THE EFFECTS OF INDUCED-PAIN ON PASAT PERFORMANCE

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THE EFFECTS OF INDUCED-PAIN ON

PASAT PERFORMANCE

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TABLE OF CONTENTS

Page

LIST OF TABLES

Table **Page**

ABSTRACT

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The present study examined the relationship between cold-pressor induced-pain, psychological variables, and performance on the Paced Auditory Serial Addition Test (PASAT). A mixed-measures ANOVA was performed to assess the effects of induced-pain on PASAT performance. The results revealed a significant difference within-subjects for pre and post PASAT as well as a significant interaction effect between condition and PASAT performance; suggesting that induced pain was associated with impaired scores. A linear regression showed that participants' initial reaction to cold-pressor pain was moderated by their desire to disengage from pain which predicted performance.

CHAPTER 1

INTRODUCTION

The Multidimensional Nature of Chronic Pain

Although there is not a universal definition, according to Fornasari (2012) chronic pain can be defined as, "pain that persists beyond the expected normal time for healing and serves no useful physiological purpose" (p. 46). According to the Committee on Advancing Pain Research, Care, and Education of the Institute of Medicine (IOM), with over 100 million sufferers chronic pain affects more Americans than diabetes, heart disease, and cancer combined (Institute of Medicine, 2011). In fact, in 2010 the total cost to the American health care system due to pain was estimated to be between $560 and $635 billion dollars, including $297-$336 billion in lost productivity (Institute of Medicine, 2011.) A review of chronic pain surveys by the American Pain Foundation (An overview of American pain surveys, 2007) found that in 2002, 59% reported trouble sleeping due to pain; 68% said pain caused them to feel anxious, irritable, or depressed; and 40% said pain interferes with their productivity and ability to work. Additionally, half of the respondents in a 2004 survey indicated that their pain was not under control (An overview of American pain surveys, 2007). Although chronic pain is a significant public health problem, the precise pathophysiological mechanisms and psychosocial factors related to chronic pain are equivocal (Fornasari, 2012).

Contributing to the difficulty in understanding chronic pain is the fact that its causes are multifaceted; with biological, psychological, and social variables interacting in complex ways to result in debilitating, persistent pain (Turk & Flor, 1999; Turk & Okifuji, 2002). The challenge for clinicians and researchers alike is to account for all variables from each dimension of the biopsychosocial model; a model which has proven to be instrumental in treating chronic pain (Turk & Okifuji, 2002). Understanding the relationship of these variables is imperative to understanding chronic pain itself. Unfortunately, the uniqueness of each presentation of the condition (fibromyalgia, chronic low back pain, multiple sclerosis, cancer related chronic pain, etc.) significantly confounds this quest. For some biological factors predominantly account for the cause of pain, while for others psychosocial factors play a large role. Hence, it is erroneous to assume homogeneity of patients (Turk & Okifuji, 2002).

Pain and Cognition

A common complaint associated with chronic pain and quintessential example of interrelated biological, psychological, and social causative factors is cognitive impairment. Research shows that chronic pain is often associated with substantial impairments to cognitive functioning (Eccleston, 1994; Sjøgren, Olsen, Thomsen, & Dalberg, 2000; Hart, Wade, & Martelli, 2003); in particular, chronic pain has been associated with impaired memory (Sjøgren, Thomsen, & Olsen, 2000; Oosterman, Derksen, Van Wijck, Veldhuijzen, & Kessels, 2011), impaired executive functioning (Abeare et al., 2010; Glass et al., 2011), impaired processing speed (Grigsby, Rosenberg, & Busenbark, 1995), impaired psychomotor speed (Sjøgren, Thomsen, & Olsen, 2000),

and impaired attention (Moore, Keogh, & Eccleston, 2012). As noted by Kreitler and Niv (2007), the cognitive impairments due to pain warrant closer inspection because they may contribute to further suffering and reduce quality of life in this population. Moreover, they may exacerbate negative affective symptoms, such as anxiety and depression, and restrict patients' ability to communicate their symptoms to healthcare professionals, which could potentially interfere with treatment interventions.

While the precise neurophysiological mechanisms that lead to such impairments are not fully understood, research suggests that pain may occupy many of the same mechanisms necessary for certain cognitive processes (Sanchez, 2011), leading to overload and subsequent deterioration. For example, pain researchers Eccleston and Crombez (1999) postulate that physical pain is a cognitive distraction that demands attention. This distraction from our normal thought processes serves to orient us toward the problem and motivate us to take action toward relief. This model of pain as a distractor suggests that attention is a resource with a limited capacity, and when one is in pain part of the "attentional resource" is occupied leaving less attention available for other cognitive processes. As a result, cognitive performance is impaired when one is in pain. However, when acute pain extends into chronic pain additional factors must be considered in order to understand the relationship between pain and cognition.

Research shows that psychosocial variables impact pain (Burton, Tillotson, Main, & Hollis, 1995; Boothby, Thorn, Stroud, & Jensen, 1999; Turner et al., 2002; Hanley et al., 2004; Osborne, Jensen, Ehde, Hanley, & Kraft, 2006). Even when controlling for

demographic variables, psychosocial variables such as beliefs about pain, social support, coping styles, and pain-related catstrophizing contribute to pain intensity, pain related interference, and psychological functioning (Osborne et al., 2006). Further research shows that attachment style (Forsythe, Romano, Jensen, & Thorn, 2012), acceptance of pain (Vernon, 2012), socioeconomic status (SES; Day & Thorn, 2010), and culture (Day & Thorn, 2010) also influence the impact of pain. As it relates to cognition, research shows that psychologic distress (amalgam of anxiety, depression, irritability, and energy levels per Kewman, Vaishampayan, Zald, & Han, 1991) and lower ratings of emotional well-being are significantly related to cognitive impairment in chronic pain patients (Kewman et al., 1991; Radanov, Dvorák, & Valach, 1992; Landrø, Stiles, & Sletvold, 1997; Grace, Nielson, Hopkins, & Berg; 1999). Although the relationship between psychosocial factors and cognitive deficits in chronic pain patients is not entirely understood, researchers have suggested that emotional distress may impact cognition through fatigue, apathy, disordered sleep, or medication effects (Kreitler & Niv, 2007).

CHAPTER II

LITERATURE REVIEW

Pain, Psychological Factors, and Cognitive Deficits

In a landmark study investigating the relationship between psychosocial factors and cognitive deficits in pain patients, Kewman and colleagues (1991) recruited 73 participants with acute or chronic musculoskeletal pain from a university outpatient facility. The final sample was 55% female and 45% male with a mean age of 42.7 (SD = 14.31). Participants were predominantly college educated and duration of pain symptoms ranged from 0 to 162 months. Patients were first asked to rate their pain, suffering, and interference on daily activities on items taken from the McGill Pain Questionnaire (McGuire, 1984). Next, they were asked to rate their pain and suffering on continuums of four psychological distress scales: 1. Sad, blue, depressed; 2. Worried, anxious, nervous; 3. Tense, irritable; 4. Tired, low energy. A composite score of psychological distress was totaled and participants then completed the Neurobehavioral Cognitive Status Examination (NCSE; Kierman, Mueller, Langston, & Van Dyke, 1987). The results showed that 32% of participants met the criteria for impairment on the NCSE with abnormally low scores in one or more domains of cognitive functioning tapped by the instrument (orientation, attention, comprehension, repetition, naming, construction,

memory, calculation, similarity, judgment). The results demonstrate that participants with the greatest cognitive deficits also scored higher on ratings of pain, suffering, and disability; suggesting that psychological distress moderates the relationship between pain level and scores on the NCSE. When psychological distress was controlled for the relationship between pain level and cognitive impairment was no longer significant. Further, a relationship was also observed between education and pain, disability, and cognitive functioning. Specifically, the results suggest that over time higher educated individuals may be more able to adjust or compensate to the effects of pain, disability, and/or cognitive deficits than their less educated counterparts. Finally, a relationship was observed between duration of pain symptoms and level of psychological distress with performance on the NCSE, with cognitively impaired participants reporting longer duration of symptoms (mean duration was 54 months for cognitively impaired participants versus a mean of 24 months for participants without cognitive impairments). However, although this relationship approached significance it could also be due to chance ($p = .073$). Taken together this study highlights the strongly intertwined relationship between psychological distress, pain, and cognitive impairment as well as the effects of education on these variables. While it is difficult to assess causality, it is clear that cognitive impairments in this population are not exclusively related to the physiological experience of pain itself.

As a result of the multidimensional nature of chronic pain, it is necessary to employ a variety of research strategies to address the issue from multiple perspectives. Although many studies have focused on samples of chronic pain patients and compared

them to healthy controls, this methodology has innate limitations given the complex nature of chronic pain. Eccleston (1995) and others argue that it is important to utilize multiple experimental paradigms to properly understand pain. Specifically, he suggests laboratory induced pain has been the most effective at parsing the "micro-cognition of pain processing and pain control" (Eccleston, 1995). This experimental paradigm allows researchers to enhance internal validity by isolating the effects of pain while controlling for confounding variables. Moreover, this methodology contributes to the pain literature through its implications for malingering (Etherton, Bianchini, Heinly, & Greve, 2006a; Etherton, Bianchini, Ciota, Heinly, & Greve, 2006b).

In contrast to research which indicates significant cognitive impairments due to pain (Eccleston, 1994; Sjøgren, Olsen, Thomsen, & Dalberg, 2000; Hart, Wade, & Martelli, 2003), the mixed results of additional studies imply a more nuanced relationship. In fact, studies on malingering (Etherton et al., 2006a; Etherton et al., 2006b) have found that neither induced nor chronic pain lead to substantial impairments on measures of processing speed and working memory. While the literature clearly shows slight impairment in cognitive functioning due to pain for certain populations (Kewman et al., 1991; Etherton et al., 2006a; Etherton et al., 2006b), the composite level of impairment is notably less than one would expect (e.g., minimal). Hence, significantly low scores may be indicative of poor effort, lack of motivation, or willful misrepresentation of abilities, excluding individuals with documented brain dysfunction (Etherton et al., 2006a; Etherton et al., 2006b). To examine the relationship between pain, malingering, and cognitive task performance, Etherton and colleagues (2006a) recruited

healthy volunteers and pulled archival data from clinical patients. For the first study, healthy college students were randomly assigned to a cold-pressor, procedural distraction simulator, or control condition and completed the two subtests of the processing speed index (PSI) of the WAIS-III (digit symbol and symbol span). The cold-pressor group took both subtests in cold-pressor induced pain. The procedural distraction condition took the subtests with their limb in a bucket of warm water to parallel the conditions of the cold-pressor procedure but without the pain induction. Participants in the simulator condition were asked to feign pain-related memory impairment and complete each subtest accordingly. The control condition took both subtests in normal conditions. The results showed that the simulator group scored significantly lower on both measures than the other groups. The cold-pressor group scored slightly lower on digit symbol than the control or procedural distraction group, but there was no significant difference between these groups on symbol search or overall PSI; suggesting that pain as an isolated variable may lead to slight impairment in processing speed but not enough to significantly lower composite PSI.

For the second study, for comparison to the group of healthy volunteers, archival data from a sample of chronic pain patients was pulled. The sample included documented chronic pain patients with no history of malingering and objectively verified pain inducing injuries, chronic pain patients with minimal physical findings who had been identified as known malingerers, and non-malingering neurological patients with conditions such as traumatic brain injuries (TBI) and memory disorders. The results showed that the malingering group scored significantly lower on both subtests and overall

PSI than the other three groups. No significant differences were observed between the chronic pain group (non-malingering), TBI, and memory disorder groups on overall PSI. Interestingly, the mean scores on overall PSI in the simulator condition in the first study were very similar to mean scores in the known malingering group in that these groups scored much lower than other groups (65.85 and 71.25, respectively). When comparing the means of the cold-pressor group (98.45) and non-malingering chronic pain group (89.48) with the means of the TBI and memory disorder patients (84.74 and 83.24), it is evident that pain does impair processing speed in some patients but not as substantially as a brain injury or memory disorder. These findings corroborate research from Kewman et al. (1991) demonstrating that pain does not act in isolation, and additional salient variables, such as education, directly impact the role of pain in cognitive task performance. Furthermore, these findings indicate that normal cognitive impairment due to pain is generally minimal to absent, and suggest that unexpectedly low scores on cognitive tasks in this population may be indicative of poor motivation or extraneous variables that should be considered.

Study Rationale and Hypotheses

The current study seeks to further understand the relationship between pain and performance on the Paced Auditory Serial Addition Test (PASAT; Gronwall, 1977). The PASAT is a highly sensitive instrument originally developed for TBI patients as a measure of processing speed (Tombaugh, 2006). However, subsequent research has revealed it to be applicable for a range of neuropsychological conditions, which is likely

due to its ability to tap into multiple constructs including attention, working memory, processing speed, and mathematics abilities (Sherman, Strauss, & Spellacy, 1997; Chronicle & MacGregor, 1998; Crawford, Obonsawin, & Allan, 1998; Lockwood et al., 2004; Tombaugh, 2006).

Specifically, attention is defined as the ability to orient towards a particular aspect of the environment and filter out irrelevant stimuli (Anderson, 2000). Working memory is defined as the amount of information an individual can process at any one time (Etherton et al., 2006b). As such, it is limited resource that is restricted by volume and time. Processing speed is conceptualized as the rate at which an individual can process information from the environment (Forn, Belenguer, Parcet-Ibars, & Ávila, 2008). Mathematic ability, as defined by Chronicle and MacGregor (1998), is the ability to complete mental arithmetic using fundamental skills such as addition, subtraction, multiplication, and division. Additional studies have used it as a composite measure of executive functioning (Dujardin et al., 2007; Hirvikoski et al., 2011). Executive functioning, as defined by the literature, is a general term for multiple cognitive processes including maintaining long-term goals, planning, rate of processing information, capacity to ignore irrelevant or distracting information, and the ability to suppress inappropriate responses (Glass et al., 2011). Research has demonstrated impaired PASAT performance in patients with Parkinson's disease (Dujardin et al., 2007), chronic non-malignant pain (Sjøgren, Christrup, Petersen, & Højsted, 2005), and most notably, multiple sclerosis (MS; Rosti, Hämäläinen, Koivisto, & Hokkanen, 2007a; Rosti, Hämäläinen, Koivisto, &

Hokkanen, 2007b; Forn, Belenguer, Parcet-Ibars, & Ávila, 2008; Bellmann-Strobl et al., 2009).

Despite evidence suggesting limited utility, particularly for individuals with low IQ (Crawford, Obonsawin, & Allan, 1998; Egan, 1988), high self-reported nervousness (Rosti, Hämäläinen, Koivisto, & Hokkanen, 2007b), low mathematic abilities (Chronicle & MacGregor, 1998), and the elderly (Tombaugh, 2006); the PASAT is widely used in clinical settings and is a core measure of cognitive impairment in MS patients (Rosti, Hämäläinen, Koivisto, & Hokkanen, 2007a). However, as noted by Tombaugh (2006), caution must be exercised when interpreting the significance of a low score. The test requires participants to listen to a series of single digit numbers, add the two most recently heard numbers, and say aloud the sum (Cardinal et al., 2008). It is a difficult task because it requires participants to remember the previous number and add it to the current number before the next number is heard. Both 2 and 3 second versions are available as well as alternate formats. Criticism of the instrument stems from the fact that it has been shown to induce autonomic arousal (Mathias, Stanford, & Houston, 2004) and contribute to negative mood (Holdwick & Wingenfeld, 1999). However, these have not been shown to modulate performance in healthy populations; but the concern is that it confounds the interpretability of results in sensitive populations, especially considering it is a difficult task even for intelligent individuals (Bidin-Brooks et al., 2011). Conversely, it has been shown to be a reliable instrument with high internal consistency (Tombaugh, 2006), and adequate sensitivity in detecting cognitive impairment in patients with MS (Rosti, Hämäläinen, Koivisto, & Hokkanen, 2007a; Rosti, Hämäläinen, Koivisto, & Hokkanen,

2007b). Although the PASAT is a widely used measure in patients with chronic pain and research has demonstrated impaired performance in select populations, the isolated effects of pain on performance have not been studied. Given the nuanced relationship between chronic pain and cognition, and the inherent limitations of the instrument, further investigation is warranted to understand precisely how pain affects performance on the PASAT. As such, the present study has two goals.

1. Explore the effects of cold-pressor-induced pain (Peckerman, Saab, & McCabe, 1991) on PASAT performance at the 2 second administration. Based on previous research which has shown impaired PASAT scores in chronic pain patients (Rosti, Hämäläinen, Koivisto, & Hokkanen, 2007a; Rosti, Hämäläinen, Koivisto, & Hokkanen, 2007b; Forn, Belenguer, Parcet-Ibars, & Ávila, 2008) it is expected that induced-pain will impair performance.

2. Examine whether psychosocial variables hypothesized to affect cognition in chronic pain serve a moderator or mediator role in the relationship between perceived pain and PASAT performance. These variables include self-reported mood, perceptions of pain, mindful awareness, and personality characteristics. These instruments were selected based on previous research identifying them as possible factors contributing to reduced cognitive performance, and to account for individual and/or group differences. Specifically, self-reported mood was included because the PASAT has been shown to induce negative mood (Holdwick & Wingenfeld, 1999). Perceptions

of pain were included to account for pain anxiety and beliefs about pain which have been shown to influence pain-related cognitive impairment (Kreitler & Niv, 2007). Mindful awareness was included because previous research (Schmertz, Anderson, & Robins, 2009) has shown a trend toward significance when correlating PASAT performance and self-reported mindfulness. Personality was included to further understand individual differences in response to pain. Specifically, to examine the relationship between personality characteristics and performance on the PASAT while in pain. Of particular interest is the construct of neuroticism, which includes being tense, moody, and anxious; and its relationship to the PASAT while in pain. Based on previous research it is expected that pain perceptions, mindful awareness, and neuroticism will impact PASAT performance.

CHAPTER III

RESEARCH DESIGN AND METHODS

Participants

This research was approved by the institutional review board of Texas State University–San Marcos. Seventy-two undergraduate participants were recruited via email from introductory psychology courses. The email explained the nature of the study and offered two to five points extra credit (at the professor's discretion) toward a test grade in exchange for participation. Thirty-four of the participants were randomly assigned to a control condition and 38 were randomly assigned to an experimental condition that received cold-pressor induced pain, although five participants assigned to the experimental condition withdrew during the study. The final sample consisted of 14 men and 53 women with roughly equal numbers of men and women in each condition.

The majority of participants had 13 years of education (N = 23, 34.3%), followed by 14 years (N = 13, 19.4%), 15 years (N = 10, 14.9%), 12 years (N = 9, 13.4%), 16 years (N = 9, 13.4%), and 17+ years (N = 3, 4.5%). Additionally, most participants were 18-19 years of age (N = 38, 56.7%), followed by 20-21 years of age (N = 17, 25.4%), 22-23 years of age (N = 8, 11.9%), and 24+ years of age (N = 4, 6.0%). Caucasian/White was the most common self-identified ethnicity (N = 30, 44.8%), followed by Hispanic/Latino (N = 24, 35.8%), African-American/Black (N = 9, 13.4%), Asian/Pacific

Islander (N = 2, 3.0%), and Mix/Other (N = 2, 3.0%). Thirty-one participants confirmed previous experience with ice-baths (46.3%), while 36 denied previous experience (53.7%). Exclusion criteria included hearing impairments, pain-related or neurological disorder, current use of analgesic medication or psychiatric medication, a history of traumatic brain injury or stroke, Raynaud's disease, or the presence of a skin disease.

Procedure

After registering through an online appointment scheduler, participants arrived in the experiment room at their designated time and were greeted by an experimenter. They were first asked to read and sign a consent form. Next, participants were randomly assigned to either a control condition, which took the PASAT with their hand in a bucket of room temperature water, or an experimental condition, which took the PASAT with their hand held in a bucket of ice water (cold-pressor procedure; Peckerman, Saab, & McCabe, 1991) to elicit pain. The cold-pressor is a bucket of ice water used in research settings to simulate the conditions of chronic pain (temperatures are usually about 33-40 degree range). It allows pain to be administered in a safe, controlled manner that will not result in permanent damage. Participants were assigned to either condition by drawing a card out of a bag without looking. The card was not replaced. To account for the possible distraction of non-pain variables which could potentially affect performance, such as keeping one's hand submerged in the bucket of water, the control group served as a "procedural distraction" group per Etherton et al. (2006). This group is identical to the experimental group in all regards except that the bucket of water they submerge their

hand in is room temperature (temperatures were generally in the 70-80 degree range), which allowed pain to be further isolated as the variable of interest potentially affecting PASAT performance.

Participants first filled out several self-report assessments, which consisted of standard demographic information including age, gender, ethnicity, education, and handedness. Participants were also asked if they had previous experience with ice baths because anecdotal reports have suggested this may increase tolerance to cold-pressor induced-pain. Additionally, participants completed the Brief Mood Introspection Scale (BMIS; Mayer & Gaschke, 1988), the Big Five Inventory (BFI; John & Srivastava, 1999), the Pain and Anxiety Symptom Scale (PASS-20; McCracken & Dhingra, 2002), and the Mindfulness Attention Awareness Scale (MAAS; Brown & Ryan, 2003). The BMIS has demonstrated sufficient validity and reliability (r = .76 to .83; Mayer & Gaschke, 1988). The BFI has been normed on tens of thousands of individuals and is one of the most widely used assessments of personality. It has strong convergent validity (r = .92 with the NEO Personality Inventory; John & Srivastava, 1999), reliability (r = .83; John & Srivastava, 1999), and test-retest reliability (r = .75 to 0.84; Rammstedt & John, 2007) The PASS-20 has demonstrated strong convergent validity (r = .95 with the original Pain Anxiety Symptom Scale), internal consistency (α = .74 to α = .94), and reliability (r = .74 to r = .87; McCracken & Dhingra, 2002); and the MAAS has demonstrated strong divergent validity (r = -.39 with the Reflection Rumination Questionnaire), high internal consistency (α = .87), and strong test-retest reliability (r = .81; Brown & Ryan, 2003).

Participants were then administered several trials of the 2-second PASAT (Gronwall, 1977). The 2-second trial was chosen as the sole measure because research has shown that participants tend to find it more difficult than the 3-second trial, and the aim of the present study was to most clearly identify group differences (e.g., the 2-second administration would more accurately identify the effects of pain on performance). Furthermore, limiting the experiment to the 2-second trial minimized the amount of time participants in the experimental group were exposed to cold-pressor pain. To account for practice effects, which research (Barker-Collo, 2005) has demonstrated is particularly pervasive at the 2-second trial, participants were administered an introductory practice trial followed by three administrations of the full 2-second trial, of which only the last two trials were scored. This approach was used because research has shown that, while practice effects occur with the PASAT, improvement due to practice eventually diminishes and participants reach a ceiling effect after the second administration. Therefore, the second administration was recorded as a baseline and the third administration was recorded as the experimental administration. These results are reported as "trial 1" and "trial 2", respectively. To protect against familiarity with the numbers being used, alternate forms were used. Half of the participants were administered the PASAT in the order of form A, form B, form A, and half were administered the test in the order of form B, form A, form B. The control group took the final trial with their hand in a bucket of room temperature water (procedural distraction). The experimental condition took the final trial while experiencing cold-pressor induced-pain. During the final trial two pain ratings were recorded on a 0 – 10 scale, where 0 is no

pain and 10 is severe pain. The first pain rating (pain rating 1) was collected after participants submerged their hand in the water (room temperature or cold-pressor) and at the end of the second trial of the PASAT (pain rating 2). Two pain ratings were collected to account for possible numbing effects which could occur during the cold-pressor administration. Both pain ratings as well as the average were used in the analyses. Within-subject differences of scores on the baseline and experimental trial of the PASAT were computed for each participant followed by a between-groups comparison.

CHAPTER IV

RESULTS

Prior to the analyses one participant's data was removed as an extreme outlier on the PASAT, and two additional participants' BFI scores were removed because of a failure to follow directions for the instrument. The final sample consisted of 66 participants, 34 in the control group and 32 in the experimental group. Reliability statistics of the self-report assessments yielded a moderate to high level of consistency with the following Chronbach's Alpha: .821 (BFI extraversion), .778 (BFI agreeableness), .724 (BFI consciousness), .742 (BFI neuroticism), .747 (BFI openness), .858 (PASS–20 cognitive/anxiety), .853 (PASS-20 fear), .701 (PASS-20 escape/avoidance), and .866 (PASS-20 physiological anxiety). Reliability of the BMIS and MAAS was .721 and .801, respectively.

A mixed-measures analysis of variance (ANOVA) was performed to assess the effects of pain on PASAT performance as well as to assess potential interactions. The results are reported in table 1. No significant differences were found between the control and experimental conditions (F (1, 64) = .643, p = .425). However, a significant difference was found between the pre and post PASAT administrations (F (1, 64) = 15.42, p = .00, partial eta squared = .194) as well as a significant interaction effect

between condition and PASAT performance (F (1, 64) = 23.63, p < .00, partial eta squared = .270). The control condition improved their performance from trial 1 to trial 2 by roughly 6 items, thus demonstrating the practice effects of the PASAT; while conversely, the experimental group slightly decreased their performance from trial 1 to trial 2 suggesting that induced-pain impacted performance.

Table 1.

Descriptive Statistics for Control and Experimental Conditions

	Trial 1		Trial 2	
Condition	N	Mean (*SD*)	N	Mean (*SD*)
Control Condition	34	27.26 (9.86)	34	33.15 (9.88)
Experimental Condition	32	28.63 (9.75)	32	28.00 (10.36)

Following the previous analysis, the individual sub-scores for personality traits (BFI), pain perception (PASS-20), mindful awareness (MAAS), pain ratings, and prior experience with ice baths were entered into a stepwise linear regression model to predict performance on the second administration of the PASAT. The model revealed only the initial pain rating and the escape-avoidance subscale score of the PASS-20 were significant predictors of PASAT performance across conditions. The coefficients can be found in Table 2 with the excluded variables located in table 3. Initially, the pain rating (pain rating 1) loaded into the model first followed by escape-avoidance. The relationship between the pain rating and the PASAT performance was notably strengthened when the

escape-avoidance score was added to the model as measured by the standardized beta weights (-.256 to -.276). The overall model had an adjusted R^2 value of .1 indicating that the model provides a small to moderate amount of explanatory power. The results suggest that the participants' initial reaction to the pain was moderated by their desire to disengage from the pain (as measured by the escape-avoidance subscale) which predicted their subsequent performance.

Table 2.

Summary of Regression Analysis - Dependent Variable: PASAT Trial 2

Variable	B	SE B	β
(Constant)	43.65	5.50	
Pain Rating1	-1.36	0.62	-0.28
Escape Avoidance	-0.62	0.31	-0.26

Note: $R^2 = .100$ *$p < .05$

Based on the results of the previous analysis, a follow-up regression was performed to test the hypothesis that the aforementioned variables (personality, pain perceptions, mindful awareness, pain ratings, and experience with ice baths) may be predictive of PASAT performance only in the presence of pain. Accordingly, the individual sub-scores for participants self-report assessments were entered into a step wise linear regression to predict performance on the second trial of the PASAT for only the experimental group. As reported in table 4, the regression identified the escape-avoidance subscale of the PASS-20 as a significant predictor of performance. The model had an adjusted R^2 value of .13 with a standardized beta weight of -.400 suggesting that

the desire to disengage from pain was more predictive of performance when pain was present. Although no other variables were shown to be predictive (table 5), it should be noted that the first pain rating strongly trended toward statistical significance (p = .06).

Table 3.

Regression Analysis Excluded Variables for Experimental and Control Conditions (N= 66)

	Model 1			Model 2		
Variable	β	*t*	*p*	β	*t*	*p*
Extraversion	-0.05	-0.37	0.71	-0.03	-0.26	0.80
Agreeableness	-0.40	-0.31	0.76	-0.01	-0.07	0.94
Conscientiousness	0.06	0.45	0.70	0.04	0.29	0.78
Neuroticism	-0.61	-0.47	0.64	-0.04	-0.27	0.79
Openness	0.15	-1.16	0.30	-0.09	-0.70	0.50
Mood introspection	0.07	0.40	0.71	0.15	1.20	0.24
Mindfulness	-0.14	-1.08	0.29	-0.16	-1.30	0.21
Pain Rating 2	-0.06	-0.32	0.75	0.01	0.00	1.00
Ice Baths	-0.07	0.05	0.10	0.03	0.21	0.84
Cognitive anxiety	-0.00	-0.00	0.10	0.20	1.36	0.18
Escape avoidance	-0.26	-2.04	0.05*	-	-	-
Fear	0.01	0.60	0.95	0.17	1.20	0.24
Physio anxiety	-0.00	-0.02	0.98	0.18	1.24	0.22

Note. Escape avoidance variable controlled for in model 2. $*p < .05$

Table 4.

Regression for Experimental Condition - Dependent Variable: PASAT Trial 2 (N = 32)

Variable	B	SE B	β
(Constant)	43.72	7.21	
Escape Avoidance	-1.04	0.45	-0.40

Note: R^2=.130. $*p < .05$.

Table 5.

Regression Analysis Excluded Variables for Experimental Condition (N= 32)

Variable	β	*t*	*p*
Extraversion	-0.11	-0.63	0.54
Agreeableness	-0.01	-0.08	0.94
Conscientiousness	0.01	0.08	0.94
Neuroticism	-0.22	-1.28	0.21
Openness	0.14	-0.80	0.43
Mood introspection	0.07	0.40	0.71
Mindfulness	-0.18	-1.02	0.32
Pain Rating 1	-0.33	-2.01	0.06
Pain Rating 2	-0.08	-0.46	0.65
Ice Baths	-0.23	1.32	0.20
Cognitive anxiety	-0.10	0.42	0.70
Fear	-0.12	0.64	0.53
Physiological anxiety	0.10	0.50	0.64

*$p < .05$.

No significant correlations were found between PASAT, pain ratings, and any of the self-report assessments for the overall sample (table 6). A positive correlation was observed, however, between the second pain rating and escape-avoidance subscale of the PASS-20 ($r = .364$, $p = .034$) for the control group, a relationship not seen in the experimental group. For the experimental group a positive correlation was observed between the fear subscale of the PASS-20 and the second pain rating ($r = .457$, $p = .007$), and between the cognitive anxiety subscale of the PASS-20 and the first pain rating ($r = .401$, $p = .021$).

Following the previous findings, a more detailed exploration of the correlations broken down by gender were undertaken with some unexpected findings. For women in both conditions, performance on the first PASAT was positively correlated with the

BMIS, a measure of pleasant and unpleasant mood (r = .289, p = .036). This relationship was not seen in men. For men in both conditions, performance on the second PASAT administration was negatively correlated with the consciousness subscale of the BFI (r = -.650, p =.016), negatively correlated with the MAAS (r = -.548, p = .042), and positively correlated with previous experience with ice baths (r = .545, p = .044). Moreover, the second pain rating was negatively correlated with the openness subscale of the BFI (r = -.757, p = .003). The large female to male ratio (52 females: 14 males) should be noted before interpreting the significance of these findings.

Table 6.

Correlations of Study Variables at Time 1 and Time 2 (N= 62)

Variable	PASAT-1	PASAT-2	Pain Average	Pain-1	Pain-2
1. Extraversion	-0.01	-0.05	-0.02	-0.00	-0.03
2. Agreeableness	-0.07	-0.07	-0.01	0.14	-0.10
3. Conscientiousness	0.04	-0.06	-0.08	-0.02	-0.11
4. Neuroticism	-0.08	-0.11	0.09	0.16	0.04
5. Openness	-0.15	-0.10	-0.20	-0.18	-0.20
6. Mood introspection	0.23	0.15	0.01	-0.01	0.02
7. Mindfulness	-0.06	0.06	-0.05	-0.08	-0.03
8. Cognitive anxiety	-0.01	0.02	-0.09	0.01	-0.14
9. Escape avoidance	-0.17	-0.22	-0.17	-0.10	-0.20
10. Fear	-0.08	-0.07	0.11	0.11	0.10
11. Physiological anxiety	-0.12	-0.50	0.01	0.06	-0.03

* < p .05. All tests are two tailed

CHAPTER V

DISCUSSION

The present study further contributes to the overall understanding of the effects of pain on cognition. Previous research has shown mixed results on how pain impacts cognition, with some research suggesting significant cognitive impairment (Sjøgren, Olsen, Thomsen, & Dalberg, 2000; Hart, Wade, & Martelli, 2003), while other research suggesting minimal deficits (Etherton et al., 2006a; Etherton et al., 2006b). Additional research has shown that cognitive task impairment only occurs in very high amounts of pain or in exceptionally difficult tasks (Eccleston, 1994). Further contributing to the difficulty in assessing the effects of pain on cognition is the well-established relationship between psychosocial factors and cognitive impairment in chronic pain patients, which research suggests are at least partially accounted for by psychosocial factors (Kreitler & Niv, 2007). However, although research has shown that patients with cognitive deficits tend to report higher levels of psychological distress (Kewman et al., 1991), it is unclear if psychosocial factors account for the same amount of variance in all patients.

As suggested by Eccleston (1995), it is necessary to approach chronic pain research from different modalities to yield a more accurate understanding of the nuanced mechanisms of pain and cognition. As such, the present study sought to contribute to the

pain literature via laboratory induced-pain to understand the relationship between pain and PASAT performance. Given the wide use of the PASAT in clinical settings, it is necessary to distinguish the degree of impairment attributable to pain from impairment attributable to other factors (i.e., neurological impairments). Further, it is important to understand the extent of practice effects in the PASAT to more accurately interpret the results.

The results of the present study suggest that induced-pain impairs performance on the PASAT. Participants in the experimental group slightly decreased their performance while in induced-pain (<1 item), as opposed to the control group who increased their performance by roughly 6 items in the procedural distraction. A mixed-measures ANOVA showed no significant difference between-groups for both trial 1 and trial 2 (p = .425), suggesting that the impact of induced-pain on performance may not have been large enough to detect a difference between groups. Nevertheless, despite a relatively small main effect for trial 2 in the experimental condition, due to the absence of a fairly large practice effect relative to the control condition, the results suggest that induced-pain impacted performance as evident by the interaction between condition and performance (table 1). The lack of improvement in the experimental condition when an improvement was expected is indicative of impairment.

Of particular importance in the present study is the role of practice effects in the interpretation of the results. Despite measures to account for practice effects, notable increases between each administration were observed in both groups, though these effects

were not present for all participants. In the experimental group the largest increase from trial 1 to trial 2 with induced pain was 15 items, while the largest decrease was 17 items. In the control group, participants increased their performance from trial 1 to trial 2 by 0 – 15 items. No participants in the control group decreased their performance. It should be noted, however, that the largest practice effect from trial 1 to trial 2 (15 items) was observed in both conditions.

Step-wise linear regression revealed that the initial pain rating (0 – 10 scale) and the escape-avoidance subscale of the PASS-20 predicted overall performance on trial 2 of the PASAT. The escape-avoidance scale consists of items that describe one's desire to prevent, disengage, or hide from pain. Items in this scale include, "I will stop any activity as soon as I sense pain coming on" and "I avoid certain activities when I hurt" (McCracken & Dhingra, 2002). Research has shown that pain escape-avoidance behavior is consistent with an avoidance-coping strategy (Felder et al., 2006), and is related to the Fear-Avoidance Model of chronic pain (Dannecker & George, 2009). The Fear-Avoidance Model posits that anxiety, catastrophizing, and fear result in disability and avoiding activities (Leeuw et al., 2007). However, researchers do not agree if escape and avoidance are separate constructs or are inter-related constructs that do not warrant a distinction (Dannecker & George, 2009).

Interestingly, the regression model did not include the other subscales of the PASS-20 as predictors of PASAT performance even though research has shown all four subscales are moderately correlated (r = .51 to r = .75; McCracken & Dhingra, 2002).

Moreover, the model also did not include the second pain rating (taken at the end of the second trial) or the average pain rating as a predictor of performance. Extrapolating from these findings, it appears the participant's initial reaction to the pain of the cold-pressor, as measured by the 0 – 10 pain rating scale, was moderated by their desire to disengage from pain, as measured by the escape-avoidance subscale, which predicted their performance on trial 2. When the initial experience of pain is perceived to be strong and unpleasant individuals who are more likely to try to disengage from pain may be less likely or less able to redirect their attention away from the pain. Thus, because some attention had to be allocated to the pain their overall attentional resource was reduced and their performance on the trial 2 of the PASAT suffered as a result. It is possible that avoiding pain may actually backfire as a coping strategy because resistance to pain through avoidance may swiftly redirect attention back toward the pain and capture more of the attentional resource as a result. Individuals with an avoidance coping strategy may be more susceptible to the cognitive impairment often observed in chronic pain patients.

A review of the data suggests that while some are strongly influenced by the effects of induced pain, many participants did not display difficulty redirecting their attention toward the PASAT and away from the induced-pain; as a result, they did not show impairment in their performance. This is consistent with the literature showing that some chronic pain patients' scores demonstrate attentional impairment (Etherton et al., 2006a; Etherton et al., 2006b); but most chronic pain patients, as most participants in the present study, show minimal or no impairment in pain. Abnormally low scores may be indicative of lack of motivation, misrepresentation of abilities, or other pathology. The

clinical implications of the present study suggest that pain-related cognitive impairments are not universal, and caution must be exercised when interpreting low scores on the PASAT in patients with chronic pain. Although most do not show substantial impairment when in pain, some are more distracted than others. Patients with a propensity toward avoidant coping (as measured by the escape-avoidance subscale of the PASS-20) and higher pain ratings may show greater impairment. It is important to consider the patients level of pain as well as a thorough assessment of his or her coping strategies and beliefs about pain. Even in conditions associated with chronic pain, caution must be exercised before assuming low scores on the PASAT are related to pain. Conditions such as MS, which can reduce processing speed through demyelination, or TBI, which can reduce many cognitive processes necessary for the PASAT, may be responsible for low scores independently of pain. Likewise, it is important to consider relevant medical history before re-administering the PASAT to assess cognitive functioning. Furthermore, the results of the present study highlight the extensive practice effects of the PASAT. Given that practice effects are expected it may be diagnostic if a patient's performance does not improve between administrations.

The present study had several limitations. First, although the results showed a slight impairment in the PASAT performance in induced pain, it is not possible to assess which cognitive processes measured by the PASAT (attention, processing speed, working memory, etc.) were specifically affected by the pain. Second, although careful directions were given to research assistants to be precise and consistent in their scoring of the PASAT, it is possible that scoring differences between examiners influenced the results.

Third, while the present study accounted for some psychosocial variables which have been shown to influence cognitive task performance in pain (e.g., pain perceptions), it did not include many relevant variables such as anxiety, depression, mathematics ability, catastrophizing, or acceptance of pain.

Future research should explore the robust practice effects of the PASAT, how they may affect interpretation of the results, and whether the absence of practice effects is diagnostic. Identifying which individuals are most susceptible to the chronic impairments due to pain should also be explored as research shows that pain-related cognitive impairment is not universal in chronic pain patients. Particular consideration should be given to further understanding the relationship between psychosocial variables and pain-related cognitive impairment for individual's most susceptible to cognitive deficits. Additionally, follow-up studies should replicate the present study to see if the results, which suggest that the initial pain experience and pain escape-avoidant behaviors predict performance, are founded. In particular, the replication study should seek to understand why the escape-avoidance subscale of the PASS-20 was a significant predictor of performance while fear and related constructs were not.

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