

AN EXPERIMENTAL INVESTIGATION INTO THE EFFECTS OF MINDFUL  
ATTENTION AND TRAIT MINDFULNESS ON ADOLESCENT PAIN

by

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DALHOUSIE UNIVERSITY

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To my parents, for making me believe I could accomplish anything.

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## ABSTRACT

Mindfulness refers to paying attention to present moment experience nonjudgmentally. It has been hypothesized that attending mindfully to painful sensations may mitigate the experience of pain. The tendency to be mindful in daily life appears to reduce pain and has a unique relationship with cognitive reactions to pain such as pain catastrophizing. However, the relationship between mindfulness and pain has received little attention among adolescents, and research with adults may not generalize to this population given important developmental differences that may affect mindfulness and pain. The current dissertation describes two studies from the same sample. The first study examined the effects of a mindful attention manipulation on experimental pain responses among adolescents. The second study investigated the relationship between trait mindfulness and real world and experimental pain variables among adolescents. In Study 1, 198 adolescents (132 females; 66 males;  $M_{\text{age}} = 15.99$  years,  $SD = 1.89$ ) completed measures of pain-related variables before being randomly assigned to a mindful attention manipulation or to a control group prior to completing an experimental pain task. Before the pain task, participants completed a measure of state mindfulness, and following the task they completed measures of situational catastrophizing and pain intensity. Results showed that, overall, the mindfulness manipulation did not impact experimental pain. However, secondary analysis showed that meditation experience moderated the effect of the manipulation such that adolescents with a regular meditation practice benefited. State mindfulness was also a significant predictor of pain intensity irrespective of condition, and this relationship was mediated by situational catastrophizing. In Study 2, the relationship between trait mindfulness was investigated in relation to daily and experimental pain responses in the same sample of adolescents. Participants completed measures of trait mindfulness, pain catastrophizing, and pain interference as well as an interview on daily pain. Results showed that increased trait mindfulness predicted reduced typical pain intensity, pain catastrophizing, and pain interference. Furthermore, trait mindfulness predicted experimental pain responses and these relationships were mediated by situational catastrophizing. Overall, these studies highlight that previous exposure to meditation may be necessary for a brief mindful attention manipulation to offer benefit during acute pain. However, trait mindfulness was found to be a strong predictor of pain responses across contexts. Reductions in pain catastrophizing appear to be an important mechanism whereby mindfulness impacts the pain experience. Overall, this work highlights the important influence that mindfulness has on the way that adolescents interpret and respond to pain in a variety of settings.

## LIST OF ABBREVIATIONS AND SYMBOLS USED

$a_1$	Path Coefficient Between Predictor Variable and Mediator Variable
ACT	Acceptance and Commitment Therapy
ADHD	Attention-Deficit Hyperactivity Disorder
ANCOVA	Analysis of Covariance
ANOVA	Analysis of Variance
$b_1$	Path Coefficient Between Mediator Variable and Outcome Variable
°C	Degrees Celsius
$c_1$	Path Coefficient of Total Effect of Predictor Variable on Outcome Variable
$c'_1$	Path Coefficient of Direct Effect of Predictor Variable on Outcome Variable
CAMM	Child and Adolescent Mindfulness Measure
CI	Confidence Interval
$F$	$F$ distribution Value of the $F$ Test for Testing Equality of Variances
$M$	Mean
MAAS-S	Mindful Attention and Awareness Scale – State Version
MBCT	Mindfulness Based Cognitive Therapy
MBSR	Mindfulness Based Stress Reduction
$n$	Sample Size
NRS-11	11-point Numerical Rating Scale
OLS	Ordinary Least Squares
$p$	p-value for Significance Testing
PCS-C	Pain Catastrophizing Scale – Child Version
PPPIIS	Pediatric Pain Interference Scale Short Form 8a
$t$	Student's $t$ Value of the $t$ Test for Testing Mean Differences
$r$	Correlation Coefficient
$R^2$	Multiple Correlation Coefficient
SCQ	Situational Catastrophizing Scale
$SD$	Standard Deviation
$SE$	Standard Error
SPSS	Statistical Package for the Social Sciences
Wald	Wald Statistic
$z$	z score
$\Delta$	Change
$\alpha$	Cronbach's Alpha
$\beta$	Logistic Regression Coefficient
$\chi^2$	Chi Square
$\eta_p^2$	Partial Eta Squared (Estimate of Effect Size)

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## CHAPTER 1: INTRODUCTION

Pain is defined as “an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage” (International Association for the Study of Pain, 1979, p. 249). Pain is a subjective experience influenced by the transduction, transmission, and modulation of sensory information (i.e., nociception), as well as the interpretation of this sensory information (Gatchel, Peng, Peters, Fuchs, & Turk, 2007). Given the complexity of the pain experience, it is no surprise that despite significant advances in our understanding of the biological mechanisms of pain and nociception (McMahon, Koltzenburg, Tracey, & Turk, 2006), purely biomedical explanations of pain inevitably fall short. The biopsychosocial model of pain hypothesizes that in order to fully appreciate an individual’s perception of and response to pain, the interrelationship between biological (e.g., nociceptive processes, peripheral processes, genetic predisposition), psychological (e.g., cognitive and affective reactions to pain, pain memories), and social factors (e.g., cultural factors, environmental stressors, social support) must be taken into consideration (Gatchel et al., 2007; Hadjistavropoulos et al., 2011).

Pain typically serves an essential purpose as a warning system to protect against acute injury and to promote healing when injury has occurred. However, it can become maladaptive when painful sensations are perceived in a negative or exaggerated way, such that they no longer function as a useful warning signal and cause unnecessary interference with activities of daily living. Specifically, pain can become problematic when painful sensations are routinely interpreted in a negative and catastrophic manner (Sullivan, Thorn et al., 2001) and/or when pain persists in the absence of noxious stimuli

or tissue healing. Despite pain's adaptive role for the majority of people, recurrent pain is also common with prevalence estimates of 19% among adults (Breivik, Collett, Ventafridda, Cohen, & Gallacher, 2006), and between 11% and 38% in pediatric populations (King et al., 2011). Recurrent pains include headache, stomachache, and musculoskeletal pains that can lead to significant levels of disability, and reduction in quality of life in some individuals (Breivik et al., 2005; Hunfeld et al., 2001), often despite no clear organic cause for the pain (e.g., head injury, colitis, arthritis). Acute pain due to injury, illness, and medical treatment is also a frequent occurrence across the lifespan and represents a significant source of distress for many individuals (Galinski et al., 2010; McGrath et al., 2000; Saastamoinen, Laaksonen, Leino-Arjas, & Lahelma, 2009). Given the pervasive and detrimental impact of pain on the lives of those affected, a wealth of research within the biopsychosocial framework has been dedicated to helping better understand the influence of psychological variables on pain with the purpose of ultimately helping individuals better manage pain.

### **Psychological Factors and Pain**

There is a strong association between pain and psychological functioning. Longitudinal research has shown that psychological variables such as anxiety and depression play a significant role in the development and persistence of recurrent pain (Stanford, Chambers, Biesanz, & Chen, 2008). The relationship between pain and psychological distress appears to be reciprocal, with increased psychological symptoms putting an individual at risk for the development and maintenance of pain problems, and the experience of pain leading to increases in psychological distress (Kroenke et al., 2011; Varni et al., 1996;). Psychological factors also have a strong influence on acute

pain responses. Specifically, increased anxiety is associated with higher levels of pain intensity following venipuncture (Bearden, Feinstein, & Cohen, 2012), higher pain intensity and analgesic consumption following surgery (Ip, Abrishami, Peng, Wong, & Chung, 2009; LaMontagne, Hepworth, & Salisbury, 2001; Palermo & Drotar, 1996), as well as negative outcomes following exposure to experimental pain (Robinson, Wise, Gagnon, Fillingim, & Price, 2004; Tsao et al., 2004).

Recently, pain catastrophizing has emerged as a robust predictor of pain outcomes across contexts, health populations, and age ranges (Quartana, Campbell, & Edwards, 2009). Pain catastrophizing refers to an individual's tendency to magnify the threat value of pain, to feel helpless in the face of pain, and an inability to control pain-related thoughts (Sullivan, Thorn et al., 2001). Pain catastrophizing is a strong predictor of pain intensity in both chronic pain (Crombez et al., 2003; Sullivan & D'Eon, 1990) and healthy community samples (Lefebvre, Lester, & Keefe, 1995), and has a strong relationship with pain-related disability among adults and young people (Crombez et al., 2003; Sullivan, Stanish, Waite, Sullivan, & Tripp, 1998). Longitudinal research has shown that pain catastrophizing is associated with the development of recurrent pain conditions even among individuals who were initially pain-free (Vervoort, Eccleston, Goubert, Buysse, & Crombez, 2010). Higher levels of pain catastrophizing are also associated with increased pain responses in experimental (Sullivan, Rodgers, & Kirsch, 2001; Verhoeven, Goubert, Jaaniste, Van Ryckeghem, & Crombez, 2011) and medical settings (Pagé, Stinson, Campbell, Isaac, & Katz, 2012; Pavlin, Sullivan, Freund, & Roesen, 2005). Several theoretical models have proposed different mechanisms of action explaining the influence of catastrophizing on pain outcomes (e.g., see Quartana et al.,

2009, for review). Pain catastrophizing may lead to attentional and information processing biases similar to those seen in individuals with anxiety and depressive disorders (Eccleston & Crombez, 1999). Individuals high in pain catastrophizing may therefore have an attentional bias towards pain-relevant stimuli, especially stimuli with a negative affective component. This bias may then lead to more attentional resources being directed towards pain and pain cues. Because increased attentional resources are directed towards pain, pain catastrophizing may have a detrimental impact on the effects of distraction as a pain reduction strategy. This potential interference with the analgesic effects of distraction is problematic given that distraction is a popular and well-validated intervention for acute forms of pain across the lifespan (Johnson, 2005).

### **Attention-based Interventions for Pain**

Attention-based interventions have long been used to help individuals cope with pain. Distraction is a common intervention that involves shifting attention away from a painful stimulus towards competing neutral or positive stimuli. Distraction is a popular coping strategy across the lifespan to deal with both acute and chronic pain (Johnson, 2005). It is believed that distraction's analgesic effects are due to the limited capacity for attentional allocation. By directing attention towards a competing stimulus, less attentional resources are available to perceive and interpret noxious stimuli, resulting in lowered pain intensity and distress (McCaul & Malott, 1984). Distraction-based interventions are quickly acquired, have little cost, and are typically well tolerated. Furthermore, most individuals who are taught distraction report that it is an effective strategy that they would use again (McCaul & Haugtvedt, 1982).



In general, distraction is effective in helping cope with acute pain in a variety of contexts. Laboratory-based studies have shown that distraction increases pain tolerance in young people (Fanurik, Zeltzer, Roberts, & Blount, 1993; Piira, Hayes, Goodenough, & von Baeyer, 2006) and adults (Fernandez & Turk, 1989). Among pediatric populations, it is also an effective intervention for needle pain (Cohen, 2008; Uman, Chambers, McGrath, & Kisely, 2008), minor musculoskeletal trauma (Tanabe, Ferket, Thomas, Paice, & Marcantonio, 2002), and during acute abdominal pain (Walker et al, 2006).

Although distraction-based interventions are effective for acute pain, effects sizes are typically small to moderate (Uman et al., 2008) and vary as a function of the population, setting, and method of delivery. When pain is novel, unpredictable, and intense, and/or is interpreted in a fearful manner, painful physical sensations may place such a strong demand on attentional resources that the use of distraction will be less effective (Eccleston & Crombez, 1999; Van Damme, Legrain, Vogt, & Crombez, 2010). Distraction appears less likely to be effective among adults who are highly fearful of pain-related situations (Roelofs, Peters, van der Zijden, & Vlaeyen, 2004), who tend to interpret symptoms of anxiety as being highly threatening (Keogh & Mansoor, 2001) or who report high levels of pain catastrophizing (Heyneman, Fremouw, Gano, Kirkland, & Heiden, 1990). Youth who are high in pain catastrophizing also tend to use distraction less in their daily life, and get less pain relief from distraction (Verhoeven et al., 2011). In addition to distraction-based interventions, researchers have also examined alternative attention-based interventions that direct attention towards pain in an adaptive manner.

### **Alternative Attention-based Interventions for Pain**

Although directing attention towards pain may seem counterintuitive and goes against a widely held belief that attending to painful stimuli will increase pain intensity (Leventhal, 1992), directing attention towards pain *in an objective manner* may reduce pain-distress associations and pain intensity. According to Leventhal and Everhart's (1979) parallel processing model, pain can be perceived and processed in one of two fashions; objectively as sensory information; or emotionally, with attention focused on potential threat value and fearful expectations regarding pain. Within this framework, these two systems are parallel. Interpreting painful sensations within an objective-sensation schema may dampen the perception of pain, whereas using the emotional schema may serve to increase pain.

Sensory-focused interventions, which involve focusing attention on the objective aspects of sensory information associated with pain have been proposed as an alternative to distraction-based interventions. Among adults there is evidence that sensory focus may provide similar analgesic effects to distraction, and in some cases may be more effective. Eccleston and Crombez's (1999) cognitive-affective model of the attentional function of pain hypothesizes that distraction will be less effective when pain is interpreted as highly threatening and places a strong demand on attentional resources. Several studies have confirmed that among adults who are highly fearful of pain or who interpret pain as threatening, sensory-focused interventions may be especially effective (Keogh & Mansoor, 2001; Roelofs et al., 2004).

Acceptance-based interventions have also been found to reduce pain. Acceptance interventions focus on feeling emotions and bodily sensations without attempts to avoid

or alter these experiences, and to notice the presence of thoughts without becoming caught up in them, resisting them, or believing/disbelieving them (Hayes, Bissett et al., 1999). This approach contrasts with control-based manipulations (e.g., distraction) where the goal of the manipulation is to replace, reduce, and otherwise alter the undesirable physical sensations, emotions, or thoughts during a painful experience. Acceptance-based interventions may work by breaking the link between private events (e.g., thoughts) and behaviours and through reduced attempts to suppress unwanted thoughts, which would otherwise paradoxically increase pain and distress (Masedo & Esteve, 2007). Among adults, acceptance-based interventions can increase pain tolerance (Hayes, Bissett et al., 1999), reduce the affective components of acute pain (Keogh, Bond, Hanmer, & Tilston, 2005), and reduce pain intensity and distress (Masedo & Esteve, 2007). Sensory focus and acceptance-based interventions also share a number of similarities with the nonjudgmental present moment awareness that characterizes mindfulness, a psychological variable that has recently received considerable attention within the context of pain.

### **Mindfulness and Pain**

Mindfulness is typically defined as paying attention to moment-to-moment internal and external experience in a nonjudgmental and accepting manner (Bishop et al., 2004; Kabat-Zinn, 1996; Shapiro, Carlson, Astin, & Freedman, 2006). Although the concept of mindfulness has its beginnings in Buddhist contemplative traditions, there is nothing inherently religious or esoteric about mindfulness, and all individuals are more or less mindful in their day-to-day lives (Kabat-Zinn, 2003). The general tendency to be mindful in daily life is known as trait mindfulness, whereas state mindfulness refers to

how mindful an individual is at a given moment in time. Definitions of mindfulness within the research literature are confusing as “mindfulness” may refer to trait or state levels of mindfulness, to formal meditation practices hypothesized to increase mindfulness (e.g., Davidson et al., 2003), or to a psychosocial construct that involves considering situations or information from multiple perspectives, with alertness to context, distinctions, openness to novelty and orientation to the present (e.g., Langer, 2000). In this thesis, the term mindfulness will be used to refer to trait and state levels of mindfulness, as well as mindfulness-based meditation, but not the psychosocial construct put forth by Langer (2000).

Mindfulness (e.g., present moment awareness with an attitude of acceptance and nonjudgment) appears antithetical to maladaptive thinking patterns that involve attempts to avoid and suppress threatening thoughts, emotions, and body sensations, which are hypothesized to be a key cause of psychological distress (Keng, Smoski, & Robins, 2011). Mindfulness first gained popularity in the field of psychology following the research of Kabat-Zinn (1982) outlining the effectiveness of mindfulness-based stress reduction (MBSR) for individuals with longstanding chronic pain. Numerous studies have now examined the effectiveness of MBSR for individuals with chronic pain (Chiesa & Serretti, 2011) and other medical illnesses (Bohlmeijer, Prenger, Taal, & Cuijpers, 2010) with promising results. These types of programs are typically 8 weeks in duration and involve regular meditation practice. It is believed that these interventions work by increasing trait mindfulness through a variety of meditative practices (Nyklíček & Cuijpers, 2008; Shapiro, Oman, Thoresen, Plante, & Flinders, 2008).

Research has confirmed that trait mindfulness is a predictor of pain outcomes such as reduced pain intensity and disability among individuals with chronic pain (Cassidy, Atherton, Robertson, Walsh, & Gillett, 2012; McCracken, Gauntlett-Gilbert, & Vowles, 2007; Schütze, Rees, Preece, & Schütze, 2010), and has a unique relationship with pain catastrophizing (Cassidy et al., 2012; Schütze et al., 2010). For example, Schütze et al. (2010) found that mindfulness was a unique and non-redundant predictor of key pain constructs such as typical pain intensity, pain catastrophizing, and pain-related disability. Mindfulness was most strongly related to pain catastrophizing, accounting for 41% of the variance in that variable. Schütze et al. (2010) argued that low levels of trait mindfulness might be a precursor to the development of catastrophic thoughts about pain because individuals who are not able to self-regulate their attention in the present moment in a non-elaborative manner would be at an increased risk for the development of secondary evaluations of painful sensations such as pain catastrophizing. Cassidy et al. (2012) further demonstrated that changes in trait mindfulness during the course of a cognitive-behavioural treatment program for pain were significantly associated with improvements in disability and psychological functioning, and the relationship between improvements in mindfulness and disability were mediated by changes in pain catastrophizing.

Unfortunately, there are a number of gaps in the current literature on the relationship between trait mindfulness and pain. To begin, no research has examined the impact of trait mindfulness on pain outcomes among an adolescent population. This is an important shortcoming as findings concerning the relationship between mindfulness and pain in adults may not generalize to youth based on important developmental differences

in attentional, cognitive, and emotional regulation abilities between these groups (Semple, Lee, & Miller, 2006). Specifically, metacognitive and self-regulation skills, which are central to the construct of mindfulness, continue to develop throughout adolescence (Dahl, 2004). In addition, existing studies have only examined the relationship between trait mindfulness and pain among samples of chronic pain patients, and no research has examined this association among the general population. Finally, most research to date on the effects of mindfulness on pain outcomes has examined its impact on self-reported pain and little research has been dedicated to understanding how trait mindfulness may alter responses to acute pain in a controlled setting. This is an important extension of this area of research as it will help us further investigate how mindfulness influences responses to acute pain, as well as increasing our understanding of potential mechanisms whereby mindfulness may influence acute pain responses.

### **A Brief Mindful Attention Manipulation for Acute Pain**

Based on similarities with sensory focus and acceptance-based interventions, it appears that a brief manipulation designed to help individuals attend to present moment experience in a nonjudgmental and accepting fashion may offer analgesic effects. In fact, mindfulness may be seen as combining important aspects of sensory focus (i.e., an objective awareness of the physical sensations) and acceptance (i.e., a nonjudgmental and accepting approach to internal events). Although standard mindfulness based interventions offered over a number of weeks have benefits for chronic pain, there is also evidence that shortened interventions may be beneficial for acute pain. Zeidan, Gordon, Merchant, and Goolkasian (2010) found that three 20-minute sessions of mindfulness meditation training decreased distress and pain during an experimental pain task, and

follow-up imaging research showed that these analgesic effects were also reflected in changes in how noxious stimuli were processed in the brain (Zeidan et al., 2011).

Although these interventions were much shorter than a typical mindfulness-based intervention (i.e., 3-4 days versus 8 weeks) they still lasted several days making their use in the context of acute pain unlikely. Petter, Chambers, and Chorney (2013) compared the effects of a single, brief (15 minute) mindful attention manipulation to a typical distraction-based intervention (guided imagery) for acute pain in children between the ages of 10 and 14 years. The mindful attention manipulation was successful in helping young people attend to their thoughts about pain without increasing pain intensity or decreasing tolerance relative to the distraction condition. No differences were found between the mindful attention manipulation and the distraction manipulation on pain outcomes, which was interpreted as an encouraging sign for the use of mindfulness given the strong empirical support for the use of distraction in pediatric populations. In addition, there was no evidence of an interaction between baseline coping styles or trait mindfulness on the effects of the experimental condition. However, a number of drawbacks of this study point to avenues for future research. First, the study did not include a no-treatment control condition and it is unknown whether this manipulation would offer any benefits over and above young people's typical coping responses. Furthermore, although pain intensity and pain tolerance were examined in this study, the impacts of the intervention on cognitive reactions to pain (e.g., pain catastrophizing) were not included as outcome measures. Given that negative catastrophic thoughts about pain have been hypothesized to mediate how mindfulness may alter the pain experience (Cassidy et al., 2012), research examining this variable may offer a potential explanation

of when and how a mindful attention manipulation works. Finally, this study did not collect any information on youth's previous experience with meditation. This is another potentially important oversight as adult research shows that previous exposure to meditation practice may be necessary in order to benefit from these types of manipulations (Grant & Rainville, 2009).

### **Pain and Mindfulness in Adolescents**

Research that helps further our understanding of the relationship between mindfulness and pain may be particularly relevant for adolescents, as this represents a period of extensive social, psychological, and physical development, as well as increasing rates of acute (McGrath et al., 2000) and recurrent (King et al., 2011) pain. Research conducted with adults may not generalize to adolescents because of a number of important developmental differences. Adolescence is a time period characterized by rapid development of metacognitive and self-regulatory abilities (Dahl, 2004), which may have a significant impact on an individual's capacity for mindfulness. In fact, measures of mindfulness among children and adolescents have been shown to represent a single factor structure (Greco, Baer, & Smith, 2011), whereas measures among adults have proven to be more complex (Baer et al., 2008). Many of the brain regions hypothesized to be involved in the alteration of the pain experience through the application of mindfulness in adults, such as the dorsolateral prefrontal cortex and the orbitofrontal cortex also undergo drastic development throughout adolescence, and appear to be among the last brain regions to fully develop (Gogtay et al., 2004). At the same time, adolescence is characterized by increases in stress reactivity and difficulties in affect regulation (Spear, 2009), which may significantly impact the effect of pain on the lives of adolescents.



Indeed, pain among adolescents has been shown to have widespread negative consequences across various realms of functioning, including; physical (Wilson & Palermo, 2012), social (Forgeron et al., 2010), academic (Dick & Pillai Riddell, 2010), and family functioning (Lewandowski, Palermo, Stinson, Handley, & Chambers, 2010). Although only a small subset of youth with recurrent or chronic pain will experience significant pain-related disability (Huguet & Miró, 2008). Furthermore, recurrent pain places youth at an increased risk of psychological distress in adulthood (Campo et al., 2001) and exposure to chronic stress such as that caused by pain can have negative impacts on the development of brain regions responsible for regulating basic affective responses to environmental stimuli (Andersen & Teicher, 2008).

Although pain is common among adolescents and can significantly interfere in their lives, only a small subset of youth will experience significant interference as a result of pain. Furthermore, variations in pain-related interference are not adequately explained by differences in pain intensity or frequency (Huguet & Miró, 2008). There is rapidly growing interest in the role of mindfulness and mindfulness-based interventions in the physical and psychological health of adolescents (Thompson & Gauntlett-Gilbert, 2008). However, no research has directly examined the influence of mindfulness in the context of pain. Correlational studies investigating mindfulness and general health in adolescents have demonstrated that mindfulness is associated with decreased neuroticism, anxiety, somatization, and perceived stress (Brown, West, Loverich, & Biegel, 2011; Greco et al., 2011), all variables which may negatively impact pain.

Mindfulness-based interventions have also been applied to a variety of adolescent populations with some promising results. For example, an 8-week MBSR program based

on Kabat-Zinn's (1996) program, but adapted for adolescents was found to reduce symptoms of depression, anxiety, and somatic symptoms among adolescents receiving outpatient treatment for mental health issues (Biegel, Brown, Shapiro, & Schubert, 2009) and many of these benefits were related to changes in trait mindfulness following treatment (Brown et al., 2011). Among adolescents and adults with attention-deficit hyperactivity disorder (ADHD), an 8-week mindful awareness program for ADHD resulted in improvements in self-reported ADHD, anxiety, and depressive symptoms as well as increased performance on behavioural measures of attention and cognitive inhibition (Zylowska et al., 2008). Furthermore, an 8-week program based on mindfulness-based cognitive therapy (MBCT; Segal, Williams, & Teasdale, 2002) but adapted to include adolescents and parents with externalizing disorders was found to result in a wide range of improvements on both youth and parent measures of externalizing symptoms (Bögels et al., 2008). A 5-week long mindfulness meditation program was also found to decrease anxiety and enhance academic performance among adolescents with poor academic performance (Beauchemin, Hutchins, & Patterson, 2008).

Other interventions, which promote mindfulness without formal meditation practices (e.g., acceptance and commitment therapy, ACT) as a component of a larger treatment package have been studied more extensively in the context of adolescent pain. For example, a randomized controlled trial of children and adolescents with longstanding chronic pain found that ACT was more effective than an active treatment control condition on a number of important pain outcomes (e.g., pain intensity, pain interference) and these improvements were also seen at a 6.5 month follow-up (Wicksell, Melin,

Lekander, & Olsson, 2009). Further research has shown that an 8-week ACT intervention may be helpful in improving quality of life among adolescents with chronic pain conditions that have pain as a major symptom such as sickle cell anemia (Masuda, Cohen, Wicksell, Kemani, & Johnson, 2011). Although there is growing evidence that mindfulness-based interventions with and without a formal meditation component that are delivered over a number of weeks may be helpful for a variety of chronic physical and mental health conditions, it remains unknown what sort of effect a brief mindfulness-based manipulation might have on acute pain, or how trait mindfulness may impact the pain experience of adolescents.

### **Experimental Paradigms for Studying Pain**

Experimental techniques for inducing pain in humans have a long history of helping researchers and clinicians understand the pain experience. Experimental pain tasks involve administering a noxious stimulus (e.g., cold, heat, electrical stimulation) to a participant who then provides a variety of pain outcomes such as perceived intensity, threshold, and tolerance. The appeal of these experimental pain tasks is that they offer a high degree of internal validity as the experimenter can control the location and duration of the stimulus, and there is a reduction of other confounding factors such as nausea, fatigue, and anxiety that are often present in clinical settings. Within the pediatric field, the cold pressor task is the most widely used experimental pain paradigm (Birnie, Petter, Noel, Boerner, & Chambers, 2012), due to the ethical acceptability and safety of the task (Birnie, Noel, Chambers, von Baeyer, & Fernandez, 2011), the existence of guidelines for its administration (von Baeyer, Piira, Chambers, Trapanotto, & Zeltzer, 2005) and its applicability to a wide variety of theoretically and clinically relevant questions.

Responses to the cold pressor task are also predictive of real world pain outcomes in this age range, such as the number of visits to a school nurse for acute somatic symptoms (Tsao, Glover, Bursch, Ifekwunigwe, & Zeltzer, 2002). Given the high degree of control over confounding variables, as well as its external validity as a predictor of real world pain outcomes, the cold pressor task offers an ideal paradigm to test the effects of a brief manipulation as well as the association between psychological variables and pain response.

### **Outline of Dissertation Studies: Goals and Hypotheses**

Based on theory and research related to the effects of attention-based manipulations for pain as well as developments within the field of mindfulness, the current dissertation project was designed to assess whether a brief manipulation based on mindfulness principles would be beneficial for adolescents undergoing acute experimental pain, as well as to investigate the relationship between trait mindfulness and pain among adolescents in both real world and experimental settings. This was accomplished through two complementary studies encompassed within a larger dissertation project. These two studies utilized the same sample of adolescents and are presented as separate manuscripts (i.e., chapters) within this dissertation.

The first study (Study 1) was a laboratory-based examination of the effects of a brief (approximately 10 minute) mindfulness-based manipulation (which we have termed “mindful attention”) on experimental pain outcomes. In this study, adolescents completed a measure of trait catastrophizing before being assigned to receive this manipulation or to a no manipulation control group prior to participating in an experimental pain task. Following the manipulation, participants completed a measure of state mindfulness. After

completing the pain task, participants answered measures of situational pain catastrophizing and pain intensity during the task. Based on findings in the pediatric literature (Petter et al., 2013) and its similarity with sensory focus and acceptance-based manipulations, it was hypothesized that the mindful attention manipulation would have beneficial effects on pain outcomes for adolescents relative to no-treatment control. Specifically, it was predicted that the manipulation would result in increased state mindfulness prior to the pain task, as well as decreases in situational pain catastrophizing and pain intensity and increases in pain tolerance. Furthermore, based on theoretical work and empirical findings among adults that individuals who report high levels of pain catastrophizing appear to benefit more from interventions which help them direct their attention towards painful sensations in an objective manner (Keogh & Mansoor, 2001; Roelofs et al., 2004) it was predicted that pain catastrophizing would moderate the effectiveness of this intervention. Follow-up secondary analyses were also conducted to examine the moderating effect of adolescents meditation experience on the effects of the manipulation given previous research has demonstrated that the effects of these types of interventions may be moderated by meditation experience (Grant & Rainville, 2009).

The second study (Study 2) examined the relationship between adolescent trait mindfulness and real world and experimental pain outcomes using questionnaire measures collected immediately prior to and during participation in Study 1. This was accomplished by having participants complete self-report measures of trait mindfulness, pain catastrophizing, and pain-related interference as well as completing an interview assessing the most commonly experienced pain over the previous three months before full participation in the procedures outlined in Study 1. Based on previous research with

adults that examined the impact of trait mindfulness on pain, it was hypothesized that trait mindfulness would be related to more positive outcomes across both experimental and real-world settings (Cassidy et al., 2012; McCracken et al., 2007; Schütze et al., 2010). Furthermore, given the unique relationship between mindfulness and pain catastrophizing (Cassidy et al., 2012), it was hypothesized that the relationship between trait mindfulness and pain interference would be mediated by reductions in pain catastrophizing across both real world and experimental settings.

CHAPTER 2:  
THE EFFECTS OF MINDFUL ATTENTION AND STATE MINDFULNESS ON PAIN  
AMONG ADOLESCENTS

The manuscript based on this study is presented below. Readers are advised that Mark Petter, under the supervision of Dr. Christine Chambers and Dr. Patrick McGrath, developed the research questions, methodology, and analytical approach for this research. He was responsible for developing the study protocol and proposal, applying for and obtaining funding to support this research, applying for and obtaining ethical approval, submitting ethical amendments, and overseeing data collection. He conducted the background research and literature review for this manuscript and was responsible for all aspects of manuscript writing. Prior to submitting the manuscript, he received editorial feedback from the study co-authors/co-investigators and other dissertation committee members. This manuscript has been submitted to a journal in the field of psychology. Mr. Petter will be responsible for making all edits and resubmitting the manuscript following the review process. The current reference for the manuscript is:

Petter, M., McGrath, P. J., Chambers, C. T., Dick, B. D. (2013). The effects of mindful attention and state mindfulness on pain among adolescents. Manuscript in review.

## Abstract

**Objective:** Attention-based coping strategies that direct attention away from pain have a strong evidence base among adolescents. However, it has been suggested that among youth high in pain catastrophizing these types of interventions may be less effective. The purpose of this study was to test the effects of a mindful attention manipulation on adolescent's experimental pain responses and to examine whether its effects were moderated by pain catastrophizing. Furthermore, the relationship between state mindfulness and experimental pain was investigated. **Methods:** 198 adolescents initially completed a measure of pain catastrophizing before being randomly assigned to a brief mindful attention manipulation or no manipulation control group prior to an experimental pain task. Participants completed measures of state mindfulness immediately prior to the pain task, and situational catastrophizing and pain intensity following the task. **Results:** Overall, the manipulation had no effect on pain outcomes, and its effects were not moderated by adolescents' pain catastrophizing. However, secondary analysis showed that previous meditation experience moderated the effect of the manipulation. Furthermore, state mindfulness immediately before the pain task predicted pain outcomes, with reductions in situational catastrophizing mediating the relationship between mindfulness and pain intensity. **Conclusions:** A brief mindful attention manipulation appeared to cue mindfulness in adolescents with prior experience meditating, reducing their catastrophizing and pain. State mindfulness was related to pain responses, with these effects mediated by reductions in catastrophic thinking.

*Keywords:* Pain, Mindfulness, Pain Catastrophizing, Meditation, Adolescents



## **The Effects of Mindful Attention and State Mindfulness on Pain among Adolescents**

Pain is defined as “an unpleasant sensory and emotional experience associated with actual or potential tissue damage” (IASP, 1979, p. 249) and both acute and chronic pains are common among adolescents (King et al., 2011; McGrath et al., 2000). As the definition implies, pain is influenced by more than the extent of physical injury, and the way in which young people cope with the sensory and emotional aspects of pain significantly impacts their pain experience (Asmundson, Noel, Petter, & Parkerson, 2012). Attention-based coping strategies are widely used in the management of pain for young people (Noel, Petter, Parker, & Chambers, 2012; Uman, Chambers, McGrath, & Kisely, 2008). Coping strategies designed to take attention away from painful stimuli (e.g., distraction) have a strong evidence base for acute pain in pediatric populations (Uman et al., 2008). These types of interventions are believed to work in large part because consciously attending to an alternative stimulus limits attentional resources available to process pain (Johnson, 2005). However, it has been theorized that when pain is highly threatening that it may place such a strong demand on attention that the effects of distraction will be reduced (Eccleston & Crombez, 1999). Evidence with pediatric populations has supported the claim that the effects of distraction are reduced when individuals view pain as highly threatening. In particular, the tendency to catastrophize about pain appears to reduce the use and effectiveness of distraction-based coping strategies among children and adolescents (Verhoeven, Goubert, Jaaniste, Van Ryckeghem, & Crombez, 2011). Pain catastrophizing refers to the tendency to magnify the threat value of pain, to feel helpless in the face of pain, and to ruminate about pain, and this variable plays a central role in psychological models of pediatric pain

(Asmundson et al., 2012). Because coping strategies that direct attention away from a painful stimulus are not always optimal, researchers have also begun examining strategies to help young people attend to painful stimuli in an adaptive manner.

Mindfulness involves paying attention, on purpose, to present moment experience, in a non-judgmental and accepting manner (Kabat-Zinn, 1996). Given its nonjudgmental focus on present-moment experience, the use of mindfulness appears to be a potentially fruitful avenue in helping adolescents attend to pain in an adaptive manner. Mindfulness also appears to combine aspects of alternative attention-based coping strategies that direct attention towards pain, such as sensory-focused (e.g., Piira, Hayes, Goodenough, & von Baeyer, 2006) and acceptance-based (Hayes et al., 1999) interventions, which have been found to reduce responses to acute pain. However, typical mindfulness-based interventions are 8-weeks in duration and place a strong emphasis on daily meditation practice, requiring more time and resources than the brief attention-based coping strategies such as distraction. Among adults, there is evidence that brief mindfulness interventions for acute pain may offer benefits. For example, Zeidan, Gordon, Merchant, and Goolkasian (2010) found that three 20-minute sessions of mindfulness-based meditation training was enough to decrease pain intensity and reduce pain sensitivity during an experimental pain task. Follow-up research from this same group found that four sessions of mindfulness training reduced pain unpleasantness and intensity and changed the way that pain was processed in multiple brain regions measured by arterial spin labeling functional magnetic resonance imaging (Zeidan et al., 2011). Although employing shorter than typical mindfulness interventions, these studies still required participants to attend multiple training sessions, once again making their

utility in the context of acute pain unlikely. A recent study of children aged 10-14 years found that a single set of mindful attention instructions administered prior to and during an experimental pain task was successful in directing attention towards the pain task, and no significant differences were found between this manipulation and a more traditional distraction-based intervention (Petter, Chambers, & Chorney, 2013). However, this study lacked a no treatment control group, and it remains unclear whether this type of manipulation is more effective than youth's typical coping responses.

The hypothesis that instructing adolescents to attend mindfully may mitigate pain is based on the assumption that a state of nonjudgmental present-moment awareness during a painful experience may buffer against negative secondary evaluations of physical sensations which are known to increase the severity of pain (Campbell et al., 2010). On a theoretical level, mindfulness appears antithetical to catastrophic thinking, which involves negative secondary processing of physical sensations as well as the individual's ability to tolerate those sensations. Evidence indicates that trait mindfulness (the tendency to be mindful over time) is associated with physical and psychological well-being among adolescents (Brown, West, Loverich, & Biegel, 2011; Greco, Baer, & Smith, 2011), and is a unique predictor of a number of outcomes in adult chronic pain populations (McCracken & Keogh, 2009), and that pain catastrophizing may mediate the relationship between mindfulness and pain outcomes (Cassidy, Atherton, Robertson, Walsh, & Gillett, 2012). However, to-date the relationship between state mindfulness, state catastrophizing, and pain outcomes have not been examined in the pain context.

The primary purpose of this project was therefore to examine the effects of a mindful attention manipulation on experimentally induced pain among adolescents. The

mindful attention manipulation was hypothesized to result in increased levels of state mindfulness, decreased catastrophic thoughts during the pain task, and ultimately decreased pain intensity and increased pain tolerance. Furthermore, it was hypothesized that the effects of this manipulation on pain outcomes would be moderated by trait levels of pain catastrophizing, such that the manipulation would be more effective among adolescents higher in pain catastrophizing. Secondary analyses examining the influence of previous meditation experience on the effects of experimental group were also conducted given the potential of meditation experience to moderate the effects of attending mindfully to pain. Specifically, individuals with previous meditation experience would be expected to benefit more from brief mindfulness manipulations (Grant & Rainville, 2009). Additionally, a secondary purpose of the project was to examine the overall relationship between state mindfulness and experimental pain outcomes, regardless of experimental condition. It was hypothesized that higher state mindfulness would result in lowered pain intensity and increased pain tolerance, and that these relationships would be mediated by lower levels of pain catastrophizing during the task.

### **Method**

The data presented in this manuscript were collected as part of a larger study examining two independent research questions. The purpose of the present study was to examine the effect of a brief mindful attention manipulation and state mindfulness on experimental pain. The other paper [Petter, Chambers, & McGrath, in review] examined the relationship between trait mindfulness and real world and experimental pain outcomes. Methods presented below contain details relevant to the present study. Ethical approval for this study was obtained from the health centre research ethics board.

## **Design**

The design of the current study was a randomized between-subjects design. Participants were randomly assigned using a random number generator to receive either the mindful attention manipulation or a no manipulation control condition before taking part in an experimental pain task.

## **Participants**

Participants were adolescents recruited through advertisements placed in local private schools, medical centers, recreation centers, camps, and other community services. Specific efforts were made to recruit adolescents with a range of meditation experiences. Advertisements were therefore placed in local meditation centers, yoga studios, and mailing lists to local meditation groups. In addition, a local private school that includes regular meditation practice as part of its curriculum gave permission for its students to take part through their school.

Exclusionary criteria for this study were as follows: (1) inability to read and write in English; (2) uncorrected vision or hearing impairment; (3) a diagnosis of attention-deficit/hyperactivity disorder; (4) a health-related medical condition, which could be made worse by placing a limb in cold water (e.g., circulation disorders, heart problems, injuries to the arms or hands); or (5) having previously taken part in a study involving the cold pressor task.

Before enrollment in the study, exclusionary criteria were assessed by a screening interview with participants. No adolescents withdrew following enrolment. One minor adverse event was reported with a participant reporting feeling light-headedness following the pain task. In this case, after having the participant lie down and drink fruit

juice, the symptoms subsided quickly. Due to this deviation in protocol this participant was removed from analysis. One more participant was also excluded due to their inability to fully understand the questionnaire materials and answer questions competently as noted by the researcher who observed this participant.

Final data analysis included 198 adolescents (132 females, 66 males) aged 13 to 18 years ( $M_{\text{age}} = 15.99$  years,  $SD = 1.89$ ) and were predominantly White ( $n = 172$ ).

### **Apparatus**

**Cold pressor task.** The cold pressor is an ethical technique for inducing pain in children and adolescents (Birnie, Noel, Chambers, von Baeyer, & Fernandez, 2011). The participant places his/her non-dominant hand up to the wrist in cold water for a maximum of four minutes (5 °C water was used). Based on recommendations for studies where pain tolerance is an outcome of interest, participants were not informed of this four-minute ceiling (Birnie, Petter, Noel, Boerner, & Chambers, 2012). Before taking part in the cold pressor task, participants were told to leave their hand in the water for as long as they could even if it was uncomfortable, but to remove it when it became too uncomfortable or hurt too much. The device used for the purposes of this study was a RU-200 Techne Dip Cooler with water temperature controlled by a Techne TE-10D Liquid Bath Thermoregulator. This device maintains a steady temperature and circulates water to prevent local warming around the participants' hand.

### **Experimental Conditions**

**Mindful attention manipulation.** Prior to the cold pressor, participants in this condition listened to an audio recording with instructions guiding them through a mindful attention exercise. This intervention was based on a mindfulness practice originally

designed by Jon Kabat-Zinn (1996), adapted for use with adolescents by Gina Biegel (2010), and was further modified by the first author (M.P.) for the experimental pain context. Prior to the cold pressor task, participants were asked to do the following, in sequence: (1) sit in an upright and relaxed posture, (2) bring their awareness to the physical sensations throughout their body, (3) notice the mind's tendency to judge sensations, and to gently let go of judgment, (4) bring their awareness to their breath without changing the breath, (5) notice when they became distracted, acknowledge what caught their attention, and bring their awareness back to the breath, (6) gently move their awareness into their arm, (7) simply notice and accept the feelings that arose throughout their arm, and (8) once again notice when they became distracted, and to return their awareness to their arm. After this 10-minute recording finished, participants were asked to fill out the state mindfulness measure. After completing the questionnaires, the recording instructed participants to use the mindful attention they had just learned during the cold pressor. In addition, participants received standard cold pressor instructions. The mindful attention script can be found in Appendix A.

**Control condition.** Participants in the control condition listened to an audio recording asking them to read quietly for 10 minutes. Participants in this group were provided with a selection of age-appropriate magazines to read during that time. After reading for 10 minutes, participants were asked to stop and fill out the questionnaire assessing state mindfulness. After filling out the questionnaire, participants were then given standard instructions for the cold pressor before completing the task.

## **Measures**

**Pain catastrophizing.** To assess trait levels of pain catastrophizing, the 13-item Pain Catastrophizing Scale – Child Version (PCS-C) (Crombez et al., 2003) was used. This measure assesses the participants' tendency to catastrophize when in pain (e.g., “When I have pain, I feel I can't go on”). Answers are given on a 5-point Likert scale with anchors of 0 – “Not at all” and 4 – “Extremely” with total scores ranging from 0 – 65 and higher scores reflecting higher levels of pain catastrophizing. The PCS-C is a widely used measure in pediatric pain research and in this sample showed excellent internal consistency with  $\alpha = .904$ .

**Meditation experience.** To assess meditation experience, a brief interview was created for the purpose of this study asking participants whether they had ever meditated before and whether they currently meditated. Participants who currently meditated were then asked how long they had been meditating, and how frequently they meditated.

**State mindfulness.** The 7-item state version of the Mindful Attention and Awareness Scale (MAAS-S) (Brown, Ryan, & Creswell, 2007) assessed how mindful adolescents were during the experimental condition (e.g., “I found myself preoccupied with the future or the past”). Answers are given on a 7-point Likert scale with anchors of 0 – “Not at all” and 6 – “Very Much”, which are then reversed scored. Total scores range from 0 to 36, with higher scores reflecting higher levels of state mindfulness. In this study the scaled showed good internal consistency with  $\alpha = .798$ .

**State catastrophizing.** In order to assess state catastrophizing during the experimental pain task, the 6-item Situational Catastrophizing Questionnaire (SCQ; Campbell et al., 2010) was used. The scale assesses how much an individual was catastrophizing during an experimental pain task (e.g., “I thought the pain might



overwhelm me”). Items are answered on a 5-point Likert scale with anchors of 0 – “Not At All” and 4 – “All the Time”. Scores range from 0 – 24 with higher scores indicating higher levels of state catastrophizing. The SCQ has been shown to be more strongly associated with acute pain responses than trait measures of pain catastrophizing. In this study, the scale had good internal consistency with  $\alpha = .880$ .

**Pain intensity.** A verbally administered 11-point numerical rating scale (NRS-11) was used to measure pain intensity. Adolescents were instructed to rate their average and worst pain on a scale of 0 – “No Pain” and 10 – “The Worst Possible Pain”. These types of numerical rating scales are well validated for use with pediatric populations (von Baeyer et al., 2010).

**Pain tolerance.** Pain tolerance times were recorded from the time that the adolescent placed their hand in the water until it was removed, up to a maximum of four minutes. The experimenter present in the testing room initially recorded the tolerance time. For 195 cases these times were double-checked by an experimenter blind to experimental condition who recorded the times based on a video recording of the cold pressor task. Agreement between the two raters was high with  $r = .995$ ,  $p < .001$ . In 3 cases, times could not be double-checked due to problems with the video equipment.

**Post cold pressor manipulation check.** A questionnaire was designed for the purpose of this study asking participants to indicate how often they tried to distract themselves during the pain task, how often they noticed their thoughts about their arm during the pain task, and whether the strategy they used to keep their hand in the water was helpful. Answers were provided on 5-point Likert scales.

## **Procedure**

Participants completed the initial screening interview and provided informed consent either at a research centre at a local tertiary care hospital or at their school. They then completed the measure of trait pain catastrophizing followed by the brief meditation experience interview before moving to a separate room to complete the cold pressor task. At this point, participants were randomly assigned to either the mindful attention or control group and received instructions accordingly. During the entire cold pressor task, an experimenter remained seated behind the participants. After the mindful attention intervention or silent reading, participants were asked to complete the measure of state mindfulness before receiving their final instructions for completion of the cold pressor. Immediately following withdrawal of the limb from the water during the cold pressor, or after reaching the four-minute ceiling, participants reported on their average pain intensity, and completed the measure of situational catastrophizing and the post cold pressor manipulation check. They then received a \$20 honorarium if they took part at the research centre or had \$20 donated to a school fundraiser on their behalf if they took part through their school.

## **Results**

### **Data Analytic Plan**

Less than 1% of items were missing from the questionnaire data. A single imputation using the expectation maximization algorithm was therefore utilized to replace these missing items (Enders, 2001) using Missing Values Analysis with SPSS 20.

A series of between-group comparisons using one-way between subjects ANOVA's and chi-square analysis were first conducted to determine if the two

experimental groups differed on any baseline characteristics. Because there were more boys in the mindful attention condition, sex was controlled for in subsequent analyses.

A series of between-subjects ANCOVAs controlling for sex were then conducted on the manipulation check outcomes to see whether the mindful attention manipulation had an effect on the strategy that adolescents used during the task and whether they felt it was helpful.

Bivariate correlations were conducted on all variables relevant to experimental pain responses. Because the pain tolerance variable had an extreme negative skew (due to ceiling effects), the variable was dichotomized into whether or not participants reached the four-minute ceiling and was thus not included in the correlation analysis.

To examine differences between experimental groups on pain outcomes, a series of ANCOVA's (controlling for sex) were conducted on the outcomes variables of state mindfulness, catastrophizing, and pain intensity. A logistic regression model was conducted to examine the effect of experimental group on the dichotomous pain tolerance outcomes. A series of moderation models using PROCESS for SPSS (Hayes, 2013) were carried out to examine whether trait pain catastrophizing interacted with experimental group in impacting pain intensity and pain tolerance outcomes after controlling for the effects of sex.

Secondary analyses examining the interaction between meditation experience and experimental group were conducted. A regular meditation practice was defined as meditating at least once a week, for at least one year. All other participants were classified as "non-meditators". This cut-off point was used, as previous research has indicated that extensive meditation practice may be necessary to see moderating effects

of these types of interventions on acute pain (Grant & Rainville, 2009). To examine whether the effects of experimental group were moderated by meditation experience, a series of moderation models using PROCESS for SPSS were conducted. This analysis was followed by independent samples t-tests to examine the nature of the effects.

To examine the relationship between state mindfulness and pain outcomes a series of hierarchical linear regression models for continuous variables, and logistic regression for dichotomous outcomes were conducted. A simple mediation model using PROCESS for SPSS was then conducted. PROCESS is a computational procedure that provides coefficient estimates for total, direct, and indirect effects of variables using OLS regression for continuous outcomes and maximum likelihood logistic regression for dichotomous outcomes. A 95% bootstrap confidence interval for the indirect effect using 10,000 bootstrap samples was used with sex included as a covariate.

Power analysis based on the following values; alpha = .05, power = .80, and 198 participants showed that this study was adequately powered to detect a small to moderate effect ( $f = .22$ ) for the main effects and interactions in the between group ANCOVA analysis, as well as a small – moderate effect ( $f^2 = .07$ ) in the hierarchical regression analysis.

### **Baseline between Group Differences**

There were no significant differences between the mindful attention and control conditions on mean age (mindful attention:  $M = 16.02$  years ( $SD = 1.90$ ); control:  $M = 15.97$  years ( $SD = 1.89$ ),  $F(1,197) = .036$ ,  $p = .851$ ) or number of regular meditators between experimental groups ( $\chi^2(1) = .625$ ,  $p = .493$ ). However there were significantly

more males in the mindful attention group ( $n = 42$ ) than in the control group ( $n = 24$ ) ( $\chi^2(1) = 6.32, p < .05$ ).

### **Manipulation Check**

After controlling for the effects of sex, participants in the mindful attention condition reported using distraction significantly less than those in the control condition (mindful attention:  $M = 1.99$  ( $SD = 1.38$ ); control:  $M = 2.44$  ( $SD = 1.36$ ),  $F(2,195) = 5.78, p < .05, \eta_p^2 = .029$ ), noticing the thoughts they had about their arm significantly more (mindful attention:  $M = 2.83$  ( $SD = 1.05$ ); control:  $M = 2.51$  ( $SD = 1.08$ ),  $F(2,195) = 4.80, p < .05, \eta_p^2 = .024$ ), and reported feeling the strategy they had used was significantly more helpful in helping them keep their hand in the water (mindful attention:  $M = 2.95$  ( $SD = 1.12$ ); control:  $M = 2.39$  ( $SD = 1.19$ )  $F(2,195) = 11.75, p < .001, \eta_p^2 = .057$ ).

### **Correlations among Key Variables**

After controlling for the effects of sex, trait pain catastrophizing was significantly related to state mindfulness ( $r = -.338, p < .001$ ), situational catastrophizing ( $r = .362, p < .001$ ), and pain intensity ( $r = .270, p < .001$ ). State mindfulness was significantly correlated with situational catastrophizing ( $r = -.387, p < .001$ ), and pain intensity ( $r = -.224, p < .001$ ). State catastrophizing was related to pain intensity ( $r = .486, p < .001$ ).

### **Effect of Experimental Group on Pain Outcomes during the Cold Pressor**

There were no differences between the two groups on measures of state mindfulness (mindful attention:  $M = 21.59, SD = 4.98$ ; control:  $M = 22.16, SD = 5.67$ ;  $F(2,195) = 1.09, p = .298, \eta_p^2 = .006$ ) prior to the cold pressor, as well as situational catastrophizing (mindful attention:  $M = 8.91, SD = 5.63$ ; control:  $8.03, SD = 5.26$ ;  $F(2,194) = 2.23, p = .137, \eta_p^2 = .011$ ), or pain intensity (mindful attention:  $M = 3.57, SD$

= 2.44; control:  $M = 3.42$ ,  $SD = 2.53$ ;  $F(2,195) = .025$ ,  $p = .875$ ,  $\eta_p^2 = .000$ ). Further chi-square analysis revealed there was no effect of experimental condition on the pain tolerance outcome ( $\chi^2(1) = .01$ ,  $p = .920$ ).

### **Interaction of Experimental Group and Pain Catastrophizing on Pain Outcome**

#### **Variables`**

There was no significant interaction between experimental group and trait levels of pain catastrophizing in predicting pain intensity ( $\Delta R^2 = .023$ ,  $F(1,193) = .49$ ,  $p = .486$ ) or pain tolerance ( $z = 1.33$ ,  $p = .184$ ).

### **Interaction of Experimental Group and Meditation Experience on Outcome**

#### **Variables**

There was a significant interaction between experimental group and meditation experience in predicting state mindfulness immediately prior to the experimental pain task ( $\Delta R^2 = .025$ ,  $F(1,193) = 5.13$ ,  $p < .05$ ). Follow-up t-tests revealed higher mindfulness for regular meditators in the mindful attention group ( $M = 26.44$ ,  $SD = 2.79$ ) compared to non-meditators in the same group ( $M = 21.12$ ,  $SD = 4.90$ ;  $t(13.46) = 5.02$ ,  $p < .001^1$ ) and non-meditators in the control condition ( $M = 22.08$ ,  $SD = 5.73$ ;  $t(92) = 2.25$ ,  $p < .05$ ). The interaction between meditation experience and experimental group was also a significant predictor of situational catastrophizing ( $\Delta R^2 = .051$ ,  $F(1,192) = 10.66$ ,  $p < .01$ ). T-tests revealed that regular meditators in the mindful attention group had significantly lower situational catastrophizing ( $M = 5.22$ ,  $SD = 4.63$ ) than regular meditators in the control condition ( $M = 10.75$ ,  $SD = 5.01$ ;  $t(19) = 2.58$ ,  $p < .05$ ), as well as non-meditators in the mindful attention condition ( $M = 9.27$ ,  $SD = 5.61$ ;  $t(99) = 2.10$ ,  $p < .05$ ). Non-meditators in the mindful attention condition reported higher catastrophizing than non-meditators in

the control condition ( $M = 7.64$ ,  $SD = 5.20$ ;  $t(174) = 1.99$ ,  $p < .05$ ). Figure 2.1 illustrates the significant interaction between experimental group and meditation experience in predicting pain intensity during the cold pressor ( $\Delta R^2 = .037$ ,  $F(1,193) = 7.42$ ,  $p < .01$ ). Regular meditators in the mindful attention condition reported significantly lower pain intensity than meditators in the control condition ( $t(19) = 2.39$ ,  $p < .05$ ), with no effect among non meditators ( $t(175) = .67$ ,  $p = .51$ ). Results of the logistic regression analysis showed that experimental group and meditation experience was also a significant predictor of the dichotomous pain tolerance outcome ( $z = 1.95$ ,  $p = .050$ ). Follow-up chi-square analysis showed that among non-meditators the intervention had no effect ( $\chi^2(1) = .292$ ,  $p = .589$ ). Among regular meditators there was a marginal effect with individuals in the mindful attention condition (4 of 9; 44%) being more likely to reach ceiling than those in the control condition (1 of 12; 8%;  $\chi^2(1) = 3.70$ ,  $p = .055$ ).

### **Relationship between State Mindfulness and Pain Outcomes**

The results of the hierarchical regression predicting pain intensity can be found in Table 2.1. After controlling for sex and state catastrophizing, state mindfulness was no longer a significant predictor of pain intensity ( $\Delta R^2 = .002$ ,  $p = .536$ ) accounting for less than 1% of the variance in this variable. Next, a hierarchical logistic regression model was carried out using state mindfulness to predict the dichotomous pain tolerance outcome after controlling for sex and state catastrophizing in Step 1. Although the overall model significantly predicted the dichotomous pain tolerance outcome ( $\chi^2(4) = 26.09$ ,  $p < .001$ , Nagelkerke  $R^2 = .172$ ), the addition of state mindfulness in the final step of the analysis did not add significantly to the model,  $\chi^2(1) = 1.35$ ,  $p = .246$ . Of the final

variables in the model, situational catastrophizing was the only unique predictor ( $\beta = -0.170$ ,  $SE = .038$ ,  $Wald = 20.02$ ,  $p < .001$ ).

### **Mediation of Relationship between State Mindfulness and Pain through Catastrophizing**

After controlling for sex, results of the mediation analysis showed that the total effect of state mindfulness on pain intensity was significant with a path coefficient of  $-0.075$  ( $SE = .023$ ),  $p < .01$ , the direct effect of state mindfulness on pain intensity was not significant with a path coefficient of  $-0.014$  ( $SE = .023$ ),  $p = .536$ , and the indirect effect of state mindfulness on pain intensity through state catastrophizing was  $-0.061$  (Boot  $SE = .014$ ; 95%  $CI = -0.091$  to  $-0.037$ ) indicating a significant effect. A Sobel test showed that the mediation path was significantly different from zero ( $z = -4.43$ ,  $p < .001$ ). A summary of the path analysis can be found in Figure 2.2.

Results showed that the total effect of mindfulness on pain tolerance was not significant ( $.025$  ( $SE = .029$ ),  $z = .865$ ,  $p = .387$ ). Mediation analysis was not conducted.

### **Discussion**

Attention-based coping strategies which direct attention away from a painful stimulus have a strong evidence-base for ameliorating acute pain in pediatric populations (Uman et al., 2008). However, as with any intervention, these types of manipulations are not effective for all young people. In particular, researchers have found that among children and adolescents who catastrophize about pain, distraction-based interventions may be less effective and it has been proposed that manipulations that direct attention towards pain in an adaptive manner may be more beneficial (Verhoeven et al., 2011). The primary purpose of this study was to examine the effects of a brief mindful attention



manipulation on pain outcomes among adolescents, and to examine whether the effects of this manipulation varied as a function of adolescents' pain catastrophizing. It was hypothesized that this manipulation would mitigate experimental pain outcomes relative to a no manipulation control condition. However, results indicated that overall this manipulation had no effect on any of the outcomes, and trait pain catastrophizing was not a significant moderator. However, follow-up secondary analyses revealed that adolescents' meditation experience was a significant moderator of the effects of experimental group on pain outcomes. These interactions were driven by the finding that adolescents with a regular meditation practice benefited from instructions to attend mindfully to pain, whereas those without regular meditation experience did not. A secondary goal of this study was to examine the association between state mindfulness and experimental pain responses. It was hypothesized that higher levels of state mindfulness would be related to decreased pain intensity, and increased pain tolerance and that these effects would be mediated by reductions in catastrophic thinking during the pain task. Results confirmed that state mindfulness was significantly associated with pain intensity and this relationship was mediated by reductions in catastrophic thinking during the pain task, although state mindfulness was not associated with pain tolerance.

The finding that this type of brief mindful attention manipulation had no effect on experimental pain outcomes is counter to previous work in both the pediatric and adult fields which has found that interventions which direct attention towards pain in an objective and non-judgmental manner are helpful in reducing the subjective experience of pain and its associated distress (e.g., Hayes et al., 1999; Piira et al., 2006). One potentially important difference between the current study and previous work with

pediatric populations is that participants in previous research (e.g., Petter et al., 2013) have received ongoing instructions on how to attend to pain objectively throughout the actual pain task. However, in the current study instructions were only presented prior to the task, with participants cued to use the previously practiced skill during the pain task. This decision was made in order to reduce the potential analgesic effects of distraction from the pain stimulus that may have been provided by listening to an audio recording during the pain task. Among adolescents relatively naïve to the practice of mindfulness this brief manipulation appears to have provided an adequate level of instruction to reduce the use of distraction and heighten awareness of thoughts during the pain task as evidenced by our manipulation check, but was not extensive enough to provide any sort of analgesic effect during the pain stimuli. In fact adolescents without a regular meditation practice that received the mindful attention manipulation reported higher levels of catastrophic thinking than those in the no-treatment control, which further supports the notion that a more robust intervention may be necessary to change the way in which young people relate to thoughts during an aversive stimuli.

The lack of a moderating effect of trait catastrophizing was also contrary to expectations. Theoretical work on the relationship between pain and attention has hypothesized that when pain is viewed as highly threatening that distraction-based interventions may be less effective (Eccleston & Crombez, 1999), and alternative coping strategies which direct attention towards pain may be more beneficial (Verhoeven et al., 2011). Although some researchers have found that interventions which direct attention towards a painful stimulus are more effective among individuals high in fear of pain, and distraction is more effective among those low in fear of pain (Roelofs, Peters, van der

Zijden, & Vlaeyen, 2004), findings in this field have not been consistent. For example, further studies have found that interventions which direct attention towards a painful stimulus in an accepting manner are more effective than distraction when the threat value of pain was low, but not high (Jackson, Yang, Li, Chen, & Huang, 2012). Pain status may also moderate the effects of intervention type with chronic pain patients showing increases in pain intensity during focused attention on experimental pain (Nouwen, Cloutier, Kappas, Warbrick, & Sheffield, 2006). In the pediatric pain field, some research has found that the effects of different intervention types are based on youth's typical coping style (Piira et al., 2006) although this finding is also inconsistent (Petter et al., 2013). Given these inconsistent findings it appears likely that the effectiveness of attention-based manipulations on pain outcomes are moderated by a complex interaction of developmental factors, preferred coping styles, individuals' typical psychological responses to pain, characteristics of the pain, and characteristics of the actual intervention (e.g., length of intervention, emotional impact, motivation to engage in manipulation).

The finding that meditation experience was a significant moderator of the effects of this manipulation is also consistent with the argument that more extensive practice may be necessary for individuals to benefit from this type of brief intervention. Although shortened versions have been shown to reduce experimental pain (Zeidan et al., 2010; Zeidan et al., 2011), evidence suggests that the more an individual engages in mindfulness-based meditation practices, the more benefits they report (Carmody & Baer, 2008). Theoretical work in the field of mindfulness has also placed a strong emphasis on mindfulness meditation practice as a form of mental training which may be necessary to reduce the reactive states of mind that typically dominate our consciousness and can

further heighten distress during aversive experiences (Bishop et al., 2004). Although all individuals may have the innate capability to attend mindfully to present-moment experience, meditation practice may be necessary for the development of this skill (Kabat-Zinn, 1996). This has potentially important clinical implications for the use of mindfulness-based interventions with adolescents experiencing pain. For example, when incorporating mindfulness practices into the treatment of pain it may be important for clinicians and adolescents to understand that increasing awareness of physical sensations of pain and cognitive reactions to those sensations may actually lead to increases in pain and distress early on in treatment before adolescents have had sufficient experience with mindfulness practice. However, once the ability to attend mindfully has been developed and practiced, simple cueing may be sufficient to cause this skill to be activated during an acute pain episode. This may be particularly relevant among clinicians interested in the applications of more long-term mindfulness-based interventions in the treatment of recurrent and chronic forms of pain in adolescents.

Although the manipulation did not benefit meditation naïve adolescents, present moment awareness (i.e., state mindfulness) was found to ameliorate negative cognitive reactions to pain, and through its relationship with pain catastrophizing during the task, was associated with lower pain intensity among all participants. These results are consistent with adult literature which has shown that present-moment awareness in the general population is associated with decreases in negative affect across a range of activities (both enjoyable and distressing; Brown et al., 2004), and adolescent research which has found the tendency to be mindful in daily life is associated with increased psychological well-being, and decreases in somatic complaints (Greco et al., 2011).

However, this is the first study in a pediatric population to demonstrate how mindfulness results in better coping during an aversive experience, showing that reductions in catastrophic thinking may be an important mechanism by which mindfulness may impact the pain experience. This finding is consistent with mindfulness theory, which postulates that present-moment awareness is antithetical to anxious and catastrophic thinking patterns (Bishop et al., 2004). However, it is unclear why this relationship was not also present in regards to the pain tolerance outcome. One potential explanation of this finding is that our measure of state mindfulness (MAAS-S) measures only the attentional component of mindfulness and does not contain items consistent with the nonjudgmental attitude promoted in mindfulness. It is possible that whereas the attentional component of mindfulness may alter the perception of pain (i.e., pain intensity), aspects of mindfulness consistent with non-judgment and acceptance are more likely to be associated with tolerance of pain.

Although this study offers some unique findings into the effects of a brief mindfulness-based manipulation for acute pain, and the relationship between state mindfulness and experimental pain outcomes among adolescents, several limitations need to be acknowledged. First of all, it is important to note that there are limitations regarding the generalizability of the results regarding the moderating influence of meditation practice. Although the current study did find that regular meditators benefited from this manipulation, the majority of these participants were recruited from a unique school setting where daily meditation practice is incorporated as part of the curriculum. Based on this unique setting, as well as the relatively low number of adolescents with a regular meditation practice ( $n = 21$ ), it is unclear whether these results would generalize to other

adolescents with meditation experience. Given this unique sample, as well as the cross-sectional design of this study, more research is needed to understand whether this relationship between meditation and the effects of mindful attention would be found in adolescents beginning a regular meditation practice and followed longitudinally.

Despite these limitations, this is the first study to examine the effects of a brief mindful attention manipulation and state mindfulness on acute experimental pain among adolescents. These results suggest that a brief mindful attention manipulation which does not offer ongoing instruction, does not benefit adolescents relatively naïve to meditation, but that among adolescents with a regular meditation practice this manipulation can significantly ameliorate pain outcomes. Furthermore, this study has highlighted the role of state mindfulness among all adolescents on the subjective pain experience, suggesting that increased state mindfulness is beneficial for adolescents undergoing acute pain, and that reductions in catastrophic thinking may be the active mechanism in this regard. Taken together, these findings suggest that future research in the field of adolescent pain directly examining the effects of more extensive mindfulness-based interventions that involve regular meditation practice is warranted. Research in this field has the potential to make a significant contribution to help researchers and clinicians assist adolescents who may have to cope with pain on a regular basis.

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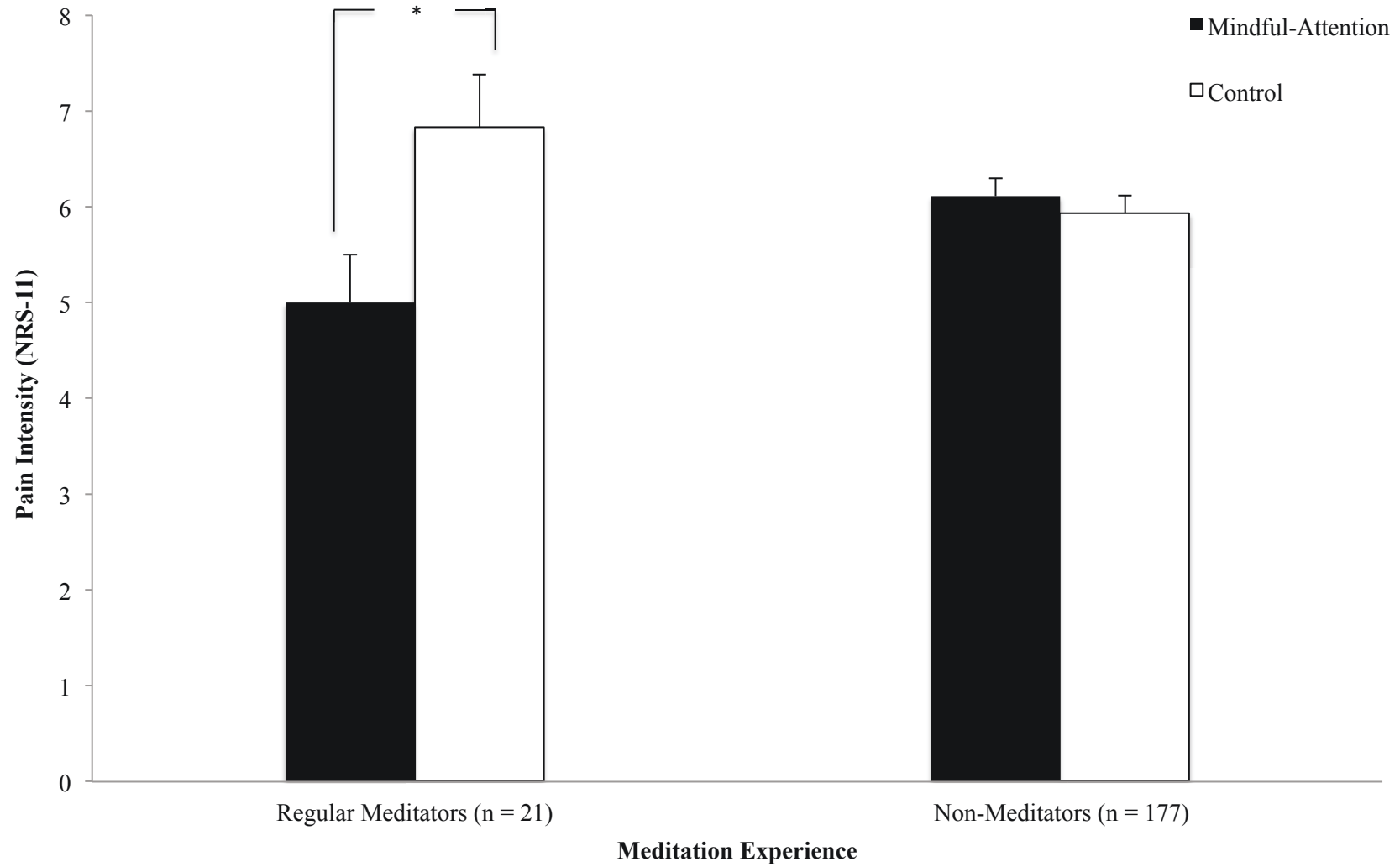
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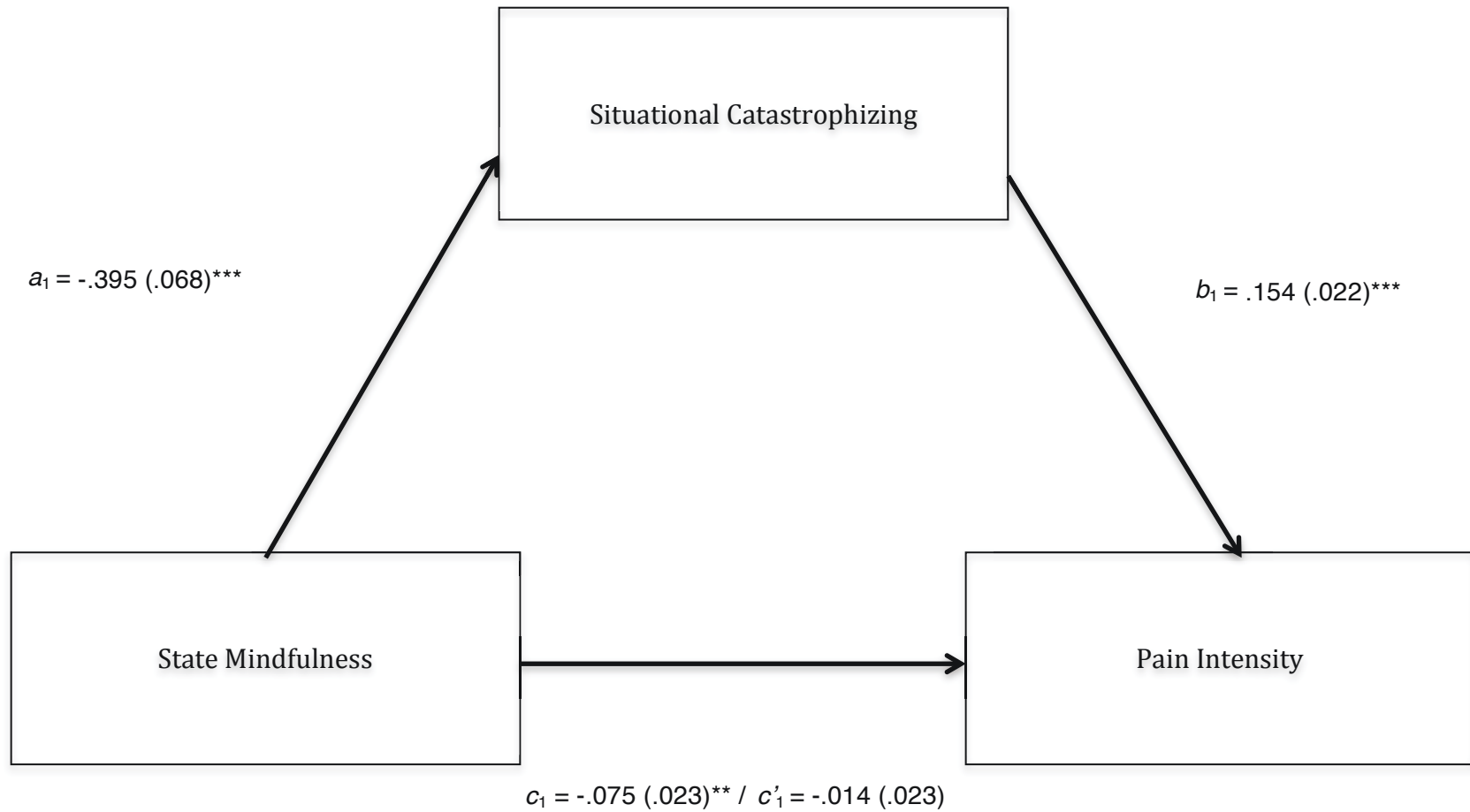
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**Footnotes**

<sup>1</sup>The  $t$ -value with unequal variances assumed was used given that Levene's Test for Equality of variance was significant.



**Figure 2.1** Mean pain intensity scores (NSR-11) based on experimental group and meditation experience. Error bars represent standard error. \* $p < .05$ .



**Figure 2.2** Path coefficients for the mediation model of the total, direct, and indirect effects of state mindfulness (MAAS-S) on pain intensity (NRS-11) through situational catastrophizing (SCQ). Standard errors are in parenthesis.  $**p < .01$ .  $***p < .001$ .

**Table 2.1** Regression models predicting experimental pain intensity by state mindfulness.

N = 198		$\beta$	$\Delta F$	$P=$	$\Delta R^2$	Cumulative $R^2$
Model (Pain Intensity)						
Step 1	Sex	-.100	1.97	.162	.010	.010
Step 2	Situational Catastrophizing	.487	60.02	<.001	.234	.244
Step 3	State Mindfulness	-.042	.39	.536	.002	.245

*Note.* The following measures were used: MAAS-S (state mindfulness), SCQ (state catastrophizing), NSR-11 (pain intensity). Beta weights ( $\beta$ ) are reported for each step along with their change in F-statistic ( $\Delta F$ ) and  $P$ -value. The change in variance at each step in the models is reported as  $\Delta R^2$  along with the cumulative variance.

CHAPTER 3:  
THE ROLE OF TRAIT MINDFULNESS IN THE PAIN EXPERIENCE OF  
ADOLESCENTS

The manuscript based on this study is presented below. Readers are advised that Mark Petter, under the supervision of Dr. Christine Chambers and Dr. Patrick McGrath, developed the research questions, methodology, and analytical approach for this research. He was responsible for developing the study protocol and proposal, applying for and obtaining funding to support this research, applying for and obtaining ethical approval, submitting ethical amendments, and overseeing data collection. He conducted the background research and literature review for this manuscript and was responsible for all aspects of manuscript writing. Prior to submitting the manuscript, he received editorial feedback from the study co-authors/co-investigators and other dissertation committee members. This manuscript was submitted to a journal in the field of pain research. Mr. Petter was responsible for making all edits and resubmitting the manuscript following the feedback from reviewers. The manuscript has been resubmitted and is currently in review. The current reference for the manuscript is:

Petter, M., Chambers, C. T., McGrath, P. J., & Dick, B. D. (2013) The role of trait mindfulness in the pain experience of adolescents. Manuscript in review.

## Abstract

Trait mindfulness appears to mitigate pain among adult clinical populations, and has a unique relationship with pain catastrophizing. However, little is understood about this phenomenon among adolescents. The association between trait mindfulness and pain in both real-world and experimental contexts was examined among a community sample of adolescents. Participants were 198 adolescents who completed measures of trait mindfulness, pain catastrophizing, and pain interference, as well as an interview on daily pain before undergoing an acute experimental pain task. Following the task they provided ratings of pain intensity and state catastrophizing during the task. Results showed that, in relation to daily pains, trait mindfulness was a significant and unique predictor of pain interference and this relationship was partially mediated by pain catastrophizing. Trait mindfulness also had an indirect relationship with experimental pain intensity and tolerance, which was mediated by catastrophizing during the pain task. These findings highlight the association between trait mindfulness and both daily and experimental pain and offer insight into how trait mindfulness may affect pain among youth. Findings are discussed in the context of current psychological models of pediatric pain and future avenues for research.

*Perspective:* This article highlights the association between trait mindfulness and pain variables among adolescents in both real world and experimental pain settings. These findings offer further evidence of the unique relationship between trait mindfulness and pain catastrophizing in impacting pain variables across pain contexts and populations.

*Keywords:* Mindfulness; Adolescents; Pain Interference; Pain Catastrophizing.



### **The Role of Trait Mindfulness in the Pain Experience of Adolescents**

Pain is a common occurrence among adolescents from the general population with approximately a third reporting recurrent pain (Stanford, Chambers, Biesanz, & Chen, 2008). A smaller percentage of these adolescents have pain that significantly interferes in their lives, and characteristics of the pain (i.e., intensity, frequency) alone do not adequately explain differences in impairment (Huguet & Miró, 2008). Clinicians and researchers have identified pain catastrophizing as an important variable in predicting adolescents' responses to pain in both acute and chronic contexts (Crombez et al., 2003; Vervoort et al., 2011). Pain catastrophizing, refers to the tendency to magnify the threat value of pain, to ruminate about pain, and to feel helpless in the face of pain (Crombez et al., 2003). Recently there has been a call for researchers in the field of pediatric pain to also consider the role that contextual cognitive behavioral variables play in the pain experience of youth (McCracken, 2011; McCracken, Gauntlett-Gilbert, & Vowles, 2007). Rather than focusing on the content of thoughts, these variables assess how an individual relates to distressing thoughts and emotions, and the influences they exert on behavior. Mindfulness is one variable within this framework that is associated with a number of pain outcomes in adult clinical populations (Cassidy, Atherton, Robertson, Walsh, & Gillett, 2012; Schütze, Rees, Preece, & Schütze, 2010), although this relationship has not been examined among youth. Mindfulness refers to a state of consciousness that involves attending to moment-to-moment experience in a nonjudgmental and accepting manner (Kabat-Zinn, 1996). This nonjudgmental awareness of experience appears to be at odds with the negative evaluations of painful sensations that characterize pain catastrophizing (Bishop et al., 2004), and some evidence suggests that pain catastrophizing may mediate

the relationship between mindfulness and other pain variables (Cassidy, et al., 2012). The purpose of this study was therefore to examine the relationship between trait mindfulness and pain variables across real-world and experimental pain settings, while also further investigating its unique relationship with pain catastrophizing.

Trait mindfulness refers to the tendency to be mindful in daily life. Importantly there are a number of interventions such as mindfulness-based stress reduction (MBSR; Kabat-Zinn, 1996), mindfulness-based cognitive therapy (MBCT; Segal, Williams, Teasdale, 2001), and acceptance and commitment therapy (ACT; Hayes, Strosahl, & Wilson, 1999), which are designed to improve physical and psychological outcomes (e.g., quality of life, adjustment to illness), with mindfulness being seen as an important mechanism of change to this end. Furthermore, modifications of these interventions have been developed specifically for youth (e.g., Biegel, Brown, Shapiro, & Schubert, 2009). Research suggests that trait mindfulness is enhanced through standard mindfulness-based interventions (Carmody & Baer, 2008). These interventions have a growing evidence-base for adult chronic pain populations (Chiesa & Serretti, 2011) and have been shown to provide benefit for individuals experiencing acute experimental pain (Kingston, Chadwick, Meron, & Skinner, 2007; Zeidan, Gordon, Merchant, & Goolkasian, 2010). Theoretical definitions of mindfulness that emphasize its non-judgmental focus on present moment experience, also point out that it appears antithetical to variables known to negatively impact the pain experience, such as pain-related catastrophizing, which involve secondary negative evaluations of current and past pain experience, as well as concerns regarding future pain (Bishop et al., 2004). Supporting this hypothesis, several studies have shown that among adults with chronic pain, trait mindfulness is associated

with decreased pain-related disability and has a unique relationship with cognitive reactions to pain such as catastrophizing (Schütze, Rees, Preece, & Schütze, 2010; Cassidy, et al., 2012). Furthermore, longitudinal research with adults has found evidence that reductions in catastrophizing may be the active mechanism that mediates the relationship between mindfulness and chronic pain outcomes (Cassidey et al., 2012). These findings have potentially important theoretical implications, as pain catastrophizing is a central variable in the fear-avoidance model of pain, which has recently been adapted for pediatric populations (Asmundson, Noel, Petter, & Parkerson, 2012). Specifically, this model predicts that catastrophic interpretations of pain lead to increases in pain-related fear and ultimately to increases in pain-related disability and interference. If increases in mindfulness are associated with decreases in catastrophizing, and ultimately decreases in pain-related interference, mindfulness may also warrant further attention in research examining the pediatric fear-avoidance model of pain.

Although there is increasing interest in the use of mindfulness-based interventions with pediatric populations (Thompson & Gauntlett-Gilbert, 2008), research examining the association between mindfulness and pain variables in adolescents is lacking. Research that has been conducted in pediatric community samples has found that trait mindfulness is associated with decreases in somatic complaints (Greco, Baer, & Smith, 2011) and that mindfulness-based interventions result in decreased somatic symptoms among adolescents with psychological disorders (Biegel et al., 2009). However, research with younger children (aged 10 – 14 years) that compared the effects of a brief mindfulness-based intervention to a distraction-based intervention for acute experimental pain did not

find evidence that trait mindfulness was related to pain responses (Petter, Chambers, & Chorney, 2013).

The current project was designed to extend this literature by examining the relationship of trait mindfulness to daily and acute experimental pain among community-recruited youth. Overall, it was hypothesized that increased levels of trait mindfulness would be associated with more positive outcomes related to day-to-day pain and that this relationship would be mediated by reductions in catastrophic thinking about pain. Specifically, given that mindfulness is characterized by a non-judgmental focus on the present moment, it was believed that adolescents who tend to be more mindful in daily life would be less likely to react to painful physical sensations in a catastrophic manner, and that because of these reductions in catastrophic reactions to pain, more mindful adolescents would experience less interference in their lives due to pain. It was therefore hypothesized that higher levels of mindfulness would be associated with decreased levels of day-to-day pain interference, and that this association would be mediated by reductions in pain catastrophizing.

In the acute experimental pain setting, it was once again believed that adolescents who tend to be more mindful would be less likely to interpret the physical sensations experienced during the task in a catastrophic fashion, and because of this reduction in catastrophic thoughts during the task, would report lower levels of subjective pain intensity, and would have increased tolerance of the task. It was therefore hypothesized that higher trait mindfulness would be associated with lower levels of experimental pain intensity and increases in pain tolerance, and that this relationship would be mediated by reductions in catastrophizing thoughts during the task.

## **Methods**

The data were collected as part of a larger study examining two distinct research questions. The purpose of the present article was to examine the association between trait mindfulness and self-reported daily and experimental pain variables. The primary purpose of this second manuscript was to examine the effect of a novel mindful-attention manipulation on experimental pain variables, although the manuscript also examined the relationship between state mindfulness and pain variables [Petter, McGrath, & Chambers, in review]. Methods presented below therefore contain details relevant to the present study only. Ethical approval for this study was obtained from the health centre research ethics board and all participants provided informed consent.

### **Participants**

Participants were adolescents recruited from the general community through advertisements in local schools, hospitals, doctors' offices, sports clubs, recreation centers, science camps, and other community services targeting adolescents, as well as advertisements in local online, print, radio, and television media. Additional efforts were made to recruit adolescents with meditation experience. With this goal in mind, a number of advertisements were placed at local Buddhist meditation centers, yoga studios, and through mailing lists to local Buddhist and non-secular meditation groups. Furthermore, a local private school, which incorporates regular meditation practice as part of its curriculum allowed its students to take part through the school.

Participants were excluded if they met any of the following criteria: (1) inability to follow instructions in English or read and write fluently in English; (2) significant uncorrected hearing or vision impairment; (3) diagnosis of attention-deficit/hyperactivity

disorder; (4) health-related medical condition that could be made worse by placing the hand in cold water (e.g., circulation disorders, heart problems, injuries to the arms or hands); or (5) having previously taken part in a study involving a cold pressor task. Participants with health conditions that are not made worse by placing the hand in cold water (e.g., asthma, chronic pain conditions) were allowed to take part.

Before being enrolled in the study, exclusionary criteria were assessed by a screening interview. No adolescents withdrew following enrolment in the study. One minor adverse event was reported with a participant feeling light-headed following participation in the cold pressor. However, these symptoms were transient and subsided quickly after the participant lay down and was offered a snack and drink. Due to this deviation from protocol this participant was removed from the final analysis. One more participant was also excluded due to a perceived inability to adequately understand the content of questionnaires and answer questions appropriately as noted by the researcher who was present during his/her participation.

Final analysis included 198 adolescents (132 females, 66 males) aged 13 to 18 years ( $M_{age} = 15.99$  years,  $SD = 1.89$ ), who were recruited from the community ( $n = 175$ ) or a local school ( $n = 23$ ). The majority of participants identified themselves as white ( $n = 172$ ), and reported that their parents were married ( $n = 131$ ).

## **Measures**

**Trait mindfulness.** The Child and Adolescent Mindfulness Measure (CAMM; Greco et al., 2011) is a 10-item questionnaire designed to measure mindfulness skills among children and adolescents. The CAMM contains items that reflect acting with present-moment awareness (e.g., “At school, I walk from class to class without noticing

what I'm doing") with an attitude of acceptance and non-judgment (e.g., "I think that some of my feelings are bad and I shouldn't have them"). Items are answered on a 5-point Likert scale with anchors of 0 – "Never True" and 4 – "Always True", which are then reverse scored. Scores range from 0-40 with higher scores indicating higher levels of trait mindfulness. This scale has been shown to be a valid measure of trait mindfulness in children and adolescents (Greco et al., 2011). In this sample the scale showed good internal consistency with  $\alpha = .846$ .

**Pain catastrophizing.** The child version of the Pain Catastrophizing Scale (PCS-C; Crombez et al., 2003) was used to measure trait levels of pain catastrophizing. This 13-item scale assesses the tendency to catastrophize about pain (e.g., "When I have pain, I feel I can't stand it anymore"). Items are answered on a 5-point Likert scale with anchors of 0 – "Not At All" and 4 – "Extremely". Scores range from 0-65 with higher scores indicating higher degrees of pain catastrophizing. The PCS-C is a valid and widely used measure in the field of pediatric pain (Crombez et al., 2003). In our sample this scale showed excellent internal consistency with  $\alpha = .904$ .

**Daily pain.** In order to assess daily pain, a structured interview was created for the purposes of this study. The interview focused on the most common pain the adolescent experienced over the previous three months. Initially, the interviewer briefly discussed any major life events (e.g., school activities, sports, holidays) that may have occurred three months prior to the interview in order to anchor the timeline for the participant. The interviewer then asked the participant to indicate any aches or pains they had over that time, providing relevant examples (e.g., headache, stomachache, tooth pain, muscle pain, back pain). The participant was asked to continue listing pains they had until

they had indicated all the pain they had experienced during that time. They were then asked to indicate which of these pains they had experienced the most often over the previous three months, and what the cause of that pain was. The rest of the interview then focused on this most common pain. Based on PedIMMPACT recommendations (McGrath et al., 2008), participants were asked to provide details on the length (i.e., how long they had been experiencing this type of pain), frequency (i.e., over the last three months how often they experienced this type of pain) and the typical intensity of their most common pain. Typical pain intensity scores were given on an 11-point numerical rating scale with anchors of 0 – “no pain” and 10 – “the worst possible pain”. Numerical rating scales are well validated in pediatric populations (von Baeyer et al., 2009). In addition, participants were asked whether they had taken any medication or missed any days of school because of their most common pain.

**Pain interference.** The National Institute of Health PROMIS Pediatric Pain Interference Scale Short Form 8a (PPPIS; Varni et al., 2010) was used to assess pain interference. The PPPIS is an 8-item measure of how much pain interferes with day-to-day functioning (e.g., “I had trouble doing schoolwork when I had pain”) over a 7-day recall period. Items are answered on a 5-point Likert scale with anchors of 0 – “Never” and 4 – “Almost Always”. Raw scores are then converted to T-scores with a population mean of 50 and a standard deviation of 10 using a standardized scoring template. T-scores range from 34 – 78 with higher scores reflecting higher levels of pain interference. The PPPIS has been normed in community populations using item-response theory (Varni et al., 2010). In this sample, the scale showed good internal consistency with  $\alpha = .870$ .



**Meditation experience.** In order to assess meditation experience, as part of the pain interview, participants were also asked to indicate whether they currently meditated, and if so, for how long they had been meditating, and how frequently they meditated. Specifically, participants were asked whether they had ever meditated before, and clarification was provided if they were unsure whether previous experiences would be considered meditation. If they indicated that they had meditated, participants were asked if they currently meditated at all, for how long they had been meditating, and how frequently they meditate.

**Experimental pain task.** The cold pressor is an ethically acceptable pain task for use with pediatric populations (Birnie, Noel, Chambers, von Baeyer, & Fernandez, 2011). The cold pressor involves having participants place their non-dominant hand up to the wrist in 5 °C water up to a maximum of 4 minutes. Based on recent recommendations for use of the cold pressor where tolerance is an outcome of interest (Birnie, Petter, Noel, Boerner, & Chambers, 2012), participants were not informed about the 4-minute ceiling. Prior to beginning the task, participants were instructed to leave their hand in the water for as long as they could, even if it was uncomfortable, but to remove it when it became too uncomfortable or hurt too much. The cold-pressor device used was a commercially available RU-200 Techne Dip Cooler controlled by a Techne TE-10D Liquid Temperature Bath Thermoregulator [Bibby Scientific Limited, Staffordshire, UK]. The device maintains a steady temperature and circulates water to prevent local warming around the participant's hand. The experimenter recorded pain tolerance as the time between when the participant first placed his/her hand in the water, until it was voluntarily withdrawn up to a maximum time of 4 minutes.

**Situational pain catastrophizing.** In order to assess catastrophizing during the experimental pain task, the Situational Catastrophizing Questionnaire (SCQ; Campbell et al., 2010) was used. The 6-item SCQ asks participants to indicate the types of thoughts and feelings they had during a pain procedure (e.g., “I thought that the pain might overwhelm me). Items are answered on a 5-point Likert scale with anchors of 0 – “Not at All” and 4 “All The Time”. Scores range from 0-24 with higher scores representing higher levels of catastrophizing. The SCQ has been shown to be more strongly associated with acute pain responses than trait measures of pain catastrophizing (Campbell et al., 2010). In this sample, the scale had good internal consistency with  $\alpha = .880$ .

**Experimental pain intensity.** A verbally administered 11-point numerical rating scale was used as the measure of pain intensity following the cold pressor. Participants were asked to rate their pain on a scale from 0 – 10 where “0” represents no pain, and “10” represents the worst pain possible. These types of numerical ratings scales are well validated for use with pediatric populations (von Baeyer et al., 2009).

### **Procedure**

After completing the initial screening interview and providing informed consent participants took part in the study either at a research centre at a tertiary care hospital, or at their school. As part of the study protocol, adolescents initially completed the measures of trait mindfulness (CAMM) and pain catastrophizing (PCS-C). Following completion of these measures, participants completed the day-to-day pain interview and the measure of pain interference (PPPIS). Next, participants completed the brief interview related to their meditation experience and then went to a separate room to complete the cold pressor task. During the cold pressor, participants were accompanied by an experimenter who

remained in the room, but seated behind the participant out of their sight to record pain tolerance times. Immediately after withdrawal of the limb from the water during the cold pressor task, or after reaching the 4-minute ceiling, participants reported their average pain intensity and completed the measure of situational catastrophizing (SCQ). They then received a \$20 honorarium if they took part at the research centre or had \$20 donated on their behalf to a fundraising event if they took part through their school.

## **Results**

### **Data Analysis**

Questionnaire data were initially checked for missing item responses. Overall, .001% of items were missing from the questionnaire data. A single imputation using the expectation maximization algorithm was therefore utilized to replace these missing items (Enders, 2001). Missing data were imputed using Missing Values Analysis within SPSS 20. To correct for the inclusion of multiple analyses in this study alpha was set to .01 for all outcomes.

First demographic pain information of the sample was analyzed. In order to describe the pain experience of our sample, we first used descriptive statistics based on the daily pain interview. To describe the meditation experience of the current sample, participants were categorized according to whether or not they currently regularly practiced meditation. Participants were considered to regularly practice if they were currently meditating at least once a week and had been meditating for at least a year. These criteria were selected as evidence suggests that extensive meditation practice may be necessary to see effects of mindfulness on pain responses (Grant & Rainville, 2009). One-way between-group ANOVA's for continuous variables and chi-square analyses for

categorical variables were conducted to examine differences between regular meditators and non-meditators.

In order to examine whether sex was related to any variables of interest and might need to be controlled in analyses, a series of independent samples *t*-tests were conducted comparing outcome measures between males and females. Because there were significant differences between the sexes on a number of variables, it was controlled for in analyses. Bivariate correlations between age and other variables were conducted. Because age was unrelated to any variables, it was not controlled for in future analyses.

To examine the association between trait mindfulness and day-to-day pain variables, bivariate correlations were calculated between all variables followed by a hierarchical regression model predicting pain interference after controlling for sex, typical pain intensity, and pain catastrophizing. Following this, a simple mediation model using PROCESS for SPSS (Hayes, 2013) was conducted to examine whether pain catastrophizing mediated the relationship between trait mindfulness and pain interference. A 95% bootstrap confidence interval for the indirect effect using 10,000 bootstrap samples was used. Sex and pain intensity were included as covariates.

To examine the association between trait mindfulness and experimental pain, a series of bivariate correlations were first conducted. A hierarchical linear regression model was then used to examine the impact of trait mindfulness on pain intensity. Following this, a mediation model using the approach previously outlined was conducted to examine the mediating effects of situational catastrophizing on the relationship between trait mindfulness and pain intensity after controlling for sex.

Finally, because the pain tolerance outcome was highly skewed (33.3% of the sample reached the 4 minute ceiling), the pain tolerance variable was dichotomized according to whether the participant reached ceiling (1) or removed their hand before the ceiling time (0). For descriptive statistics, chi square and logistic regression analyses were conducted. Hierarchical logistic regression analysis was then carried out in the same fashion as the linear regression models. Follow-up mediation analysis with PROCESS for SPSS was conducted using maximum likelihood logistic regression to examine whether the effects of trait mindfulness on pain tolerance were mediated by catastrophizing. A 95% bootstrap confidence interval for the indirect effect using 10,000 bootstrap samples was used to test for the indirect effect.

### **Results for Day-to-day Pains**

**Pain and Meditation Characteristics of Community-Recruited Sample.** In this sample, 81 participants (41%) reported a pain that occurred at least once a week, for a duration of three months, and was not muscle pain from regular physical activity. The most commonly reported pains were headache (32%), back pain (20%), muscle pain (18%), and stomachaches (12%). Only 1 participant reported having experienced no pain over the previous three months. In addition, 53% of participants reported having taken some form of pain medication in the previous three months, and 14% had missed school as a result of their pain during that time. Forty-eight participants (24%) reported that they currently had some form of meditation practice. Twenty-one participants (11%) meditated at least once a week, and had been doing so for at least one year, and were classified as regular meditators. A comparison between regular meditators and non-meditators showed no difference on age ( $F(1,197) = .01, p = .913$ ), trait mindfulness

( $F(1,197) = .83, p = .362$ ), typical pain intensity ( $F(1,197) = .10, p = .752$ ), pain catastrophizing ( $F(1,197) = .60, p = .439$ ) or pain interference ( $F(1,197) = .07, p = .789$ ). However, there were more females in the regular meditator group than males (females = 18, males = 3,  $\chi^2(1) = 3.83, p = .05$ ).

#### **Relationship between Participant Sex, Mindfulness, and Day-to-day Pain**

**Variables.** Females were found to have significantly lower scores on the measure of trait mindfulness (females,  $M = 22.49, SD = 6.98$ ; males,  $M = 25.21, SD = 6.98, t(196) = -2.62, p < .01$ ), and higher pain catastrophizing (females,  $M = 20.13, SD = 9.38$ ; males,  $M = 14.95, SD = 8.41, t(196) = 3.79, p < .001$ ) and pain-related interference (females,  $M = 51.84, SD = 5.58$ , males,  $M = 48.35, SD = 7.67, t(196) = 2.80, p < .01$ ), although there was no difference in typical pain intensity (females,  $M = 5.00, SD = 1.77$ ; males,  $M = 4.46, SD = 1.69, t(196) = 2.04, p = .043$ ).

#### **Bivariate Correlations between Age, Mindfulness, and Day-to-day Pain**

**Variables.** Table 3.1 shows the bivariate correlations between age, mindfulness, and day-to-day pain variables. Age was unrelated to any variables of interest. All relationships between mindfulness and day-to-day pain variables were significant and in predicted directions. Specifically, trait mindfulness was significantly negatively correlated with typical pain intensity, pain catastrophizing, and pain interference.

**Prediction of Day-to-day Pain Interference by Trait Mindfulness.** The results of the regression model predicting day-to-day pain interference by trait mindfulness, after controlling for earlier variables in the fear-avoidance model, are presented in Table 3.2. After controlling for the effects of sex, pain intensity, and pain catastrophizing, trait mindfulness remained a significant predictor of day-to-day pain interference accounting

for approximately 5% of the unique variance ( $\Delta R^2 = .053, p < .001$ ). Overall this model accounted for 34.6% of the variance in pain interference.

**Mediation Analysis of the Effects of Trait Mindfulness on Pain Interference, through Pain Catastrophizing.** After controlling for the effects of sex and pain intensity, results of the mediation analysis were partially consistent with predictions, as the total effect of trait mindfulness on pain interference was significant with a path coefficient of  $-.476 (SE = .07), p < .001$ , the direct effect of trait mindfulness on pain interference remained significant with a path coefficient of  $-.333 (SE = .08), p < .001$  and the indirect effect of trait mindfulness on pain interference through catastrophizing had a path coefficient of  $-.143 (Boot SE = .05) (95\% CI = -.27 \text{ to } -.04)$  indicating a significant effect. A Sobel test showed that the mediation path was significantly different from zero ( $z = -3.07, p < .01$ ).

### **Results for Experimental Pain Variables**

**Demographic Characteristic, Mindfulness and Experimental Pain.** Females and males did not differ significantly on situational catastrophizing during the pain task (females,  $M = 8.95, SD = 5.58$ ; males,  $M = 7.52, SD = 5.11$ ) ( $t(195) = 1.74, p = .083$ ) or average pain intensity (females,  $M = 6.17, SD = 1.69$ ; males,  $M = 5.75, SD = 1.96$ ) ( $t(196) = 1.56, p = .120$ ) or pain tolerance ( $\chi^2 = .920, p = .337$ ). Age was unrelated to situational catastrophizing ( $r = -.117, p = .101$ ), average pain intensity ( $r = -.074, p = .298$ ), or pain tolerance,  $\beta = .188 (SE = .084, Wald = 5.04 (df = 1), p = .025$ ). Bivariate correlations showed that trait mindfulness was significantly related to catastrophizing during the pain task ( $r = -.403, p < .001$ ) and pain intensity during the pain task ( $r = -.293,$

$p < .001$ ). Logistic regression showed that mindfulness was significantly related to pain tolerance,  $\beta = .073$  ( $SE = .024$ ), Wald = 9.49 (df = 1),  $p < .01$ .

Situational catastrophizing was also related to pain intensity ( $r = .492$ ,  $p < .001$ ), and predicted pain tolerance  $\beta = -.154$  ( $SE = .034$ ), Wald = 20.35 (df = 1),  $p < .001$ .

**Prediction of Experimental Pain Intensity by Trait Mindfulness.** The results of the regression model predicting experimental pain intensity by trait mindfulness are presented in Table 3.3. After controlling for the effects of sex and situational catastrophizing during the cold pressor task, trait mindfulness was not a significant predictor of pain experienced during the cold pressor accounting for less than 1% of the unique variance ( $\Delta R^2 = .009$ ,  $p = .124$ ).

**Mediation Analysis of the Effects of Trait Mindfulness on Experimental Pain Intensity Through Catastrophizing.** Given that trait mindfulness was no longer a significant predictor of experimental pain intensity after controlling for situational catastrophizing, a mediation model was tested. Results of this mediation analysis were consistent with predictions. The total effect of trait mindfulness on pain intensity was significant with a path coefficient of  $-.072$  ( $SE = .018$ ),  $p < .001$ , the direct effect of trait mindfulness on pain intensity was not significant with a path coefficient of  $-.027$  ( $SE = .018$ ),  $p = .124$ , and the indirect effect of trait mindfulness on pain intensity through catastrophizing had a path coefficient of  $-.045$  (Boot  $SE = .011$ ) (95% CI =  $-.068$  to  $-.026$ ) indicating a significant effect. A Sobel test showed that the mediation path was significantly different from zero ( $z = -4.36$ ,  $p < .001$ ). Results of this model can be found in Figure 3.1.



**Prediction of Experimental Pain Tolerance by Trait Mindfulness.** Next a hierarchical logistic regression model using trait mindfulness to predict the dichotomous pain tolerance outcome after controlling for sex, and situational catastrophizing during the cold pressor in Step 1 was conducted. Although the overall model was a significant predictor of pain tolerance outcome  $\chi^2(3) = 26.87, p < .001$ , Nagelkerke  $R^2 = .177$ , the addition of mindfulness in the final step of the analysis did not add significantly to the model  $\chi^2(1) = 2.13, p = .145$ . Of the final variables in the model, only situational catastrophizing uniquely contributed to the prediction of whether participants reached ceiling or not,  $\beta = -.137$  (SE = .039), Wald = 14.32 (df = 1),  $p < .001$ , whereas trait mindfulness did not,  $\beta = .037$  (SE = .026), Wald = 2.08 (df = 1),  $p = .149$ .

**Mediation of the Effects of Trait Mindfulness on Pain Tolerance Through Catastrophizing.** Given that trait mindfulness was no longer a significant predictor of experimental pain tolerance after controlling for situational catastrophizing, a mediation model was tested. Results of the mediation model indicated that, consistent with predictions, the total effect of trait mindfulness on pain tolerance was significant with a product coefficient of .072 (SE = .024),  $z = 2.99, p < .01$ , the direct effect of trait mindfulness on pain tolerance was not significant with a product coefficient of .038 (SE = .026),  $z = 1.44, p = .15$ , and the indirect effect through catastrophizing had a product coefficient of .042 (Boot SE = .015; 95% CI = .018 - .076) indicating a significant effect. A Sobel test revealed that the mediation path was significantly different from zero ( $z = 3.15, p < .01$ ).

## Discussion

The purpose of this study was to examine the association between trait mindfulness and day-to-day and acute experimental pain among adolescents. Based on research with adult populations, which has shown that individuals higher in trait mindfulness show more adaptive responses to clinical (McCracken et al., 2007; McCracken & Keough, 2009; Shütze et al., 2010) and experimental pain (Kingston et al., 2007; Zeidan et al., 2010), it was predicted that higher mindfulness would be associated with less negative reactions to pain across settings. It was further hypothesized that the relationship between mindfulness and pain variables would be mediated by reductions in pain catastrophizing. Results were largely consistent with these predictions. In regards to day-to-day pains, mindfulness was found to be a unique predictor of pain interference, accounting for approximately 5% of the unique variance in this variable, although the relationship between trait mindfulness and pain interference was only partially mediated by pain catastrophizing. In an experimental setting, mindfulness was found to have an indirect association with pain intensity and pain tolerance that was mediated by changes in pain catastrophizing, as hypothesized.

This is the first examination of the relationship between trait mindfulness and real world pain variables in the pediatric literature. These results indicate that mindfulness is negatively associated with typical pain intensity and negative cognitive reactions to pain, and that ultimately it is a unique and non-redundant predictor of how much pain interferes in the lives of youth in the general population. These results are consistent with previous research with adults, which have shown that mindfulness plays an important role in cognitive and behavioural reactions to daily pain (Cassidey et al., 2012;

McCracken et al., 2007; McCracken & Keough, 2009; Schütze et al., 2010). In addition to being the first examination of the effects of mindfulness on day-to-day pain in adolescents, this is also the first study to directly examine the relationship between trait mindfulness and pain in a community sample, as previous research in this field has largely focused on populations with long-standing chronic pain who present at tertiary care centers. This is an important extension of this field of research as mild levels of pain and pain-related interference are relatively common among adolescents, whereas chronic debilitating pain is much less common (Huguet & Miró, 2008). This study also adds to the field of research examining the relationship between mindfulness and physical and psychological wellbeing among adolescents that has shown that higher levels of trait mindfulness are associated with higher quality of life and lower levels of somatic complaints and negative affect in this age range (Greco et al., 2011).

This is also the first study with adolescents to demonstrate that mindfulness plays a potentially important role in acute experimental pain responses among youth, with similar results to those found for day-to-day pains. As hypothesized, adolescents who were more mindful had fewer catastrophic thoughts during the acute experimental pain task and because of this, ultimately experienced less pain and had higher pain tolerance. These findings build on several studies in the adult literature, which have shown that specific aspects of trait mindfulness are associated with reduced pain sensitivity during painful stimulation among experienced meditators (Grant & Rainville, 2009), and that trait mindfulness is associated with decreased anxiety and pain intensity among university students undergoing a brief mindfulness-based intervention (Zeidan et al., 2010). Only one other study in a pediatric population (aged 10 – 14 years) has examined

the impact of trait mindfulness on acute experimental pain responses, with no evidence that trait mindfulness was significantly associated with pain responses among children receiving brief attention-based interventions for acute pain (Petter et al., 2013).

The findings of this study further demonstrate the unique relationship that exists between trait mindfulness and pain catastrophizing in influencing pain variables across a variety of age ranges and settings. Given that pain catastrophizing was found to be a consistent mediator of the association between mindfulness and pain responses, it appears that reductions in catastrophic thoughts during painful events is one of the potential mechanisms whereby mindfulness may influence pain variables. This is consistent with theoretical work on the construct of mindfulness that argues that the ability to maintain focus on moment-to-moment experience should inhibit secondary elaborative processing of physical sensations (Bishop et al., 2004) and may buffer against catastrophic thoughts that are characterized by ruminating about pain, magnification of the threat value of pain, and feelings of helplessness to control pain (Crombez et al., 2003). These results are potentially important, as research with pediatric populations has shown that catastrophizing is a predictor of pain and distress during medical procedures (Vervoort et al., 2011), pain and disability among youth with chronic pain (Crombez et al., 2003), and prospectively predicts the development of chronic pain and disability in community samples (Vervoort, Eccleston, Goubert, Buysse, & Crombez, 2010). These findings may also have implications for pediatric psychological models of pain such as the fear-avoidance model, which has recently been adapted for use in pediatric populations (Asmundson et al., 2012). Specifically, this model predicts that in a sub-set of youth, maladaptive psychological responses to a painful event, such as catastrophizing, lead to

increases in pain-related anxiety and avoidance, which results in increases in pain-related interference and disability. Within this model, this study offers preliminary evidence that mindfulness may be thought of as an adaptive psychological response to pain that may lead to appropriate responses to painful events that result in limited interference and appropriate recovery. In this sense, adolescents higher in trait mindfulness may possess psychological resilience in regards to painful events.

Although mindfulness was found to have a significant association with both day-to-day pain variables as well experimental pain responses, there were important differences in these relationships. For day-to-day pains, mindfulness had a weak relationship with typical pain intensity, a strong relationship with pain catastrophizing, and a moderate relationship with pain interference (Cohen, 1988). It therefore appears that non-judgmental awareness of the present moment has a more profound impact on the way adolescents reacts to painful sensations, and the impact pain has on their life, than on the actual sensations of pain. In addition, mindfulness accounted for unique variance in pain interference above that accounted for by its relationship with pain catastrophizing, and was found to have a direct effect on pain interference in mediation analysis. It is therefore likely that mindfulness is associated with pain interference through multiple mechanisms including reductions in catastrophizing. For example, in addition to predicting lower levels of negative automatic thoughts, mindfulness has also been found to predict an increased ability to let go of negative thoughts when they occur (Frewen, Evans, Maraj, Dozois, & Partridge, 2008). Over time, this ability to let go of catastrophic thoughts may result in more mindful youth seeing them as less bothersome and intrusive, thus allowing them to continue to engage in meaningful behaviours (e.g., social activities,

school) with less interference. In the acute experimental pain context, mindfulness had a small to moderate association with pain intensity, and a moderate relationship with pain catastrophizing, once again, indicating that it has a stronger relationship with cognitive reactions to pain rather than pain sensations themselves. However, contrary to the findings with day-to-day pain interference (but consistent with predictions), trait mindfulness was not found to have a direct effect on pain intensity or pain tolerance, as the relationship between mindfulness and pain variables was mediated by reductions in state catastrophizing. In combining the findings across day-to-day and experimental settings, it appears that during acute episodes of pain, adolescents higher in trait mindfulness are less likely to respond to physical sensations of pain in a catastrophic fashion that may decrease subjective pain intensity and increase tolerance. Over time, as pain is encountered regularly in day-to-day situations youth who are more mindful, and catastrophize less about pain would therefore experience less interference in their life as a result of pain. However, it appears that the relationship between mindfulness and pain interference may be more complex than its relationship with acute pain responses and it may influence this variable through multiple mechanisms.

Given the relatively strong and consistent relationship between trait mindfulness and important pain variables, it is possible that interventions that increase trait mindfulness among adolescents could offer benefit for youth with pain. Encouragingly, previous research with adolescent psychiatric outpatients has demonstrated that trait mindfulness appears to be a modifiable variable in youth, and improvements in mindfulness are significantly related to reductions in somatic symptoms (Biegel et al., 2009; Brown, West, Loverich, & Biegel, 2011). It should be noted that more traditional

cognitive-behavioural pain management programs, which include a brief component of mindfulness training might also result in significant increases in trait mindfulness following program completion (Cassidey et al., 2012). However, the potential clinical implications of the current research should be interpreted cautiously given that this research was conducted with a community-based sample of adolescents and was largely cross-sectional in nature.

Although this study offers a number of unique insights into the influence of mindfulness on adolescent pain across a number of outcomes, there are several limitations that require consideration. The most obvious limitation of the current study is the cross-sectional design, which precludes making conclusions regarding the causal nature of the relationships being examined, especially among the day-to-day pain variables. Well-designed longitudinal research is needed to examine whether trait mindfulness is a prospective predictor of pain variables, and whether changes in trait mindfulness (e.g., as a result of intervention) result in the expected changes in pain-related variables, and furthermore whether these changes are mediated by pain catastrophizing. Secondly, the daily pain interview was developed exclusively for the purpose of this study, and relied upon retrospective recall data related to day-to-day pain, which may be influenced by recall biases. In particular, among pediatric populations, the use of retrospective measures may lead to inflated estimates of day-to-day pains (Van Den Brink, Bandell-Hoekstra, & Abu-Saad, 2001). In order to gain a more refined understanding of the relationship between mindfulness and day-to-day pain, future research should consider the use of real-time diary data to gain a more thorough understanding of how mindfulness impacts pain variables in real-time. Additionally, all

of our major outcome variables (with the exception of the pain tolerance measure) were based on a common method of reporting (self-report) which could have potentially influenced the correlations observed among variables. Future research in this field should consider multiple assessment methods including observer report and additional behavioral measures to help address this issue. Finally, it should be noted that the current study sample was predominantly White females recruited from the community and also included a unique population of young people likely to be more familiar with the concept of mindfulness due to their engagement in a personal meditation practice. Furthermore, the majority of youth with a regular meditation practice who took part in this study participated at their school, rather than at a research centre and it is unclear what effect this might have had on outcomes among this population. These results should therefore be interpreted cautiously, as the external validity to typical adolescents, as well as adolescents who present in clinical settings with chronic pain are not known.

In conclusion, among adolescents, trait mindfulness was found to be a strong predictor of a number of important outcomes related to both daily and experimental pain variables. Similar to findings in adult populations, mindfulness appears to have a unique relationship with pain catastrophizing, which was found to mediate many of the important relationships between mindfulness and pain variables. Taken together, these findings offer preliminary evidence that adolescents who are higher in trait mindfulness may be at decreased risk for more negative pain responses both in terms of day-to-day pains and responses to acute pain. This research highlights a need for further examination of mindfulness within psychological models of pain such as the pediatric fear-avoidance model. Further research examining the role of mindfulness-based interventions either on



their own or as part of a larger cognitive-behavioural protocol, in helping adolescents cope with pain also appear warranted.

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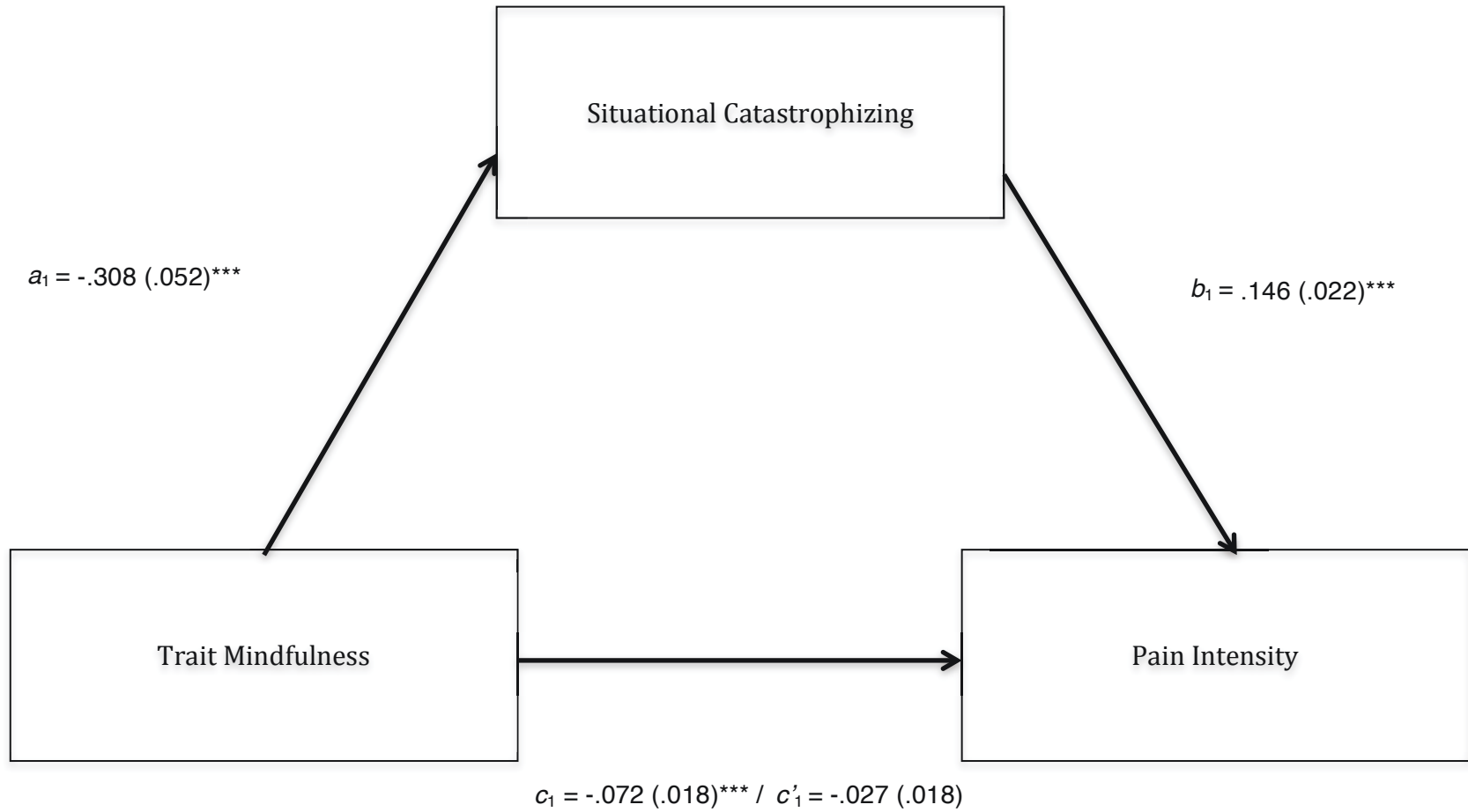
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**Figure 3.1.** Path coefficients for the mediation model of the total, direct, and indirect effects of trait mindfulness on pain intensity through situational catastrophizing. Standard errors are in parentheses.  $***p < .001$ .

**Table 3.1.** Bivariate correlations between age, mindfulness, and daily pain variables.

N = 198	Age	Trait Mindfulness (CAMM)	Typical Pain Intensity (NSR-11)	Pain Catastrophizing (PCSC)	Pain Interference (PPPIS)
Age	---				
Trait Mindfulness (CAMM)	-.078	---			
Typical Pain Intensity (NSR-11)	.017	-.198**	---		
Pain Catastrophizing (PCSC)	.068	-.546***	.238***	---	
Pain Interference (PPPIS)	.064	-.466***	.377***	.463***	---

Note. \*\* $p < .01$ . \*\*\* $p < .001$ .

**Table 3.2.** Regression model predicting day-to-day pain interference by trait mindfulness.

N = 198		$\beta$	$\Delta F$	$P=$	$\Delta R^2$	Cumulative $R^2$
Model 4 (Pain Interference)						
Step 1	Sex	-.196	7.82	<.01	.038	.038
Step 2	Pain Intensity, Pain Catastrophizing	.278 .382	34.90	<.001	.254	.293
Step 3	Trait Mindfulness	-.276	15.61	<.001	.053	.346

*Note.* The following measures were used: NSR-11 (pain intensity), CAMM (trait mindfulness), PCS-C (pain catastrophizing), PPPIS (pain interference). Beta weights ( $\beta$ ) are reported for each step along with their change in F-statistic ( $\Delta F$ ) and  $P$ -value. The change in variance at each step in the models is reported as  $\Delta R^2$  along with the cumulative variance.



**Table 3.3.** Regression models predicting experimental pain intensity from trait mindfulness.

N = 198		$\beta$	$\Delta F$	$P=$	$\Delta R^2$	Cumulative $R^2$
Model 3 (Pain During CP)						
Step 1	Sex	-.100	1.97	.162	.010	.010
Step 2	Catastrophizing	.487	60.02	<.001	.234	.244
Step 3	Trait Mindfulness	-.106	2.39	.124	.009	.253

*Note.* The following measures were used: CAMM (trait mindfulness), SCQ (pain catastrophizing during cold pressor), NSR-11 (pain during cold pressor). Beta weights ( $\beta$ ) are reported for each step along with their change in F-statistic ( $\Delta F$ ) and  $P$ -value. The change in variance at each step in the models is reported as  $\Delta R^2$  along with the cumulative variance.

## CHAPTER 4: DISCUSSION

### **Summary of Results**

This dissertation includes two complementary studies that examined the impact of a brief mindful attention manipulation on acute pain (Study 1), as well as the effects of trait mindfulness on both real world and experimental pain (Study 2) in a sample of adolescents recruited through the community. In the first study, an experimental pain task was used to investigate the effects of the mindful attention manipulation on state mindfulness, situational catastrophizing, pain intensity, and pain tolerance. To accomplish this goal, participants were randomly assigned to listen to instructions to practice mindful attention or to a no-manipulation control group (quiet reading) before completing a pain task. Following the pain task, adolescents completed measures assessing cognitive reactions to pain (situational catastrophizing), pain intensity, and pain tolerance. Results showed that although the mindful attention manipulation had the desired effect of bringing increased attention to thoughts regarding the pain task and decreased distraction during the task, it had no overall effect on pain outcomes. Secondary analyses showed that adolescents' meditation experience was a significant moderator of the effects of the manipulation. Specifically, adolescents with a regular meditation practice benefited from the manipulation, whereas those without a regular meditation practice did not. Contrary to predictions, trait catastrophizing at baseline was not a significant moderator of the effects of this intervention. Furthermore, irrespective of experimental condition, levels of state mindfulness measured immediately prior to the cold pressor task were a significant predictor of perceived pain intensity, and this relationship was mediated by lowered situational catastrophizing during the pain task.

The second study examined the relationship between trait mindfulness and both real world and experimental pain responses among the same sample of youth from Study 1. In this study, adolescents were asked to answer questionnaires assessing trait mindfulness and trait pain catastrophizing before completing an interview examining their most common pain over the previous three months as well as a measure assessing pain interference before completing the experimental pain task as outlined in Study 1. Results indicated that trait mindfulness was a significant predictor of both real world and experimental pain outcomes. Trait mindfulness was a unique and significant predictor of day-to-day pain interference such that adolescents higher in trait mindfulness had lower levels of pain interference, even after controlling for the effects of typical pain intensity and trait pain catastrophizing. Mediation analysis showed that the relationship between trait mindfulness and pain interference was only partially mediated by trait pain catastrophizing. Trait mindfulness was also a significant predictor of experimental pain responses, and this relationship was mediated by its relationship with situational catastrophizing during the pain task.

### **Mindful Attention for Acute Pain**

The primary goal of Study 1 was to examine the effects of a brief (10 minute) mindful attention manipulation on acute experimental pain among adolescents. Based on perceived similarities with other effective attention-based coping strategies such as sensory focus and acceptance-based interventions (Hayes, Bissett, et al., 1999; Keogh et al., 2005; Keogh & Mansoor, 2001; Masedo & Esteve, 2007; Piira et al., 2006; Roelofs et al., 2004), as well as promising results using a similar intervention with children (Petter et al., 2013), it was hypothesized that this manipulation would provide analgesic effects

relative to a no manipulation control condition. However, results did not support this hypothesis. Specifically, although the intervention had the desired effect of increasing attention to thoughts associated with the pain task and decreasing the use of distraction, overall, it did not result in changes in state mindfulness, situational catastrophizing, pain intensity, or pain tolerance.

There are several important differences between the current study and previous research in this field that may account for this discrepancy in results. First and foremost, the length of the manipulation used in the current study was only 10 minutes and no instruction was offered during the time participants actually had their hand in the cold water (the pain stimulus). Previous studies that have demonstrated beneficial effects of these types of manipulations in pediatric populations have all contained explicit instruction during the actual pain task. For example, in their study comparing mindfulness to distraction, Petter et al. (2013) used a similar mindful attention manipulation. However, children continued to receive instructions on how to attend mindfully during the pain task. In the study by Piira et al. (2006) that compared sensory focus and distraction-based imagery scripts, the researchers similarly provided instruction to maintain the sensory-focused imagery throughout the duration of the pain task. The rationale for not offering instruction during the cold pressor task in the current study was to ensure that any analgesic effects demonstrated were a result of youth attending mindfully to the pain stimulus and not due to the distraction of listening to instructions while engaged in the pain task. This is consistent with work in adult populations that has provided instructions prior to, but not during pain tasks (Hayes et al., 1999; Keogh et al., 2005; Keogh & Mansoor, 2001; Masedo & Esteve, 2007; Roelofs et al., 2004). Although

much of the appeal of attention-based manipulations is that they take little time to administer and do not require extensive training on the part of the person teaching or engaging in the manipulation, it may be that our intervention was too brief for adolescents to benefit. In particular, by increasing awareness of thoughts during the pain task without offering more lengthy opportunity for practice or ongoing instruction, our manipulation may have simply activated adolescents' previously existing cognitive schemas related to pain, without providing an extensive enough intervention to alter those schemas. Among youth with a history of meditation this manipulation may have cued a mindfulness schema characterized by more nonjudgmental and observational views of pain consistent with the manipulation instructions. However, among adolescents without a history of regular meditation the manipulation may have activated a typical pain-related schema characterized by negative and catastrophic thoughts about the pain. This interpretation would also potentially explain the significant increase in situational catastrophizing among youth without a regular meditation practice who received the mindful attention intervention. This ability to take a more objective stance with the content of thoughts has been termed "reperceiving" and is theorized to be one of the mechanisms whereby mindfulness has its impact (Shapiro et al., 2006). Importantly, it is believed that this shift in perspective is a developmental process that can be accelerated through mindfulness practice. Given that this ability to view the content of consciousness in a more decentered fashion may develop over time, it is possible that when first exposed to this shift in perspective, that more extensive instruction may be necessary. This may be especially important among youth, as many of the brain regions hypothesized to play an important role in this process during the pain experience are still

developing (Zeidan, Grant, Brown, McHaffle, & Coghill, 2012). This is consistent with standard mindfulness-based interventions that include extensive instruction early on, and progress to more independent practice later into the program (Kabat-Zinn, 1996).

### **Mindful Attention and Previous Meditation Experience**

Although our mindful attention manipulation did not show an overall effect on pain outcomes, secondary moderation analysis indicated that the effects of this intervention were moderated by adolescents' previous meditation experience. These findings are consistent with adult literature that has found that brief instruction-based manipulations were helpful for participants with extensive meditation practice, but not among meditative naïve individuals (Grant & Rainville, 2009). Among youth who meditated at least once a week, and had been doing so for at least a year, this manipulation had the desired effect of increasing state mindfulness, and decreasing situational catastrophizing and pain intensity during the pain task. This finding is consistent with the mindfulness theory that the practice of formal meditation helps to develop and refine the skill to attend mindfully (Bishop et al., 2004; Kabat-Zinn, 1996; Shapiro et al., 2006), which may be especially important when enduring aversive stimuli. It is hypothesized that although all human beings may have a basic innate capability to attend mindfully to the present moment, meditation practices provide the scaffolding for the development of this skill (Kabat-Zinn, 2003). In other words, although a meditation practice is not a prerequisite for an individual to attend mindfully to present moment experience, the act of meditating offers a platform to practice this skill on a consistent basis. This may be especially important when it comes to a shift in perspective towards the content of thoughts, as without a sustained practice it may be difficult to avoid

habitual patterns of thinking (Kabat-Zinn, 1996). There has been considerable debate in the mindfulness literature regarding how much meditation practice is necessary to see benefits from this type intervention. Research on mindfulness-based stress reduction interventions (which are typically 8-10 weeks in length) has shown that the more an individual practices mindfulness meditation, the more positive outcomes they appear to derive from the intervention (Carmody & Baer, 2008). However, other evidence suggests that there is no relationship between the length of the intervention itself and effect sizes (Carmody & Baer, 2009). One study examining a shortened mindfulness intervention found that three 20-minute sessions of mindfulness practice spread out over consecutive days resulted in decreases in distress and pain during an acute experimental pain task (Zeidan et al., 2010). A follow-up imaging study by the same research group which expanded training to four 20-minute sessions confirmed the analgesic effects of this shortened mindfulness meditation training and also found that this length of meditation practice was enough to alter the way that pain was perceived in the brain (Zeidan et al., 2011). Although both of these interventions are relatively brief compared to typical mindfulness-based interventions which last 8 weeks and include a daily meditation practice component, they are still much more intensive than the brief attention-based manipulation tested in the current study. It is therefore entirely possible that adolescents would be able to learn to use mindfulness meditation as a way to modulate pain if given the opportunity for more practice. However, without this opportunity it appears that this type of brief intervention may simply draw attention to the typically negative cognitive reactions that youth experience during acute pain experiences. It remains unclear what

minimum amount of practice, or extent of instruction, would be necessary to alter the typical thinking patterns during pain, and thus see analgesic effects among adolescents.

### **Mindful Attention and Pain Catastrophizing**

It was further hypothesized that the effects of the mindful attention manipulation would be moderated by participants' trait levels of pain catastrophizing. This hypothesis was based largely on previous research comparing attention-based manipulations that direct attention towards and away from a painful stimulus. Directing attention away from a painful stimulus (i.e., distraction) has been found to be an effective intervention for acute pain, with mild to moderate analgesic effects (Hanson, Gaud, Wathen, & Macmillan, 2008; Tanabe et al., 2002; Uman et al., 2008). However, distraction may be less effective, or may actually increase pain among individuals who interpret painful sensations in a threatening manner (Verhoeven et al., 2011). It has been theorized that this is may be because when pain is perceived as threatening it can place such a strong demand on attentional resources that attempting to shift attention to an alternative stimulus may be difficult or impossible, resulting in increases in stress and pain (Eccleston & Crombez, 1999). In these cases, some evidence with adults suggests that manipulations that direct attention towards pain in an adaptive manner may be more effective (Keogh & Mansoor, 2001; Roelofs et al., 2004). The current results do not support this hypothesis, as the mindful attention manipulation was not found to be more effective among youth who scored higher in pain catastrophizing. A closer examination of this research indicates that this moderating effect is not entirely consistent across different samples and manipulations. For example, Jackson et al. (2011) found that an acceptance-based manipulation was superior to distraction in improving pain tolerance.



However, counter to this hypothesis, follow-up analysis revealed that the acceptance manipulation was actually more effective when participants were given information indicating that the pain task was extremely safe (low threat), rather than information highlighting the dangers of the task (high threat). Other researchers have shown that the relative effects of attention-based manipulations may be moderated by the duration of the pain (Nouwen, Clouthier, Kappas, Warbrick, & Sheffield, 2006). In particular, sensory focus manipulations appeared to increase pain intensity initially, but resulted in decreases in pain intensity over time relative to distraction. Others studies have shown that distraction may only be beneficial for individuals high in pain catastrophizing if there is an incentive to engage in the distraction task (Verhoeven et al., 2010). Within the pediatric field, research has also shown that children's typical way of coping with pain may moderate the effects of distraction versus sensory-focused manipulations (Piira et al., 2006), although this finding is also inconsistent as other studies have found no interaction between baseline coping style and the effects of different attention-based interventions among children aged 10 to 14 years old (Petter et al., 2013). In summary, it appears that although baseline levels of pain catastrophizing may impact the effects of some attention-based manipulations, this finding is far from universal.

### **Trait Mindfulness and Day-to-day Pains**

The primary goal of Study 2 was to investigate the relationship between trait mindfulness and pain in both real world and experimental contexts among adolescents. Based on previous research that has shown that trait mindfulness is a significant predictor of important outcomes among adult chronic pain populations (McCracken et al., 2007; Schütze et al., 2010) and has a unique relationship with pain catastrophizing (Cassidy et

al., 2012; Schütze et al., 2010) it was predicted that trait mindfulness would be a significant predictor of pain interference, and that this relationship would be mediated by pain catastrophizing. Results supported both of these hypotheses as trait mindfulness was a significant and non-redundant predictor of pain interference and this relationship was partially mediated by pain catastrophizing. Specifically, adolescents who tend to be more mindful in their day-to-day lives had lower typical pain intensity, had fewer catastrophic thoughts about their pain, and ultimately experienced less interference in their daily lives as a result of pain. Although this is the first study in a pediatric population to directly examine the impact of trait mindfulness on pain outcomes, it is also in line with other studies that have found that increased mindfulness is generally associated with better outcomes in relation to both physical and mental health. In particular mindfulness has been found to predict somatic complaints, internalizing symptoms, and perceived stress in pediatric populations (Brown et al., 2011; Greco et al., 2011) all factors that are known to influence the pain experience. Additionally, this is the first study to examine the relationship between mindfulness and pain among a community sample rather than a clinical sample, which is important as the vast majority of adolescents (and adults) who regularly experience pain and pain-related interference do not have a degree of disability that would require they receive treatment in a specialty pain clinic. Overall, these findings provide further evidence that the relationship between mindfulness and pain may be valid among both clinical and non-clinical populations.

The finding that the relationship between mindfulness and pain interference was only partially mediated by pain catastrophizing indicates that mindfulness is also a unique and non-redundant predictor of pain outcomes in this population. So, although present

moment awareness with an attitude of nonjudgment is associated with decreased catastrophic thoughts about pain, it is also a predictor of pain interference over and above this association. Among the current sample, it appears that mindfulness may affect pain interference through multiple mechanisms, which may include reductions in pain catastrophizing. This makes sense from a theoretical standpoint as mindfulness is likely to be associated with numerous influences on pain-related interference. For example, trait mindfulness has been shown to predict lower levels of negative automatic thoughts (e.g., catastrophic thoughts) as well as an increased ability to let go of those thoughts when they occur (Frewen, Evans, Maraj, Dozois, & Partridge, 2008). In the context of pain, youth who are more mindful may therefore have a different quality of experience towards catastrophic thoughts, viewing them as less intrusive and less bothersome (Frewen et al., 2008). In this way, the frequency of these thoughts may not be the only mechanism whereby mindfulness and catastrophizing are related to pain. In addition, mindfulness has been found to be a predictor of increased task persistence (Evans, Baer, & Segerstrom, 2009). As this relates to pain, adolescents who are more mindful may be more likely to continue with important tasks even in the face of pain and catastrophic thoughts. Finally, youth who are higher in trait mindfulness also tend to have higher levels of positive affect and lowered negative affect as well as lower levels of perceived stress (Brown et al., 2011), all factors that may influence pain interference over and above pain catastrophizing.

### **Mindfulness and Acute Experimental Pain Responses**

In addition to examining the relationship between trait mindfulness and day-to-day pain, Study 2 also investigated the relationship between mindfulness and responses to

acute experimental pain. Once again, based on research that has shown that mindfulness has a unique relationship with pain catastrophizing (Cassidy et al., 2012; Schütze et al., 2010) in predicting pain outcomes, it was hypothesized that pain catastrophizing would mediate the relationship between mindfulness and pain outcomes. Results indicated that adolescents who are more mindful had fewer catastrophic thoughts during the pain task, and through this reduction in catastrophic thoughts, reported decreases in pain intensity and demonstrated increases in pain tolerance. This experimental finding therefore offers a potential explanation of how mindfulness may directly affect responses to acute pain. This finding is consistent with theoretical work that has stated that the self-regulation of attention on present moment experience should inhibit secondary elaborative processing of physical sensations, as awareness of these sensations enters the stream of consciousness (Bishop et al., 2004). In other words, individuals who are more mindful may attend more to the objective sensations associated with noxious stimuli rather than emotional reactions to those sensations that can increase the threat value of pain (Leventhal & Everhart, 1979). This finding is consistent with other empirical work outside of the field of pain that has shown that trait mindfulness is generally associated with reductions in negative automatic thoughts and the ability to let go of thoughts when they occur (Frewen et al., 2008). This ability to let go of negative thoughts may be particularly important in the context of experimental pain as attempts to suppress thoughts has been found to paradoxically increase pain (Sullivan, Rouse, Bishop, & Johnston, 1997).

It is also important to note the differences found in the relationship between mindfulness, catastrophizing, and pain across real world and acute experimental pain

contexts. Specifically, in the experimental pain task, reductions in catastrophic thinking appear to completely mediate the relationship between mindfulness and pain, providing preliminary evidence that this may be the mechanism of action whereby mindfulness affects acute pain responses. In the context of real world pain however, catastrophizing may be one of several potential mechanisms through which mindfulness affects pain outcomes.

Results from Study 1 examining the relationship between state mindfulness immediately prior to the pain task and pain outcomes were largely consistent with the findings regarding trait mindfulness. In particular, state mindfulness was shown to predict pain catastrophizing and pain intensity with the relationship between mindfulness and pain intensity mediated by reductions in catastrophic thinking. However, contrary to findings regarding trait mindfulness, state mindfulness was not found to have a relationship with pain tolerance. This discrepancy may be due to differences between the measurement tools used to assess trait and state mindfulness. The measure of trait mindfulness used in this study (The Child and Adolescent Mindfulness Measure; Greco et al., 2011) contains items that assess both the tendency to focus on moment-to-moment experience, as well as a nonjudgmental and accepting attitude towards that experience, whereas the measure of state mindfulness (The Mindful Awareness and Attention Scale – State Version; Brown, Ryan, & Creswell, 2007) contains items that only assess present moment awareness. It is possible that a focus on present moment experience may help reduce the physical sensation of pain, but that an attitude of nonjudgment towards this experience is necessary to alter behavioural reactions towards that experience when confronted with noxious stimuli.

## **Clinical Implications**

The results of these studies have potential clinical applications, and also point to the need for further research. In the context of acute experimental pain the mindful attention manipulation examined in Study 1 was ineffective in providing analgesic relief to youth without previous meditation experience. Results from the type of experimental pain used in these studies have been hypothesized to be most comparable to acute clinical pains that last several minutes to a few hours (e.g., procedural pain, postoperative pain) rather than visceral or chronic pain (von Baeyer et al., 2005). It appears that the use of this type of manipulation in acute clinical contexts would offer no benefit, and may actually increase catastrophic thoughts in these settings among adolescents who do not meditate regularly. However, among adolescents with a preexisting meditation practice they may be effective. It should be emphasized once again that these conclusions can only be drawn regarding brief (e.g., 10 minute) instruction-based manipulations that do not offer ongoing coaching during the actual painful period. Given that interventions that are administered over several days do appear to offer benefit for adults undergoing these types of pain (Zeidan et al., 2010; Zeidan et al., 2011), it is unclear if this would also be true among adolescents. The question remains what would be an adequate “dose” of mindfulness training in order to experience beneficial effects in this population, and this question would have to be balanced against the clinical utility of using the intervention in a health care setting. Specifically, much of the appeal of distraction and other attention-based manipulations is that they can be implemented with relatively little cost and time commitment on the part of the health care providers or patient, which is likely a major part of their appeal in the context of brief procedural pain. However, in cases where an

adolescent may be hospitalized for an extended period of time and exposed to a number of painful medical procedures (e.g., a burn victim who must undergo repeated dressing changes / physiotherapy) or who may experience more frequent somatic complaints, a more extensive intervention may be warranted. Further research to identify a minimum dose of mindfulness to offer analgesic effects in this setting would therefore be beneficial. However, there are a number of questions that remain in this regard. For example, researchers could examine whether ongoing coaching and reminders during painful stimulation is enough to help youth attend mindfully, or whether several training sessions spread out over a number of days is necessary for this to be effective. In addition, among adolescents with meditation experience, it would be of interest to know what treatment dose is necessary to cue the use of mindful attention.

Despite the lack of an effect for the mindful attention manipulation, the finding that trait and state levels of mindfulness were significantly associated with decreases in cognitive, somatosensory, and behavioural responses to pain in both real world and experimental settings is encouraging news for clinicians interested in the applications of standard mindfulness-based interventions for pain among youth. This may be especially be the case when considering previous findings that mindfulness interventions result in changes in trait mindfulness (Biegel et al., 2009) and that these changes in trait mindfulness are associated with improvements in psychological symptoms among a heterogeneous group of psychiatric outpatients (Brown et al., 2011). However, it should be emphasized once again that the current findings regarding this relationship were cross-sectional in nature and investigated in a community sample of adolescents. Further research is necessary to examine the effects of mindfulness programs on trait mindfulness

among youth with, or at the risk of developing, problems with pain. It should also be noted that there is evidence with adult chronic pain populations that standard cognitive-behavioural interventions that include a component of training in mindfulness may also enhance trait mindfulness and reduce pain related disability (Cassidy et al., 2012). It is therefore possible for clinicians utilizing cognitive-behavioural therapy interventions to increase trait mindfulness without making drastic changes to their programs through the addition of a mindfulness component.

### **Study Limitations**

The current study has a number of strengths. These include the use of an experimental paradigm, the investigation of the influence of mindfulness across contexts with multiple measures, and the inclusion of a unique population of adolescents with significant meditation practice. However, these strengths are balanced against several limitations that point to a need for future research. To begin with, this study relied largely on self-report measures to examine the nature of the relationship between mindfulness and pain. This was done given the internal and subjective nature of these variables, and recommendations for this method of assessment in the context of pain (McGrath et al., 2008). However, this presents several potential issues in terms of the interpretation of these results. To begin with, researchers have questioned whether these types of self-report measures are an adequate measure for seemingly abstract and complex construct as mindfulness (Grossman, 2011). Specifically, there is concern that individuals may have little insight into how mindful or mindless they are in their day-to-day lives, that these type of self-report measures may not be interpreted uniformly among individuals with and without meditation experience (Grossman, 2011). However, research has shown that



although these measures have their shortcomings, as is the case of all self-report questionnaires, they appear to be valid and reliable measures of mindfulness as they appear responsive to changes experienced by individuals undergoing mindfulness training, and appear to be the active mechanism whereby this training yields psychological benefits (Brown et al., 2011). A potentially important expansion of this research would therefore be to follow adolescents receiving training in mindfulness meditation in order to examine whether these types of behavioural indicators (e.g., frequency of meditation practice) of mindfulness also impact pain outcomes in adolescents. Additional pain measures such as behavioural coding of responses to pain and proxy report from other important informants such as parents may help further refine our understanding of these relationships and avoid response biases because of common methods of measurement.

Additionally, given that the current project was conducted with a group consisting mainly of White females recruited from the community, it is unknown whether the observed results are generalizable outside of that population. Furthermore, the results concerning the interaction between previous meditation experience and the mindful attention manipulation were examined within a unique group of adolescents who attend a private school that incorporates meditation into its daily curriculum, and underwent testing in their school setting rather than in the laboratory. This difference in study setting represents a potential confounding factor, and given the relative uniqueness of this population it is unclear whether these results would also be observed among other adolescent samples with meditation experience. Future research examining the influence of mindfulness among adolescents from more varied backgrounds will be necessary to

confirm this relationship. In addition, it will be necessary to conduct longitudinal research with treatment naïve adolescents with no previous history of meditation to examine whether the development of a mindfulness meditation practice leads to increases in trait mindfulness as have been shown in adults.

### **Concluding Remarks**

In summary, the two studies presented here provide evidence that a brief mindful attention manipulation offers little benefit to adolescents without meditation experience undergoing experimental pain, but may be helpful for youth with a regular meditation practice. Furthermore, it highlights the significant association between trait mindfulness and the somatosensory, cognitive, and behavioural aspects of the pain experience in both real world and experimental settings. This study makes an important contribution to the field of adolescent pain research. It is the first study to examine the use of a brief attention-based intervention that directs youth attention mindfully towards pain, and to examine the moderating role of pain catastrophizing and meditation experience in this regard. It is also the first study to examine the impact of trait mindfulness on the pain experience of a community sample of adolescents. The results of the two studies comprising this dissertation have also provided an answer for how mindfulness may protect adolescents against maladaptive responses to pain, as reductions in pain catastrophizing appear to be an important mediator of acute pain outcomes associated with mindfulness. These findings are promising for the inclusion of mindfulness-based components as part of longer-term interventions to help youth deal with acute and recurrent pains and point to a need for more research on this topic in adolescents.

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## Appendix A

Before you put your hand in the water, we are going to have you do an exercise designed to help you become aware of what you are experiencing moment-to-moment without judging or trying to change what is taking place. We call this type of awareness “mindful-attention”. This “mindful-attention” will involve observing your breath and body, while also noticing the thoughts and feelings that come up in your mind. When using “mindful-attention” we don’t want you to try and change anything that you are experiencing, but rather to accept things just as they are in this moment. Because this will be a new way of paying attention, you may experience thoughts and feelings differently than you have before. After practicing “mindful-attention”, we want you to try and use this type of awareness when you have your hand in the water.

The first part of this “mindful-attention” involves sitting in the proper position to help you bring your awareness to what is taking place moment by moment. We want you to sit away from the back of your chair, in a straight and upright posture with your feet touching the ground in front of you. Let your arms rest on your legs with your shoulders relaxed. The purpose of this part of the exercise is to sit in a dignified but relaxed posture like how a king or queen might sit. If you are comfortable doing so, you may close your eyes gently. Now I want you to take a moment to bring your awareness to how your whole body is feeling in this very moment. Take a second to notice the feelings in your head, down through your body, in your arms and legs. Notice the feeling of pressure where your body comes in contact with the chair, and where your feet are touching the floor. Take a second and just notice where you are at this very moment. How do you feel right now? Notice how your mind has a tendency to judge how you feel as being “good”

or being “bad”. Just notice this thought, gently let go of it, and bring your attention back to your body sitting here in your chair.

Now, I would like you to bring your focus and awareness to your breath. Just become aware of the fact that you are breathing, without trying to change your breath. You may notice that your chest and belly gently rise as you breathe in and gently fall as you breathe out. Feel the sensation of your breath moving throughout your body. Now, notice the feeling of the air as it comes in and out through the tip of your nose, or through your mouth. Simply feel your breath as it comes in, and feel your breath as it goes out. Can you hear your breath coming in and out of your body? Does the feeling of your breath at your nose or your mouth change from second to second? Sooner or later, you will become distracted from your breath by other thoughts or feelings. This is perfectly normal. When you notice that your attention has wandered away from your breath, just notice what thought or feeling has caught your attention and gently bring your focus back to your breath. Every time you notice that your mind has wandered away from your breath, congratulate yourself for noticing that you have become distracted, and gently bring your attention back to your breath.

Now I want you to gently bring your focus into the arm that you DON'T write with. Notice the feelings of each individual finger, and the space in between them. Notice the feeling of touch and pressure where your hand rests on your leg. Move your attention up through the palm and back of your hand, your wrist, your forearm, elbow and upper arm. Try not to judge what you are feeling in your arm as “good” or “bad”, simply notice what you are feeling as it happens moment-by-moment and accept that this is what you are feeling at this moment. When you pay attention this way, you may notice that the



feelings in your arm change from second to second. Once again, when you become aware that your attention has wandered away from the feelings in your arm, just notice what thought or feeling caught your attention, thank yourself for noticing that you were distracted, and gently bring your focus back to your arm. Now I want you to slowly bring your attention back to the room around you. You may take this time to stretch or move around for a few seconds **[pause]**. **At this point participants were instructed to complete the MAAS-S**

In about a minute, I am going to ask you to put your hand in the water up to your wrist as I demonstrated earlier. You are going to place your hand in the water with your palm open, and once it is in the water up to the wrist, I want you to try to move it as little as possible. Once your hand is in the water, I would like you to leave it there as long as you can, even if it becomes uncomfortable. You may remove your hand when it hurts too much to continue. While your hand is in the water, I want you to use the “*mindful-attention*” that you have just been practicing. Again I would like you to sit in an upright but relaxed posture, with your feet on the floor and your back straight. Take a second to notice your breath. Now bring your focus down into the hand that you are going to put in the water. While your hand is in the water, try to be aware of and accept all the feelings in your hand, without judging them as good or bad. Try to notice how the feelings in your hand change from moment to moment. If you notice at any time that during this task you become distracted, just notice what caught your attention and gently bring your focus back into your hand. In just a second I am going to ask you to put your hand in the water. Keeping your “*mindful-attention*” on this hand, you can put it in the water now **[start timing]**.