaires such as the Short-Form McGill Pain Questionnaire 2 (SF-MPQ-2) by Melzack (1987), the Prospective-Retrospective Memory Questionnaire by Smith et al. (2000), the Emotional Regulation Questionnaire (ERQ) by Gross and John (2003), and the Mindful Attention Awareness Scale (MAAS) by Brown and Ryan (2003). Demographic information was also collected (see Appendix D).

The Short-Form McGill Pain Questionnaire 2 (SF-MPQ-2) is a 24-item questionnaire used to measure pain. The questionnaire is highly used in clinical research and has been

psychometrically validated (Katz, & Melzack, 2011; Lovejoy, Turk, & Morasco, 2012; Trudeau et al., 2012; Dworkin et al., 2015). The questionnaire is scored by summing the point values for responses (0-10) to the first 22 items, with sub-scores for sensory pain, affective pain, and neuropathic pain. In addition, the last two items give separate scores for present pain intensity (0-10) and overall intensity (0-5). Higher scores tend to related to greater subjective experience of pain. The internal consistency of the survey for the current sample was high with a Cronbach's alpha of .93.

The Prospective-Retrospective Memory Questionnaire is a 16-item questionnaire used to measure both retrospective and prospective memory. The questionnaire has been assessed for both internal consistency and construct validity (Crawford, Smith, Maylor, Della Sala, & Logie, 2003; Crawford, Henry, Ward, & Blake, 2006; Kliegel & JÄger, 2006; Tate, 2020). The questionnaire is broken down into four categories with two questions in each category for prospective memory (short-term, long-term, self-cued, and environmentally-cued) and retrospective memory(short-term, long-term, self-cued, and environmentally-cued). Scoring is conducted by calculating the average score between each 5-point Likert scale response. The internal consistency of the survey for the current sample was high with a Cronbach's alpha of .91.

The Emotion Regulation Questionnaire is a 10-item questionnaire that assesses both cognitive reappraisal and expressive suppression. Cognitive reappraisal refers to cognitive change that alters the impact of an emotion, expressive suppression refers to inhibiting emotional expression or behaviors (Gross & John, 2003). Cognitive reappraisal has been shown to be related to healthier outcomes than expressive suppression (Cutuli, 2014). The questionnaire is widely used and has been psychometrically validated (Preece, Becerra, Robinson, & Gross,

2019). The questionnaire produces a score for each dimension by calculating the average of the Likert scale responses corresponding to each dimension. The internal consistency of the survey for the current sample was high with a Cronbach's alpha of .80.

The Mindful Attention Awareness Scale is a 15-item scale. The scale measures mindfulness and attention to present stimuli (Brown & Ryan, 2003). The scale has been psychometrically assessed with multiple populations and demonstrates robust psychometric properties (Carlson & Brown, 2005; MacKillop & Anderson, 2007). Scoring is conducted by calculating the mean of the Likert scale responses. The internal consistency of the survey for the current sample was high with a Cronbach's alpha of .90.

Each of these questionnaires were chosen based on their relevance to the desired variables (pain, prospective memory, attention, emotional regulation) and their prominence in their respective fields (Smith, Del Sala, Logie, & Maylor, 2000; Gross, & John, 2003; Brown, & Ryan, 2003; Carlson, & Brown, 2005; Dworkin et al., 2009). The last part of the questionnaire gathered demographic information and information on previous health information, such as conditions that may impact attention or memory. Following the questionnaire, participants were automatically redirected to Pavlovia to complete a prospective memory task (focal and non-focal) and an anti-saccade task to objectively measure prospective memory and attention. Both tasks were built and designed using PsychoPy3, an open source package catering to the behavioral sciences (Peirce et al., 2019).

For the prospective memory task, participants engage in an ongoing task, such as lexical decision task (i.e., decide if letter strings form a word or nonword, see Appendix E), and are simultaneously asked to remember to perform a prospective memory (PM) action (e.g., press the 7 key). The PM task consisted of a focal task and a non-focal task. The focal task engages more

direct processes and the non-focal task requires greater processing of the PM cue. Non-focal tasks are theorized to require more strategic monitoring than focal cues (Cona, Bisiacchi, & Moscovitch, 2014). Previous findings indicate that these processes may be uniquely impacted by pain, where non-focal cues are negatively impacted by pain but focal cues are not (Pitães et al., 2018). Therefore, both tasks are incorporated in the current investigation. The cue for the focal task was the word "youth". For non-focal, deeper processing, the cue was any word beginning with the letter "s". During each ongoing task there were eight instances of a cue appearing. The program recorded correct responses, response times, and errors. In addition, participants completed an anti-saccade task to evaluate their attentional mechanisms (Unsworth, Spillers, Brewer, & McMillan, 2011). For this task, attentional processes were measured by recording responses and reaction times to pro-saccade stimuli and anti-saccade stimuli (see Appendix F).

Participants did not receive any monetary compensation for their involvement in the study. Rather, credits were assigned through the SONA system for research participation. The study was available online and was accessible on or off campus. Time of completion was not regulated but was recorded as an additional measure. The purpose of this part of the investigation is to evaluate individual's awareness of these processes. The results from this self-report data will give additional insight into whether these processes are perceived consciously or whether the impact of these factors is more reliably measured through experimental or clinical assessments. These conclusions were made by comparing results of this part of the investigation to the results from part two.

Part Two

Participants. Participants were recruited from Research Match and Prolific. All aspects of this evaluation were compliance with, and approved by UTA's institutional review board

(IRB). Research Match is a free and voluntary platform for participants to sign up to take part in scientific research. Prolific is an online recruiting platform where researchers can pay participants to take part in scientific research. Participants were screened for reoccurring and/or chronic pain (pain persisting longer than 12 weeks), for simplicity this sample is referred to as the pain sample. By signing up for and completing the questionnaire participants acknowledged their consent, which was written into the procedure (see Appendix A). Sample size estimates were calculated using the same methods outlined in Part 1 of the investigation, such that the study aimed to recruit 200 participants based on power analysis via pwrSEM (Wang & Rhemtulla, 2020).

Procedures. Procedures reflected those described for Part One of the investigation. Participants were asked to complete an online questionnaire (see Appendix B) to their best ability. The questionnaire was administered through QuestionPro following signup and redirection from Research Match or Prolific. Questions were drawn from relevant questionnaires such as the Short-Form McGill Pain Questionnaire 2 (SF-MPQ-2) by Melzack (1987), the Prospective-Retrospective Memory Questionnaire by Smith et al. (2000), the Emotional Regulation Questionnaire (ERQ) by Gross and John (2003), and the Mindful Attention Awareness Scale (MAAS) by Brown and Ryan (2003). In addition, the questionnaire consisted of demographic assessments (Appendix D). Following the questionnaire participants were automatically redirected to Pavlovia to complete a prospective memory task (focal and non-focal) and an anti-saccade task to objectively measure prospective memory and attention (see Appendix E and Appendix F).

Following completion of these tasks, the participants were thanked for their time and/or redirected back to Prolific. Participants recruited through Research Match were volunteers and

did not receive monetary compensation. Participants recruited from Prolific receive monetary compensation at a rate of 7 USD per hour.

CHAPTER THREE

RESULTS

Analyses were conducted and interpreted using SPSS Version 26 for frequencies, correlations, regressions, and Analysis of Variance tests. Additionally, PROCESS Macro was used as an add on package in SPSS to conduct analyses relating to mediation and/or moderation (Hayes, 2017). The statistical program R was used to compute prospective memory values and attention values and aggregate the data.

Participants.

A total of 360 participants completed the study. Participant data were excluded from the study (31 cases) if participants failed either of the two attention checks within the prospective memory tasks (see Appendix G for a sample of the attention check). Additionally, data was excluded for those who did not provide an identifier (Prolific ID) to link survey data to the online experiment data (5 cases).

The overall sample size for the study was 324 participants (53.4% female, 46.6% male). Part One had a sample size of 141 participants (78% female, 22% male) recruited from the UTA SONA system (university sample). Part Two had a sample size of 183 (34.4% female, 65.6% male) recruited from Research Match and Prolific (pain sample). The average age was 26.01 years old (SD = 10.99), with ages ranging from 18 years to 79 years. Approximately 7% of the sample were Black, 13% were Asian, 18% were Hispanic, and 60% were White. See Appendix H and Appendix I for demographic frequencies

Data.

Data were compiled into one excel sheet using an R script to more easily create a dataset in SPSS. The data were then screened, where any participants who failed the prospective memory checks were automatically excluded. In addition, the first three trials for the antisaccade task and the prospective memory tasks were excluded. The three trials lagging after a prospective memory cue detection were also excluded. Means for accuracy and reaction time for each participant were then calculated and the data were aggregated. Reaction times were calculated based on correct responses only.

Part One: Analyses Using only University Participants

Frequencies. It was revealed that 44% of the sample were experiencing some kind of pain stimulus. The majority of participants reported that their pain was somatic (45.4%), followed by headache pain (32.6%), and visceral pain (12.1%). Approximately 8% reported experiencing multiple types of pain (such as headache and visceral pain). Additionally, 80% reported that their pain was located in one region of their body versus multiple regions (19%). Pain lasting longer than three months was reported in 14.9% of participants, where the majority reported that their pain had persisted for two days or less (67.9%). Approximately, 60% of the sample failed to produce a prospective memory response (detect the cues) to both the focal and non-focal tasks.

Descriptive Statistics. Mean accuracy for the antisaccade task was 74%. Mean accuracy for the ongoing lexical decision-making task during the focal and non-focal prospective memory evaluations were 92.8% and 90.7%, respectively. The mean number of focal cue detections were 2.68 (out of 8 possible detections) and 1.28 for non-focal cues.

Group Differences. Assumptions for normality, outliers, and homogeneity were assessed prior to conducting any Multivariate Analysis of Variance (MANOVA) tests. Normality and outliers were assessed by reviewing histogram charts and evaluating scores of skewness and kurtosis. Those variables that had skew and kurtosis values outside of the range of -2 to +2 were further assessed by visualizing normal Q-Q plots, and boxplots. Homogeneity was assessed using Box's M and Levene's tests. Variables of concern, based on skewness and kurtosis, included ongoing task accuracy for prospective memory (focal and non-focal tasks), ongoing task reaction time for prospective memory (focal and non-focal tasks), and age. Data for these variables were collected for exploratory, reporting purposes and were not intended for any of the anticipated analyses, therefore no transformations were conducted.

A MANOVA was conducted to determine if there were differences between those that report experiencing pain during the experiment and those that reported no pain during the experiment. The independent variables (IV) were pain (pain present, no pain) and sex (female, male). The dependent variables (DV) were attention reports (MAAS), prospective memory reports (PRMQ), cognitive reappraisal reports (ERQ) and expressive suppression reports (ERQ). The multivariate test revealed a significant main effect for sex, $F(4,134) = 3.50$, $p = .009$, $\eta p2 = .10$. There was no significant difference for pain presence and no significant interaction.

Evaluation of the between-subjects effects revealed a significant difference for cognitive reappraisal reports, $F(1,137) = 7.68$, $p = .006$, $\eta p2 = .05$, between females ($M = 4.28$, $SE = .13$) and males ($M = 5.08$, $SE = .26$) and a trending significant difference for expressive suppression reports, $F(1,137) = 2.96$, $p = .087$, $\eta p2 = .02$, between females ($M = 3.79$, $SE = .12$) and males ($M = 4.28$, $SE = .26$). The data suggest that males report using both cognitive reappraisal and expressive suppression more often than females.

An additional MANOVA was conducted with the same IVs to evaluate the dependent variables of focal prospective memory (focal cues detected), non-focal prospective memory (non-focal cues detected), attention accuracy (antisaccade accuracy), and attention reaction time (antisaccade reaction time). The multivariate test revealed a main effect trending towards significance for pain presence, $F(4,134) = 2.06$, $p = .089$, Pillai's Trace = .06, $\eta p2 = .06$. Between-subjects effects revealed that there was a significant difference for antisaccade accuracy, $F(1,137) = 6.33$, $p = .013$, $\eta p2 = .04$. Those that reported they were experiencing pain ($M = .80$, $SE = .03$) had higher accuracy on the antisaccade task than those who reported no pain present($M = .70$, $SE = .02$).

Associations. Several correlations were conducted to determine which variables of interest were related to pain intensity. Before running each analysis, those who reported no pain during the time of testing were excluded from the analysis to facilitate interpretation. As expected, pain intensity was negatively related to prospective memory for non-focal cue detection, $r(59) = -.39$, $p = .002$, where greater pain intensity was associated with fewer correct prospective memory non-focal detections. There was also an unexpected relationship between pain intensity and focal cue detection, $r\ (59) = -.34$, $p = .007$, where greater pain intensity was associated with fewer correct prospective memory focal detections. There was no relationship between pain intensity for emotion regulation, attention (objective or subjective), or subjective reports of prospective memory (MASS). See Appendix J for the zero-order correlation matrix.

Predictions. Correlation analyses indicated that there were significant relationships between pain and non-focal cue detections and between pain and focal cue detections. Regression analyses were run to further evaluate these relationships and determine how cue detections change with pain intensity. Before running each analysis, those who reported no pain

during the time of testing were excluded from the analysis to facilitate interpretation. A simple linear regression revealed that pain intensity significantly predicted the number of non-focal cues detected, β = -.39, $t(60)$ = -3.30, p = .002 and explained a significant proportion of variance, R^2 = .15, $F(1,60)$ = 10.91, p = .002. An additional regression revealed that pain intensity significantly predicted the number of focal cues detected, β = -.34, $t(60)$ = -2.81, p = .007 and explained a significant proportion of variance, R^2 = .12, $F(1,60)$ = 7.92, p = .007.

Mediation Analysis. Three mediation analysis tests were theoretically relevant. One to evaluate survey responses for reported emotion regulation with reported attention and reported memory, one to evaluate survey responses for emotion regulation with objective measures of attention and objective measures of prospective memory (using focal cue detections as the outcome variable) and one to evaluate survey responses for emotion regulation with objective measures of attention and objective measures of prospective memory (using non-focal cue detections as the outcome variable). However, a significant relationship between pain and prospective memory needs to be established before exploring mediation. This relationship was found for objective measures of prospective memory (cue-detections) but not for subjective reports of prospective memory (PRMQ). Therefore, only two mediation analyses were conducted, one to evaluate prospective memory using focal cue detections as the outcome variable and one using non-focal cue detections as the outcome variable. Before running the analysis, those who reported no pain during the time of testing were excluded from the analysis. In addition, the assumptions for regression were evaluated before conducting any tests. No transformations or changes were performed.

The first mediation analysis included pain intensity (SF-MPQ), cognitive reappraisal (ERQ), attention (antisaccade accuracy), and prospective memory (focal cue detections) as the

variables of interest. There was no significant mediation for cognitive reappraisal or attention. The second analysis included pain intensity (SF-MPQ), cognitive reappraisal (ERQ), attention (antisaccade accuracy), and prospective memory (non-focal cue detections) as the variables of interest. There was no significant mediation by cognitive reappraisal or attention. See Appendix K to view both models.

Part Two: Analyses Using only Research Match and Prolific Participants

Frequencies. Results indicate that 74.3% of the sample were experiencing some kind of pain stimulus at the time of the experiment. Similar to part one, the majority of participants reported that their pain was somatic (63.4%), followed by headache pain (23.5%), and visceral pain (4.4%). Approximately 7% reported experiencing multiple types of pain. Additionally, 69% reported that their pain was located in one region of their body versus multiple regions (31%). Pain lasting longer than three months was reported in 32.2% of participants, whereas 35% reported that their pain had persisted for two days or less. Approximately, 56% of the sample failed to produce a prospective memory response to both the focal and non-focal cues.

Descriptive Statistics. Mean accuracy for the antisaccade task was 74.5%. Mean accuracy for the ongoing lexical decision-making task during the focal and non-focal prospective memory evaluations were 94.3% and 92.6%, respectively. The mean number of focal cue detections were 2.96 (out of 8 possible detections) and 1.93 for non-focal cues.

Group Differences. Assumptions for normality, outliers, and homogeneity were assessed prior to conducting any statistical analyses. Normality and outliers were assessed by reviewing histogram charts and evaluating scores of skewness and kurtosis. Those variables that had skew and kurtosis values outside of the range of -2 to +2 were further assessed by visualizing normal Q-Q plots, and boxplots. Homogeneity was assessed using Box's M and Levene's tests.

Variables of concern, based on skewness and kurtosis, included ongoing task accuracy for prospective memory (focal and non-focal tasks), ongoing task reaction time for prospective memory (focal and non-focal tasks), reaction time for the prospective memory practice task, and prospective memory non-focal cue detection. Other than cue detection, data for these variables were collected for exploratory, reporting purposes and were not intended for any of the analyses, therefore no transformations were conducted for those variables. Since cue detection data were intended for analysis, further evaluation was conducted. It was found that two outliers were driving the non-normal distribution therefore data for those participants were excluded from further analyses.

A MANOVA was conducted to determine if there were differences between those that report experiencing pain during the experiment and those that reported no pain during the experiment. The independent variables were pain (pain present, no pain) and sex (female, male). The dependent variables (DV) were attention reports (MAAS), prospective memory reports (PRMQ), cognitive reappraisal reports (ERQ) and expressive suppression reports (ERQ). The multivariate test revealed a significant main effect for sex, $F(4,174) = 5.03$, $p = .001$, $\eta p2 = .10$. There was no significant difference for pain presence and no significant interaction. Evaluation of the between-subjects effects revealed a significant difference for expressive suppression reports, $F(1,177) = 16.46$, $p < .001$, $\eta p2 = .09$, between females ($M = 3.26$, $SE = .21$) and males ($M = 4.29$, $SE = .15$) and a trending significant difference for cognitive reappraisal reports, $F(1,177) = 3.55$, $p = .061$, $\eta p2 = .02$, between females ($M = 3.97$, $SE = .18$) and males ($M = 4.38$, $SE = .13$). Like the university sample, these data suggest that males report using expressive suppression and cognitive reappraisal more than females.

An additional MANOVA was conducted to evaluate the pain vs no pain group and sex differences for attention scores (derived from the antisaccade test), focal prospective memory scores (derived from the PM task), and non-focal prospective memory scores (derived from the PM task). The multivariate test did not reveal a significant difference between pain groups or sex. Between-subjects effects were not evaluated since the multivariate test was not significant.

Associations. Again, several correlations were conducted to determine which variables of interest were related to each other. Before running each analysis, those who reported no pain during the time of testing were excluded from the analysis to facilitate interpretation. There was no relationship between pain intensity for emotion regulation, attention (subjective or objective), or prospective memory (subjective or objective).

Predictions. Correlation analysis indicated that the relationship between pain and non-focal cue detections was not significant. Furthermore, the relationship between pain and focal cue detections was not significant. Regression analyses were run to further evaluate these variables. Before running each analysis, those who reported no pain during the time of testing were excluded from the analysis to facilitate interpretation. A simple linear regression was conducted to determine if pain intensity significantly predicted the number of non-focal cues detected. Additionally, a simple linear regression was conducted to determine if pain intensity significantly predicted the number of focal cues detected. It was revealed that pain intensity did not predict prospective memory scores for focal or non-focal cues.

Mediation Analysis. Three mediation analysis tests were, again, theoretically relevant. One to evaluate survey responses for reported emotion regulation with reported attention and reported memory, one to evaluate survey responses for emotion regulation with objective measures of attention and objective measures of prospective memory (using focal cue detections

as the outcome variable) and one to evaluate survey responses for emotion regulation with objective measures of attention and objective measures of prospective memory (using non-focal cue detections as the outcome variable). However, a significant relationship between pain and prospective memory had to be established before exploring mediation. This relationship was not found for pain between any of the prospective memory measures. Therefore, mediation analysis was not appropriate and was not conducted.

Overall Investigation: Analyses Using all Participants

Since the intended sample size was not achieved many of the tests were underpowered. Therefore, the following analyses were conducted to explore results for the entire dataset.

Frequencies. In total, 61% of the sample were experiencing some kind of pain stimulus. The majority of participants reported that their pain was somatic (55.6%), followed by headache pain (27.3%), and visceral pain (7.8%). Approximately 7% reported experiencing multiple types of pain (such as headache and visceral pain). Additionally, 74% reported that their pain was located in one region of their body versus multiple regions (26%). Pain lasting longer than three months was reported in 25% of participants, where the majority reported that their pain had persisted for two days or less (46.6%). Approximately, 58% of the sample failed to produce a prospective memory response (detect the cues) to both the focal and non-focal cues.

Descriptive Statistics. Mean accuracy for the antisaccade task was 74%. Mean accuracy for the ongoing lexical decision-making task during the focal and non-focal prospective memory evaluations were 93.7% and 91.8%, respectively. The mean number of focal cue detections were 2.84 (out of 8 possible detections) and 1.56 for non-focal cues.

Group Differences. Assumptions for normality, outliers, and homogeneity were assessed prior to conducting any statistical analyses. Normality and outliers were assessed by reviewing

histogram charts and evaluating scores of skewness and kurtosis. Those variables that had skew and kurtosis values outside of the range of -2 to +2 were further assessed by visualizing normal Q-Q plots, and boxplots. Homogeneity was assessed using Box's M and Levene's tests. Variables of concern, based on skewness and kurtosis, included ongoing task accuracy for prospective memory (focal and non-focal tasks), ongoing task reaction time for prospective memory (focal and non-focal tasks), and age. Data for these variables were collected for exploratory, reporting purposes and were not intended for any of the anticipated analyses, therefore no transformations were conducted.

To evaluate whether pain had an impact on prospective memory, attention, or emotion regulation, a MANOVA was conducted. The independent variables (IV) were pain presence (pain vs no pain) and sex (male, female). The dependent variables (DV) were reported memory (PRMQ), reported attention (MAAS), reported cognitive reappraisal (ERQ), and reported expressive suppression (ERQ). The Box's M test was significant, $p = .023$, therefore, Pillai's Trace statistics are reported. The multivariate test revealed a significant main effect of pain, $F(4,315) = 2.95$, $p = .021$, Pillai's Trace = .04, $\eta p2 = .04$, and a significant main effect of sex, $F(4,315) = 5.37$, $p < .001$, Pillai's Trace = .06, $\eta p2 = .06$. There was no significant interaction between pain presence and sex.

Between-subjects effects indicated that pain presence revealed significant differences for reported cognitive reappraisal, $F(1,318) = 7.55$, $p = .006$, $\eta p2 = .023$, and reported prospective memory, $F(1,318) = 4.16$, $p = .042$, $\eta p2 = .01$. Additionally, there was a difference trending towards significance for reported attention, $F(1,318) = 2.79$, $p = .096$, $\eta p2 = .009$. It was revealed that those in the pain group had lower cognitive reappraisal reports ($M = 4.19$, $SE = .09$) than those in the no pain group ($M = 4.59$, $SE = .11$) and reported more attention errors ($M =$

3.31, *SE* = .07) than those in the no pain group(*M* = 3.14, *SE* = .08). However, those in the pain group (*M* = 3.07, *SE* = .06) also reported less prospective memory errors than those in the no pain group (*M* = 3.25, *SE* = .07).

Evaluation of between subjects effects for sex revealed significant differences for reported cognitive reappraisal, $F(1,318) = 6.13$, $p = .014$, $\eta p2 = .02$, between females (*M* = 4.21, *SE* = .10) and males (*M* = 4.57, *SE* = .11). Additionally, there was a significant difference for reported expressive suppression, $F(1,318) = 16.02$, $p < .001$, $\eta p2 = .05$ between females (*M* = 3.61, *SE* = .11) and males (*M* = 4.24, *SE* = .12). The data suggest that males report using both cognitive reappraisal and expressive suppression more often than females.

Another MANOVA was conducted to evaluate whether pain presence or sex had an impact on objective measures of attention or memory. The independent variables were pain presence (pain vs no pain) and sex (male, female). The dependent variables were focal prospective memory (focal cues detected), non-focal prospective memory (non-focal cues detected), attention accuracy (antisaccade accuracy), and attention reaction time (antisaccade reaction time). The multivariate analysis did not reveal any significant results.

Associations. Several correlations were conducted to determine which variables of interest were related to each other. Before running each analysis, those who reported no pain during the time of testing were excluded from the analysis to facilitate interpretation. As expected, pain intensity was negatively related to prospective memory for non-focal cue detection, $r(193) = -.15$, $p = .039$, where greater pain intensity was associated with fewer correct prospective memory non-focal detections. There was also an unexpected relationship between pain intensity and focal cue detection, $r(193) = -.19$, $p = .006$, where greater pain intensity was associated with fewer correct prospective memory focal detections. There was also a significant

relationship between pain intensity and antisaccade reaction time, $r(193) = .14$, $p = .048$. There was no relationship between pain intensity and emotion regulation (ERQ), subjective repots of prospective memory (PRMQ), subjective reports of memory (MAAS), or antisaccade accuracy (objective attention). See Appendix L for the zero-order correlation matrix.

Predictions. Similar to Part One, correlation analyses indicated that there were significant relationships between pain and non-focal cue detections and between pain and focal cue detections. Regression analyses were run to further evaluate these relationships and determine how cue detections change with pain intensity. Before running each analysis, those who reported no pain during the time of testing were excluded from the analysis to facilitate interpretation. Simple linear regression revealed that pain intensity significantly predicted the number of non-focal cues detected, $\beta = -.15$, $t(194) = -2.08$, $p = .039$ and explained a significant proportion of variance, $R^2 = .02$, $F(1,194) = 7.11$, $p = 039$. An additional regression revealed that pain intensity significantly predicted the number of focal cues detected, $\beta = -.19$, $t(194) = -2.76$, $p = .006$ and explained a significant proportion of variance, $R^2 = .04$, $F(1,194) = 7.60$, $p = 006$.

Mediation. Three mediation analysis tests were theoretically relevant. One to evaluate survey responses for reported emotion regulation with reported attention and reported memory, one to evaluate survey responses for emotion regulation with objective measures of attention and objective measures of prospective memory (using focal cue detections as the outcome variable) and to evaluate survey responses for emotion regulation with objective measures of attention and objective measures of prospective memory (using non-focal cue detections as the outcome variable). Before conducting mediation analyses, the relationship between pain intensity and each prospective memory outcome was measured. This relationship was found for focal and non-focal measures of prospective memory (see correlations and predictions previously discussed)

and but not for subjective reports of prospective memory (PRMQ). Therefore, only two mediation analyses were conducted. Before running each analysis, those who reported no pain during the time of testing were excluded from the analysis to facilitate interpretation. In addition, the assumptions for regression were evaluated before conducting any tests. No transformations or changes were performed.

The first mediation analysis included pain intensity (SF-MPQ), cognitive reappraisal (ERQ), attention (antisaccade accuracy), and prospective memory (focal cue detections) as the variables of interest. There was no significant mediation for cognitive reappraisal or attention. The second analysis included pain intensity (SF-MPQ), cognitive reappraisal (ERQ), attention (antisaccade accuracy), and prospective memory (non-focal cue detections) as the variables of interest. There was no significant mediation by cognitive reappraisal or attention. See Appendix M to view both models.

Comparisons

Samples. While the university sample and pain sample were very different based on percent reporting current pain, their mean percentages for the objective tests were fairly similar (See Table 1). Overall, the most consistent finding across samples was the main effect of sex on emotion regulation. Specifically, males consistently reported higher use of expressive suppression and cognitive reappraisal. The university sample and total sample revealed significant associations and predictions for pain intensity and prospective memory (not found in the pain sample). No meditation was found in any of the samples.

Table 1

Frequency and Descriptive Comparisons

	University Sample	Pain Sample	Overall
Reported Pain	44%	74.3%	61%
Antisaccade Accuracy	74%	74.5%	74%
Ongoing task accuracy (focal)	92.8%	94.3%	93.7%
Ongoing task accuracy (non-focal)	90.7%	92.6%	91.8%
Focal cue detections	34%	37%	36%
Non-focal cue detections	16%	24%	20%

Note. Percentages are provided for convenient comparison, means were not statistically evaluated for differences.

Measures. Different measures of prospective memory produced consistent findings. Reports of pain intensity were positively related to self-reports of prospective memory errors and reports of pain intensity were positively related to missed prospective memory cues. Attention measures also produced consistent findings. Pain intensity was positively related to reports of attention errors and pain intensity was positively related to longer reaction times in the antisaccade task.

Exploratory Findings

Through additional investigation, it was found that mediation may be better achieved by adding pain affect into the model. These findings were exploratory, as such they should be considered with caution. However, when evaluating the relationship between pain affect and memory, partial mediation was achieved (see Figure 2). The marginally significant relationship between affect (sub-category of SF-MPQ) and memory (PRMQ), $t(60) = -1.93$, $p = .059$, is no

longer significant after inclusion of pain intensity (SF-MPQ) and attention (MAAS) into the model, $t(58) = .03$, $p = .62$. Furthermore, the total effect is significantly different from zero 95%CI[-.307, -.039], and the indirect path (from affect to attention to memory) is significantly different from zero 95%CI[-.285, -.051].

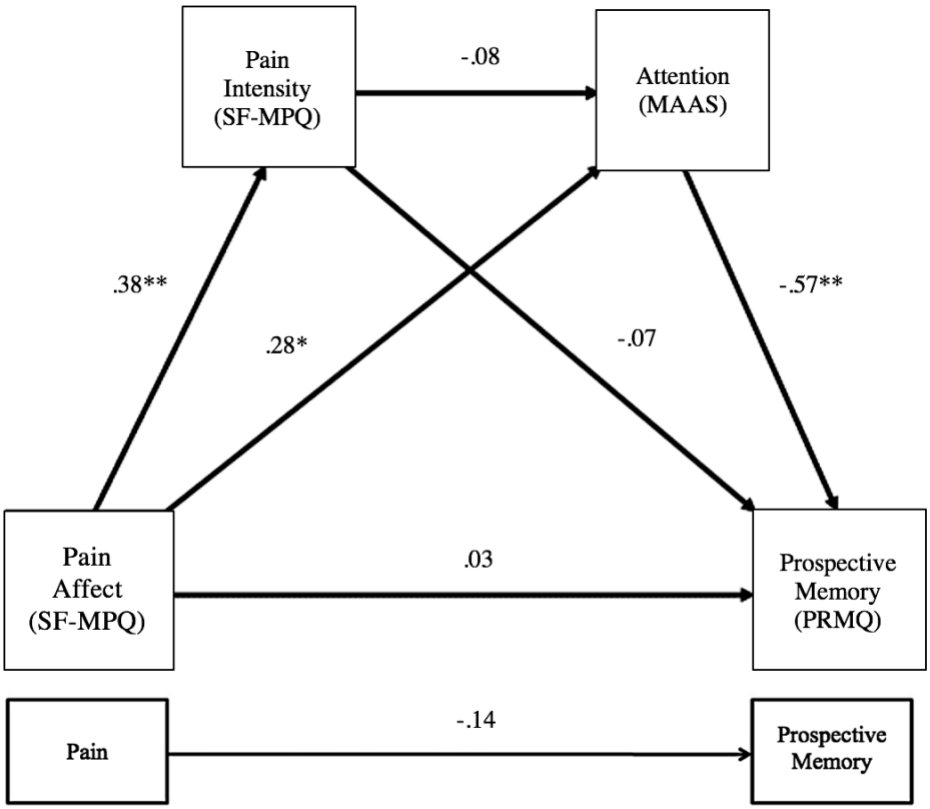


Figure 2. Exploratory model with pain affect as a mediating variable.

CHAPTER FOUR

DISCUSSION

The purpose of this study was to validate previous findings and expand on what is known about the relationship between pain and prospective memory. The negative impact of pain on prospective memory was replicated. Increased pain intensity had a negative outcome on prospective memory performance when evaluated through a predictive model. Additionally, the

hypothesis that pain would be impacted by attention was supported (Legrain, Iannetti, Plaghki, & Mouraux, 2011; Moore, Keogh, & Eccleston, 2012). Pain intensity positively predicted longer reaction times in the antisaccade task. Lastly, it was found that females had significantly different reports of emotion regulation, supporting previous research (Ricarte, Bravo, Latorre, Ros, & Watkins, 2016).

Contrary to previous findings, the relationship between pain and prospective memory was present for both focal and non-focal cues (see Appendix N). Additionally, pain did not predict emotion regulation reports. Theory suggests that attention and emotion regulation should impact the relationship between pain and prospective memory (Erskine, Morley, & Pearce, 1990; Gross, 2002; Houlihan et al., 2004; Veldhuijzen, Kenemans, de Bruin, Olivier, & Volkerts, 2006). However, inclusion of these constructs in a double mediation model did not produce significant mediation. It was also surprising that sex did not interact with pain. It was predicted that females with pain would have more prospective memory errors and attention errors due to previous findings that females report lower thresholds and tolerances towards pain stimuli (Fillingim, King, Ribeiro-Dasilva, Rahim-Williams, & Riley III, 2009; Fillingim, 2017).

It is possible that use of self-report measures for emotion and/or attention are not appropriate for capturing such constructs when applying the effects to prospective memory and pain. It is also possible that the sample size for the study was not large enough. Many of the analyses conducted were underpowered. It was originally proposed that a sample of 200 would be needed for each part of the study. The sample size achieved was 141 and 181 for part one and two, respectively.

The sample size for each mediation analysis was even further reduced due to the exclusion of those who reported not experiencing pain at the time of the experiment. Data for

these participants were excluded from the pain intensity variable to facilitate interpretation of results. To clarify, participants were instructed to fill out the pain questions based on their current pain or on their most recent experience of pain. The intensity scores included those who were in pain and those who weren't (but were reporting on their last instance of pain). To avoid convoluting interpretation, the scores for those that weren't in pain but gave a pain intensity score for their last experience of pain were excluded from the analysis.

Another element to consider is that the design of this study did not allow for much control. Internal validity was very low. In previous investigations pain type, location, intensity, and duration were all experimentally controlled. In the current investigation each of these factors varied. Therefore, there was likely a higher degree of error. Unfortunately, due to restrictions put in place as a result of the COVID-19 pandemic, in person experimental measures were not possible.

Comparison of the university sample to the pain sample found that results from the university sample were a better reflection of the initial hypotheses than the results from the pain sample. Surprisingly, pain was not associated with prospective memory in the pain sample, but was in the university sample. This could be due to the demographic characteristic of each sample. The university sample would have consisted of less variation for age, education, and location. Whereas the pain sample, recruited through Prolific and Research Match, had greater demographic dissimilarities. It is possible that demographic heterogeneity lead to differences in variation of the scores and subsequent outcomes.

Another consideration based on recruitment is the fact that a large proportion of the pain sample were paid (161 out of 181). Those that were paid were recruited through Prolific. Many participants from Prolific were excluded from the study due to failing the attention checks used

to verify that the participants understood the instructions of the study. Even though participants were filtered out based on these criteria, it is possible that some participants understood the instructions but were still not fully engaged in the task. To further underscore this point, in the total sample, 188 participants out of 322 failed to detect a single prospective memory cue (focal and non-focal). In the future, if sample size allows, participants who fail to detect any prospective memory cues should be excluded from analysis.

While the current investigation was not able to expand on the relationship between pain and prospective memory based on inclusion of emotion regulation and attention, exploratory findings indicate that pain affect and attention may be applicable for future investigations. Significant mediation between pain affect and prospective memory was achieved with inclusion of pain intensity and attention as the mediating variables. Further investigation should be conducted to determine whether this was a true effect or a type I error.

Considerations.

Self-Report and Experimental Comparisons. Subjective reports from the study provide understanding of how participants interpret and report on pain, memory, attention, and emotional regulation. While self-report designs have some inherent weaknesses, such as lack of causality, there are also many benefits to conducting this type of investigation. From these findings, it was discovered that males report high use of expressive suppression. This is in agreement with previous literature, however, most other studies find no differences for cognitive reappraisal (Gross & John, 2003; Matsumoto, Yoo, & Nakagawa, 2008; Balzarotti, John, & Gross, 2010; Melka, Lancaster, Bryant, & Rodriguez, 2011; Wiltink et al. 2011). The current study found no sex differences for reporting of pain, memory, or attention. These findings are particularly

surprising regarding the lack of interaction between pain and sex. Numerous studies have established that there are gender and sex differences for pain (Fillingim et al., 2009).

The current findings indicate the extent of self-awareness that participants have about their cognitive processes. For example, associations between pain and self-reported memory were consistent with associations between pain and objective measures of memory, suggesting that participants' subjective interpretation of their prospective memory abilities matched objective measures. However, results from the self-report measures suggest that naturally occurring pain produced different outcomes than previously reported experimentally induced pain, where experimentally induced pain did not impact focal memory (Pitaes et al., 2018). Inconsistencies between the designs could indicate that there may be separate systems being evaluated by the different measures. Future research should aim to verify the differences and elucidate using physical and psychological perspectives.

Limitations. There are also some inherent limitations to this research. Firstly, the major benefit to understanding the pain and memory relationship is to target treatments and aids for those who are most vulnerable. Individuals who tend to be most vulnerable to issues with pain or memory are the elderly and those diagnosed with chronic pain (Oosterman et al., 2011). Therefore, some of the information gained from the current sample of college aged students may not be generalizable to those most vulnerable. The information gained through those who reported persistent or chronic pain is beneficial, however, many of those participants were also young and the issues with sample size complicate the confidence of interpreting results. Such that, some effects may have been lost due to low power. Furthermore, there is a concern that the cue detections were low for the focal task compared to previous findings (Ball, &

Aschenbrenner, 2018). There is a possibility that this is due to pain. However, further evaluation is needed to verify this trend.

While this is a concern, there is still benefit to identifying relevant variables for future research with the elderly and chronic pain patients, such as pain affect. Another inherent issue with the study is the possibility of self-selection. While participants would have been randomly assigned to a pain condition in an experimental design, the individuals in the current study may have been interested for personal reasons relating to pain, memory, or monetary gain (compensation). Additionally, the prospect of discussing pain may have discouraged some individuals from participating and this may have limited the diversity of our sample. Lastly, the current analysis did not evaluate age or other sociodemographic factors. Such factors, particularly age, are important considerations for pain and memory.

Future Directions. Results from this investigation could help to guide future research. Specifically, future studies consider that self-report measures of emotion regulation did not produce any outcomes relating to pain despite the large amount of theoretical evidence to the contrary. More objective measures may be better suited to evaluate the relationship between pain and emotion regulation and to determine mediation. Conversely, both self-report and objective measures of attention were involved with the relationship between pain and memory. Future research should aim to elucidate this relationship further. Unfortunately, there are still may aspects about these interacting variables that are unknown. For example, it is unknown whether there is a certain pain threshold to impact prospective memory processes. It is also undetermined whether there is a plateau for memory errors induced by pain intensity. Future research should aim to evaluate these unknow qualities and should focus on possible applications of the accumulating knowledge in the field. Specifically, research could evaluate whether awareness of

these interactions may allow individuals to be more mindful of their behaviors and use relevant strategies to prevent forgetting. Additionally, future investigations could evaluate these targets as factors for cognitive therapies. Evaluating these variables in this way could help to improve health outcomes for those at risk or vulnerable to memory issues. Lastly, future research should elucidate the impact of pain affect on prospective memory and further explore the combined application of affect and attention in mediation and moderation models.

Conclusions

The current study aimed to confirm whether pain and prospective memory are related and identify whether attention and emotional regulation are involved in the relationship. The current findings highlight that caution should be used when trying to generalize results from self-report measures. Furthermore, results from this experiment verify that pain impacts prospective memory and further elucidation could be used to help future treatments and cognitive exercises for those who are vulnerable to memory errors. This is particularly relevant for those who are elderly. At old age there is a "perfect storm" of variables that can negatively impact memory and health (Einstein & McDaniel, 1990; McLachlan et al., 2011). The elderly tend to experience natural cognitive decline that negatively impacts memory (Deary et al., 2009). Additionally, the elderly population has a high proportion of chronic pain sufferers, where chronic pain negatively impacts memory (Muñoz & Esteve, 2005; Moriarty et al., 2011; Van Hecke, Torrance, & Smith, 2013). Furthermore, medications to treat chronic pain tend to negatively impact cognition (Bruera, Macmillan, Hanson, & MacDonald, 1989; Ling et al., 2007; Friswell et al., 2008). Lastly, comorbidities to chronic pain, such as anxiety and depression, have also been shown to negatively impact cognition and memory (Christopher & MacDonald, 2005; Robinson, Vytal, Cornwell, & Grillon, 2013; Lukasik, Waris, Soveri, Lehtonen, & Laine, 2019). Therefore, further

elucidation of the variables that are involved in pain and memory, such as pain affect, could be very impactful for those who are vulnerable.

References

Albuquerque, B., Häussler, A., Vannoni, E., Wolfer, D. P., & Tegeder, I. (2013). Learning and memory with neuropathic pain: impact of old age and progranulin deficiency. *Frontiers in behavioral neuroscience*, *7*, 174.

Baddeley, A. D. (1976). The psychology of memory. *New York*.

Baker, K. S., Gibson, S., Georgiou-Karistianis, N., Roth, R. M., & Giummarra, M. J. (2016). Everyday executive functioning in chronic pain: specific deficits in working memory and emotion control, predicted by mood, medications, and pain interference. *The Clinical journal of pain*, *32*(8), 673-680.

Ball, B. H., & Aschenbrenner, A. J. (2018). The importance of age-related differences in prospective memory: Evidence from diffusion model analyses. *Psychonomic Bulletin & Review*, *25*(3), 1114-1122.

Balzarotti, S., John, O. P., & Gross, J. J. (2010). An Italian adaptation of the emotion regulation questionnaire. *European Journal of Psychological Assessment*.

Berna, C., Leknes, S., Holmes, E. A., Edwards, R. R., Goodwin, G. M., & Tracey, I. (2010). Induction of depressed mood disrupts emotion regulation neurocircuitry and enhances pain unpleasantness. *Biological psychiatry*, *67*(11), 1083-1090.

Berryman, C., Stanton, T. R., Bowering, K. J., Tabor, A., McFarlane, A., & Moseley, G. L. (2014). Do people with chronic pain have impaired executive function? A meta-analytical review. *Clinical psychology review*, *34*(7), 563-579.

Brown, K. W., & Ryan, R. M. (2003). The benefits of being present: mindfulness and its role in psychological well-being. *Journal of personality and social psychology*, *84*(4), 822.

Bruera, E., Macmillan, K., Hanson, J., & MacDonald, R. N. (1989). The cognitive effects of the administration of narcotic analgesics in patients with cancer pain. *Pain*, *39*(1), 13-16.

Buhle, J., & Wager, T. D. (2010). Performance-dependent inhibition of pain by an executive working memory task. *Pain*, *149*(1), 19–26. doi: 10.1016/j.pain.2009.10.027

Bukola, I. M., & Paula, D. (2017). The effectiveness of distraction as procedural pain management technique in pediatric oncology patients: a meta-analysis and systematic review. *Journal of pain and symptom management*, *54*(4), 589-600.

Carlson, L. E., & Brown, K. W. (2005). Validation of the Mindful Attention Awareness Scale in a cancer population. *Journal of psychosomatic research*, *58*(1), 29-33.

Cona, G., Bisiacchi, P. S., & Moscovitch, M. (2014). The effects of focal and nonfocal cues on the neural correlates of prospective memory: insights from ERPs. *Cerebral cortex*, *24*(10), 2630-2646.

Cook, C., Ball, B. H., & Brewer, G. A. (2014). No effects of executive control depletion on prospective memory retrieval processes. *Consciousness and cognition*, *27*, 121-128.

Christopher, G., & MacDonald, J. (2005). The impact of clinical depression on working memory. *Cognitive neuropsychiatry*, *10*(5), 379-399.

Crawford, J. R., Henry, J. D., Ward, A. L., & Blake, J. (2006). The Prospective and Retrospective Memory Questionnaire (PRMQ): Latent structure, normative data and discrepancy analysis for proxy-ratings. *British journal of clinical psychology*, *45*(1), 83-104.

Crawford, J., Smith, G., Maylor, E., Della Sala, S., & Logie, R. (2003). The Prospective and Retrospective Memory Questionnaire (PRMQ): Normative data and latent structure in a large non-clinical sample. *Memory, 11*(3), 261-275.

Cutuli, D. (2014). Cognitive reappraisal and expressive suppression strategies role in the emotion regulation: an overview on their modulatory effects and neural correlates. *Frontiers in systems neuroscience*, *8*, 175.

Davis, K. D., Taylor, S. J., Crawley, A. P., Wood, M. L., & Mikulis, D. J. (1997). Functional MRI of pain-and attention-related activations in the human cingulate cortex. *Journal of Neurophysiology*, *77*(6), 3370-3380.

Deary, I. J., Corley, J., Gow, A. J., Harris, S. E., Houlihan, L. M., Marioni, R. E., ... & Starr, J. M. (2009). Age-associated cognitive decline. *British medical bulletin*, *92*(1), 135-152.

Dick, B. D., & Rashiq, S. (2007). Disruption of attention and working memory traces in individuals with chronic pain. *Anesthesia & Analgesia*, *104*(5), 1223-1229.

Dworkin, R. H., Turk, D. C., Revicki, D. A., Harding, G., Coyne, K. S., Peirce-Sandner, S., ... & Farrar, J. T. (2009). Development and initial validation of an expanded and revised version of the Short-form McGill Pain Questionnaire (SF-MPQ-2). *PAIN®*, *144*(1-2), 35-42.

Eccleston, C. (1994). Chronic pain and attention: a cognitive approach. *British Journal of Clinical Psychology*, *33*(4), 535-547.

Eccleston, C., & Crombez, G. (1999). Pain demands attention: A cognitive–affective model of the interruptive function of pain. *Psychological bulletin*, *125*(3), 356.

Einstein, G. O., & McDaniel, M. A. (1990). Normal aging and prospective memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *16*(4), 717.

Erskine, A., Morley, S., & Pearce, S. (1990). Memory for pain: A review. *Pain*, *41*(3), 255–265. doi: 10.1016/0304-3959(90)90002-U

Euston, D. R., Gruber, A. J., & McNaughton, B. L. (2012). The role of medial prefrontal cortex in memory and decision making. *Neuron*, *76*(6), 1057-1070.

Fattori, V., Hohmann, M. S., Rossaneis, A. C., Pinho-Ribeiro, F. A., & Verri, W. A. (2016). Capsaicin: current understanding of its mechanisms and therapy of pain and other pre-clinical and clinical uses. *Molecules*, *21*(7), 844.

Fillingim, R. B. (2017). Sex, gender, and pain. In *Principles of Gender-Specific Medicine* (pp. 481-496). Academic Press.

Fillingim, R. B., King, C. D., Ribeiro-Dasilva, M. C., Rahim-Williams, B., & Riley III, J. L. (2009). Sex, gender, and pain: a review of recent clinical and experimental findings. *The journal of pain*, *10*(5), 447-485.

Forkmann, K., Schmidt, K., Schultz, H., Sommer, T., & Bingel, U. (2016). Experimental pain impairs recognition memory irrespective of pain predictability. *European Journal of Pain*, *20*(6), 977-988.

Friswell, J., Phillips, C., Holding, J., Morgan, C. J., Brandner, B., & Curran, H. V. (2008). Acute effects of opioids on memory functions of healthy men and women. *Psychopharmacology*, *198*(2), 243-250.

Fritz, M. S., & MacKinnon, D. P. (2007). Required sample size to detect the mediated effect. *Psychological science*, *18*(3), 233-239.

Gatzounis, R., Schrooten, M. G., Crombez, G., & Vlaeyen, J. W. (2018). Forgetting to remember? Prospective memory within the context of pain. *European Journal of Pain*, *22*(3), 614-625.

Gibson, S. J., & Farrell, M. (2004). A review of age differences in the neurophysiology of nociception and the perceptual experience of pain. *The Clinical journal of pain*, *20*(4), 227-239.

Grégoire, S., Michaud, V., Chapuy, E., Eschalier, A., & Ardid, D. (2012). Study of emotional and cognitive impairments in mononeuropathic rats: effect of duloxetine and gabapentin. *PAIN®*, *153*(8), 1657-1663.

Grisart, J., Van der Linden, M., & Bastin, C. (2007). The contribution of recollection and familiarity to recognition memory performance in chronic pain patients. *Behaviour research and therapy*, *45*(5), 1077-1084.

Gross, J. J. (2002). Emotion regulation: Affective, cognitive, and social consequences. *Psychophysiology*, *39*(3), 281-291.

Gross, J. J., & John, O. P. (2003). Individual differences in two emotion regulation processes: implications for affect, relationships, and well-being. *Journal of personality and social psychology*, *85*(2), 348.

Hayes, A. F. (2017). *Introduction to mediation, moderation, and conditional process analysis: A regression-based approach*. Guilford publications.

Houlihan, M. E., McGrath, P. J., Connolly, J. F., Stroink, G., Finley, G. A., Dick, B., & Phi, T. T. (2004). Assessing the effect of pain on demands for attentional resources using ERPs. *International journal of psychophysiology*, *51*(2), 181-187.

Ishizuka, K., Hillier, A., & Beversdorf, D. Q. (2007). Effect of the cold pressor test on memory and cognitive flexibility. *Neurocase*, *13*(3), 154-157.

Jamison, R. N., Sbrocco, T., & Parris, W. C. (1989). The influence of problems with concentration and memory on emotional distress and daily activities in chronic pain patients. *The International Journal of Psychiatry in Medicine*, *18*(2), 183-191.

Katz, J., & Melzack, R. (2011). The McGill Pain Questionnaire: Development, psychometric properties, and usefulness of the long form, short form, and short form-2.

Keefe, F. J., Lumley, M., Anderson, T., Lynch, T., & Carson, K. L. (2001). Pain and emotion: new research directions. *Journal of clinical psychology*, *57*(4), 587-607.

Kliegel, M., & JÄger, T. (2006). Can the prospective and retrospective memory questionnaire (PRMQ) predict actual prospective memory performance?. *Current Psychology*, *25*(3), 182-191.

Kuhajda, M. C., Thorn, B. E., Klinger, M. R., & Rubin, N. J. (2002). The effect of headache pain on attention (encoding) and memory (recognition). *Pain*, *97*(3), 213-221.

Legrain, V., Iannetti, G. D., Plaghki, L., & Mouraux, A. (2011). The pain matrix reloaded: a salience detection system for the body. *Progress in neurobiology*, *93*(1), 111-124.

Ling, J., Campbell, C., Heffernan, T. M., & Greenough, C. G. (2007). Short-term prospective memory deficits in chronic back pain patients. *Psychosomatic medicine*, *69*(2), 144-148.

Lötsch, J., Walter, C., Felden, L., Preibisch, C., Nöth, U., Martin, T., ... & Oertel, B. G. (2012). Extended cortical activations during evaluating successive pain stimuli. *Social cognitive and affective neuroscience*, *7*(6), 698-707.

Lovejoy, T. I., Turk, D. C., & Morasco, B. J. (2012). Evaluation of the psychometric properties of the revised short-form McGill Pain Questionnaire. *The Journal of Pain*, *13*(12), 1250-1257.

Low, L. A. (2013). The impact of pain upon cognition: what have rodent studies told us?. *Pain*, *154*(12).

Lukasik, K. M., Waris, O., Soveri, A., Lehtonen, M., & Laine, M. (2019). The relationship of anxiety and stress with working memory performance in a large non-depressed sample. *Frontiers in psychology*, *10*, 4.

Lumley, M. A., Cohen, J. L., Borszcz, G. S., Cano, A., Radcliffe, A. M., Porter, L. S., ... & Keefe, F. J. (2011). Pain and emotion: a biopsychosocial review of recent research. *Journal of clinical psychology*, *67*(9), 942-968.

MacKillop, J., & Anderson, E. J. (2007). Further psychometric validation of the mindful attention awareness scale (MAAS). *Journal of Psychopathology and Behavioral Assessment*, *29*(4), 289-293.

Matsumoto, D., Yoo, S. H., & Nakagawa, S. (2008). Culture, emotion regulation, and adjustment. *Journal of personality and social psychology*, *94*(6), 925.

Mazza, S., Frot, M., & Rey, A. E. (2018). A comprehensive literature review of chronic pain and memory. *Progress in Neuro-Psychopharmacology and Biological Psychiatry*, *87*, 183-192.

McLachlan, A. J., Bath, S., Naganathan, V., Hilmer, S. N., Le Couteur, D. G., Gibson, S. J., & Blyth, F. M. (2011). Clinical pharmacology of analgesic medicines in older people: impact of frailty and cognitive impairment. *British journal of clinical pharmacology*, *71*(3), 351-364.

Melka, S. E., Lancaster, S. L., Bryant, A. R., & Rodriguez, B. F. (2011). Confirmatory factor and measurement invariance analyses of the emotion regulation questionnaire. *Journal of clinical psychology*, *67*(12), 1283-1293.

Melzack, R. (1987). The short-form McGill pain questionnaire. *Pain*, *30*(2), 191-197.

Metz, A. E., Yau, H. J., Centeno, M. V., Apkarian, A. V., & Martina, M. (2009). Morphological and functional reorganization of rat medial prefrontal cortex in neuropathic pain. *Proceedings of the National Academy of Sciences*, *106*(7), 2423-2428.

Miller, A. K., Basso, M. R., Candilis, P. J., Combs, D. R., & Woods, S. P. (2014). Pain is associated with prospective memory dysfunction in multiple sclerosis. *Journal of Clinical and Experimental Neuropsychology*, *36*(8), 887–896. doi: 10.1080/13803395.2014.953040

Moore, D. J., Keogh, E., & Eccleston, C. (2012). The interruptive effect of pain on attention. *The Quarterly Journal of Experimental Psychology*, *65*(3), 565-586.

Moriarty, O., McGuire, B. E., & Finn, D. P. (2011). The effect of pain on cognitive function: a review of clinical and preclinical research. *Progress in neurobiology*, *93*(3), 385-404.

Muñoz, M., & Esteve, R. (2005). Reports of memory functioning by patients with chronic pain. *The Clinical journal of pain*, *21*(4), 287-291.

Norton, C. M., Ibinson, J. W., Pcola, S. J., Reder, L. M., Fiez, J. A., & Vogt, K. M. (2020). Neutral auditory words immediately followed by painful electric shock show reduced next-day recollection. *bioRxiv*.

Ochsner, K. N., Ludlow, D. H., Knierim, K., Hanelin, J., Ramachandran, T., Glover, G. C., & Mackey, S. C. (2006). Neural correlates of individual differences in pain-related fear and anxiety. *Pain*, *120*(1-2), 69-77.

Oosterman, J. M., Derksen, L. C., van Wijck, A. J., Veldhuijzen, D. S., & Kessels, R. P. (2011). Memory functions in chronic pain: examining contributions of attention and age to test performance. *The Clinical journal of pain*, *27*(1), 70-75.

Paquet, C., Kergoat, M. J., & Dubé, L. (2005). The role of everyday emotion regulation on pain in hospitalized elderly: Insights from a prospective within-day assessment. *Pain, 115*(3), 355-363.

Peyron, R., Laurent, B., & Garcia-Larrea, L. (2000). Functional imaging of brain responses to pain. A review and meta-analysis (2000). *Neurophysiologie Clinique/Clinical Neurophysiology*, *30*(5), 263-288.

Peirce, J., Gray, J. R., Simpson, S., MacAskill, M., Höchenberger, R., Sogo, H., ... & Lindeløv, J. K. (2019). PsychoPy2: Experiments in behavior made easy. *Behavior research methods*, *51*(1), 195-203.

Pincus, T., & Morley, S. (2001). Cognitive-processing bias in chronic pain: a review and integration. *Psychological bulletin*, *127*(5), 599.

Pitães, M., Blais, C., Karoly, P., Okun, M. A., & Brewer, G. A. (2018). Acute pain disrupts prospective memory cue detection processes. *Memory*, *26*(10), 1450-1459.

Preece, D. A., Becerra, R., Robinson, K., & Gross, J. J. (2019). The emotion regulation questionnaire: psychometric properties in general community samples. *Journal of personality assessment*.

Rainville, P. (2002). Brain mechanisms of pain affect and pain modulation. *Current opinion in neurobiology*, *12*(2), 195-204.

Ren, W. J., Liu, Y., Zhou, L. J., Li, W., Zhong, Y., Pang, R. P., ... & Wu, C. Y. (2011). Peripheral nerve injury leads to working memory deficits and dysfunction of the hippocampus by upregulation of TNF-α in rodents. *Neuropsychopharmacology*, *36*(5), 979-992.

Ricarte, J. J., Bravo, N, B., Latorre, J. M., Ros, L., & Watkins, E. (2016). Age and gender differences in emotion regulation strategies: Autobiographical memory, rumination, problem solving and distraction.

Richards, G. C., Lluka, L. J., Smith, M. T., Haslam, C., Moore, B., O'Callaghan, J., & Strong, J. (2018). Effects of long-term opioid analgesics on cognitive performance and plasma cytokine concentrations in patients with chronic low back pain: a cross-sectional pilot study. *Pain reports*, *3*(4).

Robinson, O. J., Vytal, K., Cornwell, B. R., & Grillon, C. (2013). The impact of anxiety upon cognition: perspectives from human threat of shock studies. *Frontiers in human neuroscience*, *7*, 203.

Rode, S., Salkovskis, P. M., & Jack, T. (2001). An experimental study of attention, labelling and memory in people suffering from chronic pain. *Pain*, *94*(2), 193-203.

Rowe, J. B., Toni, I., Josephs, O., Frackowiak, R. S., & Passingham, R. E. (2000). The prefrontal cortex: response selection or maintenance within working memory?. *Science*, *288*(5471), 1656-1660.

Schiltenwolf, M., Akbar, M., Hug, A., Pfuller, U., Gantz, S., Neubauer, E., ... & Wang, H. (2014). Evidence of specific cognitive deficits in patients with chronic low back pain under long-term substitution treatment of opioids. *Pain physician*, *17*(1), 9-20.

Schnurr, R. F., & MacDonald, M. R. (1995). Memory complaints in chronic pain. *The Clinical journal of pain*.

Seminowicz, D. A., & Davis, K. D. (2007). A re-examination of pain–cognition interactions: implications for neuroimaging. *Pain*, *130*(1), 8-13.

Sheffield, D., Biles, P. L., Orom, H., Maixner, W., & Sheps, D. S. (2000). Race and sex differences in cutaneous pain perception. *Psychosomatic medicine*, *62*(4), 517-523.

Smith, G., Del Sala, S., Logie, R. H., & Maylor, E. A. (2000). Prospective and retrospective memory in normal ageing and dementia: A questionnaire study. *Memory*, *8*(5), 311-321.

Tate, R. L. (2020). *A compendium of tests, scales and questionnaires: The practitioner's guide to measuring outcomes after acquired brain impairment*. Psychology Press.

Thompson, R. F., & Kim, J. J. (1996). Memory systems in the brain and localization of a memory. *Proceedings of the national academy of sciences*, *93*(24), 13438-13444.

Trudeau, J., Turk, D., Dworkin, R., Benson, C., Biondi, D., Kim, M., ... & Katz, N. (2012). Validation of the revised short form McGill Pain Questionnaire (SF-MPQ-2) for self-report of pain qualities in patients with acute low back pain. *The Journal of Pain*, *13*(4), S4.

Tulving, E. (1993). What is episodic memory?. *Current directions in psychological science*, *2*(3), 67-70.

Unsworth, N., Spillers, G. J., Brewer, G. A., & McMillan, B. (2011). Attention control and the antisaccade task: A response time distribution analysis. *Acta psychologica*, *137*(1), 90-100.

Van Hecke, O., Torrance, N., & Smith, B. H. (2013). Chronic pain epidemiology and its clinical relevance. *British journal of anaesthesia*, *111*(1), 13-18.

Veldhuijzen, D. S., Kenemans, J. L., de Bruin, C. M., Olivier, B., & Volkerts, E. R. (2006). Pain and attention: attentional disruption or distraction?. *The Journal of Pain*, *7*(1), 11-20.

Verhaeghen, P., & Salthouse, T. A. (1997). Meta-analyses of age–cognition relations in adulthood: Estimates of linear and nonlinear age effects and structural models. *Psychological bulletin*, *122*(3), 231.

Wang, Y. A., & Rhemtulla, M. (2020). Power analysis for parameter estimation in structural equation modeling: A discussion and tutorial.

Whitlock, E. L., Diaz-Ramirez, L. G., Glymour, M. M., Boscardin, W. J., Covinsky, K. E., & Smith, A. K. (2017). Association between persistent pain and memory decline and dementia in a longitudinal cohort of elders. *JAMA internal medicine*, *177*(8), 1146-1153.

Wiltink, J., Glaesmer, H., Canterino, M., Wölfling, K., Knebel, A., Kessler, H., ... & Beutel, M. E. (2011). Regulation of emotions in the community: Suppression and reappraisal strategies and its psychometric properties. *GMS Psycho-Social-Medicine*, *8*.

Zogg, J. B., Woods, S. P., Sauceda, J. A., Wiebe, J. S., & Simoni, J. M. (2012). The role of prospective memory in medication adherence: a review of an emerging literature. *Journal of behavioral medicine*, *35*(1), 47-62.

APPENDIX A

Informed Consent Document

TITLE OF RESEARCH PROJECT
The Cognitive Mechanisms of Pain

RESEARCH TEAM

Principal Investigator
Maxine Geltmeier
Department of Psychology
Email: maxine.geltmeier@uta.edu

Faculty Advisor
Dr. Perry Fuchs
Department of Psychology
Email: fuchs@uta.edu

IMPORTANT INFORMATION ABOUT THIS RESEARCH PROJECT
The research team above is conducting a study about pain and cognition. You can choose to participate in this research study if you are 18 years of age or older.

This study has been reviewed and approved by an Institutional Review Board (IRB). An IRB is an ethics committee that reviews research with the goal of protecting the rights and welfare of human research subjects. Your most important right as a human subject is informed consent. You should take your time to consider the information provided by this form and the research team and ask questions about anything you do not fully understand before making your decision about participating.

TIME COMMITMENT
Participation in this study will take approximately 60 minutes. You may complete the study virtually, anywhere you are comfortable.

RESEARCH PROCEDURES
If you decide to participate in this research study, this is the list of activities that we will ask you

to perform as part of the research:

1. Read the informed consent and indicate your decision to proceed with the study.
2. Complete a survey about pain and emotional regulation.
3. Complete cognitive exercises through online participation.

POSSIBLE BENEFITS
A potential direct benefit of participation is the opportunity to provide information that may inform future research efforts.

POSSIBLE RISKS/DISCOMFORTS
There are no perceived risks or discomforts for participating in this project. Should you experience any discomfort, please inform the principal investigator.

COMPENSATION
For SONA participants: Upon completion of the task, you will receive .5 credits for every 30 minutes.
For Prolific participants: Upon completion of the task, you will receive $7.00 for every hour that is spent on the task.
For Research Match Participants: Participation is voluntary and no compensation will be provided.

ALTERNATIVE OPTIONS
There are no alternative options offered for this study.

CONFIDENTIALITY
The research team is committed to protecting your rights and privacy as a research subject. All data collected for this study will be stored in a secure location on the UTA campus and/or a secure UTA server for at least three (3) years after the end of this research.

The results of this study may be published and/or presented without naming you as a participant.

While absolute confidentiality cannot be guaranteed, the research team will make every effort to protect the confidentiality of your records as described here and to the extent permitted by law. In addition to the research team, the following entities may have access to your records, but only on a need-to-know basis: the U.S. Department of Health and Human Services and the FDA (federal regulating agencies), and the reviewing IRB.

CONTACT FOR QUESTIONS
Questions about this research study or reports regarding an injury or other problem may be directed to Maxine Geltmeier at Maxine.geltmeier@uta.edu or to Dr. Perry Fuchs at fuchs@uta.edu. Any questions you may have about your rights as a research subject or complaints about the research may be directed to the Office of Research Administration; Regulatory Services at 817-272-3723 or regulatoryservices@uta.edu.

CONSENT
By proceeding to the next page of the survey, you are confirming that you understand the study's purpose, procedures, potential risks, and your rights as a research subject. By agreeing to participate, you are not waiving any of your legal rights. You can refuse to participate or discontinue participation at any time, with no penalty or loss of benefits that you would ordinarily have.

Appendix B

Model Specification:

```
Y ~ b2 * M2 + b1 * M1 + c * X
M2 ~ a2 * X
M1 ~ a1 * X
indirect2 := a2 * b2
indirect1 := a1 * b1
total := c + (a2 * b2) + (a1 * b1)
M2 ~ M1
```

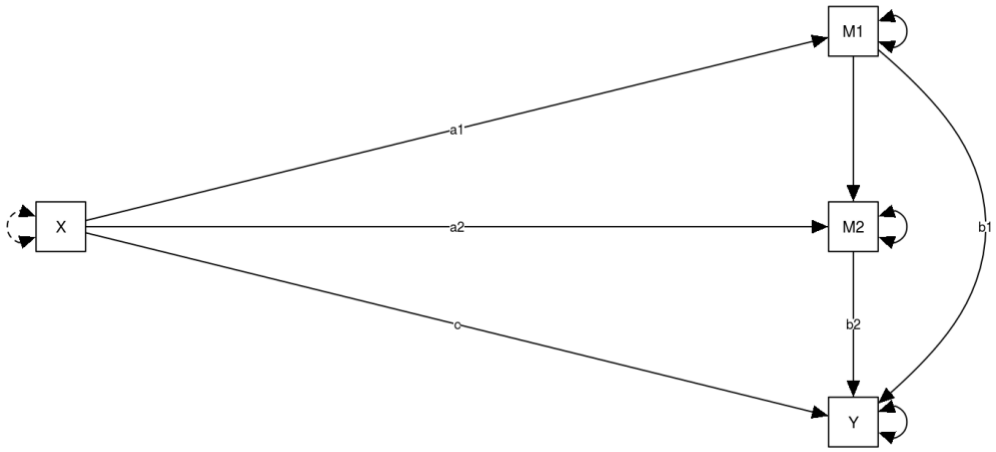
Y = Prospective Memory
X = Pain
M1 = Emotional Regulation
M2 = Attention

Power Analysis for 200 participants when path values are all estimated at .25

Parameter	Value	Power
Y ~ M1	0.25	0.98
Y ~ M2	0.25	0.97
Y ~ X	0.25	0.93
M1 ~ X	0.25	0.97
M2 ~ X	0.25	0.97
M1 ~ M2	0.25	0.98
Indirect 2	0.25	0.86
Indirect 1	0.25	0.82
Total	0.25	1.00

Tool Website: https://yilinandrewang.shinyapps.io/pwrSEM/

Visualization:



APPENDIX C

Pain and Prospective Memory Questionnaire

The following questions are listed to evaluate pain and memory processing. Some of the questions may seem irrelevant to your personal situation but please do not skip any questions. Please answer all of the following questions to the best of your ability.

1. Are you currently experiencing any physical pain symptoms? (For example, headache, back pain, mouth pain, joint pain, pain from an injury, etc.) (Y/N) ____

a) If yes, please skip to question 2.
b) If no, please indicate when you last experienced any pain symptoms:
    a. Yesterday
    b. Earlier this week
    c. Last week
    d. Two weeks ago
    e. Three weeks ago
    f. One month ago
    g. Longer that one month ago

If you answered "yes" to Question 1 please describe your current pain in the following questions. If you answered "no" to Question 1 please describe your last instance of a pain experience in the following questions.

2. Please describe the location of your pain. _____

3. Please describe the source or reason for your pain. (For example, headache, joint pain, pain from an injury etc.)_____

4. Please mark your answers to the best of your ability based on the list of words that describe some of the different qualities of pain and related symptoms. Please rate the intensity of each of the pain types and related symptoms you feel currently (or most recent experience of pain if you are not currently in pain).

With 0 being no pain and 10 being the worst pain you can imagine. Use 0 if the word does not describe your pain or related symptoms.

a. Throbbing Pain:
0□ 1□ 2□ 3□ 4□ 5□ 6□ 7□ 8□ 9□ 10□

b. Shooting Pain:
0□ 1□ 2□ 3□ 4□ 5□ 6□ 7□ 8□ 9□ 10□

c. Stabbing Pain:
0□ 1□ 2□ 3□ 4□ 5□ 6□ 7□ 8□ 9□ 10□

d. Sharp Pain:
0□ 1□ 2□ 3□ 4□ 5□ 6□ 7□ 8□ 9□ 10□

e. Cramping Pain:

0□ 1□ 2□ 3□ 4□ 5□ 6□ 7□ 8□ 9□ 10□

f. Gnawing Pain:

0□ 1□ 2□ 3□ 4□ 5□ 6□ 7□ 8□ 9□ 10□

g. Hot/Burning Pain:

0□ 1□ 2□ 3□ 4□ 5□ 6□ 7□ 8□ 9□ 10□

h. Aching Pain:

0□ 1□ 2□ 3□ 4□ 5□ 6□ 7□ 8□ 9□ 10□

i. Heavy Pain:

0□ 1□ 2□ 3□ 4□ 5□ 6□ 7□ 8□ 9□ 10□

j. Tender:

0□ 1□ 2□ 3□ 4□ 5□ 6□ 7□ 8□ 9□ 10□

k. Splitting Pain:

0□ 1□ 2□ 3□ 4□ 5□ 6□ 7□ 8□ 9□ 10□

l. Tiring/Exhausting:

0□ 1□ 2□ 3□ 4□ 5□ 6□ 7□ 8□ 9□ 10□

m. Sickening:

0□ 1□ 2□ 3□ 4□ 5□ 6□ 7□ 8□ 9□ 10□

n. Fearful:

0□ 1□ 2□ 3□ 4□ 5□ 6□ 7□ 8□ 9□ 10□

o. Punishing/Cruel:

0□ 1□ 2□ 3□ 4□ 5□ 6□ 7□ 8□ 9□ 10□

p. Electric/Shock Pain:

0□ 1□ 2□ 3□ 4□ 5□ 6□ 7□ 8□ 9□ 10□

q. Cold/Freezing Pain:

0□ 1□ 2□ 3□ 4□ 5□ 6□ 7□ 8□ 9□ 10□

r. Piercing:

0□ 1□ 2□ 3□ 4□ 5□ 6□ 7□ 8□ 9□ 10□

s. Pain through light touch:

0□ 1□ 2□ 3□ 4□ 5□ 6□ 7□ 8□ 9□ 10□

t. Itching:

0□ 1□ 2□ 3□ 4□ 5□ 6□ 7□ 8□ 9□ 10□

u. Tingling/Pins n’ Needles:

0□ 1□ 2□ 3□ 4□ 5□ 6□ 7□ 8□ 9□ 10□

v. Numbness:

0□ 1□ 2□ 3□ 4□ 5□ 6□ 7□ 8□ 9□ 10□

w. Itching:

0□ 1□ 2□ 3□ 4□ 5□ 6□ 7□ 8□ 9□ 10□

x. Evaluative overall intensity of total pain experience.

No pain□ Mild□ Discomforting□ Distressing□ Horrible□ Excruciating□

5. Below is a collection of statements about your everyday experience. Using the 1-6 scale below, please indicate how frequently or infrequently you currently have each experience. Please answer

according to what really reflects your experience rather than what you think your experience should be. Please treat each item separately from every other item.

1	2	3	4	5	6
almost always	very frequently	somewhat frequently	somewhat infrequently	very infrequently	almost never

a. _____ I could be experiencing some emotion and not be conscious of it until sometime later.
b. _____ I break or spill things because of carelessness, not paying attention, or thinking of something else.
c. _____ I find it difficult to stay focused on what's happening in the present.
d. _____ I tend to walk quickly to get where I'm going without paying attention to what I experience along the way.
e. _____ I tend not to notice feelings of physical tension or discomfort until they really grab my attention.
f. _____ I forget a person's name almost as soon as I've been told it for the first time.
g. _____ It seems I am "running on automatic," without much awareness of what I'm doing.
h. _____ I rush through activities without being really attentive to them.
i. _____ I get so focused on the goal I want to achieve that I lose touch with what I'm doing right now to get there.
j. _____ I do jobs or tasks automatically, without being aware of what I'm doing.
k. _____ I find myself listening to someone with one ear, doing something else at the same time.
l. _____ I drive places on 'automatic pilot' and then wonder why I went there.
m. _____ I find myself preoccupied with the future or the past.
n. _____ I find myself doing things without paying attention.
o. _____ I snack without being aware that I'm eating.

6. We would like to ask you some questions about your emotional life, in particular, how you control (that is, regulate and manage) your emotions. The questions below involve two distinct aspects of your emotional life. One is your <u>emotional experience</u>, or what you feel like inside. The other is your <u>emotional expression</u>, or how you show your emotions in the way you talk, gesture, or behave. Although some of the following questions may seem similar to one another, they differ in important ways. For each item, please answer using the following scale:

1----------	2---------	3----------	4----------	5---------	6----------	7
Strongly Disagree			Neutral			Strongly Agree

a. ____ When I want to feel more positive emotion (such as joy or amusement), I change what I'm thinking about.
b. ____ I keep my emotions to myself.
c. ____ When I want to feel less negative emotion (such as sadness or anger), I change what I'm thinking about.
d. ____ When I am feeling positive emotions, I am careful not to express them.
e. ____ When I'm faced with a stressful situation, I make myself think about it in a way that helps me stay calm.
f. ____ I control my emotions by not expressing them.

g. ____ When I want to feel more positive emotion, I change the way I'm thinking about the situation.
h. ____ I control my emotions by changing the way I think about the situation I'm in.
i. ____ When I am feeling negative emotions, I make sure not to express them.
j. ____ When I want to feel less negative emotion, I change the way I'm thinking about the situation.

7. In order to understand why people make memory mistakes, we need to find out about the kinds of mistakes people make, and how often they are made in normal everyday life. We would like you to tell us how often these kind of things happen to you. Please indicate by ticking the appropriate box. Please mark your answers to the best of your ability.

a. Do you decide to do something in a few minutes' time and then forget to do it?
Very Often □ Quite Often□ Sometimes□ Rarely□ Never□

b. Do you fail to recognize a place you have visited before?
Very Often □ Quite Often□ Sometimes□ Rarely□ Never□

c. Do you fail to do something you were supposed to do a few minutes later even though it's there in front of you, like take a pill or turn off the kettle?
Very Often □ Quite Often□ Sometimes□ Rarely□ Never□

d. Do you forget something that you were told a few minutes before?
Very Often □ Quite Often□ Sometimes□ Rarely□ Never□

e. Do you forget appointments if you are not prompted by someone else or by a reminder such as a calendar or diary?
Very Often □ Quite Often□ Sometimes□ Rarely□ Never□

f. Do you fail to recognize a character in a radio or television show from scene to scene?
Very Often □ Quite Often□ Sometimes□ Rarely□ Never□

g. Do you forget to buy something you planned to buy, like a birthday card, even when you see the shop?
Very Often □ Quite Often□ Sometimes□ Rarely□ Never□

h. Do you fail to recall things that have happened to you in the last few days?
Very Often □ Quite Often□ Sometimes□ Rarely□ Never□

i. Do you repeat the same story to the same person on different occasions?
Very Often □ Quite Often□ Sometimes□ Rarely□ Never□

j. Do you intend to take something with you, before leaving a room or going out, but minutes later leave it behind, even though it's there in front of you?
Very Often □ Quite Often□ Sometimes□ Rarely□ Never□

k. Do you mislay something that you have just put down, like a magazine or glasses?

Very Often □ Quite Often□ Sometimes□ Rarely□ Never□

l. Do you fail to mention or give something to a visitor that you were asked to pass on?
Very Often □ Quite Often□ Sometimes□ Rarely□ Never□

m. Do you look at something without realising you have seen it moments before?
Very Often □ Quite Often□ Sometimes□ Rarely□ Never□

n. If you tried to contact a friend or relative who was out, would you forget to try again later?
Very Often □ Quite Often□ Sometimes□ Rarely□ Never□

n. Do you forget what you watched on television the previous day?
Very Often □ Quite Often□ Sometimes□ Rarely□ Never□

p. Do you forget to tell someone something you had meant to mention a few minutes ago?
Very Often □ Quite Often□ Sometimes□ Rarely□ Never□

Please answer all of the following questions to the best of your ability.

8.Gender _____ 9.Date of Birth _____

10. Handedness (L or R) ____

11. Years of schooling and/or highest degree or diploma. _____

12. To what ethnic group do you belong? Please check below: (Optional)

____Caucasian/White (non-Hispanic): Persons with origins in any of the original peoples of Europe, North Africa, or the Middle East.
____Black (non-Hispanic): Persons with origins in any of the black racial groups of Africa.
____Oriental/Asian or Pacific Islander: Persons with origins in any of the original peoples of the Far East, Southeast Asia, the Indian subcontinent, or the Pacific Islands.
____American Indian or Alaskan Native: Persons with origins in any of the original peoples of North America, and who maintain cultural identification through tribal affiliation or community recognition.
____Hispanic: Persons of Mexican, Puerto Rican, Cuban, Central or South American, or other Spanish culture or origin, regardless of race.
____ Other (please clarify): _____

13. Please list any prescription medications that you are currently taking that might affect your memory or attention:_____

14. Have you ever been diagnosed with an attention disorder? (Y/N) ____

If yes, please explain. _____

15. Have you ever been diagnosed with an emotion disorder? (Y/N) ____
If yes, please explain. _____

16. Have you ever been diagnosed with a pain disorder? (Y/N) ____
If yes, please explain. _____

17. Have you ever suffered from a brain or head injury resulting in hospitalization (Y/N)
If yes, when was the injury and what was the diagnosis?
_____

APPENDIX D

Demographic Questionnaire

Participant ID (to be filled out by experimenter)_____

Date_____

1.Gender _____ 2.Date of Birth _____3.Age _____

4. Handedness (L or R)____

5. Years of schooling and/or highest degree or diploma. _____

6. To what ethnic group do you belong? Please check below: (Optional)

____Caucasian/White (non-Hispanic): Persons with origins in any of the original peoples of Europe, North Africa, or the Middle East.
____Black (non-Hispanic): Persons with origins in any of the black racial groups of Africa.
____Oriental/Asian or Pacific Islander: Persons with origins in any of the original peoples of the Far East, Southeast Asia, the Indian subcontinent, or the Pacific Islands.
____American Indian or Alaskan Native: Persons with origins in any of the original peoples of North America, and who maintain cultural identification through tribal affiliation or community recognition.
____Hispanic: Persons of Mexican, Puerto Rican, Cuban, Central or South American, or other Spanish culture or origin, regardless of race.
____ Other (please clarify): _____

7. Please list any prescription medications that you are currently taking that might affect your memory:_____

8. Have you ever experienced brain injury? (Y/N) ____
If yes, please explain. _____

9. Do you wear glasses or corrective lenses? _____ Approximately when was your last eye exam? _____

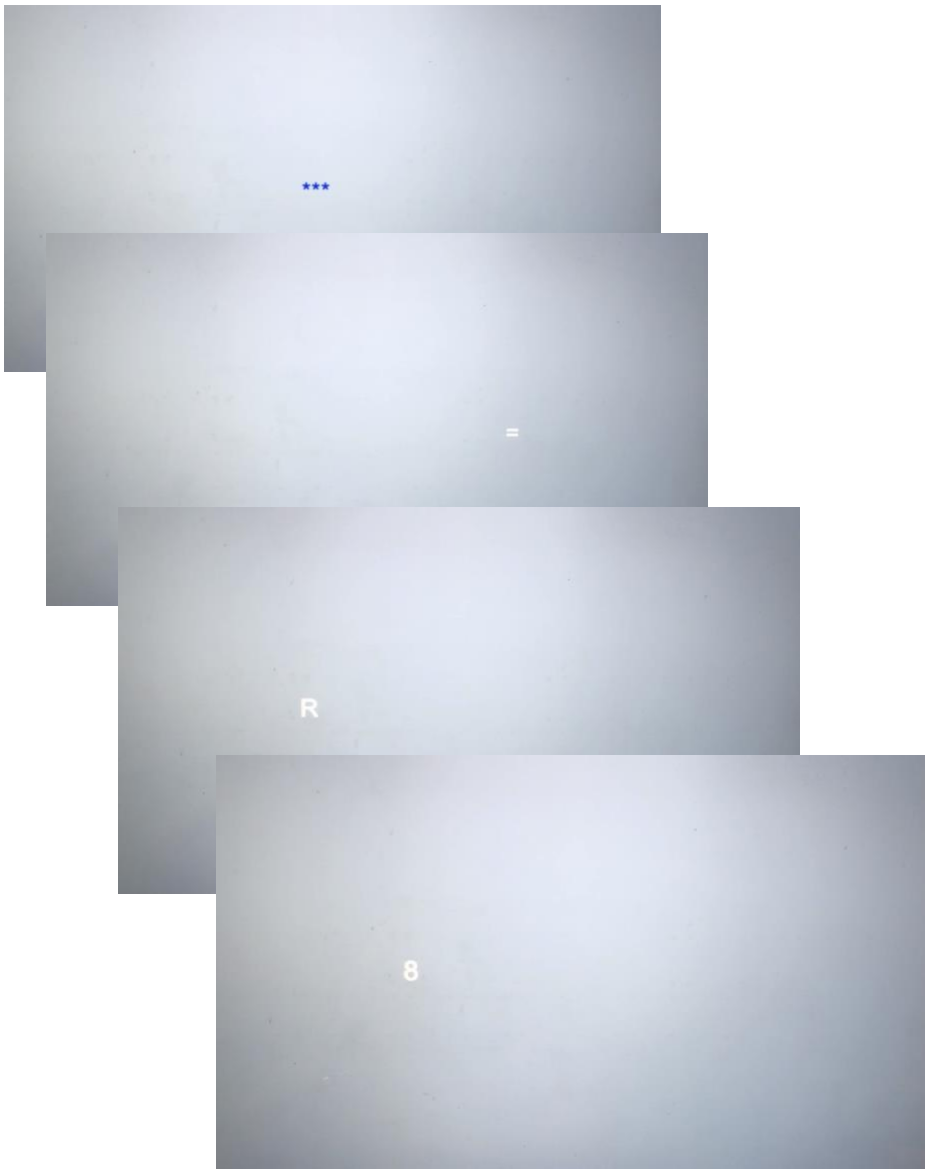
APPENDIX E

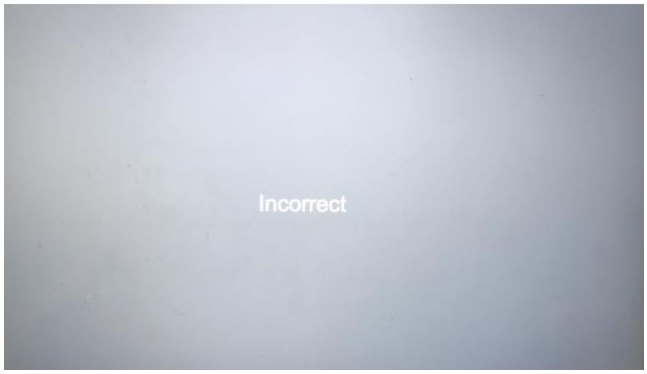
Ongoing Lexical Decision Task Examples

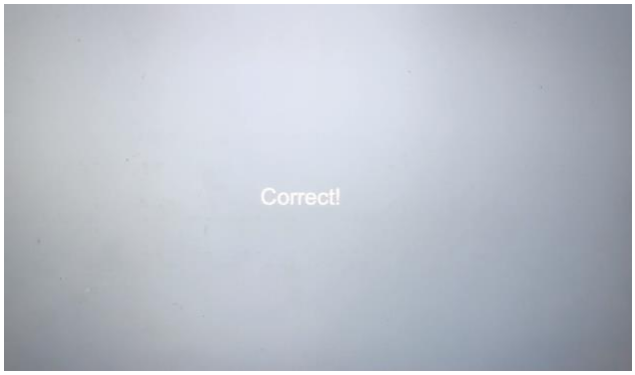
Word	Non-Word
TWITCH	TWOTCH
PRETTY	PRITTY
FLUNG	FLONG
PLEE	PLAE
CRAZY	CROZY
WHAT	WHOT
HOUSE	HOISE
FARMER	FURMER
TABLE	TIBLE
PARTY	PURTY
INSULT	INSILT
CRYING	CRYONG
TURTLE	TORTLE
PLEASE	PLEESE
TANGO	TINGO
WINDOW	WANDOW
CRADLE	CRIDLE
HEAP	HOAP
HELLO	HILLO
CARRY	CIRRY
FLUNK	FLONK
HAIRY	HAURY
BLACK	BLICK
UNDER	UNDAR

APPENDIX F

Antisaccade Sequence (Target Keys = B, P, R)







APPENDIX G

Prospective Memory Cue Check

Which of the following should you have responded to with the ‘7’ key? Indicate your answer with the corresponding number (eg. 1,2,3,4)

1)Youth
2)Child
3)Oppes
4)Success

APPENDIX H

University Sample Frequencies

Table X1

Age Frequencies

	Frequency	Percent
young (18-35)	136	96.5
middle-aged (36-55)	5	3.5
Total	141	100.0

Table X2

Sex Frequencies

	Frequency	Percent
female	110	78.0
male	31	22.0
Total	141	100.0

Table X3

Education Frequencies

	Frequency	Percent
unclear/other	10	7.1
GED	2	1.4
HS	56	39.7
some college	48	34.0
associates degree	21	14.9
bachelor's degree	3	2.1
Missing	1	.7
Total	141	100.0

Table X4

Ethnicity

	Frequency	Percent
Black	17	12.1
Asian or Pacific Islander	35	24.8
Hispanic	43	30.5
White	41	29.1
Other	5	3.5
Total	141	100

Table X5

Attention Disorder Diagnosed

	Frequency	Percent
Yes	11	7.8
No	130	92.2
Total	141	100.0

Table X6

Emotion Disorder Diagnosed

	Frequency	Percent
Yes	14	9.9
No	127	90.1
Total	141	100.0

Table X7

Pain Disorder Diagnosed

	Frequency	Percent
Yes	8	5.7
No	133	94.3
Total	141	100.0

Table X8

Brain Injury

	Frequency	Percent
Yes	6	4.3
No	135	95.7
Total	141	100.0

APPENDIX I

Pain Sample Frequencies

Table X1
Age Frequencies

	Frequency	Percent
young (18-35)	136	75.1
middle-aged (36-55)	35	19.3
older adults (56 and older)	9	5.0
Missing	1	.6
Total	181	100.0

Table X2
Sex Frequencies

	Frequency	Percent
female	63	34.8
male	118	65.2
Total	181	100.0

Table X3
Education

	Frequency	Percent
unclear/other	7	3.9
drop out, no GED	2	1.1
GED	1	.6
HS	49	27.1
some college	33	18.2
associates degree	3	1.7
bachelor's degree	52	28.7
master's degree	33	18.2
PhD	1	.6
Total	181	100.0

Table X4

Ethnicity

	Frequency	Percent
Black	4	2.2
Asian	6	3.3
Hispanic	16	8.8
White	152	84.0
Other	3	1.7
Total	181	100.0

Table X5

Attention Disorder Diagnosed

	Frequency	Percent
Yes	11	6.1
No	170	93.9
Total	181	100.0

Table X6

Emotion Disorder Diagnosed

	Frequency	Percent
Yes	36	19.9
No	145	80.1
Total	181	100.0

Table X7

Pain Disorder Diagnosed

	Frequency	Percent
Yes	33	18.2
No	148	81.8
Total	181	100.0

Table X8

Brain Injury

	Frequency	Percent
Yes	15	8.3
No	166	91.7
Total	181	100.0

APPENDIX J

University Sample Zero-Order Correlation Matrix

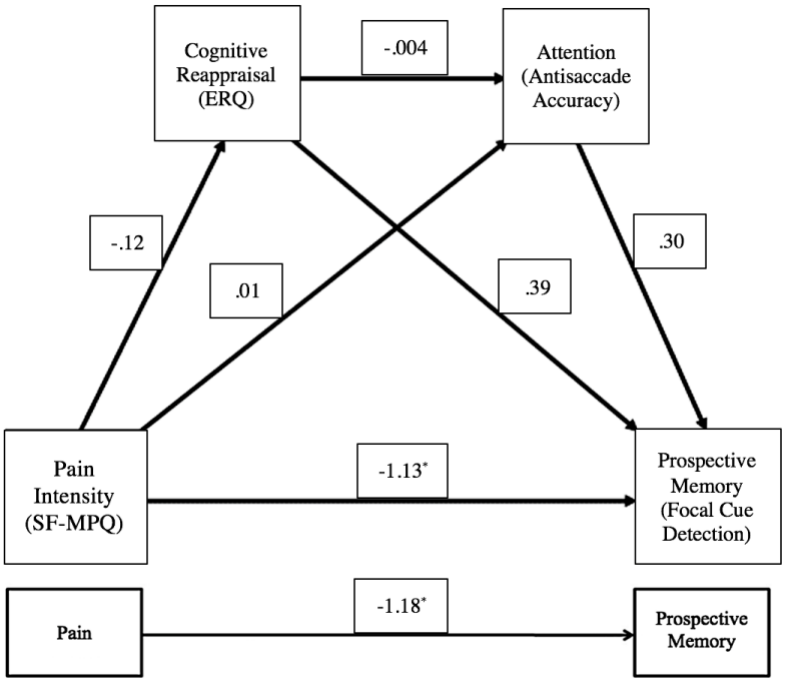
Correlation Matrix

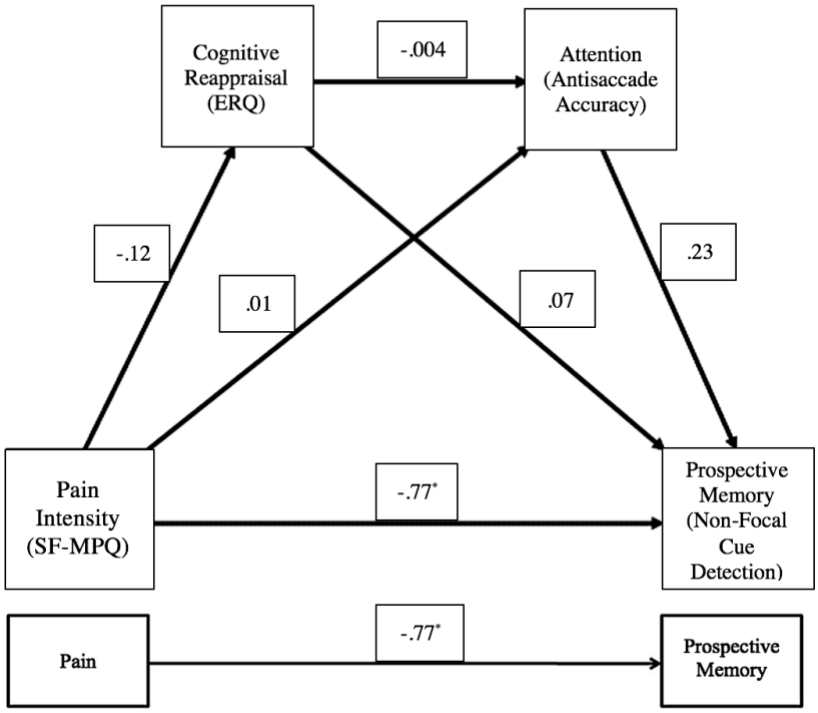
		Pain Intensity	Antisaccade accuracy	Antisaccade RT	PM non-focal cue detections	PM focal cue detections	Prospective Memory (PRMQ)	Attention (MAAS)	Cognitive Reappraisal (ERQ)	Expressive Suppression (ERQ)
Pain Intensity	Pearson Correlation	1	-0.145	0.102	-0.112	-0.154	-0.116	0.014	0.139	-0.008
	Sig.		0.096	0.241	0.199	0.076	0.181	0.869	0.110	0.930
	N	134	134	134	134	134	134	134	134	134
Antisaccade accuracy	Pearson Correlation	-0.145	1	-.207*	0.163	0.128	0.021	-0.030	-0.006	-0.057
	Sig.	0.096		0.016	0.060	0.141	0.808	0.731	0.949	0.513
	N	134	134	134	134	134	134	134	134	134
Antisaccade RT	Pearson Correlation	0.102	-.207*	1	-0.051	-0.024	0.113	-0.079	0.017	-0.114
	Sig.	0.241	0.016		0.560	0.782	0.193	0.367	0.843	0.188
	N	134	134	134	134	134	134	134	134	134
Non-focal detections	Pearson Correlation	-0.112	0.163	-0.051	1	.845**	-0.148	0.030	-0.058	-0.168
	Sig.	0.199	0.060	0.560		0.000	0.088	0.728	0.505	0.052
	N	134	134	134	134	134	134	134	134	134
Focal cue detections	Pearson Correlation	-0.154	0.128	-0.024	.845**	1	-0.119	0.016	-0.040	-0.152
	Sig.	0.076	0.141	0.782	0.000		0.172	0.857	0.644	0.079
	N	134	134	134	134	134	134	134	134	134
PM (PRMQ)	Pearson Correlation	-0.116	0.021	0.113	-0.148	-0.119	1	-.541**	0.128	-0.018
	Sig.	0.181	0.808	0.193	0.088	0.172		0.000	0.140	0.834
	N	134	134	134	134	134	134	134	134	134
Attention (MAAS)	Pearson Correlation	0.014	-0.030	-0.079	0.030	0.016	-.541**	1	-.221*	.191*
	Sig.	0.869	0.731	0.367	0.728	0.857	0.000		0.010	0.027
	N	134	134	134	134	134	134	134	134	134
Reappraisal (ERQ)	Pearson Correlation	0.139	-0.006	0.017	-0.058	-0.040	0.128	-.221*	1	.190*
	Sig.	0.110	0.949	0.843	0.505	0.644	0.140	0.010		0.028
	N	134	134	134	134	134	134	134	134	134
Suppression (ERQ)	Pearson Correlation	-0.008	-0.057	-0.114	-0.168	-0.152	-0.018	.191*	.190*	1
	Sig.	0.930	0.513	0.188	0.052	0.079	0.834	0.027	0.028	
	N	134	134	134	134	134	134	134	134	134

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

APPENDIX K

Non-Significant Mediation Models for the University Sample





APPENDIX L

Total Sample Zero-Order Correlation Matrix

Correlation Matrix

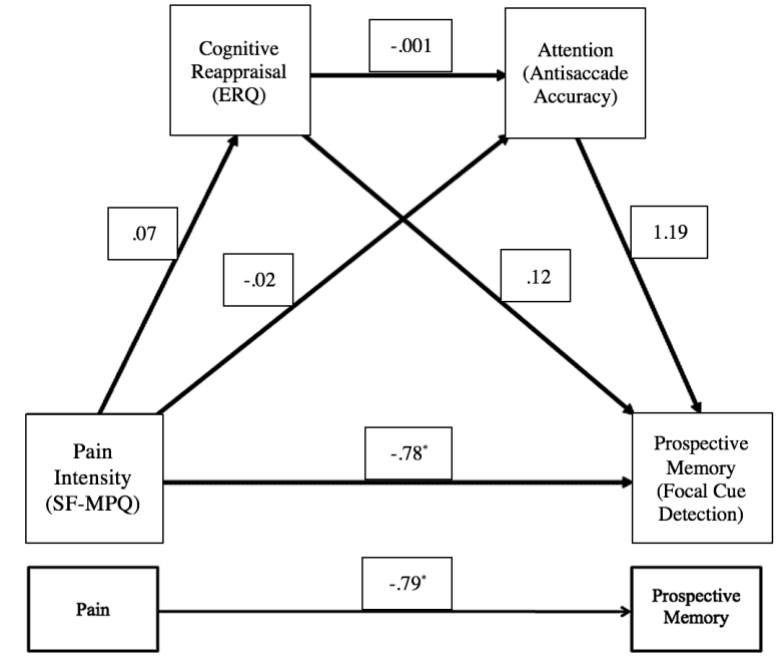
		Pain Intensity	Antisaccade accuracy	Antisaccade RT	PM non-focal cue detections	PM focal cue detections	Prospective Memory (PRMQ)	Attention (MAAS)	Cognitive Reappraisal (ERQ)	Expressive Suppression (ERQ)
Pain Intensity	Pearson Correlation	1	0.036	0.154	-.392**	-.341**	-0.157	0.143	-0.089	-0.072
	Sig.		0.779	0.233	0.002	0.007	0.224	0.267	0.494	0.579
	N	62	62	62	62	62	62	62	62	62
Antisaccade accuracy	Pearson Correlation	0.036	1	-0.218	0.007	0.000	-0.070	0.150	-0.029	0.179
	Sig.	0.779		0.088	0.958	0.997	0.591	0.244	0.822	0.165
	N	62	62	62	62	62	62	62	62	62
Antisaccade RT	Pearson Correlation	0.154	-0.218	1	0.185	0.134	-0.039	-0.006	-0.020	0.069
	Sig.	0.233	0.088		0.150	0.300	0.762	0.965	0.879	0.595
	N	62	62	62	62	62	62	62	62	62
Non-focal detections	Pearson Correlation	-.392**	0.007	0.185	1	.815**	-0.212	0.118	0.082	0.233
	Sig.	0.002	0.958	0.150		0.000	0.098	0.359	0.527	0.068
	N	62	62	62	62	62	62	62	62	62
Focal cue detections	Pearson Correlation	-.341**	0.000	0.134	.815**	1	-0.160	0.134	0.183	0.174
	Sig.	0.007	0.997	0.300	0.000		0.213	0.298	0.154	0.177
	N	62	62	62	62	62	62	62	62	62
PM (PRMQ)	Pearson Correlation	-0.157	-0.070	-0.039	-0.212	-0.160	1	-.693**	0.025	-0.023
	Sig.	0.224	0.591	0.762	0.098	0.213		0.000	0.850	0.862
	N	62	62	62	62	62	62	62	62	62
Attention (MAAS)	Pearson Correlation	0.143	0.150	-0.006	0.118	0.134	-.693**	1	0.000	0.169
	Sig.	0.267	0.244	0.965	0.359	0.298	0.000		0.998	0.189
	N	62	62	62	62	62	62	62	62	62
Reappraisal (ERQ)	Pearson Correlation	-0.089	-0.029	-0.020	0.082	0.183	0.025	0.000	1	.275*
	Sig.	0.494	0.822	0.879	0.527	0.154	0.850	0.998		0.031
	N	62	62	62	62	62	62	62	62	62
Suppression (ERQ)	Pearson Correlation	-0.072	0.179	0.069	0.233	0.174	-0.023	0.169	.275*	1
	Sig.	0.579	0.165	0.595	0.068	0.177	0.862	0.189	0.031	
	N	62	62	62	62	62	62	62	62	62

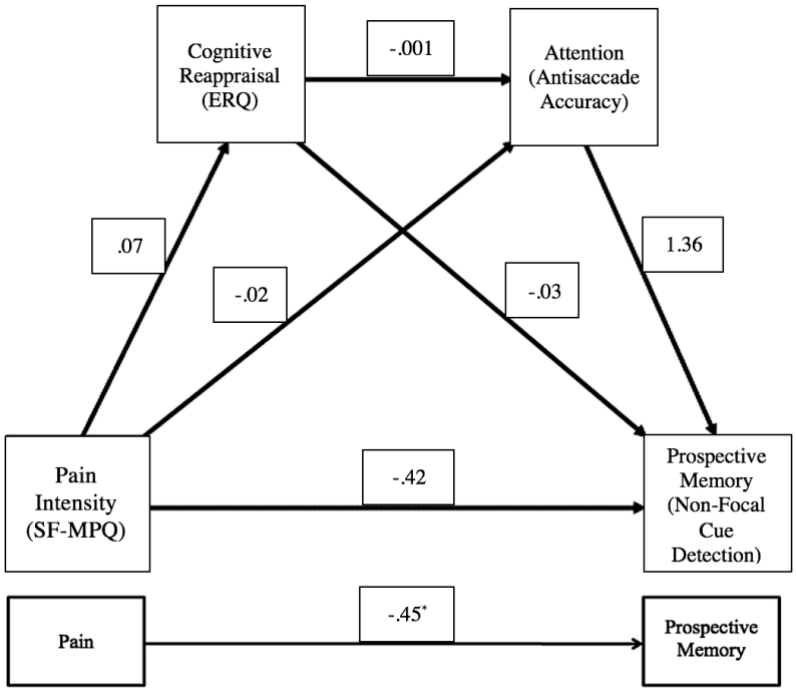
*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

APPENDIX M

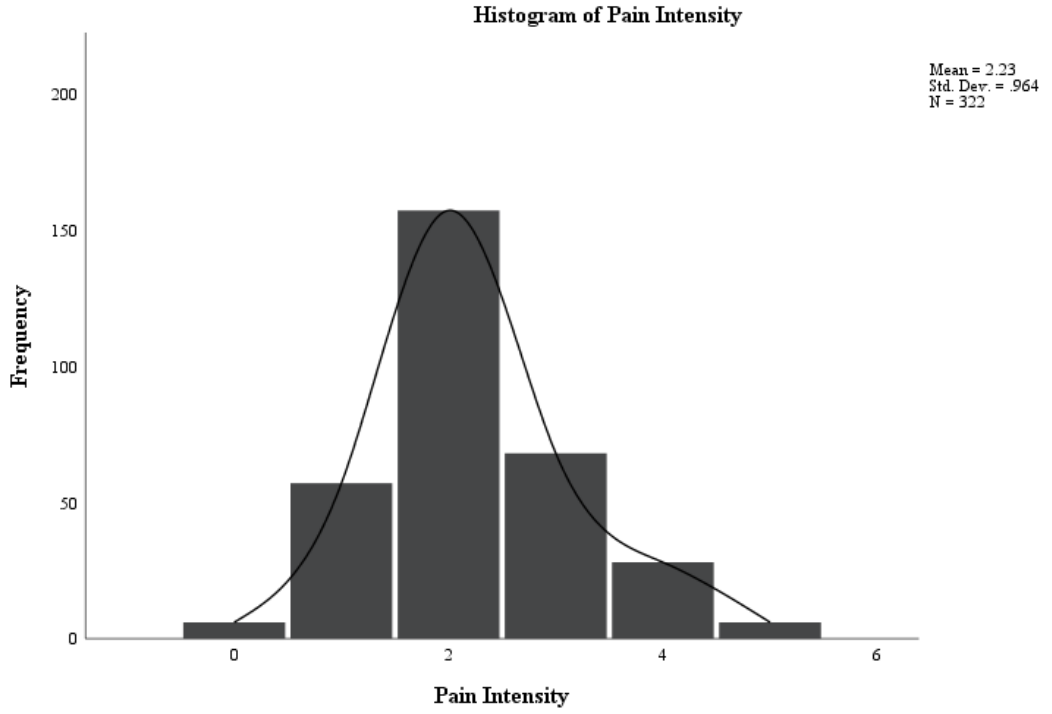
Non-Significant Mediation Models for the Total Sample

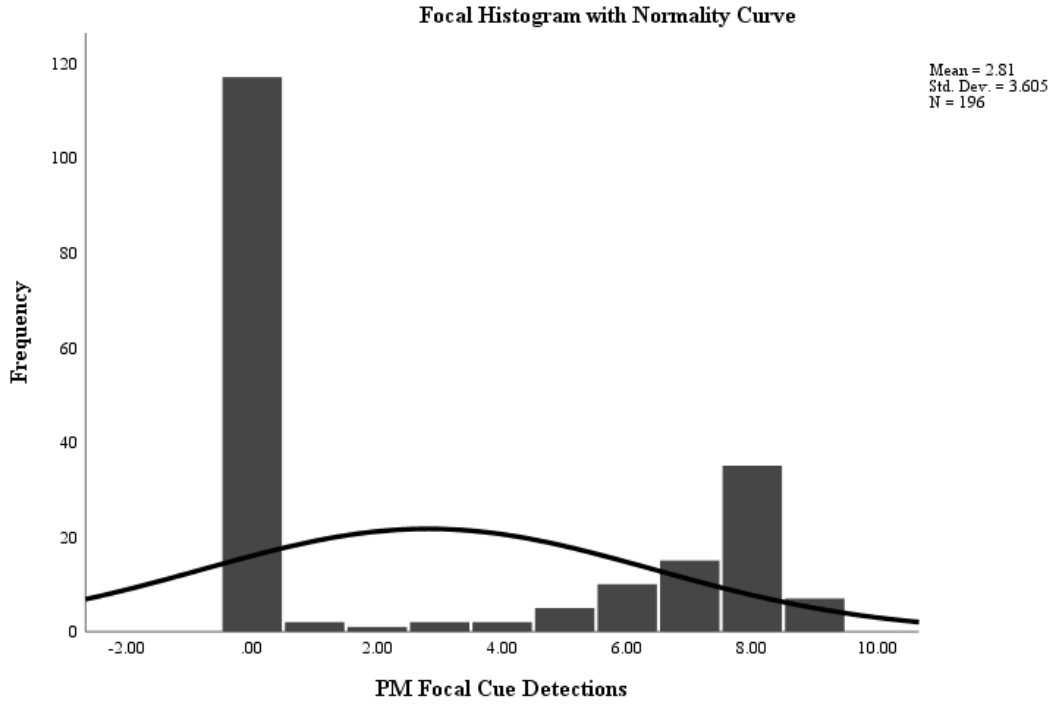


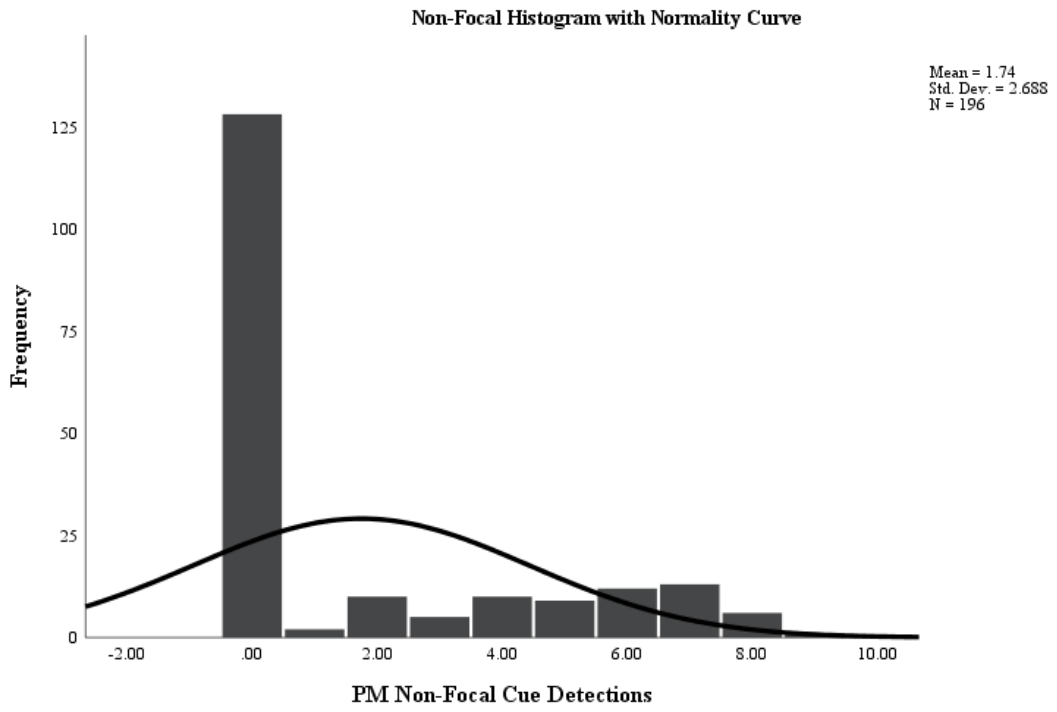


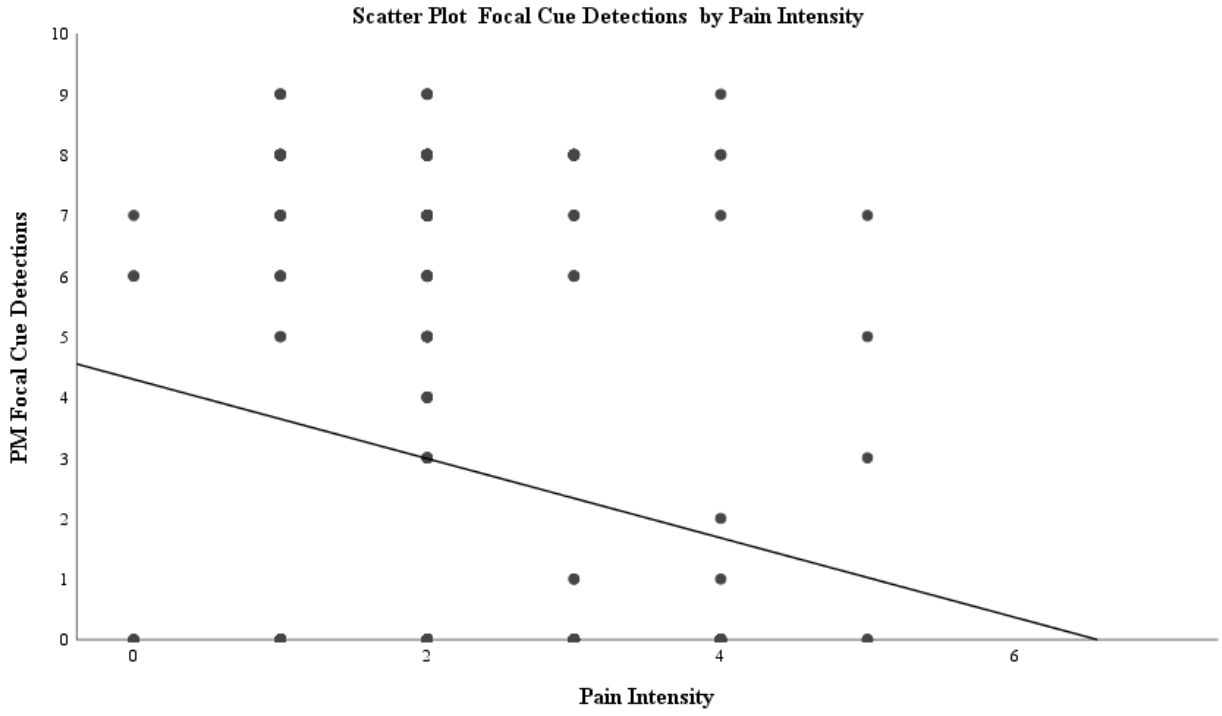
APPENDIX N

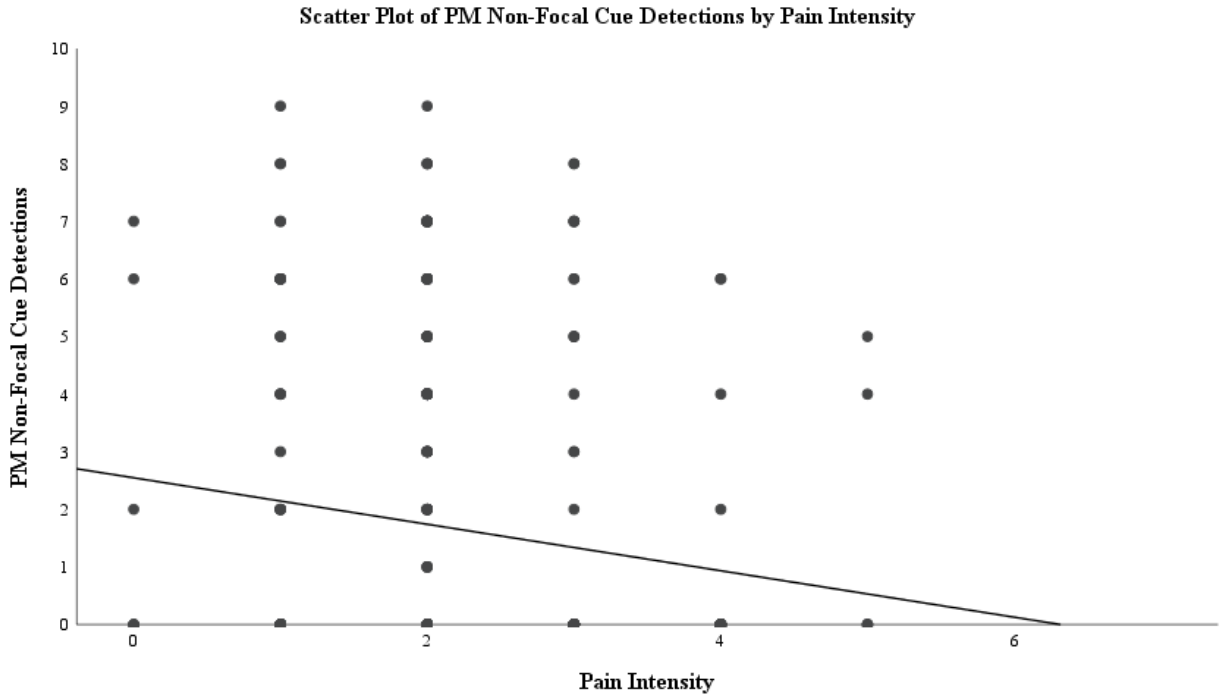
Frequencies and Scatter Plots for Pain and Prospective Memory Variables






Non-Focal Histogram with Normality Curve
Mean = 1.74
Std. Dev. = 2.688
N = 196
Frequency
125
100
75
50
25
0
-2.00
.00
2.00
4.00
6.00
8.00
10.00
PM Non-Focal Cue Detections


Scatter Plot Focal Cue Detections by Pain Intensity
PM Focal Cue Detections
10
9
8
7
6
5
4
3
2
1
0
0
2
4
6
Pain Intensity


Scatter Plot of PM Non-Focal Cue Detections by Pain Intensity
PM Non-Focal Cue Detections
10
9
8
7
6
5
4
3
2
1
0
0
2
4
6
Pain Intensity