EXAMINING THE ROLE OF INTOLERANCE OF UNCERTAINTY IN THE
EXPERIENCE OF PAIN

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Isaac Hahn, candidate for the degree of Master of Arts in Clinical Psychology, has presented a thesis titled, *Examining the Role of Intolerance of Uncertainty in the Experience of Pain*, in an oral examination held on April 26, 2019. The following committee members have found the thesis acceptable in form and content, and that the candidate demonstrated satisfactory knowledge of the subject material.

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Abstract

The pain experience is impacted by physical, psychological, and social factors (Asmundson & Wright, 2004). Symptoms of anxiety and related disorders have been associated with varied pain syndromes, particularly chronic pain (i.e., pain lasting longer than 3 months [International Association for the Study of Pain, 1994]; Asmundson, Norton, & Vlaeyen, 2004a). Chronic pain models implicate pain-related fear and anxiety as leading to activity avoidance, impeded healing, and prolonged pain (Asmundson et al., 2004a; Vlaeyen & Linton, 2000). Indeed, researchers have focused on pain-related fear and anxiety, and anxiety sensitivity (AS) as key risk factors for chronic pain (Carleton & Asmundson, 2012). Contemporary research and theory has underscored intolerance of uncertainty (IU) as a key construct underlying anxiety and AS (Carleton, 2012; Hong & Cheung, 2015), implying a possible relationship with chronic pain (Carleton & Asmundson, 2012); nevertheless, little research has explored the role of IU in pain experiences. The present study examined IU and chronic pain experiences. Online participants \((n = 470)\) with chronic lower back pain (CLBP) or no history of chronic pain completed self-report measures of pain-related constructs online, as well as a behavioural task to assess response to risk and uncertainty. Participants’ responses on the behavioural task and self-report measures were compared to evaluate between-group differences based on the presence of CLBP. The degree of uncertainty participants report about their pain was considered as well. IU was associated with pain characteristics, such that participants with CLBP exhibited higher IU. Risk-taking behaviour did not differ between groups. The risk task used may have an ecological validity limitation with respect to pain. IU contributed unique variance to reported pain. Significant positive
correlations among IU, pain, AS, and pain-related anxiety were identified. The results have implications for understanding chronic pain, and for treatment research to explore whether mitigating uncertainty or IU may reduce pain and pain-related anxiety.
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Dedication

Dedicated to my parents.
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1.0 Introduction

Pain is a complex experience influenced by psychological, social, and physical factors (Asmundson, Norton, & Vlaeyen, 2004a; Vlaeyen & Linton, 2000). Anxiety is a key psychological factor in the pain experience (Asmundson et al., 2004a). Broadly defined, anxiety involves cognitions focused on possible negative outcomes, a negative emotional state, and physiological arousal (Barlow, 2000). Anxiety has consistently been implicated in the experience of pain (e.g., Asmundson & Carleton, 2008; Tang & Gibson, 2005; Vlaeyen & Linton, 2000). Intolerance of uncertainty (IU) may also play an important role in the cognitive processes underlying the pain experience; specifically, IU appears to be a key construct underlying anxiety (Carleton, 2012; 2016a) and therein potentially pain (Carleton & Asmundson, 2012). Researchers have provided initial evidence of IU as a relevant construct in the pain experience, demonstrating that IU is positively associated with subjective acute pain intensity, but not pain tolerance, in water immersion tasks (e.g., Helsen, Goubert, & Vlaeyen, 2013; Macatee et al., 2015). To date, the role of IU in chronic pain has not been extensively studied. The impact of IU on physical activity avoidance due to the possibility of experiencing pain in individuals with chronic pain also remains unclear. Pain and chronic pain are inherently uncertain; individuals with higher IU may find the uncertainties inherent in chronic pain (e.g., what pain means, when pain will occur, how long pain will persist) more distressing. IU may contribute to avoidance of physical activities when the outcome (i.e., whether pain or injury will occur) is uncertain. By examining underexplored anxiety-related factors, such as IU, in relation to uncertain risk and reward for individuals with chronic pain, the
The present study may provide new insights into pain processes and, therein, new avenues for treatment.

The present investigation was a cross-sectional, observational study designed to examine relationships between IU, pain, and factors implicated in models of chronic pain (e.g., pain-related anxiety). The present study was also designed to examine how individuals with chronic pain respond to situations involving uncertain risk. Responses on a behavioural risk task served as a proxy for measuring how individuals with and without chronic pain respond to perceived risk of pain. While such a behavioural task is necessarily an artificial representation of responses to risk in the real world, researchers have provided evidence that such tasks can be fairly accurate proxies for real-world behaviour (Lejuez et al., 2002). First, an overview of pain, chronic pain, and theoretical models of pain is provided. Second, specific anxiety-related constructs from the fear-avoidance model of chronic pain are discussed. Third, IU, as well as research on IU and pain, are described in detail. Fourth, the purpose, experimental procedure, rationale, and associated measurement tools for the present study are described. Fifth, the results, limitations, and implications of the present study are discussed.

1.1 Pain

Using an entirely biomechanical definition, pain refers to nociception, which is a neurobiological response to tissue damage or potential tissue damage (i.e., something that will cause tissue damage if not addressed; Loeser & Treede, 2008; Verma, Sheikh, & Ahmed, 2015). Afferent nociceptive signals create aversive sensations that facilitate adaptive behaviours (e.g., withdrawing your hand from a flame). Pain is therefore
adaptive, providing a cue for mitigating and avoiding tissue damage (Riva, Wesselmann, Wirth, Carter-Sowell, & Williams, 2014).

Different actions or forces (e.g., thermal change, electrical charge, physical pressure) may cause different pain sensations (e.g., ischemic pain and cold pain may be rated as more unpleasant than hot pain, even at similar subjective intensities; Rainville, Feine, Bushnell, & Duncan, 1992), which may be experienced differently depending on context (e.g., attentional factors, sensation location, intensity, interpretation of meaning; Bortsov et al., 2014; Ecclestone & Crombez, 1999; Jepma, Jones, & Wager, 2014; Tracy, Georgiou-Karistianis, Gibson, & Giummarra, 2016). The location of pain sensations and the types tissues involved also affect pain; for example, neuropathic, visceral, dermal, and muscular pain may not be perceived in the same way (Austin & Henderson, 2011; Rossi & Neubert, 2009; Toft Hansen & McMillan, 2010; Uematsu, Shibata, Miyauchi, & Mashimo, 2011).

In addition to physical experiences, pain involves psychological experiences (see Asmundson & Wright, 2004). The idea that nociception comprises most, if not all, of the pain experience was widely accepted in the past (e.g., Descartes, 1664; see for review Jackson, 2002); however, subsequent researchers argued that nociception represents only one component of the pain experience (e.g., Gatchel, Peng, Peters, Fuchs, & Turk, 2007). Contemporary theory posits pain as a broad term describing an unpleasant experience that encompasses a range of sensations, as well as associated emotions and cognitive processes (Melzack & Wall, 1965; Verma et al., 2015; Vlaeyen & Linton, 2000). Cognitive processes such as attention may also influence the pain experience by shifting sensation salience (Eccleston & Crombez, 1999). Attention then influences actions in
response to pain (e.g., escape behaviours). Pain can interrupt attention focused elsewhere, but such interruptions are typically moderated by sensation type, context, and individual differences (Eccleston & Crombez, 1999). In addition, as described below, several psychological factors (e.g., pain-related anxiety) are thought to be key in the development and maintenance of pain chronicity (Vlaeyen & Linton, 2000).

Pain is also influenced by social factors. Experiences with and avoidance of pain occur within the context of one’s social environment, which in turn may influence behaviours related to pain (Asmundson & Wright, 2004; Vlaeyen & Linton, 2000). Social support may play a complex role in pain chronicity and associated psychological distress (see for review López-Martínez, Esteve-Zarazaga, & Ramírez-Maestre, 2008). The pain experience is therefore a product of the summation and interaction of several processes, such as nociceptive mechanisms, emotional states, thoughts, and behaviours (Turk & Flor, 1999; Vlaeyen & Linton, 2000).

1.2 Chronic Pain

Chronic pain is differentiated from acute pain primarily based on duration. Researchers have suggested diverse time spans for defining chronicity (e.g., longer than six months; Potter & Jones, 1992). That said, the most consistent definition classifies pain persisting beyond three months as chronic pain (International Association for the Study of Pain, 1994). The societal impact of chronic pain, psychological issues associated with chronic pain, broad factors involved in the development of chronic pain, treatment approach, and treatment outcomes are discussed next. A review of influential models of chronic pain is provided before describing specific individual difference factors implicated in chronic pain development.
Chronic pain has been associated with substantial socioeconomic impact (Robinson & Vetter, 2009). Chronic lower back pain (CLBP) alone costs billions of dollars annually in direct health expenditures (Luo, Pietrobon, Sun, Liu, & Hey, 2004) and secondary losses (e.g., lost workplace productivity; McCarberg & Billington, 2006). Chronic pain leads to between 260 and 300 billion dollars in annual health care spending in the United States of America (Gaskin & Richard, 2012). The large expenditures reflect high chronic pain incidence rates, with estimates ranging from 8 to 60% across several Western nations (Phillips, 2003). In Canada, approximately 25% of the general population report currently experiencing chronic pain (Boulanger, Clark, Squire, Cui, & Horbay, 2007), with CLBP being a prominent condition (Townsend et al., 2005).

Pain without an identifiable cause is referred to as idiopathic pain. Chronic pain experiences associated with identifiable biological pathology are typically addressed with physical interventions (e.g., pharmaceutical or surgical interventions; Asmundson et al., 2014) that should ameliorate the pain experience (Waddell, 1987); however, there is substantial and longstanding evidence that pain nonetheless persists for some individuals even in the absence of identifiable biological pathology (i.e., idiopathic pain; see for review, Vlaeyen & Linton, 2012). Indeed, pain severity as a function of nociceptive activation is of primary importance for acute pain, but may be of secondary importance for chronic pain and disability (Leeuw et al., 2007). Beliefs about pain based on personal and observed experience, as well as intentional learning, appear to influence how individuals view and experience pain (Sullivan, Bishop, & Pivik, 1995; Sullivan et al., 2001; Turk & Rudy, 1992). Several dispositional factors, particularly anxiety-related factors, have also been implicated in the development and maintenance of chronic pain.
(see for review, Vlaeyen & Linton, 2012). Contemporary researchers agree that psychological and environmental factors, as well as biological factors, contribute to the pain experience being far more complex than nociception alone and influence the transition from acute to chronic pain (see for review Asmundson & Wright, 2004; Katz, Asmundson, McRae, & Halket, 2009; Katz & Seltzer, 2009; Vlaeyen & Linton, 2012).

For example, anxiety focused on possible future pain may contribute to behaviours that prolong pain (Asmundson, Gómez-Pérez, Richter, & Carleton, 2014).

Researchers have examined relationships among anxiety, anxiety-related constructs, and both acute (e.g., Helsen et al., 2013) and chronic pain (see Asmundson & Katz, 2009). Results indicate that persons with chronic pain are more likely to have clinically-significant difficulties with anxiety, depression, and increased risk for completed suicide relative to healthy controls (e.g., Asmundson & Katz, 2009; Kessler et al., 2005a; Kessler, Chiu, Demler, & Walters, 2005b; Lerman et al., 2015; Poole, White, Blake, Murphy, & Bramwell, 2009; Tang & Crane, 2006; Townsend et al., 2005).

Accordingly, the pain experience may contribute to psychopathological symptoms, the symptoms may be facilitating the pain experience, or the two may be mutually maintaining due to underlying vulnerability factors (Asmundson, Coons, Taylor, & Katz, 2002; Carleton & Asmundson, 2012; Lerman, Rudich, Brill, Shalev, & Shahar, 2015). Several models have been proposed to explain the process of pain, how pain becomes chronic, and the roles of psychological factors in the subjective experience of pain.

1.3 Models of Chronic Pain

1.3.1 Psychodynamic models of chronic pain. Psychodynamic theorists argued that pain is influenced by psychological factors even when not wholly proportional to
tissue damage (see for review Gatchel et al., 2007; Merskey & Spear, 1967).

Psychodynamic researchers proposed pain that does not appear to directly correspond with injury could be caused by psychological issues (i.e., hysteria or conversion) brought on by trauma (Atarodi, 2010; Freud & Breuer, 1893; Prokop, 1986). Fear and dissociated memories of trauma were posited to be paired with co-occurring nociceptive experiences, therein persisting as implicit memory and contributing to ongoing pain (Ruden, 2008; Freud & Breuer, 1893; Freud, 1920). Some researchers argue that elevations on the hysteria and conversion scales from the Minnesota Multiphasic Personality Inventory (Schiele, Baker, & Hathaway, 1943) in persons with chronic pain may indicate traumatic repression (Prokop, 1986); however, others suggest the same elevations indicate patients struggling to ensure their pain is noticed and taken seriously (e.g., Prokop, 1986; Waddell, Main, Morris, Di Paola, & Gray, 1984). Psychodynamic research and models underscored the inadequacy of biomedical models to fully explain pain processes (Engel, 1977). The lack of evidence for a clear and consistent relationship between injury and pain became increasingly apparent, but psychodynamic explanations were generally judged to be inadequate because suggestions that chronic pain is simply a manifestation of another distinct mental disorder were not supported in treatment research (e.g., Large, 1986).

1.3.2 Gate Control Theory. Early researchers suggested that pain without identifiable pathology was attributable to microtraumas (e.g., Erichsen, 1866a, 1866b) or traumatic neuroses (e.g., Oppenheim, 1889; Weisaeth & Eitinger, 1993). Similarly, during World War II there was substantial evidence of inconsistencies in pain reports from soldiers with objectively comparable injuries (Beecher, 1946). Accordingly,
researchers concluded there was no direct relationship between tissue damage and reported pain experience (Beecher, 1959a, 1959b), therein demanding neurobiological explanations beyond nociception. Gate Control Theory (Melzack & Wall, 1965) posited an explanation for the wide variations observed in pain experiences.

Gate Control Theory (Melzack & Wall, 1965) postulates that a series of biomechanical “gates” regulate the activation and intensity of pain transmissions to and from the central and peripheral nervous systems. Pain sensations result from summation and interaction of ascending nociceptive signals from the peripheral nervous system, as well as descending signals from the central nervous system. The theory posits that the central nervous system controls a gating mechanism in the substantia gelatinosa, a unit of neural cells that run along the spinal cord (Melzack & Wall, 1965). The gates are thought to open and close based, in part, on descending inputs from the brain that include thoughts, emotions, and attention, which helps explain the interactive relationship between psychological phenomena and nociception in the pain experience (Melzack & Katz, 2004; Melzack & Wall, 1965). Revisions to the original Gate Control Theory have further specified the presence of parallel pathways (e.g., cognitive-evaluative, affective-motivational, somatosensory; Melzack, 1990; Melzack, 2001; Melzack & Wall, 1994) collectively called the neuromatrix (Melzack, 1999; Melzack & Katz, 2004). The neuromatrix is a system of pain-related neurons in the brain, including the limbic system and thalamocortical regions, and develops according to genetic and environmental influences (Melzack, 1999). Neural impulses send signals to the brain and those signals may persist even after an injury has healed (Melzack, 1999). Therefore, the transition from acute to chronic pain involves the activity and interactions between the structures of
the neuromatrix. Pain will increase or be maintained if the neuromatrix gating system remains open.

Contemporary authors have reiterated the value of Gate Control Theory in providing a model of pain perception that incorporates external stimuli and nociceptive neurons, as well as individual internal experiences (Asmundson et al., 2014). Gate Control Theory allowed for a role of cognition and emotion in the pain experience, but gave relatively less attention to the impact of behaviours on pain. Subsequent researchers worked to identify behaviours that contributed to reducing or maintaining pain, and how behaviour affects biological processes, leading to models of pain involving learning, behaviour, and biopsychosocial elements (e.g., Fordyce, 1976; Turk, Meichenbaum, & Genest, 1983).

1.4 Biopsychosocial and Fear-Avoidance Models.

1.4.1 Learning and biobehavioural models of chronic pain. Learning theorists elaborated on the integration of psychological and social dimensions of the pain experience through the development of operant behavioural models (Fordyce, 1976; Fordyce et al., 1982). The models focused on the influence of reinforcement patterns on pain experiences. Pain and injury were considered aversive stimuli, and were thought to serve as positive punishment, facilitating avoidance that is initially adaptive (i.e., avoidance is negatively reinforced by reducing pain, promoting healing, and reducing the chance of re-injury). Avoidance becomes maladaptive when individuals do not re-engage in normal levels of activity as an injury heals, therein inhibiting healing and prolonging pain (Asmundson & Wright, 2004). Cognitive and behavioural components of pain have long been considered important factors in chronic pain (e.g., Turk et al., 1983). The most
critical diatheses were identified as individual propensities to automatically respond fearfully to pain. The learning and biobehavioural models received substantial research attention, but produced mixed results (Asmundson & Wright, 2004); nevertheless, such models formed the basis for later biopsychosocial and fear-avoidance models.

1.4.2 Biopsychosocial models. Biomedical models appear insufficient for explaining chronic pain and disability, as there are few if any objective physiological indicators for chronic pain (Leeuw et al., 2007). Increased reports of chronic pain and disability in the population exceed what can be accounted for by increases in physical trauma (Freburger et al., 2009; Waddell, 1987). Accordingly, psychological factors such as beliefs, perceptions, and patterns of reinforcement have all been implicated as critical for the pain experience (see for review Turk & Rudy, 1992). Negative experiences and thoughts surrounding pain contribute to avoidance behaviours, which maintain pain and inhibit healthy activity; avoidance behaviours are a potential target for treatment within a biopsychosocial conceptualization of pain (see for review Asmundson et al., 2014). Other societal- and behavioural-level factors may also contribute to increased chronic pain. For example, body weight may affect chronic pain (e.g., via increased pressure on muscles and joints), although the relationship is complex and involves other important social and lifestyle factors (Okifuji & Hare, 2015; Wright et al., 2010). Issues with medication for chronic pain and medication misuse by patients may also contribute to chronic pain (Kouyanou, Pither, & Wesseley, 1997).

Biopsychosocial models of pain describe how nociception, cognitions, behaviours, goals, and social environments (e.g., social support) collectively contribute to the pain experience (Asmundson et al., 2004a; Asmundson & Wright, 2004; Turk &
Okifuji, 2002; Vlaeyen & Linton, 2000). Several biopsychosocial models have received empirical support (see for reviews, Asmundson et al., 2004a; Asmundson & Wright, 2004), providing new avenues for managing and treating acute and chronic pain (Asmundson, Vlaeyen, & Crombez, 2004; Bailey, Carleton, Vlaeyen, & Asmundson, 2010). Fear-avoidance models are prominent biopsychosocial models (see Vlaeyen & Linton, 2012) and are detailed below.

1.4.3 Fear-avoidance models. The premise of the first fear-avoidance model of chronic pain was based on the potential for acute pain responses to significantly impact subsequent pain responses (Lethem, Slade, Troup, & Bentley, 1983). The model outlines two broad pain responses, confrontation of pain and avoidance of pain. People who believe pain is temporary are motivated to eliminate pain, engaging in healthy behaviours, such as a gradual return to activity. In contrast, people who fear pain may experience elevated pain perception and avoid physical activity, thereby inhibiting recovery (Lethem et al., 1983; Vlaeyen & Linton, 2000).

Subsequent fear-avoidance models of chronic pain included more detailed considerations of key psychological constructs (e.g., AS, pain-related fear, catastrophizing) and how dispositional factors and learning affect subsequent behaviour and pain (Asmundson, Norton, & Norton, 1999; Asmundson et al., 2004a; Vlaeyen & Linton, 2000, 2012). Fear-avoidance models of pain highlighted maladaptive cognitive processes and individual difference factors in the experience of pain, such as rumination, excessive focus on pain, and catastrophizing about pain (e.g., Sullivan, Stanish, Waite, Sullivan, & Tripp, 1998); however, the role of pain catastrophizing has since been reduced and the relationships between key variables are posited as reflexive (Bergbom et
al., 2012; Wideman et al., 2009; Wideman et al., 2011; Wideman et al., 2013). Fear and avoidance associated with potentially pain-inducing activities can reciprocally increase anxiety, prolong injury, and impair recovery (Asmundson et al., 1999; Asmundson et al., 2014; Asmundson & Wright, 2004; Vlaeyen & Linton, 2000). As fear of pain increases, so does the anticipation that pain will be aversive (Asmundson et al., 1999). Coupled with avoidance behaviours, pain-related fear and anxiety can have a stronger impact on the pain experience than nociception (Asmundson, Norton, & Allerdings, 1997; Asmundson et al., 1999; Crombez, Vlaeyen, Heuts, & Lysens, 1999).

Researchers continue to make successive evidence-based improvements on the fear-avoidance model to better explain pain-related behaviour (Crombez, Eccleston, Van Damme, Vlaeyen, & Karoly, 2012; Pincus, Vogel, Burton, Santos, & Field, 2006; Wideman, Adams, & Sullivan, 2009; Wideman et al., 2013). Figure 1 graphically summarizes the fear-avoidance models and highlights the central roles of fear and anxiety in producing ongoing pain or gradual recovery. Figure 2 graphically summarizes the fear-avoidance models in greater detail and highlights the role of pain perception, as well as fear and anxiety.

Fear, anxiety, and avoidance are influential to some extent in most forms of chronic pain (see Asmundson & Wright, 2004); nevertheless, certain syndromes are primarily accounted for by lasting physical pathology (e.g., diabetic neuropathy; Russell & Zilliox, 2014). Ameliorating neuropathic pain may not be possible with existing treatments. Accordingly, the present study is focused on CLBP, which can be particularly exacerbated and maintained by fear and avoidance (Asmundson & Wright, 2004).

Activity avoidance following an injury can initially be adaptive; however,
Figure 1. The fear-avoidance model of chronic pain (adapted from Leeuw et al., 2007). Based on the fear-avoidance model of Vlaeyen and Linton (2000) and the fear-anxiety-avoidance model of Asmundson et al. (2004a). Thank you to Springer for permission to reproduce the figure for the current thesis.
Figure 2. Fear-anxiety-avoidance model of chronic pain (Asmundson et al., 2004a). Solid lines represent direct links between variables. Dashed lines represent indirect feedback links between variables. Thank you to Oxford University Press for permission to reproduce the figure for the current thesis.
prescribing activity avoidance as a treatment approach for injury and chronic pain without encouraging a gradual return to activity may lead patients to maintain avoidance for longer than necessary (Bailey et al., 2010; Waddell, 1987). Contemporary fear-avoidance models emphasize fear, anxiety, and avoidance as key factors facilitating chronic pain and disability (Asmundson & Carleton, 2008; Asmundson & Wright, 2004; Asmundson et al., 2014; Leeuw et al., 2007; Vlaeyen & Linton, 2012). Fear is related to escape behaviours and anxiety is related to avoidance of future situations where pain is a possible outcome (Asmundson et al., 2004a). Maladaptive cognitive processes (e.g., ruminating) may influence interpretation and perceived consequences of physical sensations, including nociception (e.g., Asmundson & Wright, 2004; Drahovzal, Stewart, & Sullivan, 2006). When individuals flee perceived or expected pain, the fear, anxiety, and escape behaviours are reinforced, increasing the likelihood of continued avoidance (Abrams, Carleton, & Asmundson, 2007; Leeuw et al., 2007; Vlaeyen & Linton, 2012). Pain-related avoidance behaviours in response to pain-related fear and anxiety, therefore, are responses to perceived risk. Researchers have studied risk-taking in the context of acute pain, demonstrating that individuals with higher IU may avoid risk of pain (Macatee et al., 2015). There is evidence that individuals with CLBP perform more poorly on risk tasks when pain risk is not salient; but, how such individuals respond to chronic pain-related risk is unclear (Biagianti et al., 2012; Tamburin et al., 2014). Since chronic pain involves avoidance of perceived risk (Vlaeyen & Linton, 2012), examination of risk-taking behaviours in individuals with chronic pain may provide useful insight (e.g., Macatee et al., 2015).

1.5 Individual Difference Factors Involved in Pain
The contemporary fear-avoidance model is predicated on the influence of anxiety and behavioural avoidance on the pain experience (Asmundson et al., 2014). Anxiety is influenced by a variety of psychological factors that have been identified as important elements of the pain experience; for example, there is substantial evidence for relationships between pain, pain-related fear, pain-related anxiety, and AS (Asmundson et al., 2004a; Carleton & Asmundson, 2012; Carleton, Sharpe, & Asmundson, 2007b; Crombez et al., 1999; Elfving et al., 2007; Esteve & Camacho, 2008; Leeuw et al., 2007; Ocañez, McHugh, & Otto, 2010; Taylor et al., 2007; Vlaeyen & Linton, 2000, 2012). Each construct appears to play a distinct role in driving chronic pain (Asmundson et al., 2014; Asmundson & Katz, 2009).

1.5.1 Pain-Related Fear and Anxiety. The terms “pain-related fear” and “pain-related anxiety” have historically been used almost interchangeably (e.g., McCracken, Gross, Aikens, & Carnrike, 1996; Ochsner et al., 2006); however, contemporary researchers suggest disentangling pain-related fear and pain-related anxiety by paralleling Barlow’s (2000) distinction between fear and anxiety. Pain-related fear is specifically present-oriented, referring to a negative emotional reaction to immediate or imminent pain, whereas pain-related anxiety is future-oriented, focusing on concerns about potential pain and uncertain consequences of pain (e.g., Asmundson et al., 2014; Barlow, 2000; Carleton & Asmundson, 2012; Carleton & Asmundson, 2009; Leeuw et al., 2007; McCracken et al., 1992; McCracken & Dhingra, 2002). Pain-related fear may be experienced concurrently with pain produced by movements (e.g., bending causes pain and the individual fears that the pain indicates an injury and disability); in contrast, pain-related anxiety may be experienced in anticipation of bending because of the uncertain
potential experiences of pain, injury, and disability (Carleton & Asmundson, 2012; Helsen et al., 2013).

Pain-related fear and anxiety can both influence subjective pain intensity (Thibodeau, Welch, Katz, & Asmundson, 2013a), likely contributing to worsened pain, with greater levels of fear and anxiety. Both constructs are present in the general population (Asmundson & Wright, 2004), and appear to be normally distributed with a continuous latent structure (Abrams et al., 2007). Pain-related fear and anxiety both contribute to behaviours (e.g., escape, avoidance) and psychological responses (e.g., anxiety, depression) that can prolong pain (Asmundson et al., 2014). Evidence indicates that pain-related anxiety is elevated in individuals with anxiety disorders, implicating factors underlying general anxiety as also underlying pain-related anxiety (Carleton et al., 2009). Anxious individuals expect negative future events (Miranda & Mennin, 2007), and pain-related anxiety is correlated with expecting pain and negative consequences from pain (Turk & Okifuji, 2002). Taken together, pain-related fear and anxiety have been suggested as among the most important constructs for explaining how chronic musculoskeletal pain develops and is sustained (Carleton & Asmundson, 2012).

Classical conditioning, operant learning, and observational learning are influential in pain-related cognitions and behaviour. Pain-related fear and anxiety likely develop as a function of classical conditioning processes (De Peuter, Van Diest, Vansteenkoven, Van den Bergh, & Vlaeyen, 2011). Interoceptive information (e.g., rapid heart rate) may become a triggering pain cue when bodily sensations become paired with pain. Pairing non-nociceptive sensations with nociception and pain may contribute to developing fear of pain (i.e., bodily sensations become conditioned stimuli paired with the pain and an
associated fear response; De Peuter et al., 2011). Avoidance behaviours (e.g., avoiding activity or movement) are negatively reinforcing if they temporarily reduce or prevent worsening of pain (Fordyce, Shelton, & Dundore, 1982). Therefore, pain avoidance behaviour may persist via operant learning. Pain-related fear may also be acquired indirectly, via observational learning and secondary sources of information, facilitating pain-related anxiety in anticipation of future nociception (e.g., Helsen et al., 2013; Turk & Okifuji, 2002). For example, partners’ observed responses to pain may influence perceptions of pain in members of romantic dyads (see for review Leonard, Cano, & Johansen, 2006), suggesting attitudes and responses to pain are influenced by observed experiences of pain.

1.5.2 Anxiety Sensitivity. People typically experience physical sensations accompanying anxiety (e.g., increases in heart rate, sweating; Barlow, 2000) and those sensations can be perceived as unpleasant or even threatening (Taylor et al., 2007). AS refers to the dispositional tendency to believe that the bodily sensations of anxiety will have negative physical (e.g., illness), social (e.g., people thinking one is strange), or cognitive (e.g., being unable to shift focus away from anxious thoughts) consequences (Reiss, Peterson, Gursky, & McNally, 1986). Nociception is a bodily sensation, which suggests a potential relationship with AS (Greenberg & Burns, 2003); however, the extent and specific nature of the relationship between pain and AS remains debated (Carleton, Abrams, Asmundson, Antony, & McCabe, 2009; Greenberg & Burns, 2003; for a meta-analytic review see Ocañez et al., 2010).

AS appears critical to the self-perpetuating cycle of fear, anxiety, avoidance, and maladaptive pain-related behaviours (Asmundson, Abrams, & Collimore, 2008;
Asmundson & Norton, 1995; Asmundson et al., 1999; Muris et al., 2001; Ocañez et al., 2010). People high in AS may be more likely to experience pain-related fear and anxiety, interpreting pain as signalling a serious problem and engaging in more pain avoidance behaviours (Asmundson & Norton, 1995; Asmundson, Kuperos, & Norton, 1997a; Asmundson & Taylor, 1996; Ocañez et al., 2010). AS and fear of pain appear substantially interrelated (r = .65; Muris, Vlaeyen, & Meesters, 2001), but are considered independent constructs (Asmundson & Taylor, 1996). AS accounts for a significant proportion of the variance in pain anxiety symptoms beyond the variance accounted for by fear of pain (Muris et al., 2001). In addition, AS correlates with perceptions of pain as threatening, facilitating avoidance behaviours (Asmundson, Norton, & Allerdings, 1997). Individuals with high AS appear to attend more closely to pain than people with low AS (Asmundson et al., 1997b). During pain experiences, AS appears to facilitate selective attention for physical sensations, including nociception (Asmundson, Kuperos, & Norton, 1997; Asmundson & Wright, 2004; Leeuw et al., 2007). Paying too much attention (i.e., hypervigilance) to pain sensations is associated with more severe reported pain (Goubert, Crombez, & Van Damme, 2004); however, there is no evidence that AS correlates with nociceptive sensitivity – how strongly pain is felt (Esteve & Camacho, 2008; Keogh & Birkby, 1999; Keogh et al., 2006).

The relationship between AS and fear of pain may involve a focus on physical sensations; but, the physical sensations may become threatening only as a function of perceived uncertainty (Carleton, 2016a, 2016b; Carleton et al., 2007b). Indeed, the inherently uncertain nature of anxiety-related symptoms (e.g., without sufficient certainty, heart palpitations may be reasonably interpreted as potential precursors to pain
or death) supports an interaction between tolerating uncertainty and AS levels (Carleton et al., 2007b; Carleton et al., 2014b), and therein pain-related avoidance behaviours (Asmundson, Norton, & Allerdings, 1997; Asmundson & Taylor, 1996; Carleton & Asmundson, 2012). Measuring both IU and AS in chronic pain research is, therefore, well founded.

1.6 Intolerance of Uncertainty

IU has received considerable research attention in the context of anxiety (e.g., Carleton, 2012; 2016a; 2016b; Hong & Cheung, 2015). Accordingly, the potential role of IU as a broadly influential, transdiagnostic factor involved in psychological disorders is discussed herein. The theoretical background of the IU construct, as well as its relevance to anxiety and uncertainty is reviewed. A review of recent pain research incorporating IU is provided, as well as relationships between IU and key components of the fear-avoidance model.

Definitions of IU have varied over the past several decades (see for review Carleton, 2012); nevertheless, the IU construct was recently defined as “an individual’s dispositional incapacity to endure the aversive response triggered by the perceived absence of salient, key, or sufficient information, and sustained by the associated perception of uncertainty” (Carleton, 2016a, p. 31). IU involves an anxious response to uncertainty (Dugas, Schwartz, & Francis, 2004). Contemporary models conceptualise IU in two dimensions: prospective and inhibitory (Carleton et al., 2012; Hong & Lee, 2015; Mahoney & McEvoy, 2011). Inhibitory IU involves behavioural inhibition (e.g., feeling paralyzed by doubt due to active situational uncertainty). Prospective IU involves uncertainty about the future and associated distress (e.g., feeling distressed by unexpected
events; Carleton et al., 2012). The two theorised dimensions have received strong psychometric support (Carleton, Norton, & Asmundson, 2007a; Hong & Lee, 2015).

Early researchers suggested IU influenced the development and persistence of anxiety, and was specifically and causally related to generalized anxiety disorder (e.g., Dugas, Gagnon, Ladouceur, & Freeston, 1998). Subsequently, consensus grew regarding the potential transdiagnostic influence and utility of IU (Carleton, 2012; 2016a; 2016b; Einstein, 2014; Gentes & Ruscio, 2011; Holaway et al., 2006; Hong & Cheung, 2015). Evidence from clinical and non-clinical populations indicates IU may influence a range of different clinical presentations. IU is elevated in panic (Carleton et al., 2012), generalized anxiety disorder (Carleton et al., 2012; Gentes & Ruscio, 2011), obsessive compulsive disorder (Carleton et al., 2012; Gentes & Ruscio, 2011; Sarawgi, Oglesby & Cougle, 2013; Steketee, Frost, & Cohen, 1998), and major depressive disorder (Carleton et al., 2012; Gentes & Ruscio, 2011). IU scores across clinical, community, and undergraduate samples generally occur on a normal distribution within sample groups, with higher means in clinical samples (Carleton et al., 2012). The mechanisms of influence for IU on different disorders is not yet entirely clear (Carleton, 2016a; Clark, 2002; Shihata et al., 2016); however, meta-analytic evidence indicates that IU may be a particularly relevant vulnerability factor for the anxiety disorders (Hong & Cheung, 2015).

Recent research suggests distinguishing between trait IU and situation-specific IU (IU-SS) may be useful (Mahoney & McEvoy, 2012a). IU-SS may be more strongly related than trait IU to symptom level in specific disorders (e.g., anxiety, depression; Mahoney & McEvoy, 2012a). IU-SS focused on uncertainty related to presenting
problems (e.g., pain and injury), as opposed to trait IU, could therefore be particularly relevant for individuals with chronic pain as well. Such a suggestion is speculative at the current time. To the author’s knowledge, IU-SS has not yet been applied to chronic pain.

Contemporary researchers have emphasized the need for further study of the role of IU in specific disorders and the clinical utility of IU-based interventions (e.g., Carleton, 2016a; Gentes & Ruscio, 2011; Thibodeau, Carleton, Gómez-Pérez, & Asmundson, 2013b). Identifying constructs like IU that underlie multiple disorders helps to clarify theory and inform clinical practice (e.g., through transdiagnostic approaches; Barlow et al., 2011). Methodological overlap between clinical treatment manuals is common and differences between manualized techniques are often small (Wilamowska et al., 2010). Comorbidity (e.g., with CLBP, anxiety, depression) is common (Kessler et al., 2005b), and transdiagnostic treatments may offer a practical solution for individuals with multiple disorders, including CLBP (Barlow et al., 2011).

Pain experiences involve uncertainty (Carleton & Asmundson, 2012); for example, movement of a limb after a musculoskeletal injury may produce pain, but a recovering patient will often not know whether pain will occur until movement is attempted. There is also uncertainty with respect to the cause of pain because chronic pain is often idiopathic (Diatchenko, Nackley, Slade, Fillingim, & Maixner, 2006). The substantial evidence that IU facilitates anxiety in uncertain contexts (Carleton, 2016a) suggests that IU would also facilitate pain-related anxiety (Carleton & Asmundson, 2012). Pain-related anxiety already plays an important role in contemporary fear-avoidance models for pain (Asmundson et al., 2014), and some researchers have postulated that IU may be critical in fear and avoidance of pain (e.g., Carleton, 2016b;
Overall, IU may serve as a critical underlying factor for AS (Carleton, Sharp, & Asmundson, 2007), which may in turn underlie pain-related anxiety (Greenberg & Burns, 2003), and all of which may contribute to the development and maintenance of chronic pain (Asmundson, Coons, Taylor, & Katz, 2002; Carleton, 2016b; Carleton & Asmundson, 2012). Individual differences in IU may therein represent an influential component of the pain experience (Asmundson & Carleton, 2008; Carleton & Asmundson, 2012).

Few experimental studies have measured IU or uncertainty in the context of acute or chronic pain. In a study examining the effect of perceived certainty of risk (i.e., possibility of future pain) on physiological arousal during pain (Epstein & Roupenian, 1970), participants were told the probability of experiencing an electric shock was 5%, 50%, or 95%. Each group received one shock-free trial followed by a trial where everyone received a shock (i.e., no differences in stimuli between groups; Epstein & Roupenian, 1970). Stimuli were intended to be “very unpleasant, but not painful” (Epstein & Roupenian, 1970, p.21); nevertheless, reports of pain severity were not collected after establishing an appropriate stimulus intensity for participants. Mismatches between expectation and outcome (e.g., experiencing a shock after being told the chance of shock was only 5%) led to increased anticipatory anxiety in participants (Epstein & Roupenian, 1970). The results suggested that uncertainty provoked anxiety and distress, a notion supported by subsequent research (see for review Carleton, 2016a, 2016b); however, providing participants with a specific probability regarding pain may have increased certainty by creating a fixed expectation.
Researchers extended previous experimental results (e.g., Epstein & Roupenian, 1970) by demonstrating the relevance of IU in pain experiences with a warm water immersion task (Helsen et al., 2013). Facial expression videos depicting pain or neutrality were paired with either videos depicting models’ hands immersed in coloured water contained in open tanks, or with closed tanks without hand immersion. Different colours of water were consistently paired with pained or neutral expressions. Tank condition (i.e., open or closed) became associated with pain or no pain, leading participants to develop pain-related fear focused on a particular tank. Results of the study demonstrated that IU and fear of pain moderated perceptions of threat; specifically, higher IU was associated with greater pain-related fear, as well as perceived pain unpleasantness, intensity, and harmfulness (Helsen et al., 2013). Avoidance was also higher when observed facial expressions depicted pain. The study results were interpreted as providing evidence that IU influences pain-related fear as well as the perception of thermal stimuli (Helsen et al., 2013).

Unpredictable dermal and visceral pain induction studies have provided further evidence that IU may increase pain-related anxiety and perceived pain intensity. For example, researchers have varied predictability in pairing visual cues with visceral pain stimuli in classical conditioning paradigms (Labrenz et al., 2016; Meulders, Vansteenkoven, & Vlaeyen, 2012). The researchers presented images of rectangles or circles that reliably signalled either no pain or the onset of pain for one group, or were unreliable signals for a second group (Labrenz et al., 2016). The results indicated self-reported pain perception was higher in the unpredictable condition. The increased pain perception in the uncertainty condition was underscored by higher neural activation in
pain regulation centres, relative to neural activation in the certain condition, measured using functional magnetic resonance imaging.

Pain induction paradigms provide evidence for a role of uncertainty in pain responses; however, the relationship between stimulus unpredictability, physiological response, and the subjective experience of pain is unclear. In one study, proprioceptive cues were paired with electrical dermal pain stimuli following a classical conditioning paradigm (Meulders et al., 2012). Painful stimuli were applied, either predictably or not, in response to participants moving an analog stick as part of a decision-making task. Study participants with higher pain-related anxiety reported higher pain intensity, particularly when the painful stimuli were unpredictable. A replication study extended the results to demonstrate pain-related fear was learned faster when pain stimuli were unpredictable (Meulders & Vlaeyen, 2013). There has been contrasting evidence from research using randomly administered pain stimuli to reduce subjective pain intensity (e.g., Quelhas Martins, McIntyre, & Ring, 2015). Reducing subjective pain by exposing individuals to unpredictable pain may parallel the effects of exposure therapy for chronic pain (e.g., Vlaeyen, de Jong, Geilen, Heuts, & van Breukelen, 2002). The relationship between pain-related fear and the unpredictability of pain is, therefore, not entirely clear.

Researchers have measured IU and related traits alongside other constructs involved in pain (e.g., Epstein & Roupenian, 1970; Helsen et al., 2013; Macatee et al., 2015), and some have manipulated certainty during pain anticipation (Seidel et al., 2015). To date, researchers studying IU and pain have not examined IU and related traits in samples with distinct, pre-existing pain syndromes. Researching acute pain can facilitate inferences regarding chronic pain (e.g., Helsen et al., 2013); nevertheless, the role of
psychological factors in chronic pain may be best understood by investigating relevant constructs and behaviours in individuals with chronic pain (e.g., via measures of pain-related anxiety, avoidance behaviours; Asmundson & Wright, 2004; Vlaeyen & Linton, 2000, 2012). Induced acute pain may not allow for potential reciprocal relationships between IU and pain to develop, nor reflect the uncertainty involved in ongoing chronic pain; moreover, the clinical applications of pain research in psychology are typically focused on ameliorating chronic pain, as psychological interventions for acute pain that resolves without treatment may be less necessary. By examining IU and related traits in the context of a behavioural risk task among participants with and without CLBP, the present study will help to clarify the relationships among IU, pain, and anxiety. Doing so may inform research on improved psychological treatment for individuals with existing chronic pain.

1.7 The Potential Role of Uncertainty in Pain

The relationship between uncertainty and the pain experience remains unclear, and little is known about the potential role of IU in pain experiences and syndromes (see for review Carleton, 2016a). IU appears influential across a range of disorders (Carleton et al., 2012) and may be important in the pain experience (Carleton & Asmundson, 2012). Despite evidence of the association between IU and several components of anxiety that are related to pain (e.g., Hong & Cheung, 2015), as well as suggestions that IU and pain are related (Carleton, 2016b; Carleton & Asmundson, 2009), limited research has explored the roles of uncertainty and IU in pain experiences for individuals who experience chronic pain. In chronic pain, the meaning, occurrence, and consequences of pain may be uncertain (Crombez et al., 1996; Carleton & Asmundson, 2012; Vlaeyen &
Linton, 2012). Therefore, greater IU, coupled with the uncertainties inherent in CLBP (e.g., not knowing whether or to what extent physical activity may lead to pain or other negative consequences), may promote behavioural avoidance and continued maintenance of chronic pain. Perceived risk of incurring negative consequences through physical activity, along with the subjective acceptability of risk, ought to relate to IU. Key components of the fear-avoidance model (i.e., AS and pain-related anxiety) are thought to influence chronic pain through contributions to behaviour (i.e., avoidance), not simply by amplifying subjective pain. In the same way, IU is expected to influence maintaining behaviours (i.e., activity avoidance) as well as the subjective intensity of and distress associated with pain. Assessing whether differences in IU exist between individuals with CLBP and individuals with no history of chronic pain, as well as whether IU predicts pain-related avoidance behaviours, is a critical first step.

2.0 Purpose and Hypotheses

The present study was designed to examine relationships between IU and chronic pain, as well as differences in behavioural responses to uncertainty between individuals with and without CLBP. Accordingly, the present study included participants reporting chronic lower back pain, as well as control participants reporting no history of chronic pain and no ongoing acute pain. Participants completed a series of self-report measures assessing trait IU, pain-related anxiety, IU-SS, and pain characteristics, as well as questions on subjective certainty regarding the occurrence of pain (Carleton, 2016a). Additionally, participants completed a behavioural task involving uncertainty and risk that explicitly refers to activities that may lead to pain. In the present context, subjective
certainty regarding the occurrence of pain was assessed via self-report (see Appendix A; Carleton, 2016a).

2.0.1 Hypothesis 1. Previous studies have demonstrated associations between IU, AS, and pain-related anxiety. Fear of pain has been correlated with IU in a sample undergoing induced acute pain; but, fewer studies have examined the aforementioned constructs in individuals with chronic pain (Helsen et al., 2013). With acute pain, individuals are more likely to experience certainty because of an identifiable mechanism and perhaps a perception that pain will be time-limited. With chronic pain, the cause and expected length of time for pain is less certain. Individuals with chronic pain regularly engage with pain-related uncertainty. Therefore, the first hypothesis is that IU will be positively correlated with self-reported AS, uncertainty regarding pain, unpredictability regarding pain, pain-related anxiety, and disability (Carleton, 2012, 2016a, 2016b; Carleton et al., 2007; Carleton et al., 2012; Gentes & Ruscio, 2011).

2.0.2 Hypothesis 2. IU has received support as a transdiagnostic factor underlying anxiety, appears associated with constructs implicated in the fear-avoidance model, and appears elevated in persons with various psychological difficulties often comorbid with chronic pain (e.g., anxiety, depression; Carleton et al., 2012; Hong & Cheung, 2015). Further, IU has been suggested to contribute to pain experiences (Carleton & Asmundson, 2012; Hong & Cheung, 2015). Accordingly, the second hypothesis for the present research is that participants self-reporting CLBP (i.e., lower back pain more days than not, lasting three months or more) will report statistically significantly higher IU than controls.
2.0.3 Hypothesis 3. The fear-avoidance model suggests individuals with chronic pain tend to avoid perceived pain-related risk due to the uncertain potential for pain (i.e., activity may lead to pain and injury; Vlaeyen & Linton, 2012). Individuals with chronic pain may therefore be less willing to risk possible pain than individuals without chronic pain. To augment self-report measures, a modified Balloon Analogue Risk Task (BART; see method section) was used as a behavioural proxy for pain-related risk-taking under uncertainty (Carleton, 2016a). The BART is a computerized task wherein participants sequentially inflate a digital image of a balloon. Inflations increase potential reward, but risk of a balloon “popping”, resulting in reward loss, increases with inflation. Reward can only be obtained by ceasing inflation before balloon rupture and participants must therefore attempt to balance risk with reward. The modified BART frames the task as a proxy for rewarding activities that may trigger pain. Accordingly, the third hypothesis is that participants with chronic pain will score lower on the modified BART than control participants, irrespective of IU scores (Carleton, 2016a; Vlaeyen & Linton, 2012). Interactions with IU scores could occur, but main effects have not been previously tested with the present experimental design. Therefore, an interaction effect is not hypothesised. IU, AS, and pain-related anxiety are presumed to additionally contribute to risk aversion, consistent with the fear-avoidance model; however, the potential role of IU in fear and avoidance with CLBP is not yet clear.

2.0.4 Hypothesis 4. IU has been identified as a core factor underlying anxiety (Carleton et al., 2016b). Anxiety-related constructs contribute to fear and avoidance of chronic pain (Vlaeyen & Linton, 2000). IU may therein help explain relationships between anxiety and pain, but may also contribute independently to the pain experience
due to the inherent uncertainty of pain (Carleton & Asmundson, 2012). Accordingly, the fourth hypothesis for the present study is that IU scores will account for statistically significant, unique variance in reported degree of chronic pain/discomfort in regression models, such that variance in reported pain cannot be attributed solely to other anxiety measures.

**2.0.5 Hypothesis 5.** Trait IU is theoretically relevant to risk-taking and individuals with higher IU may avoid greater uncertainty associated with greater risk (Carleton, 2012, 2016a). Therefore, IU-SS is also likely to contribute variance to avoidance of pain-inducing risk-taking behaviour. Accordingly, the fifth hypothesis is that trait IU and IU-SS irrespective of chronic pain status, will account for a statistically significant proportion of variance in degree of risk taking on the modified BART, such that higher IU predicts lower risk-taking scores. Due to limited existing evidence on IU in the context of chronic pain, there are no hypotheses regarding interaction effects between IU scores and degree of reported pain on BART performance. CLBP is associated with activity avoidance, and IU ought to be associated with avoidance of feared situations in general. Suggestions of an interaction effect would therefore be consistent with theory. The novelty of the present experimental design renders a specific interaction hypothesis somewhat more tenuous. The present results will inform future tests of interaction effects, which should be evaluated.

Prior research has demonstrated mixed results regarding sex differences in chronic pain (see for review Robinson, Wise, Riley, & Atchison, 1998). Accordingly, there are no hypotheses regarding specific sex differences in reported pain. Group mean comparisons between male and female participants will be tested in exploratory analyses.
to identify any statistically significant differences in self-report scores for pain and other variables of interest.

3.0 Methods

3.1 Participants

The present sample consisted of 527 participants recruited through Amazon Mechanical Turk (MTurk), an online crowd sourcing platform used to recruit participants for surveys. Participants were required to have completed at least 50 tasks on MTurk, and were required to have a 95% approval rating for past participation. Including some parameters for restricting participation is recommended by Amazon to avoid low-quality or automated responses. A short screener questionnaire to determine participant eligibility was hosted on MTurk. A planned minimum number of individuals to screen was not pre-determined; data on the proportion of the MTurk participant pool who would be eligible for the present study were not available and could not be reasonably estimated. Accordingly, screeners were kept open to new participants until a sufficient number of persons were identified as eligible for participation in the present study.

An a priori power analysis was performed to determine the number of participants required \( (f = .25, \alpha = .05, K = 2) \). The results indicated a total sample size of 400 participants would provide 80% power to detect group differences and interactions in the proposed regression analyses. The conservative effect size estimate was based on previous research exploring similar constructs (e.g., Carleton, Thibodeau, Osborne, Taylor, & Asmundson, 2014a; Carleton et al., 2014b; Carleton et al., 2012; Esteve & Camacho, 2008). A planned \( n \) of 450 included oversampling to compensate for missing or incomplete data. The obtained total of 527 participants included partial completers
who typically completed one or two measures before dropping out. There were 470 participants out of the 527 who completed all questionnaires. There were 242 participants who completed the modified BART. Recruitment was discontinued when eligible MTurk users were no longer signing up for the present study.

Screeners were initially open only to residents of Canada. Very few individuals participated in the screener, and identifying enough eligible participants was determined infeasible given the small population of Canadian MTurk users. Screeners were then opened to USA residents only. Since individuals living in two different countries experience different healthcare systems and social contexts (Hargreaves et al., 2015), a decision was made to exclusively use data collected from USA participants in order to avoid possible effects from country of residence. Researchers have noted differences in healthcare access between Canadian residents and USA residents (Lasser, Himmelstein, & Woolhandler, 2006). Such differences could conceivably allow country of residence to have unaccounted for effects on results.

Participants were assigned to two groups based on reported pain history. Control group participants were excluded if they reported ongoing acute pain, chronic headaches of any kind, fibromyalgia, or irritable bowel syndrome (see Asmundson, Peluso, Carleton, Collimore, & Welch, 2010). Participants in the CLBP group were subject to the same exclusion criteria, with the exception of chronic pain history; current CLBP that has lasted at least three months was the primary inclusion criterion for the CLBP group. Despite reporting no acute pain on the screener survey, several participants in the control group then reported some (i.e., greater than zero) current acute pain in the main survey. Participants in the control group reporting acute pain were then excluded from analyses.
in order to be consistent with planned exclusion criteria. Across both groups, only individuals who passed all attention checks were included in final analyses. The resulting number of participants was 326, with 108 in the control group and 218 in the CLBP group.

3.2 Equipment

**Inquisit 4 (Millisecond, 2017).** Inquisit is a software program developed by the Millisecond company for computerized administration of psychological tests and tasks. The Inquisit program was used to run a modified version of the BART (Lejuez et al., 2002). Participants completed questionnaires and the modified BART on their own personal computers or mobile devices.

**Modified Balloon Analogue Risk Task (BART; Lejuez, et al., 2002, Appendix B).** The BART is a computerized behavioural task designed to assess decision-making regarding risk. In the original BART, participants view a computer screen displaying a balloon and air pump, and reward totals in the form of money collected (Lejuez et al., 2002). The reward money collected increases each time a participant clicks a button to inflate the balloon. Participants may choose to collect money at any time, ending the trial; alternatively, participants may continue inflating the balloon, which may pop and consequently reset collectible money to zero. The screen displays total money earned across the task, as well as money earned on the previous balloon. In the original validation study, real money was given as reward, but subsequent research has provided evidence supporting the validity of imaginal rewards in the BART (Benjamin & Robbins, 2007; Lejuez et al., 2002). Pumping the balloon is reinforcing based on rewards of additional money, up to a point unknown to the participant (i.e., risk and potential reward
increase over time, until the balloon pops). The riskiness score on the modified BART is determined by number of clicks on the “inflate” button. The BART has demonstrated convergent validity with measures of impulsivity, behavioural constraint, sensation-seeking, and self-reported willingness to engage in risky behaviour (Lejuez et al., 2002). Researchers have also evidenced the BART as having good test-retest reliability (White, Lejuez, & de Wit, 2008).

The probability of a negative event (i.e., a balloon-pop equivalent) during the BART was identical for all participants. Both participant groups completed the same task. Accordingly, variations in riskiness should be attributable to intra-individual factors and group differences.

Previous studies have modified various elements of the BART (see for review, White et al., 2008) and have successfully utilised imagined rewards as well as non-monetary rewards in the task (Benjamin & Robbins, 2007; Lawyer, 2013). Researchers have argued in favour of tailoring the BART to behaviours of interest to improve ecological validity (Lawyer, 2013). Accordingly, pain- and activity-related reward may be more relevant to pain- and activity-related risk behaviours. All participants may be expected to have had prior experiences with pain arising during or subsequent to physical activity. Therefore, instructions were designed to relate to physical activity and be equally applicable to both participant groups. Instructions were identical for both groups (see Appendix B). Balloon inflation was conceptualised for participants as them engaging in an enjoyable, but potentially pain-inducing, activity relevant to their personal experiences of pain. Instead of money, rewards associated with each click were conceptualised as minutes spent doing their enjoyable activity. A popped balloon
represented pain/injury and consequent loss of time engaged in positive activity because the participant pushed too far. Participants could discontinue a trial before damage occurs, thereby foregoing further potential reward in order to reduce risk of pain (i.e., balloon disintegration in the task, not real pain). The modified BART was intended to gauge participants’ willingness to risk potential pain by engaging in an enjoyable physical activity. The described modifications were intended to reflect real-world decision making in response to risk and uncertainty related to pain. The original BART corresponds with risk-taking across several different areas of behaviour (e.g., health practices, drug use, gambling; Lejuez et al., 2002), despite the artificial nature of the task and lack of explicit focus on specific areas of behaviour.

The BART was applied in the present study to augment self-report measures, and was not pre-tested. The use of the modified BART in the present study represents a preliminary test. Prior research has not tested the BART in the context of chronic pain. Given the time and investment required to identify and recruit individuals with CLBP, pre-testing the present modifications to the BART without prior examples of such a protocol appeared not to be feasible. The relatively low predicted effect size also presented a barrier to recruiting enough individuals with whom to pre-test the present BART modifications without exhausting too large a portion of the apparently small eligible population of MTURK participants. Including and evaluating a behavioural task (i.e., the BART) was a secondary aim of the present study.

3.3 Self-Report Measures

Syndrome Characteristics Survey (SCS; Appendix A). To evaluate participants’ perceived certainty regarding the occurrence of pain, a 2-item questionnaire
was created for the purpose of the present study. The measure was intended to obtain an index of how certain participants were that they would experience pain in their daily life, and how well participants felt their pain could be predicted in their daily life. Subjective certainty regarding the occurrence of pain (i.e., how certain participants are that pain will continue, that activity in general will reliably cause pain), as well as subjective predictability (i.e., how accurately participants can anticipate pain, how often pain is preceded by identifiable events or activities), were assessed using a 5-point, Likert-type scale ranging from 1 (completely uncertain or completely unpredictable) to 5 (completely certain or completely predictable). In the present sample, internal consistency for the two-item SCS was high (Cronbach’s α = .83).

**Intolerance of Uncertainty Scale, Short Form (IUS-12; Carleton, Norton, & Asmundson, 2007, Appendix C).** The original Intolerance of Uncertainty Scale consisted of 27 items (Freeston et al., 1994). Item responses are based on a 5-point Likert-type scale ranging from 1 (not at all characteristic) to 5 (entirely characteristic of me). The IUS-12 is a shortened form that measures how people respond to uncertainty in general, ambiguous events/situations, and the future. The IUS-12 correlates very strongly with the original 27-item version, rs = .94 to .96 (Carleton et al., 2007a; Khawaja & Yu, 2010) and appears to have a continuous latent structure (Carleton, Weeks, Howell, Asmundson, Antony, & McCabe, 2012). The IUS-12 was used instead of the original 27-item version, because the IUS-12 is briefer than the original measure and the more recent Intolerance of Uncertainty Index (Carleton, Gosselin, & Asmundson, 2010; Gosselin et al., 2008), but still effectively measures trait IU (e.g., Khawaja & Yu, 2010). The IUS-12 has a well-supported two-factor structure (Carleton et al., 2007a; McEvoy & Mahoney,
2011; Hong & Lee, 2015), with both subscales showing identically high internal consistencies (\(\alpha = .85\); e.g., Carleton et al., 2007a). The two IUS-12 subscales consist of prospective IU (7 items; e.g., “I can’t stand being taken by surprise”) and inhibitory IU (five items; e.g., “When it’s time to act, uncertainty paralyses me”). The IUS-12 appears psychometrically sound with evidence for robust internal consistency, convergent validity and discriminant validity, in each of the two subscales (prospective IU and inhibitory IU), as well as for overall score (Carleton et al., 2007a; McEvoy & Mahoney, 2011; Hong & Lee, 2015). In the current sample, internal consistency for the IUS-12 was high (Cronbach’s \(\alpha = .93\)).

**Intolerance of Uncertainty Scale – Situation Specific Version (IUS-SS; Mahoney & McEvoy, 2012a, Appendix D).** The IUS-SS is a modified version of the IUS-12, with statements flexibly modified to address how people respond to uncertainty in specific situations (e.g., “uncertainty about my pain keeps me from living a full life”). Item response mechanisms and scoring are otherwise identical to procedures used for the IUS-12. The IUS-SS appears to have a one-factor structure, implying situational IU may be a unitary construct (Mahoney & McEvoy, 2012a). The IUS-SS appears psychometrically sound with evidence for high internal consistency (Cronbach’s \(\alpha = 0.94\); Mahoney & McEvoy, 2012a), convergent validity, and divergent validity. The initial validation study found the IUS-SS and IUS-12 to be highly correlated (\(r = 0.69\); Mahoney & McEvoy, 2012a). Research supports the utility of differentiating IU-SS and trait IU (Mahoney & McEvoy, 2012a). Therefore, the IUS-SS was included as a measure of IU-SS in the proposed study. In the present sample, internal consistency for the IUS-SS was high (Cronbach’s \(\alpha = .96\)).
Anxiety Sensitivity Index-3 (ASI-3; Taylor et al., 2007, Appendix E). The ASI-3 measures fears surrounding symptoms of anxiety and beliefs about whether physical symptoms lead to harmful outcomes (e.g., “It scares me when my heart beats rapidly”). There are 18 items on the ASI-3. Item responses are based on a 5-point Likert-type scale ranging from 0 (agree very little) to 4 (agree very much). The ASI-3 is divided into three factors (i.e., cognitive, social, somatic) paralleling the theoretical components of AS (i.e., fear of cognitive dyscontrol, fear of socially observable signs of anxiety, fear of somatic sensations; Taylor, Koch, Woody, & McLean, 1996). The three-dimensional structure has received support from factor analysis and the ASI-3 has greater factorial validity than the original (Peterson & Reiss, 1992). Internal consistency is also higher for the ASI-3 than for the original ASI (Peterson & Reiss, 1992; Taylor et al., 2007). Evidence exists for the discriminant, convergent, and criterion validity of the ASI-3 (Taylor et al., 2007). In the present sample, internal consistency for the ASI-3 was high (Cronbach’s α = .94).

The Pain Anxiety Symptoms Scale-Short Form (PASS-20; McCracken and Dhingra, 2002, Appendix F). The PASS-20 is a shortened, 20-item version of the Pain Anxiety Symptoms Scale (PASS; McCracken, Zayfert, & Gross, 1992). The present study used the PASS-20 to measure pain-related anxiety. Item responses are based on a 6-point Likert-type scale ranging from 0 (never) to 5 (always), which assess how often anxious thoughts about pain occur. The measure consists of four subscales (five items each) that address different components of pain-related anxiety. The subscales measure the fear component (e.g., “Pain sensations are terrifying”), the cognitive component (e.g., “I can't think straight when in pain”), the physiological component (e.g., “Pain makes me
nauseous”), and the escape/avoidance component (e.g., “I will stop any activity as soon as I sense pain coming on”). The subscales provide scores that can be considered separately, or summed as an overall measure of pain-related anxiety. Research suggests the scale is factorially valid for the total and subscale scores in both non-clinical (Abrams et al., 2007) and clinical samples (Coons, Hadjistavropoulos, & Asmundson, 2004). In the present sample, internal consistency for the PASS-20 was high (Cronbach’s α = .96).

**Patient Health Questionnaire (PHQ-9; Kroencke, Spitzer, & Williams, 2001, Appendix G).** The PHQ-9 is a 9-item screening tool for depression (Kroencke et al., 2001), developed from a subset of items from the Patient Health Questionnaire (Spitzer, Kroencke, & Williams, 1999). The present study used the PHQ-9 to further characterize the sample of participants given that chronic pain can also be comorbid with depressive symptoms (e.g., Kindermans et al., 2011). Item responses are based on a 4-point Likert-type scale ranging from 0 (not at all) to 3 (nearly every day) reflecting frequency of each symptom over the past two weeks (e.g., “Feeling down, depressed, or hopeless”). Scores are summed to obtain a total severity score. A recent review of proposed factor structures for the PHQ-9 concluded that a two-factor model representing somatic and non-somatic items provides a good fit (Petersen et al., 2015). The PHQ-9 has high internal consistency and reliability (Kroencke, Spitzer, Williams, & Löwe, 2010). In the present sample, internal consistency for the PHQ-9 was high (Cronbach’s α = .92).

**Short-form McGill Pain Questionnaire (SF-MPQ; Melzack, 1987, Appendix H).** The SF-MPQ is a self-report measure to assess the characteristics and intensity of pain experiences. The measure is split into a 15-item section in which respondents rate the usual severity of pain experiences, a rating question to describe current pain, and a
visual analogue scale (VAS) to estimate current pain intensity (Melzack, 1987). The 15-item pain rating index includes commonly used adjectives that describe sensory and affective aspects of pain, and for each adjective respondents rate the severity of each pain quality (e.g., “sharp”) in relation to the respondent’s own pain. Item responses are based on a 4-point Likert-type scale ranging from 0 (none) to 3 (severe) (Melzack, 1987; Wright, Asmundson, & McCreary, 2001). The SF-MPQ 6-point (no pain to excruciating) present pain index and VAS with two text anchors (no pain to worst possible pain) are used to evaluate active pain intensity. VAS have been used in prior investigations of pain experiences (e.g., Binzer et al., 2003). Researchers have provided evidence for the validity and reliability of VAS in measuring actual pain (Downie et al., 1978; Ferraz et al., 1990). An additional VAS, ranging from no pain to severe pain, was added to assess average pain levels during the two weeks prior to participation (Boonstra, Preuper, Balk, & Stewart, 2014). Several researchers have previously used the SF-MPQ to measure chronic pain (e.g., Boonstra et al., 2014; Love, Leboeuf, & Crisp, 1989; Uysal, Ascigil, & Turunc, 2017).

The SF-MPQ has correlated highly and positively with the original MPQ (Melzack & Katz, 2001). The SF-MPQ demonstrates good factorial validity for both sensory and affective components (.78 and .76 respectively; Wright et al., 2001). Researchers have evidenced good reliability for the SF-MPQ total score (Grafton, Foster, & Wright, 2002). In the present sample, internal consistency for the SF-MPQ pain rating index was high (Cronbach’s α = .91).

**Pain Disability Questionnaire (PDQ; Anagnostis, Gatchel, & Mayer, 2004, Appendix I).** The PDQ was developed as a measure to assess the functional status of
individuals with chronic musculoskeletal pain conditions. The measure includes 15 items divided into two subscales: the Functional Status Component (FSC) and the Psychosocial Component (PC). Each item provides a statement related to pain and functioning (e.g., “Does your pain affect your ability to walk or run?”), followed by a VAS anchored by descriptive terms (e.g., no problems to cannot walk/run at all). A higher score on each item represents greater disability. The present study used the PDQ to better characterize the sample in terms of disability, rather than measuring pain severity only and provide a more complete picture of study participants’ experiences with chronic pain. Researchers demonstrated very high test-retest reliability and internal consistency for the PDQ (Anagnostis et al., 2004; Moreira Giordano, Costa Alexandre, Matheus Rodrigues, & Orpinelli Coluci, 2012). Convergent validity is evidenced by strong correlations with other measures of pain disability (e.g., the Oswestry Low Back Pain Disability Questionnaire, the Million Visual Analogue Scale; Anagnostis et al., 2004). Indeed, the PDQ appears more closely associated with certain measures of depression, anxiety, and pain intensity than other measures of functional ability examined in the PDQ initial validation study. Divergent validity is evidenced by negative correlations between PDQ scores and quality of life (Moreira Giordano et al., 2012). Individuals with chronic pain conditions exhibit higher PDQ scores than individuals with acute pain or no pain (Anagnostis et al., 2004; Moreira Giordano et al., 2012). PDQ scores appear moderately correlated with pain severity self reports (Moreira Giordano et al., 2012). In the present sample, internal consistency for the PDQ was high (Cronbach’s α = .96).

**Screener Survey (Appendix M).** A 7-item screener based on inclusion criteria for the control group and the CLBP group was developed to assess participant eligibility.
Each item asks whether a participant has a particular syndrome involving pain (e.g., “Do you have fibromyalgia?”), with two options for answering (yes or no). The screener survey was designed to identify participants meeting inclusion criteria who could then be invited to participate in the present study.

3.4 Procedure

Participation in the present study was completed online. Volunteers used their own personal electronic devices. Volunteers first completed a screener survey to determine eligibility. Eligible participants were then assigned custom MTurk qualifications permitting access to the study. Once volunteers arrived at the main survey webpage to initiate participation, they were provided with a detailed informed consent page (Appendix J). Eligible volunteers who consented to participate were assigned group designations (i.e., Group 1 or Group 2) based on the presence or absence of self-reported CLBP without a formal diagnosis. Participants reporting no history of chronic pain were assigned to the control group. All participants completed online self-report measures and then participated in the modified BART. Questionnaires were completed on the Qualtrics survey platform and the behavioural task was hosted using the Millisecond online platform designed for data collection using behavioural/performance tasks. Testing occurred in a single session that lasted approximately one hour.

3.5 Analytic Plan

Bootstrapping was performed on all hypothesis tests to reduce the effects of outliers and extreme scores across measures. A Bonferroni correction was applied to all analyses to reduce possible effects of statistical error inflation. Accordingly, the experimental alpha level was set at .01.
3.5.1 Hypothesis 1. Significant, positive correlations were hypothesised among IU and other constructs (i.e., IU-SS, AS, uncertainty and unpredictability of pain, pain-related anxiety, and disability) already considered influential in chronic pain and/or related to IU. Hypothesis 1 was tested using zero-order correlational analyses.

3.5.2 Hypothesis 2. IU was hypothesised to be statistically significantly higher in the CLBP group than the control group. Hypothesis 2 was tested using independent samples t-tests to assess group differences in trait IU. Group (i.e., CLBP; no pain) was entered as the independent variable, and IUS-12 scores (i.e., trait IU) were entered as the dependent variable.

3.5.3 Hypothesis 3. Participants with CLBP were hypothesised to report lower mean risk scores than the control group. Hypothesis 3 was tested using independent samples t-tests to assess mean differences in risk-taking behaviour. Group designation (i.e., CLBP; no pain) was entered as the independent variable, and mean risk score was entered as the dependent variable.

3.5.4 Hypothesis 4. IU and IU-SS were hypothesised to account for unique variance in reported average pain, beyond the contributions of AS and pain-related anxiety. Hypothesis 4 was tested using hierarchical linear regression analysis. Chronic pain was assessed with the SF-MPQ VAS score and functioned as the criterion variable. IUS-12 score was entered at Step 1, and ASI-3, PASS-20, and IUS-SS scores were entered at Step 2, following a chronological rationale for variable entry (i.e., theoretically lower-order variables entered at earlier steps; Lewis, 2007).

3.5.5 Hypothesis 5. IU and IU-SS were hypothesised to account for unique variance in BART performance. Hypothesis 5 was tested using hierarchical linear
regression analysis to assess the predictive utility of IU and pain-related anxiety on risk-taking behaviour. Modified BART risk score functioned as the criterion variable. IUS-12 score was entered at Step 1, and IUS-SS and PASS-20 scores were entered at Step 2, following a chronological rationale for variable entry. Entering correlated variables at separate steps of a hierarchical regression analysis should avoid problematic multicollinearity (Pedhazur, 1982).

Previous evidence has been mixed with respect to sex differences in chronic pain (Robinson et al., 1998). Accordingly, there were no a priori hypotheses regarding statistically significant differences between male and female participants; tests for sex differences were exploratory. Potential differences between male and female participants on any of the variables measured, as well as interactions by CLBP status and sex, were assessed using a factorial ANOVA.

4.0 Results

4.1 Participants

4.1.1 MTurk Screening. In total, 5,077 potential participants completed the online screener. There were 1,003 potential participants who met inclusion criteria for the pain-free control group and 353 who met inclusion criteria for the CLBP group. There were 527 potential participants who chose to participate in the present study, 309 who were pain free and 218 who reported CLBP. Some participants did not complete all measures, but were included in analyses where data were available. In total, 242 participants chose to do the modified BART; as such, sample sizes vary across analyses. A decision was made to exclude control group participants who reported any acute pain
at the time of participation in the main survey. The resulting sample consisted of 326 participants, and statistics are reported accordingly.

4.1.2 Participant Characteristics. Participants included 133 males and 193 females ($N = 326; M_{age} = 35.18$ years, $SD = 10.73$, range: 18-70). The CLBP group consisted of 84 males and 134 females ($M_{age} = 34.63$ years, $SD = 10.34$, range: 18-66). The pain-free group consisted of 49 males and 59 females ($M_{age} = 36.30$ years, $SD = 11.45$, range: 19-70). All participants reported identifying with their biological sex. All participants reported currently residing in the USA. Ethnic background and other demographic data were not collected. Some researchers have identified differences in experiences with CLBP across different ethnocultural backgrounds (e.g., Sanders et al., 1992); however, such variables were beyond the scope of the present study. Once the association between IU and CLBP has been further clarified, researchers should assess potential ethnocultural differences.

4.2 Descriptive Statistics

All statistical analyses were conducted using IBM SPSS Statistics (IBM Corporation, 2016). Means and standard deviations were computed for self-report measures and modified BART performance. Descriptive statistics are presented in Table 1.

Control group mean IU, AS, and pain-related anxiety appeared broadly similar to levels previously reported in community and undergraduate samples (Abrams et al., 2007; Carleton et al., 2012; Taylor et al., 2007). One prior study reported a community IUS-12 mean of 29.53, which is slightly lower than the observed control group mean in the present study (Carleton et al., 2012). A prior study on AS reported ASI-3 means
ranging from 12.8-16.4 in primarily undergraduate samples across several nations, similar to the present results (Taylor et al., 2007). Prior research on pain-related anxiety reported a nonclinical sample mean of 24.04, which is slightly higher than the observed control group mean in the present study (Abrams et al., 2007). Whether observed distributions in the present study are statistically significantly different from prior reports is not clear. Due to the focus on anxiety and pain, it may be that the present study attracted individuals who have a particular interest in pain, who think about it more often, and who may be somewhat anxious people.

### 4.3 Primary Analyses

**4.3.1 Correlations.** Statistically significant, positive correlations were identified among each of the IUS-12, IUS-SS, ASI-3, PASS-20, and PDQ ($p < .01$; see Table 2). The two items of the SCS were statistically significantly and positively correlated with each other ($p < .01$); however, the SCS did not statistically significantly correlate with other measures, except the PDQ, after a Bonferroni correction (all $ps > .01$). Accordingly, Hypothesis 1 was generally supported.

**4.3.2 Independent Samples t-Tests.** IUS-12 scores differed statistically significantly between groups, such that individuals with CLBP reported higher levels of IU than did their control group counterparts, $t(306) = 3.83, p < .001$, Cohen’s $d = .44$ as such, Hypothesis 2 was supported. Riskiness scores on the modified BART did not differ statistically significantly between groups, $t(145) = -1.20, p > .05$, Cohen’s $d = .16$ The absence of statistically significant differences between groups on risk taking in the modified BART was contrary to expectations; as such, Hypothesis 3 was not supported.
4.3.3 Regression Analyses. Box plots indicated that two outliers were present in the ASI-3 scores. Box plots also indicated four outliers were present in the BART performance. In evaluating Hypothesis 4, self-reported average pain over the past two weeks was entered as the criterion variable. The IUS-12 was entered as a predictor at Step 1 (Model 1). The IUS-SS, ASI-3, and PASS-20 were entered as predictors at Step 2 (Model 2; see Table 3). Due to the presence of significant correlations among variables entered in the regression models for Hypothesis 4, multicollinearity diagnostics were performed. Since the entered predictors were all statistically significantly correlated, some multicollinearity must therefore have been present; however, zero-order correlations, VIF, and tolerance values were all within ranges generally considered acceptable (i.e., tolerance above .10, VIF below 10, zero-order correlations below .8; Field, 2013; Meyers, Gamst, & Guarino, 2013). The extent of multicollinearity among predictor variables did not appear high enough to signify a substantial problem. Model 1 was statistically significant, $F(1, 304) = 33.23$, $p < .001$, $R^2 = .10$. The beta coefficient for the IUS-12 in Model 1 was also statistically significant, $\beta = .31$, $t = 5.76$, $p < .001$. Model 2 was statistically significant, $F(4, 301) = 40.68$, $p < .001$, $R^2 = .35$. Model 2 improved the variance accounted for relative to Model 1, $\Delta F = 39.01$, $p < .001$. Each of the predictor variables entered accounted for a unique and statistically significant proportion of the variance in self-reported average pain (see Table 3). IUS-12 remained significant in Model 2; however, the coefficient shifted from a positive value in Model 1 to a negative value in Model 2. The IUS-SS, ASI-3, and PASS-20 coefficients each had positive values in Model 2. When a Bonferroni correction was applied to reduce the risk of Type 1 error due to inflated experimental error, the obtained Model 2 coefficient
Table 1.

*Descriptive statistics.*

<table>
<thead>
<tr>
<th></th>
<th>Control/CLBP</th>
<th>Control/CLBP</th>
<th>Control/CLBP</th>
</tr>
</thead>
<tbody>
<tr>
<td>IUS-12</td>
<td>108/218</td>
<td>31.75/36.74</td>
<td>11.88/10.72</td>
</tr>
<tr>
<td>IUS-SS</td>
<td>108/217</td>
<td>21.97/34.72</td>
<td>10.57/11.51</td>
</tr>
<tr>
<td>ASI-3</td>
<td>108/217</td>
<td>16.21/28.07</td>
<td>13.11/16.06</td>
</tr>
<tr>
<td>PASS-20</td>
<td>108/216</td>
<td>20.33/43.06</td>
<td>18.31/21.70</td>
</tr>
<tr>
<td>PHQ-9</td>
<td>108/215</td>
<td>3.50/7.74</td>
<td>5.00/6.30</td>
</tr>
<tr>
<td>PDQ</td>
<td>107/212</td>
<td>2.35/39.60</td>
<td>4.90/27.73</td>
</tr>
<tr>
<td>VAS-present</td>
<td>108/215</td>
<td>0.00/32.31</td>
<td>0.00/20.99</td>
</tr>
<tr>
<td>VAS-recent</td>
<td>108/215</td>
<td>3.96/39.94</td>
<td>9.09/19.58</td>
</tr>
<tr>
<td>Average Pump Count</td>
<td>108/99</td>
<td>20.61/18.97</td>
<td>10.22/10.88</td>
</tr>
</tbody>
</table>

*Note:* IUS-12 = Intolerance of Uncertainty Scale – Short Form; IUS-SS = Intolerance of Uncertainty Scale – Situation Specific Version; ASI-3 = Anxiety Sensitivity Index 3; PASS-20 = Pain Anxiety Symptoms Scale – Short Form; PHQ-9 = Patient Health Questionnaire; PDQ = Pain Disability Questionnaire; VAS-present = reported current pain during study participation; VAS-recent = reported average pain intensity over the past two weeks; Average Pump Count = individual mean number of pumps on each modified BART balloon trial.
Table 2.

Zero-order correlations.

<table>
<thead>
<tr>
<th></th>
<th>IUS-12 Control/CLBP/All</th>
<th>IUS-SS Control/CLBP/All</th>
<th>ASI-3 Control/CLBP/All</th>
<th>PASS-20 Control/CLBP/All</th>
<th>PDQ Control/CLBP/All</th>
<th>SCS Control/CLBP/All</th>
</tr>
</thead>
<tbody>
<tr>
<td>IUS-12</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IUS-SS</td>
<td>.44**/.75**/.65**</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASI-3</td>
<td>.72**/.61**/.66**</td>
<td>.36**/.63**/.62**</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PASS-20</td>
<td>.45**/.61**/.58**</td>
<td>.49**/.75**/.75**</td>
<td>.53**/.76**/.74**</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PDQ</td>
<td>.06/.34**/.34**</td>
<td>.18*/.50**/.60**</td>
<td>.10**/.46**/.50**</td>
<td>.26**/.57**/.63**</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>SCS</td>
<td>-.08/-..04/-.01</td>
<td>-.21**/-..06/-.05</td>
<td>-.06/-..01/-.07</td>
<td>-.20**/-..09/-.02</td>
<td>.04/..01/-.18**</td>
<td>-</td>
</tr>
</tbody>
</table>

Note: IUS-12 = Intolerance of Uncertainty Scale – Short Form; IUS-SS = Intolerance of Uncertainty Scale – Situation Specific Version; ASI-3 = Anxiety Sensitivity Index 3; PASS-20 = Pain Anxiety Symptoms Scale – Short Form; PDQ = Pain Disability Questionnaire; SCS = Syndrome Characteristics Survey. ** = p < .01 (one tailed); * = p < .05 (one tailed)
for ASI-3 was no longer individually significant ($p = .05$).

At Step 2 in the original Model 2, partial and semi-partial correlations for the IUS-12 decreased and underwent a sign change, while the zero-order correlation remained positive. Another predictor may be interacting with the IUS-12, likely the IUS-SS. As a predictor of reported pain, the IUS-SS may be a more valid predictor than the IUS-12, and the IUS-SS appears to share some variance with the IUS-12 in the regression model. Indeed, IU-SS as a construct is theoretically dependent upon IU. Regression analyses for Hypothesis 4 were re-run with specific variables removed for exploratory purposes to better assess the inter-relationships.

The regression analysis for Hypothesis 4 was repeated without the IUS-12 as a predictor variable. Removing the IUS-12 as a predictor resulted in slightly less variance being accounted for (i.e., without the IUS-12, $R^2 = .34$; with the IUS-12, $R^2 = .35$). The regression analysis for Hypothesis 4 was then repeated without the IUS-SS as a predictor variable. Removing the IUS-SS as a predictor resulted in less variance accounted for (i.e., without the IUS-SS, $R^2 = .29$; with the IUS-SS, $R^2 = .35$). Partial correlation results indicated that the IUS-SS was more closely related to reported pain than was the IUS-12. Both the IUS-SS and the IUS-12 were likely uniquely related to reported pain, with a greater portion of variance subsumed by the IUS-SS. A portion of the variance in reported pain appears to be shared between the IU and IU-SS constructs. IU-SS focused on pain ought to account for most of the variance IU in reported pain. In retrospect, elements of IU not subsumed by the IUS-SS focused on pain contributing less variance to reported pain is consistent with theory. Some collinearity between the IUS-12 and the IUS-SS likely resulted in the coefficient change in the IUS-12 predictor, and the
regression model may be somewhat unreliable. The ASI-3, PASS-20, and at least the combined effects of the IUS-12 and IUS-SS all appear to contribute to unique variance in self-reported average pain. The significance of each model and of individual variables entered supported Hypothesis 4, with the caveat that the IUS-SS appears more related than the IUS-12.

A hierarchical linear regression analysis was performed to test Hypothesis 5, with modified BART risk score entered as the criterion variable. Due to the presence of significant correlations between predictor variables entered, multicollinearity diagnostics were conducted. Tolerance and VIF statistics were within acceptable limits; no apparent problems with multicollinearity were observed. The IUS-12, IUS-SS, and PASS-20 were entered as predictors (see Table 4). The IUS-12 was entered at Step 1 (Model 1); the IUS-SS and the PASS-20 were entered at Step 2 (model 2). Model 1 was not statistically significant ($F[1, 143] = .10, p > .05, R^2 = .00$). Model 2 approached statistical significance ($F[3, 141] = 2.61, p = .05$, adjusted $R^2 = .03$), accounting for unique incremental variance over Model 1 ($ΔF = 3.86, p < .05$). No individually significant coefficients were identified in either Model 1 or Model 2 (all $ps > .05$). As such, Hypothesis 5 was largely not supported. Statistical power was low for analyzing Hypothesis 5. Individually significant predictors may have been identified with a larger sample size.

4.4 Exploratory Analyses

Given the inconsistencies in previously observed responses across men and women (Robinson et al., 1998), the present study did not include a priori hypotheses
## Table 3.

*Hierarchical linear regression analysis predicting VAS Average Recent Pain.*

<table>
<thead>
<tr>
<th>Model</th>
<th>Independent Variables</th>
<th>Coefficients</th>
<th>Model Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$b$</td>
<td>LLCI</td>
</tr>
<tr>
<td>1</td>
<td>IUS-12</td>
<td>.67</td>
<td>.44</td>
</tr>
<tr>
<td>2</td>
<td>IUS-12</td>
<td>-.37</td>
<td>-.66</td>
</tr>
<tr>
<td></td>
<td>IUS-SS</td>
<td>.74</td>
<td>.42</td>
</tr>
<tr>
<td></td>
<td>ASI-3</td>
<td>.22</td>
<td>-.04</td>
</tr>
<tr>
<td></td>
<td>PASS-20</td>
<td>.24</td>
<td>.08</td>
</tr>
</tbody>
</table>

*Note.* Confidence intervals are 95% bias corrected and are based on 1000 bootstrapped samples. LLCI = Lower Limit Confidence Interval; ULCI = Upper Limit Confidence Interval; IUS-12 = Intolerance of Uncertainty Scale – Short Form; IUS-SS = Intolerance of Uncertainty Scale – Situation Specific Version; ASI-3 = Anxiety Sensitivity Index 3; PASS-20 = Pain Anxiety Symptoms Scale – Short Form.
Table 4.

*Hierarchical linear regression analysis predicting BART Total Pump Count.*

<table>
<thead>
<tr>
<th>Model</th>
<th>Independent Variables</th>
<th>Coefficients</th>
<th>Model Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<tr>
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<td></td>
<td>.03</td>
<td>.00</td>
</tr>
<tr>
<td></td>
<td>IUS-12</td>
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<td></td>
<td>IUS-SS</td>
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<td>-.39</td>
</tr>
<tr>
<td></td>
<td>PASS-20</td>
<td>-.07</td>
<td>-.20</td>
</tr>
</tbody>
</table>

*Note.* Confidence intervals are 95% bias corrected and are based on 1000 bootstrapped samples. LLCI = Lower Limit Confidence Interval; ULCI = Upper Limit Confidence Interval; IUS-12 = Intolerance of Uncertainty Scale – Short Form; IUS-SS = Intolerance of Uncertainty Scale – Situation Specific Version; PASS-20 = Pain Anxiety Symptoms Scale – Short Form.
regarding any sex differences. Instead, sex was considered in exploratory analyses. A factorial ANOVA was conducted to test for sex differences on study variables, as well as interaction effects from sex and CLBP status. No statistically significant main effects of sex were observed (all $p$s > .05). No statistically significant interaction effects were observed (all $p$s > .05).

5.0 Discussion

The present study investigated the relationships among IU and constructs considered influential in pain experiences. A substantial body of research indicates that AS, pain-related fear, and pain-related anxiety, in conjunction with behavioural avoidance, are influential in the development and maintenance of chronic pain (e.g., Asmundson et al., 2008; Asmundson & Norton, 1995; Asmundson et al., 1999; Asmundson et al., 2014; Carleton & Asmundson, 2012; Muris et al., 2001; Ocañez et al.; Turk & Okifuji, 2002). Accordingly, anxiety appears important for understanding chronic pain in theoretical and clinical contexts.

Increasing evidence supports IU as a transdiagnostic construct that underlies anxiety more generally (Carleton, 2012; 2016a; 2016b; Carleton et al., 2012; Einstein, 2014; Gentes & Ruscio, 2011; Holaway et al., 2006; Hong & Cheung, 2015) and IU may also contribute to chronic pain (Carleton & Asmundson, 2012). Chronic pain syndromes inherently involve uncertainty regarding the occurrence and persistence of pain. Individuals cannot always make accurate interpretations of physiological signals (Norton & Asmundson, 2003; Taylor et al., 2007) or know what to expect regarding the occurrence of pain (De Peuter et al., 2011). Despite evidence that IU is highly related to and may underlie AS, and that anxiety is related to chronic pain (Carleton, 2012; Carleton
& Asmundson, 2012; Hong & Cheung, 2015), research on the relationship between IU and acute or chronic pain is limited. Accordingly, the present study was designed to help clarify relationships among IU and other constructs considered influential in chronic pain. Additionally, the present study compared responses to uncertainty associated with pain during a behavioural task between individuals reporting no chronic pain and individuals reporting CLBP. Examining group-wise differences on various measures relevant to anxiety and chronic pain should help to elucidate the roles of IU and related constructs.

5.0.1 **Hypothesis 1.** Positive correlations were predicted among all self-report measures used. Prior researchers have identified associations among constructs implicated in the fear-avoidance models, as well as IU (e.g., Asmundson et al., 2004a; Carleton & Asmundson, 2012; Carleton, Sharpe, & Asmundson, 2007b; Crombez et al., 1999; Elfving et al., 2007; Esteve & Camacho, 2008; Helsen et al., 2013; Leeuw et al., 2007; Ocañez, McHugh, & Otto, 2010; Taylor et al., 2007; Vlaeyen & Linton, 2000, 2012). Hypothesis 1 was largely supported; specifically, statistically significant correlations were observed among self-report measures (i.e., of IU, IU-SS, AS, pain-related anxiety, and disability). Most of the observed correlations were medium to large in magnitude (i.e., \( r \) values from .1 to .3 are considered small, values from .3 to .5 are considered medium, values greater than .5 are considered large; Cohen, 1988). Positive relationships between IU, anxiety- and depression-related variables (i.e., IU-SS, AS, pain-related anxiety, disability) are consistent with prior research (e.g., Carleton et al., 2012). The present results further evidence the potential importance of inter-related fundamental constructs and broader symptom challenges (Carleton, 2016a). IU appears
involved in several factors already considered influential in chronic pain (e.g., AS, pain-related anxiety) and the present results help to further detail those relationships.

IU and IU-SS were correlated, with a large $r$ value observed. The association between IU and IU-SS is consistent with the nature of the IU-SS construct. IU-SS is a subset of trait IU and is dependent on IU. Individuals with high IU may find uncertainty easier or more difficult to tolerate depending on the situation (Carleton, 2016a, 2016b). Possible negative future events are distressing for individuals with high IU; however, possible negative future events are not always serious in nature. Not knowing the outcome of some situations (e.g., being uncertain about the imminent taste sensation of an inexpensive sandwich) might not cause distress in individuals with high IU, while uncertainty could become highly distressing in other situations (e.g., being uncertain about the forthcoming results of a medical pathology test). IU-SS should be dependent on trait IU and should allow for more nuanced examinations of potential distress associated with uncertainty and anxiety (e.g., uncertain future pain; Mahoney & McEvoy, 2012a).

Measuring IU focused on pain enables a clearer understanding of how individuals respond to uncertainty surrounding chronic pain. IU-SS is directly applicable to experiences of interest (i.e., pain). Furthermore, comparing IU and IU-SS allows researchers to evaluate whether IU related to pain is particularly distressing.

IU was significantly correlated with AS, and the large observed association was consistent with prior research (e.g., Carleton et al., 2007b; Macatee et al., 2015). Uncertainty regarding the meaning of physiological sensations is central to AS. Individuals might decide to dismiss arising concerns (e.g., seeking medical attention if symptoms are known to signify imminent cardiac arrest) if the nature and eventual
outcomes of physiological experiences (e.g., increased heart rate) related to anxiety are
known. Since individuals are typically uncertain as to the meaning of ambiguous
symptoms, worries may not be easily dismissed. Indeed, IU appears to at least partially
underlie the AS construct (Carleton, 2016b; Carleton et al., 2007b). The observed
relationship between IU and AS is therefore consistent with existing evidence and
theoretical conceptualizations of the two constructs.

IU and pain-related anxiety were correlated, with a large $r$ value observed. Such a
relationship provides support for previous suggestions that IU may contribute to or
underlie pain-related anxiety. When pain-related anxiety is elevated, activity avoidance is
typically elevated as well (Asmundson et al., 2014; Carleton & Asmundson, 2012). If an
individual were certain that pain-related anxiety (e.g., concerns that going for a short
walk will lead to serious and lasting pain) is unfounded (i.e., an individual knows the
outcome of future events), then worry would cease and activity would not be avoided.
Uncertainty is therefore a necessary component of pain-related anxiety (Carleton, 2016b).
Such a notion is consistent with evidence that IU is a transdiagnostic construct that may
represent a fundamental fear (Carleton, 2016a).

IU was correlated with disability due to CLBP, with a medium $r$ value observed.
The present study was the first to test the relationship between IU and self-reported
disability due to chronic pain. IU may relate to disability via anxiety and avoidance of
physical activity. The fear-avoidance model identifies pain-related fear and anxiety as
drivers of physical activity avoidance, which contributes to disuse and disability
(Asmundson & Wright, 2004; Vlaeyen & Linton, 2012); therefore, IU may influence
disability indirectly. Alternatively, the daily uncertainties involved in chronic pain (e.g.,
not knowing how severe pain will be today or how pain will affect/limit one’s activities) may promote greater activity avoidance and consequent disability for individuals with higher IU. Chronic pain experiences could also potentially influence IU (e.g., the experience of pain might raise IU as a function of reinforcement), or the relationship could be reciprocal. The nature of the mechanisms underlying the relationship between IU and disability for individuals with CLBP remains unclear.

AS was associated with IU-SS scores, with medium to large correlations observed depending on participant group. IU-SS (i.e., IU focused on pain) and AS (i.e., anxiety focused on physiological symptoms of anxiety) are somewhat similar concepts already (Carleton et al., 2007b). Being unable to interpret anxiety symptoms as harmless or threatening is an experience of uncertainty. Individuals with higher AS may see pain as more threatening (Asmundson et al., 1997). Pain that may occur in the future may then be a source of elevated pain-related anxiety for individuals with higher AS. In any case, the present results support the interrelatedness of IU, AS, and IU-SS.

Pain-related anxiety was correlated with IU-SS, and the observed association was large in magnitude. The observed association could indicate that uncertainty regarding future pain is a key part of why pain-related anxiety is distressing. Uncertainty surrounding the possibility of future pain experiences may account for much of pain-related anxiety, at least for individuals with increased IU; however, the present study design prohibits causal inferences. Like other related constructs, such as pain-related anxiety (and AS; Asmundson et al., 2008), higher IU may create greater vulnerability to developing pain-related anxiety and pain chronicity. Alternatively, repeated experiences
of unpredictable or uncertain pain could influence the development of IU. Finally, chronic pain and IU may be reciprocally influencing each other.

5.0.2 Hypothesis 2. Participants with CLBP were expected to display greater IU than control participants. IU is closely associated with anxiety (Carleton, 2016a) and anxiety plays a central role in fear-avoidance models of chronic pain (Asmundson et al., 2014; Asmundson et al., 1999; Asmundson & Wright, 2004; Bailey et al., 2010; Bergbom et al., 2012; Leeuw et al., 2007; Lethem et al., 1983; Vlaeyen & Linton, 2000, 2012; Wideman et al., 2013). Therefore, IU was expected to be elevated for participants with CLBP relative to participants without. Observing such a difference would provide support for IU as a potentially influential construct in models of chronic pain. Based on the present results, in general, people with CLBP might be expected to have elevated IU. Indeed, researchers have suggested IU may partly underlie AS, as well as pain-related anxiety (Carleton, 2012; 2016a; 2016b; Carleton et al., 2007b). Such a role would be consistent with evidence supporting the transdiagnostic utility of IU in conceptualizing anxiety (Carleton, 2016a).

Independent sample t-tests identified significant differences in IU scores between groups. Participants with CLBP reported elevated IU compared to the control group. Elevated IU scores among the CLBP group suggest that exposure to uncertain and sometimes unpredictable negative events (i.e., pain experiences) could influence IU. Alternatively, higher levels of IU that predate experiences of chronic pain may contribute to greater distress for individuals who experience uncertain negative events (e.g., the occurrence or potential for pain and/or injury to be aggravated by a variety of physical activities, along with uncertainty regarding the meaning and consequences of such pain
and/or injury) on a chronic basis; as such, if uncertainty is already an object of elevated anxiety (i.e., IU is high), then the anxiety and avoidance characteristic of chronic pain could be precipitated or exacerbated by IU.

5.0.3 Hypothesis 3. Individuals with CLBP often engage in excessive avoidance of physical activity (Vlaeyen & Linton, 2012). Such avoidance is typically motivated by a desire to reduce a perceived risk of incurring pain and further injury (Carleton & Asmundson, 2012; Leeuw et al., 2007; Vlaeyen & Linton, 2012). The CLBP group in the present study was expected to be more risk-averse than the pain free control group on the modified BART. The task was conceptualized for participants as a representation of engaging in physical activity that may trigger musculoskeletal pain. As in real world settings, the potentially rewarding nature of a physical activity was highlighted. During the task, participants were also reminded to frame their decisions in the context of their pain experiences. A BART balloon ‘popping’ represented an occurrence of pain. Since participants reporting CLBP would be expected to exhibit significantly more anxiety and avoidance behaviours related to chronic pain (e.g., utilizing one’s back muscles), Hypothesis 3 predicted that the CLBP group would demonstrate significantly less risk taking than controls on the modified BART. Contrary to expectations, independent samples t-tests failed to detect a difference. The groups did not differ on BART performance and Hypothesis 3 was not supported.

Several explanations can be posited for the absence of support for Hypothesis 3. Individuals with CLBP may be less risk-averse when considering physical activities that are considered especially personally meaningful or enjoyable. Participants were instructed to imagine an activity that is of particular personal value. When potential
reward is perceived as high, such a perception might carry more weight in decision making than perceived risk. Perhaps the desire to engage in highly reinforcing activities overrides pain-related anxiety, to an extent. As a corollary, significant effects may have been found if participants were asked to focus on physical activities that provide little reinforcement (e.g., lifting heavy boxes). Such a phenomenon may vary per individual factors (e.g., current and recent severity of pain, type and nature of chronic pain syndromes). Alternatively, the modified BART may not be an effective analogue of real world behaviour. The imaginal focus of the task may have been insufficient to elicit behaviour representative of responses to real threat of pain, despite evidence supporting imaginal reward on the BART in other contexts (Benjamin & Robbins, 2007). Pre-testing the modified BART may have provided additional insight into how best to apply the BART in the present study. Without prior examples of such a protocol, pre-testing the present modifications to the BART after identifying and recruiting individuals with CLBP appeared to be a suboptimal use of resources in the context of a thesis. In addition, risk-taking related to physical activity may have been assessed by using a retrospective self-report of activity engagement and avoidance over a period of time. In order to compare the BART’s association with naturalistic behaviour, participants could potentially have been asked to list feared physical activities and the typical patterns of avoidance of and engagement in such activities.

5.0.4 Hypothesis 4. Anxiety and the expectation of future pain experiences are often elevated in individuals with chronic pain (Asmundson & Carleton, 2008; Asmundson and Katz, 2009; Asmundson & Wright, 2004; Asmundson et al., 2014; Leeuw et al., 2007; Turk & Okifuji, 2002; Vlaeyen & Linton, 2012). The occurrence and
recurrence of pain may involve uncertainty in many different ways, with different foci, and at different time points (Carleton & Asmundson, 2012). Individuals with chronic pain may be certain that they will continue to experience pain regularly; however, pain experiences are often episodic (i.e., pain waxes and wanes, and pain-free moments may occur – the definition of chronic pain does not require that pain occurs all the time; International Association for the Study of Pain, 1994). Individuals may be uncertain about exactly when pain will occur, or if a particular physical activity will lead to a pain episode (i.e., pain is not 100% predictable and expected pain may not necessarily occur during physical activity; Crombez et al., 1996). The meaning of pain is also often uncertain (e.g., is re-injury going to occur, how long is pain going to last, what will the consequences be; Turk & Okifuji, 2002). Given the inherently uncertain nature of chronic pain, in addition to the strong association between IU and various forms of anxiety, IU and IU-SS were hypothesised to account for unique variance in self-reported average pain (Hypothesis 4).

Hierarchical linear regression analysis revealed that IU was significantly associated with average pain at Step 1, and that the addition of IU-SS, pain-related anxiety, and AS in Model 2 significantly improved the variance accounted for by the model. Both IU and IU-SS remained individually significant in Model 2. The present results add to evidence that IU may be an influential factor in chronic pain (e.g., Helsen et al., 2013; Macatee et al., 2015). Furthermore, the individual significance of IU-SS supports the utility of including situation-specific IU when considering anxiety focused on an isolated set of worries (e.g., pain-related anxiety), as opposed to diffuse anxiety. Indeed, IU-SS was the largest coefficient in the final model for Hypothesis 4. Therefore,
IU-SS appears closely related to average pain levels among individuals with CLBP, and the fourth hypothesis was largely supported.

The sign change of the $\beta$ coefficient for IU (i.e., from positive in Model 1 to negative in Model 2) likely occurred due to the interrelatedness of IU and IU-SS. Model 1 did not include IU-SS, whereas Model 2 included IU-SS. There appeared to be some collinearity between measures for IU and IU-SS. Since IU-SS referred to uncertainty regarding pain in particular, IU-SS may have captured some of the variance accounted for by trait IU in Model 1. IU-SS is theoretically dependent on trait IU, and likely suppressed the IU variable to some degree. Alternatively, IU could actually have a negative relationship with pain, in contrast to the purported role of IU in anxiety and therein avoidance. The latter explanation is less likely. The observed sign change is likely a mathematical artefact, rather than an indication that IU negatively influences pain. The IU-SS variable likely suppressed the IU variable in regression models, masking the contributions of trait IU.

5.0.5 Hypothesis 5. Individuals with chronic pain avoid activities perceived as involving risk of pain (Asmundson & Wright, 2004; Asmundson et al., 2014; Leeuw et al., 2007; Vlaeyen & Linton, 2012). IU and pain-related anxiety may contribute to activity avoidance (Abrams et al., 2007; Asmundson et al., 2014; Carleton, 2016b; Carleton & Asmundson, 2012; Helsen et al., 2013; Macatee et al., 2015). Individuals with elevated IU may avoid greater uncertainty associated with greater risk (Carleton, 2012, 2016a). Pain-related anxiety has been associated with physical activity avoidance in persons with chronic pain (Asmundson et al., 2014; Carleton & Asmundson, 2012). IU and IU-SS, as well as pain-related anxiety, were all expected to account for unique
incremental variance in participation in risk-taking behaviours (i.e., score on the modified BART). Individuals with higher IU and pain-related anxiety can be expected to behave with greater caution when faced with situational uncertainty and (imaginal) threat of pain; however, the fifth hypothesis was not supported.

Hierarchical linear regression analysis of IU, IU-SS, and pain-related anxiety as correlates of risk-taking did not identify any individually significant correlates, despite a statistically significant overall final model. A trend toward significance was observed in the IU coefficient ($p = .07$). A small sample size on the modified BART increased the likelihood of a Type 2 error in failing to reject the null hypothesis; therefore, IU and other correlates may have reached statistical significance if the originally planned 400 participants had completed the modified BART. Although regression models may not have accounted for a large proportion of variance in risk-taking, statistically significant results would have reinforced the relevance of IU and pain-related anxiety in responding to uncertain future pain. Alternately, the variables included may be simply unrelated to risk-taking related to physical activity and pain, although the trend toward significance even with a low sample size appears to suggest otherwise. Obtaining a larger sample size in the present study may not have been practicable. After a time, there were no new participants choosing to participate on MTurk. Some effects could have gone undetected, though issues with the BART appear more likely.

The modified BART may be a poor representation of real-world risk and avoidance with respect to pain. Including images of physical activity and muscle exertion in the BART might have helped make the experimental activity more similar to real-world activity. Given the possible lack of representativeness in the modified BART, the
presence of any nearly significant correlates becomes potentially important and informative. Even in an unrepresentative task that fails to elicit naturalistic responses to risk, IU may still hold some observable relevance to uncertain risk. Observing participants’ real-world behaviours in naturalistic environments would likely yield more useful information. Collecting self-reported information about participants’ engagement in and avoidance of physical activities may be a pragmatic approach, although some limitations remain with self-reports. While ecological validity in the modified BART appears to have been acceptable for a simulated/imaginal task, the experimental conditions may not truly match real world exposure to reinforcing but potentially harmful activities; however, mirroring real world conditions in the experimental environment to ensure ecological validity is necessarily limited in simulated/imaginal tasks. Another possibility is that some participants may have simply rushed through the task without carefully attending to instructions or taking the task seriously; but, removing participants who had shorter completion times (a potential indicator of rushing) than expected on the BART did not appreciably change the results.

5.0.6 Overview of Hypothesis Tests. Overall, the present study identified several prominent relationships among constructs relevant to anxiety and chronic pain in a sample of individuals with and without CLBP. IU was elevated in individuals with CLBP, compared to controls. Further, IU accounted for significant, unique variance in reported average recent pain levels. Indeed, IU and IU-SS had the largest coefficients observed for the criterion of reported pain. Task performance when faced with imaginal risk and reward may not help to distinguish individuals with CLBP from individuals
without chronic pain. The present results have implications for research design in future projects, and particularly for understanding how IU may be involved in chronic pain.

5.1 Limitations and Strengths.

5.1.1 Limitations. The limitations of the present study provide potentially important directions for future research. First, sample size was low for the modified BART. Reduced sample size lowers statistical power and increases the risk of Type 2 error. There may be real differences between individuals with CLBP and pain-free controls on the modified BART that were simply undetected in the present study. Use of the modified BART in the present study represented a preliminary investigation for the utility of using the BART to assess responses to imagined pain in a simulated context. The BART may not be as useful as was hoped; nevertheless, conclusions about the utility of the BART could only be made after completing the present study.

Second, the modified BART may not be well suited for the intended purpose in the present study. The novel use of the BART to assess risk-taking related to physical activity represented a preliminary test of the utility of the BART for comparing individuals with and without chronic pain. There is precedent for such modification of the BART as well as the use of imaginal activity and reward in behavioural tasks (Benjamin & Robbins, 2007; Lawyer, 2013). There is considerable evidence that individuals with CLBP are more avoidant of physical activity than healthy controls, as outlined in the fear-avoidance model (Asmundson et al., 2004a; Leeuw et al., 2007; Vlaeyen and Linton, 2000, 2012). Given the large body of literature supporting physical activity avoidance and aversion to perceived risk of pain in individuals with chronic pain (e.g., Abrams et al., 2007; Asmundson et al., 2014; Asmundson et al., 1999; Asmundson & Wright, 2004;
Leeuw et al., 2007; Turk & Okifuji, 2002; Vlaeyen & Linton, 2000, 2012), the lack of significant group differences here suggests that the BART, and perhaps other simulations, may not always correspond to real world risk-taking behaviour among chronic pain participants. Such an explanation appears more consistent with theory than assuming insufficiencies in sample sizes or perceived reward values. The current evidence suggests that the BART did not demonstrate validity for pain-related uncertainty. Despite past evidence of the generalizability of the BART to activities that may involve pain and/or detriment to one’s health, the BART may have an ecological validity limitation with respect to pain. There may be something unique about pain and behavioural avoidance of pain-related risk, such that the BART does not relate to pain-related risk taking and avoidance.

An artificial task related to pain without definite, material risk or reward may be insufficiently meaningful to elicit responses similar to real world behaviour. Developing better analogue tasks would be particularly beneficial to online research. Assessing participants in person and incorporating real physical activity into the experimental procedure may address the limitations inherent in simulations. In the present study, the utility of the BART may have been better evaluated had participants additionally completed a questionnaire retrospectively self-reporting real-world patterns of physical activity approach or avoidance, which then could have been considered alongside BART performance to provide a more complete picture of responses to perceived risk of pain. Alternatively, using uncertain threat of real acute pain (e.g., through a heat or cold pressor task) may provide a useful proxy for activity avoidance related to chronic pain. Prior researchers have examined uncertainty in the context of acute pain (e.g., Helsen et
al., 2013). Applying such protocols in an experimental paradigm focused on physical activity avoidance would be a novel goal that would improve understanding of how uncertainty and IU influence behaviours associated with chronic pain. Evaluating individual responses to uncertain acute pain would undoubtedly increase understanding of the relationships between IU, situational uncertainty, and pain.

Third, geographical restriction can be considered a limitation of the present study. The present sample of participants included individuals residing in the USA only; therefore, results may not generalize well to other countries where life experiences may be different. Different healthcare systems may result in different experiences with chronic pain (e.g., due to access to medical care, availability of psychological services). Sociocultural practices and beliefs regarding pain may also differ across regions, and such cultural factors may affect experiences with, and responses to, chronic pain (e.g., attitudes toward seeking medical and psychological services, beliefs about the significance of pain, beliefs about the causes of pain). Testing participants across many different countries would necessitate either another online study, or extensive collaboration with researchers at various international institutions.

Fourth, the present study was cross-sectional in design. Observing changes in variables of interest over time would allow for true predictive relationships to be tested, providing greater depth to the present results. Constructs entered as statistical predictors of criterion variables in regression analyses are not predictive. Significant relationships identified in the present study have implications for future longitudinal research to further clarify the nature of such relationships.
Fifth, data on healthcare access and coverage were not collected. Individuals with CLBP may have different experiences with the development and maintenance of chronic pain as a function of access to medical and psychological services. Having data regarding participants’ insurance coverage, access to services, and ability to pay for services would be beneficial in comparing the present results with chronic pain research in different nations under different healthcare systems. Collecting additional data regarding the nature of participants’ CLBP would have also helped provide a clearer picture of the sample. Given the relatively small sample size in the present study, statistical comparisons between individuals within the CLBP group on such variables may not have been achievable. Individuals with CLBP may have differences within the group, but there is no truly homogeneous group of pain patients. Individuals with CLBP at least represent a clear subset of individuals with chronic pain. There may be differences present among participants with CLBP (e.g., with respect to sudden versus gradual onset, with respect to cause of CLBP, with respect to the presence of psychological difficulties); nevertheless, the present sample size was too low and information was not available to test for such differences. Doing so offers an important avenue for future research.

5.1.2 Strengths. Despite the noted limitations, the present study has several strengths. First, approximately 470 participants completed self-report questionnaires in full and the a priori power analysis indicated a sample size of approximately 400 participants would provide adequate statistical power to conduct planned analyses. Following more restrictive participant filtering, 326 participants remained, and results of hypothesis tests did not differ appreciably from the initial sample. As such, the observed group differences and relationships among self-reported constructs of interest are
believed to be robust. Recruiting participants online allowed a larger number of potential participants to be invited in less time than traditional methods require, despite limits that included issues with BART completion.

A second strength of the present study was the use of hierarchical regression analysis to help clarify whether IU can be subsumed in other constructs or is indeed distinct. Analyses to evaluate IU as a mediator in the relationship between anxiety-related constructs, reported pain, and risk taking were also considered; however, the relatively limited existing research on IU in CLBP and the relatively smaller sample size appeared to make mediation hypotheses somewhat more tenuous. Measuring IU alongside constructs implicated in the fear-avoidance models allows for potential identification of unique variance accounted for by IU. Utilizing pain and disability measures commonly employed in chronic pain research means the present results can be more meaningfully compared to prior research. The present results provide novel understanding of the potential role of IU in fear and avoidance of chronic pain by examining relationships among IU and related constructs, and the variance in pain-related criteria accounted for by such constructs.

Third, recruiting participants with current CLBP represents a major strength of the present study. Comparing CLBP and control groups enables clearer understanding of how relevant constructs vary between individuals with no pain and individuals with current chronic pain. A locally recruited, in-person sample of participants may not have included enough CLBP participants meeting inclusion criteria to draw robust conclusions for the broader CLBP population, and recruitment may have taken longer.
Fourth, while restricting participation to USA residents may limit generalizability, doing so allowed for greater confidence that results were not influenced by differences between Canadian and American healthcare supports. Geographically unbalanced groups (e.g., having more Canadians than Americans in the control group and having no Canadians in the CLBP group) might have produced results that reflect different experiences with healthcare providers (e.g., greater personal difficulties with cost of healthcare and healthcare access in the USA compared to Canada; Blendon, Schoen, DesRoches, Osborn, & Zapert, 2003; Lasser et al., 2006), rather than authentic differences between individuals with CLBP and pain-free controls in similar environments. Uneven distributions of individual differences would have cast doubt on the present results. Identifying a sufficient number of Canadian participants on MTurk eligible for the present study would not have likely been possible, due to the relatively small population of MTurk users in Canada. During initial attempts to recruit Canadian participants on MTurk for the present study, fewer than 40 individuals completed the screener survey. In the later sample of 5077 US residents who completed the screener survey, only 4.3% were eligible for the CLBP group and chose to participate. There are always intra-national variations in healthcare systems, but selecting the USA allowed for a sufficient number of participants to be recruited, while avoiding more highly contrasting experiences typical of multinational samples. Overall, the present study has several strengths and provides novel information that can inform the design of future studies.

5.2 Implications.
The present results have implications for understanding interrelationships between IU and chronic pain. Relationships among IU and constructs implicated in fear-avoidance models of chronic pain (i.e., pain-related anxiety, AS) provide insight into the potential contributions of each construct to the development and maintenance of chronic pain. Differences between CLBP and control groups in IU suggest a potential role for elevated IU in the development and/or maintenance of chronic pain. Results regarding the performance on the behavioural task have additional implications for measuring responses to pain by proxy. Simulations without risk of real pain may be insufficiently discomfiting and therein may not reflect real-world avoidance behaviours. Comparisons with self-reports of physical activity avoidance and naturalistic observations are necessary.

The present results indicate that IU, along with IU-SS, AS, and pain-related anxiety, are significant correlates of reported pain in hierarchical regression analyses. The unique variance accounted for by IU supports suggestions that IU may be influential in the development and/or maintenance of chronic pain. Further, the present results support IU-SS as a relevant construct in examining specific objects of uncertainty (e.g., situations related to pain). Including targeted IU-SS measures alongside the IUS-12 may be useful for research questions involving IU and particular foci of anxiety. AS and pain-related anxiety still contributed unique variance to reported pain, suggesting that the role of anxiety in chronic pain may not be totally subsumed by IU; however, the present results support notions that IU may directly and indirectly influence both AS and pain-related anxiety (Carleton, 2016a; Carleton et al., 2007b; Helsen et al., 2013).
Anxiety negatively impacts the experience of pain by promoting maladaptive avoidance behaviours (e.g., Asmundson & Wright, 2004). As IU may also be influential in pain and pain-related anxiety (Carleton, 2016b; Carleton & Asmundson, 2012), research investigating the relationship between IU and pain may further our understanding of the development and maintenance of chronic pain. Knowing how specific psychological constructs are involved in the experience of pain can inform treatment of acute and chronic pain, as well as the anxiety and distress that often surround chronic pain (Bailey et al., 2010). Interventions targeting specific constructs are available, and if a construct (e.g., IU) contributes to presenting problems (e.g., chronic pain), then psychological treatment focused on the specific construct might be beneficial for the patient. For example, since psychoeducation is a key component of many psychological treatments for chronic pain (Eccleston, Williams, & Morley, 2009), explicit instruction regarding IU and how IU may affect anxiety and avoidance behaviours in chronic pain may improve beneficial effects of psychoeducation. Change in IU during treatment for various psychological difficulties (e.g., diagnoses of GAD, social anxiety, panic disorder, major depression, OCD) predicted changes in symptom levels, regardless of specific diagnoses (Boswell, Thompson-Hollands, Farchione, & Barlow, 2013). IU-focused therapy for GAD has produced significant decreases in GAD symptoms, as well as IU levels (van der Heiden, Muris, & van der Molen, 2012). Researchers have suggested that IU should be considered in treatment of any issue related to anxiety and maladaptive avoidance (Boswell et al., 2013). Given evidence supporting IU-reduction as a potential means to reduce anxiety and avoidance generally, similar results could potentially occur with pain-related anxiety and avoidance. Such suggestions
will need to be tested. Implications for psychoeducation and treatment will become clearer through future research on IU in chronic pain.

In line with previous research, constructs related to anxiety and to chronic pain were positively correlated in the present study (e.g., Asmundson et al., 2008; Carleton et al., 2007b; Helsen et al., 2013; Muris et al., 2001; Ocañez et al., 2010). The present results add to evidence indicating close relationships among IU, AS, pain-related anxiety, and reported disability. Further, such associations are present in participants with CLBP and in pain-free controls. The present results add to evidence that IU, in particular, is ubiquitous in the general population; as such, in line with previous recommendations (e.g., Carleton et al., 2012), preventative interventions may be beneficial.

IU may be a useful construct in distinguishing between individuals with CLBP from those without ongoing pain. Participants in the CLBP group had significantly higher IU than did pain-free controls. One likely explanation for higher IU scores among the CLBP group is that IU drives excessive anxiety and avoidance, given prior support for IU as a transdiagnostic factor (e.g., Carleton, 2012, 2016a, 2016b; Carleton et al., 2012; Hong & Cheung, 2015). IU may have an indirect effect on chronic pain via anxiety, as pain-related anxiety is critical to maladaptive fear and avoidance of activity. Indeed, IU likely underlies or at least exacerbates pain-related anxiety (Carleton, 2016b). The present results are consistent with suggestions that IU is critical to anxiety in general. Differences in IU scores observed between groups implicate IU as a potentially important factor in chronic pain; in addition, differences in IU might contribute to different experiences with pain (e.g., by facilitating the transition from acute to chronic pain).
At least one study has used a task similar to the BART in presenting threat of real acute pain (Macatee et al., 2015); however, the present study is the first to utilize the BART with individuals who have chronic pain. The present study also provides new evidence regarding responses to uncertainty in chronic pain by experimentally studying how responses to uncertain risk vary between individuals with and without chronic pain. Based on the present results, the BART may not be well-suited for obtaining an index of naturalistic behaviour. Incorporating real physical activity or threat of pain, as well as collecting self-report data on activity avoidance, would likely be a more informative approach; however, there may be ethical and practical considerations with asking individuals with CLBP to engage in physical activity.

A major strength of the present study was including participants with current chronic pain in a study of IU. Evidence of associations between IU, IU-SS, and reported pain across control and chronic pain participants supports the need for future investigations to examine potential causal links between IU and pain (e.g., through manipulation of uncertainty in pain-induction tasks). IU was not associated with increased BART risk avoidance, suggesting future research should further explore the role of uncertainty in pain-related behaviour using different behavioural measures. IU contributed unique, statistically significant variance to reported pain, a novel finding that reinforces suggestions that IU could be an important factor to consider in chronic pain. Further, participants with CLBP demonstrated statistically significantly higher IU scores compared to healthy controls. To the author’s knowledge, the present study is the first to examine differences in IU levels between individuals with CLBP and controls with no pain. The present results further support uncertainty and IU as important elements of
pain-related fear and anxiety, and of fear more generally; in addition, the present results extend the theoretical and clinical relevance of the IU construct across anxiety and pain-related syndromes.

5.3 Future Directions. The present study had several limitations and strengths. The present limitations and strengths both provide new directions for future research. There are several areas that warrant further investigation to clarify and expand upon the present results. Future research should include IU in fear-avoidance models. The present study has demonstrated that individuals with CLBP display elevated IU compared to pain-free controls. Prior researchers have suggested IU is a core, underlying component of anxiety (Carleton, 2012, 2016a, 2016b; Hong & Cheung, 2015). IU may partly underlie both AS and pain-related anxiety, given the inherently uncertain nature of anxious thoughts characteristic of each construct. The AS and pain-related anxiety constructs may not be entirely subsumed by IU; indeed, AS and pain-related anxiety are useful in obtaining a clearer picture of individuals’ specific foci of anxiety. Adding IU to fear-avoidance models of chronic pain should result in a greater proportion of the variance in pain-related behaviours and outcomes accounted for, thereby improving theory in chronic pain research. IU was strongly associated with components of the fear-avoidance models in the present study. Longitudinal research would be particularly useful in examining how IU may influence and be influenced by related constructs. Future studies should look at manipulating situational uncertainty to better assess IU’s role in physical activity and avoidance. Tracking changes in IU and participant outcomes (e.g., chronic pain, distress associated with chronic pain, general mental health) would enhance our understanding of IU and the role of IU in chronic pain.
IU could have a causal role in the development and maintenance of chronic pain, or could be a consequence of chronic pain or other instigating circumstances (e.g., repeated exposure to stressful, uncertain events). Elevated IU may represent a risk factor for the transition from acute to chronic pain, which may be relevant for preventing the development of chronicity via avoidance behaviours driven partly by IU. Individuals with higher IU could be more apt to respond to pain with excessive avoidance behaviours. Since any causal role of IU in chronic pain remains unclear, the possibility of IU representing a risk factor is speculative at the current time. Clarifying the interactive influences of IU, AS, and pain-related anxiety on pain (i.e., how the development of IU influences, is influenced by, or parallels AS) will inform theory and therein opportunities for interventions. Examining the influence of environmental factors (e.g., uncertain and stressful events, which may contribute to the development of anxiety; Allen, Rapee, & Sandberg, 2008), neurological factors (e.g., hypothalamic-pituitary-adrenal axis activation, which is involved in stress and anxiety; Graeff & Zangrossi, 2010), and psychological factors (e.g., AS and related traits) on IU would enhance our understanding of the IU construct. Disentangling such relationships is beyond the scope of the present study; therefore, future researchers should seek to clarify the direction of the relationship between IU and chronic pain using longitudinal designs.

Studies examining IU and chronic pain in new contexts should examine healthcare access as well. To improve our understanding of how IU relates to chronic pain, researchers should test whether relationships differ as a function of healthcare access (e.g., public or private, quality of care, financial burden associated with using services). The healthcare experiences of individuals with chronic pain will inevitably
differ across nations and socioeconomic strata. Access to and financial cost of healthcare tends to be a more common source of difficulty in the USA than in Canada, and other differences in patient experiences (e.g., satisfaction with care) may differ across nations (Blendon et al., 2003; Hargreaves et al., 2015; Lasser et al., 2006). Challenges faced by persons seeking medical care, therefore, may vary considerably between different national and sociocultural environments. Data are sparse regarding how international differences may specifically affect individuals with chronic pain. Quantifying such differences in experience, alongside IU and chronic pain, will help clarify inter-relationships among relevant variables.

The utility of artificial proxies for pain-related behaviours remains unclear. Future studies should test simulated behavioural tasks (e.g., the BART and other risk tasks) alongside in vivo behavioural measures in naturalistic environments. Comparing simulated tasks with real-world behaviours would allow researchers to refine existing behavioural measures or develop more appropriate new measures for risk-taking, avoidance, and other pain-related behaviours. Future studies may be able to garner more useful behavioural data in online studies if a simulated task with stronger ecological validity can be developed.

Future research on the role of anxiety in domains beyond chronic pain should include IU; the present study, coupled with the substantial body of evidence supporting IU as a transdiagnostic construct (e.g., Carleton, 2012, 2016a, 2016b; Carleton et al., 2012; Hong & Cheung, 2015), strongly support the broad importance of IU in anxiety. If IU represents a fundamental fear (Carleton, 2016b), models of anxiety likely need restructuring in order to accurately reflect the hierarchical relationships between
constructs contributing to anxiety. The present study does not indicate a clear best route to re-examining existing models of anxiety; however, the present study does support the need to incorporate IU into conceptualizations of pain-related anxiety.

Given the importance of fear and anxiety in pain experiences, researchers have developed treatments to reduce fear and anxiety surrounding pain (for review see Bailey et al., 2010). Graded in vivo exposure (GiVE) and acceptance and commitment therapy (ACT) appear to be effective treatments for pain-related anxiety, fear, catastrophizing, kinesiophobia (i.e., fear of movement due to believing movement may cause re-injury; Picavet, Vlaeyen, & Schouten 2002), and pain itself (for review see Bailey et al., 2010). The present results suggest IU is associated with pain and pain-related fear and anxiety. Researchers have recently provided evidence that IU may be a necessary precursor for the development of pain-related anxiety, and that IU could potentially influence pain chronicity (Fischerauer, Talaei-Khoei, Vissers, Chen, & Vranceanu, 2018). Therefore, future researchers may follow up on the present study by exploring the utility of transdiagnostic interventions that address IU in individuals with chronic pain.

Prior research results demonstrate that reductions in IU are associated with reductions in symptom levels for certain disorders and that targeted IU interventions can reduce IU (Boswell et al., 2013; McEvoy & Erceg-Hurn, 2016; Oglesby, Allan, & Schmidt, 2017, Stevens, Rogers, Campbell, Björgvinsson, & Kertz, 2018; Talkovsky & Norton, 2016; van der Heiden et al., 2012). Given the apparent association between IU, CLBP, and constructs implicated in fear-avoidance models, future research on IU-focused interventions could include participants with chronic pain. As a corollary, research on interventions for chronic pain would benefit from including participant
groups receiving IU-focused interventions; doing so would allow fear, avoidance, and pain-related outcomes to be measured as a function of IU. Such research would clarify the potential role of IU in chronic pain, as well as the utility of IU as a target of transdiagnostic interventions. Further understanding the role of IU in pain and avoidance of activities perceived as risky will help provide a foundation for improved theoretical models and clinical treatments for pain.

6.0 Conclusion

The present study examined the relationships between chronic pain, IU, IU-SS, AS, and pain-related anxiety. The present study was also designed to investigate untested suggestions regarding a potential role of IU in chronic pain. Improving our understanding of constructs associated with chronic pain helps to inform underlying theory and clinical interventions.

Participants with CLBP in the present study displayed higher levels of IU than pain-free control participants, suggesting that higher IU may be involved in the development and/or maintenance of CLBP. The direction of such a relationship, or whether the relationship is causal, remains unclear. IU accounted for a significant and unique portion of the variance in reported recent pain. Given the unique contribution of IU to variance in reported pain, researching the possible inclusion of IU in the fear-avoidance model is an appropriate next step. Significant relationships were observed among IU and multiple constructs (i.e., pain-related anxiety, AS, disability) implicated in chronic pain. Trait IU may influence the development of associated traits (e.g., AS), given theory identifying IU as a trait that arises early in life. Indeed, the development of IU, AS, and associated traits might be explained by similar biopsychosocial factors that
contribute to anxiety in general and thereby increase vulnerability to elevated IU, AS, and the maladaptive behaviours and difficulties associated with anxiety-related traits. Such biopsychosocial factors could include behavioural inhibition (Fox, Henderson, Marshall, Nichols, & Ghera, 2005), stressful environments (Degnan, Almas, & Fox, 2010), and neurological as well as genetic differences (Gross & Hen, 2004). The nature of specific biopsychosocial factors leading to the development of IU and AS remains speculative at the present time, and the relevant components and interrelationships therein may be complex. The absence of group differences in modified BART performance ran contrary to expectations, suggesting the BART may not be an adequate proxy for activity avoidance. The BART could be an accurate representation of perceived risk, and individuals with CLBP simply do not respond to imminent risk differently than pain-free controls. The latter explanation is less likely.

Clinical assessments for individuals with chronic pain may benefit from measuring IU, given mounting evidence that IU contributes to, or underlies, AS and pain-related anxiety. Future researchers should seek to clarify the influence of IU on chronic pain and traits associated with chronic pain via longitudinal studies. Further exploring IU in the context of chronic pain will clarify the nature of the relationship between the two (e.g., whether IU may cause avoidance leading to pain chronicity).

IU-focused transdiagnostic interventions may be helpful in ameliorating psychological and behavioural factors that contribute to the development and maintenance of chronic pain. Future research on IU-focused interventions for CLBP should measure constructs related to IU (e.g., AS) and use experimental designs to determine whether changes in IU lead to changes in other constructs or symptoms (see,
for example, Mahoney & McEvoy, 2012b). The present study enhances our understanding of the relationships among IU, constructs implicated in the fear-avoidance model, disability, and pain severity. The present study further supports the transdiagnostic utility of IU and provides direction for future research.
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Appendices
Appendix A: Syndrome Characteristics Survey

I. How certain are you of when/if your pain will occur?

1. Completely uncertain  
2. Somewhat uncertain  
3. Not sure/Neutral  
4. Somewhat certain  
5. Completely certain

II. How predictable is your pain?

1. Completely unpredictable  
2. Somewhat unpredictable  
3. Inconsistently predictable  
4. Somewhat predictable  
5. Completely predictable
Appendix B: BART Scripts for Participants

**Instructions: Control Condition and CLBP Condition**

Now you're going to see 30 balloons, one after another, on the screen. For each balloon, you can click on the button that will pump up the balloon. Each time you click the pump button, the balloon pumps up a little more.

BUT remember, balloons pop if you pump them up too much. Imagine that pumping the balloon means engaging in an activity that may cause you pain. Engaging in enjoyable activities that may cause pain (e.g., gardening, playing hockey, going for a run) allows you to have fun, but each time you use a muscle there is a possibility, no matter how remote, that you may experience pain or even become injured. In the current activity, the balloon popping means you have experienced substantial pain; as such, you must decide how many times you are willing to pump up each balloon. Some of these balloons might pop after just one pump. Others might not pop until they fill the whole screen.

Each pump of the balloon earns 10 seconds of time doing an enjoyable activity. But if a balloon pops, that means you end up experiencing a painful episode as a result of participating in the activity. To stop the activity and avoid potential pain, click the button labeled ~"Collect Time~".

Once you collect time or pop a balloon, a new balloon will appear.

Treat the amount of time you have at the end of the experiment as the total time you were able to spend in your enjoyable activity.

Continue to see the summary

**Summary of imagined activity:**
* You earn 12 seconds of pleasant activity for each pump.
* You get to count the time from a balloon not popping as pain-free pleasant activity when you click ~"Collect Time~".
* You end up experiencing a painful episode from participating in the activity when a balloon pops.
* There are just 30 balloons.

Now, do you have any questions?

Start when you are ready.
Appendix C: Intolerance of Uncertainty Scale – Short Form

**Intolerance of Uncertainty Scale – Short Form (IUS-12)**

Please circle the number that best corresponds to how much you agree with each item.

<table>
<thead>
<tr>
<th>Item</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Unforeseen events upset me greatly.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>2. It frustrates me not having all the information I need.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>3. Uncertainty keeps me from living a full life.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>4. One should always look ahead so as to avoid surprises.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>5. A small unforeseen event can spoil everything, even with the best of planning.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>6. When it’s time to act, uncertainty paralyses me.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>7. When I am uncertain I can’t function very well.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>8. I always want to know what the future has in store for me.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>9. I can’t stand being taken by surprise.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>10. The smallest doubt can stop me from acting.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>11. I should be able to organize everything in advance.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>12. I must get away from all uncertain situations.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>
Appendix D: Intolerance of Uncertainty Scale – Situation Specific Version (Mahoney & McEvoy, 2012)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>Not at all characteristic of me</th>
<th>A little characteristic of me</th>
<th>Somewhat characteristic of me</th>
<th>Very characteristic of me</th>
<th>Entirely characteristic of me</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Unforeseen events associated with my pain upset me greatly</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>It frustrates me not having all the information I need about my pain</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>Uncertainty about pain keeps me from living a full life</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>One should always look ahead so as to avoid surprises with pain</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>A small unforeseen event with my pain can spoil everything, even with the best planning</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>When it’s time to act, uncertainty about pain paralyses me</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>7</td>
<td>When I am uncertain about my pain I can’t function very well</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>8</td>
<td>I always want to know what the future has in store for me for my pain</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>9</td>
<td>I can’t stand being taken by surprise by pain</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>10</td>
<td>The smallest doubt about pain can stop me from acting</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>11</td>
<td>I should be able to organise everything in advance for my pain</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>12</td>
<td>I must get away from all uncertainty regarding my pain</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>
Appendix E: Anxiety Sensitivity Index-3

**Anxiety Sensitivity Index-3 (ASI-3)**

Please circle the number that best corresponds to how much you agree with each item. If any items concern something that you have never experienced (e.g., fainting in public), then answer on the basis of how you think you might feel if you had such an experience. Otherwise, answer all items on the basis of your own experience. Be careful to circle only one number for each item and please answer all items.

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Very little</th>
<th>A little</th>
<th>Some</th>
<th>Much</th>
<th>Very much</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>It is important for me not to appear nervous.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>2.</td>
<td>When I cannot keep my mind on a task, I worry that I might be going crazy.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>3.</td>
<td>It scares me when my heart beats rapidly.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>4.</td>
<td>When my stomach is upset, I worry that I might be seriously ill.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>5.</td>
<td>It scares me when I am unable to keep my mind on a task.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>6.</td>
<td>When I tremble in the presence of others, I fear what people might think of me.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>7.</td>
<td>When my chest feels tight, I get scared that I won’t be able to breathe properly.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>8.</td>
<td>When I feel pain in my chest, I worry that I’m going to have a heart attack.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>9.</td>
<td>I worry that other people will notice my anxiety.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>10.</td>
<td>When I feel “spacey” or spaced out I worry that I may be mentally ill.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>11.</td>
<td>It scares me when I blush in front of people.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>12.</td>
<td>When I notice my heart skipping a beat, I worry that there is something seriously wrong with me.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>13.</td>
<td>When I begin to sweat in a social situation, I fear people will think negatively of me.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>14.</td>
<td>When my thoughts seem to speed up, I worry that I might be going crazy.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>15.</td>
<td>When my throat feels tight, I worry that I could choke to death.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>16.</td>
<td>When I have trouble thinking clearly, I worry that there is something wrong with me.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>17.</td>
<td>I think it would be horrible for me to faint in public.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>18.</td>
<td>When my mind goes blank, I worry there is something terribly wrong with me.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

*Scoring:* Physical concerns = sum of items 3, 4, 7, 8, 12, 15; Cognitive concerns = sum of items 2, 5, 10, 14, 16, 18; Social concerns = sum of items 1, 6, 9, 11, 13, 17
Appendix F: Pain-Anxiety Symptoms Scale – Short Form

**Pain Anxiety Symptoms Scale-20 (PASS-20)**

Please use the following scale to rate how often you engage in each of the following thoughts or activities. Circle the number beside the statement to indicate your rating.

<table>
<thead>
<tr>
<th></th>
<th>Never</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>I can’t think straight when in pain</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>2.</td>
<td>During painful episodes it is difficult for me to think of anything besides the pain</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>3.</td>
<td>When I hurt I think about pain constantly</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>4.</td>
<td>I find it hard to concentrate when I hurt</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>5.</td>
<td>I worry when I am in pain</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>6.</td>
<td>I go immediately to bed when I feel severe pain</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>7.</td>
<td>I will stop any activity as soon as I sense pain coming on</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>8.</td>
<td>As soon as pain comes on I take medication to reduce it</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>9.</td>
<td>I avoid important activities when I hurt</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>10.</td>
<td>I try to avoid activities that cause pain</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>11.</td>
<td>I think that if my pain gets too severe it will never decrease</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>12.</td>
<td>When I feel pain I am afraid that something terrible will happen</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>13.</td>
<td>When I feel pain I think I might be seriously ill</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>14.</td>
<td>Pain sensations are terrifying</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>15.</td>
<td>When pain comes on strongly I think that I might become paralysed or more disabled</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>16.</td>
<td>I begin trembling when engaged in an activity that causes pain</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>17.</td>
<td>Pain seems to cause my heart to pound or race</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>18.</td>
<td>When I sense pain I feel dizzy or faint</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>19.</td>
<td>Pain makes me nauseous</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>20.</td>
<td>I find it difficult to calm my body down after periods of pain</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>
Appendix G: Patient Health Questionnaire

**Patient Health Questionnaire**

Over the last 2 weeks, how often have you been bothered by any of the following problems?

<table>
<thead>
<tr>
<th>Problem</th>
<th>Not at all</th>
<th>Several days</th>
<th>More than half the days</th>
<th>Nearly every day</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Little interest or pleasure in doing things</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>2. Feeling down, depressed, or hopeless</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>3. Trouble falling or staying asleep, or sleeping too much</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>4. Feeling tired or having little energy</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>5. Poor appetite or overeating</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>6. Feeling bad about yourself—or that you are a failure or have let</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>yourself or your family down</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Trouble concentrating on things, such as reading the newspaper</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>or watching television</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Moving or speaking so slowly that other people could have noticed?</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Or the opposite — being so fidgety or restless that you have been</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>moving around a lot more than usual</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Thoughts that you would be better off dead or of hurting yourself in</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>some way</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(For office coding: Total Score = ______ + ______ + ______)

If you checked off any problems, how difficult have these problems made it for you to do your work, take care of things at home, or get along with other people?

- Not difficult at all
- Somewhat difficult
- Very difficult
- Extremely difficult
Appendix H: Short-Form McGill Pain Questionnaire

Short-Form McGill Pain Questionnaire
(Melzack, 1987)

Please place a check mark ✓ in the blank space underneath the word (none, mild, moderate, or severe) that best describes the intensity of each adjective you currently or frequently experience.

<table>
<thead>
<tr>
<th></th>
<th>NONE</th>
<th>MILD</th>
<th>MODERATE</th>
<th>SEVERE</th>
</tr>
</thead>
<tbody>
<tr>
<td>THROBBING</td>
<td>0)</td>
<td>1)</td>
<td>2)</td>
<td>3)</td>
</tr>
<tr>
<td>SHOOTING</td>
<td>0)</td>
<td>1)</td>
<td>2)</td>
<td>3)</td>
</tr>
<tr>
<td>STABBING</td>
<td>0)</td>
<td>1)</td>
<td>2)</td>
<td>3)</td>
</tr>
<tr>
<td>SHARP</td>
<td>0)</td>
<td>1)</td>
<td>2)</td>
<td>3)</td>
</tr>
<tr>
<td>CRAMPING</td>
<td>0)</td>
<td>1)</td>
<td>2)</td>
<td>3)</td>
</tr>
<tr>
<td>GNAWING</td>
<td>0)</td>
<td>1)</td>
<td>2)</td>
<td>3)</td>
</tr>
<tr>
<td>HOT-BURNING</td>
<td>0)</td>
<td>1)</td>
<td>2)</td>
<td>3)</td>
</tr>
<tr>
<td>ACHING</td>
<td>0)</td>
<td>1)</td>
<td>2)</td>
<td>3)</td>
</tr>
<tr>
<td>HEAVY</td>
<td>0)</td>
<td>1)</td>
<td>2)</td>
<td>3)</td>
</tr>
<tr>
<td>TENDER</td>
<td>0)</td>
<td>1)</td>
<td>2)</td>
<td>3)</td>
</tr>
<tr>
<td>SPLITTING</td>
<td>0)</td>
<td>1)</td>
<td>2)</td>
<td>3)</td>
</tr>
<tr>
<td>TIRING-EXHAUSTING</td>
<td>0)</td>
<td>1)</td>
<td>2)</td>
<td>3)</td>
</tr>
<tr>
<td>SICKENING</td>
<td>0)</td>
<td>1)</td>
<td>2)</td>
<td>3)</td>
</tr>
<tr>
<td>FEARFUL</td>
<td>0)</td>
<td>1)</td>
<td>2)</td>
<td>3)</td>
</tr>
<tr>
<td>PUNISHING-CRUUEL</td>
<td>0)</td>
<td>1)</td>
<td>2)</td>
<td>3)</td>
</tr>
</tbody>
</table>

Please rate your present level of pain on the following scale:

NO | ------------------------------------------ | WORST
PAIN |------------------------------------------| POSSIBLE
PAIN

Please rate your average level of pain, over the last two weeks, on the following scale:

NO | ------------------------------------------ | WORST
PAIN |------------------------------------------| POSSIBLE
PAIN

Please rate your present level of pain by placing a check mark ✓ in the blank space beside the appropriate adjective:

0 NO PAIN
1 MILD
2 DISCOMFORTING
3 DISTRESSING
4 HORRIBLE
5 EXCRUCIATING

Score:
Appendix I: Pain Disability Questionnaire

Does your pain interfere with your normal work inside and outside

Please read:
This survey asks for your views about how your pain now affects how you function in everyday activities. This information will help you and your doctor know how you feel and how well you are able to do your daily tasks at this time.

Please answer every question by making an "X" along the line to show how much your pain problem has affected you (from having no problems at all to having the most severe problems you can imagine).

BE SURE TO ANSWER ALL QUESTIONS.

1) Does your pain interfere with your normal work inside and outside the home?
   Work normally [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ]
   Unable to work at all [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ]

2) Does your pain interfere with personal care (such as washing, dressing, etc.)?
   Take care of myself completely [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ]
   Need help with all my personal care [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ]

3) Does your pain interfere with your traveling?
   Travel anywhere I like [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ]
   Only travel to see doctors [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ]

4) Does your pain affect your ability to sit or stand?
   No problems [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ]
   Cannot sit/stand at all [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ]

5) Does your pain affect your ability to lift overhead, grasp objects, or reach for things?
   No problems [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ]
   Cannot do at all [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ]

6) Does your pain affect your ability to lift objects off the floor, bend, stoop, or squat?
   No problems [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ]
   Cannot do at all [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ]

7) Does your pain affect your ability to walk or run?
   No problems [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ]
   Cannot walk/run at all [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ]

8) Has your income declined since your pain began?
   No decline [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ]
   Lost all income [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ]

9) Do you have to take pain medication every day to control your pain?
   No medication needed [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ]
   On pain medication throughout the day [ ] [ ] [ ] [ ] [ ] [ ] [ ]

10) Does your pain force you to see doctors much more often than before your pain began?
    Never see doctors [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ]
    See doctors weekly [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ]

11) Does your pain interfere with your ability to see the people who are important to you as much as you would like?
    No problem [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ]
    Never see them [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ]

12) Does your pain interfere with recreational activities and hobbies that are important to you?
    No interference [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ]
    Total interference [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ]

13) Do you need the help of your family and friends to complete everyday tasks (including both work outside the home and housework) because of your pain?
    Never need help [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ]
    Need help all the time [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ]

14) Do you now feel more depressed, tense, or anxious than before your pain began?
    No depression/tension [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ]
    Severe depression/tension [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ]

15) Are there emotional problems caused by your pain that interfere with your family, social, or work activities?
    No problems [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ]
    Severe problems [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ]
Appendix J: Informed Consent Form

Department of Psychology
University of Regina
Administration-Humanities Building
3737 Wascana Parkway
Regina, Saskatchewan

Participant Consent Form

Anxiety and the Experience of Pain

**Researcher(s):** Isaac Hahn, principal investigator (Graduate Student, Faculty of Graduate Studies and Research), Department of Psychology, University of Regina, 306-337-2473 (Anxiety and Illness Behaviours Lab telephone), anxietylab.pain.study@gmail.com

**Supervisor:** Dr. R. Nicholas Carleton, Department of Psychology, 306-585-4595, nick.carleton@uregina.ca

**Purpose and Objectives of the Research:**
- The purpose of this study is to better understand different psychological factors in individuals with chronic lower back pain. Our goal is to learn more about how thoughts and emotions may be related to pain and anxiety.
- Data from this study will be used in a Master’s thesis, as well as presentations, scientific journal articles and professional communications.
- Data will be used for secondary purposes in future studies, which may focus on various topics.

**Procedures:**
- Participation will involve completion of questionnaires, and a computerized task. After determining study eligibility through a very brief online screener, you will complete questionnaires online before proceeding with the online task. These will consist of questions asking about anxiety, thoughts and concerns about pain, responses to uncertainty, and depression. The online task involves a simple game wherein you click a button to inflate a digital balloon and decide when to stop, in order to try to avoid popping the balloons. The task is meant to be an imagined representation of injury risk during physical activities. Total participation is estimated to take 45 minutes. All activities will be completed in a single online session.
- To complete the online task, you will be asked to download Inquisit Web, a java-based application provided by Millisecond Software. The download will allow your responses in the task to be automatically submitted online. The Millisecond security and privacy statement is available online at https://www.millisecond.com/products/securitystatement.aspx
- For more general information, you can go to http://www.millisecond.com
- Please feel free to contact the principal investigator with any questions regarding the procedures and goals of the study or what is involved in participation.
Funded by: Canadian Institutes of Health Research: Canada Graduate Scholarship – Masters

Potential Risks:

- Participation in this study involves completing questionnaires that ask personal questions about things like fear, anxiety, and depression, which some people may find temporarily upsetting. You may choose not to answer questions you feel uncomfortable with. Participation is anonymous. No personally identifying information will be recorded.

Risks will be addressed by:

- You may discontinue participation in the study at any time, with no penalty.
- In the unlikely event that you become distressed as a result of participating in the study, we encourage you to consult with your family doctor, or call 911 if you feel at risk of harming yourself or others.
- In Canada, you may visit https://suicideprevention.ca/need-help/ for links to crisis centers in your region and other information. You may also wish to consult the websites of the Canadian Psychological Association (http://cpa.ca/) for more information about mental health resources in your region.
- In the United States, you may visit https://suicidepreventionlifeline.org/ to connect with crisis centers in your region by telephone. You may also wish to consult the websites of the American Psychological Association (https://www.apa.org/) for more information about mental health resources in your region.
- Please always remember that you matter and there are people who want to help.

Compensation:

You will be awarded one dollar for your participation in the study. An MTurk completion code is provided at the end of the survey. The code will only be visible once you have completed the survey and brief task.

Confidentiality:

- Your responses will be confidential. Names and personally identifying information will not be stored in the raw data.
- Data will be maintained for 7 years and then destroyed.
- Identifying information will not be included in publications.
- Your personal information will not be connected to your responses.
- Storage of Data:
  - Electronic data will be encrypted and stored on password-protected computers. All data will be kept for 7 years.
  - After 7 years, study data will be destroyed.

Right to Withdraw:

- Your participation is voluntary and you do not need to answer questions or participate in activities you are not comfortable with. You may withdraw from the
study at any time without penalty. You do not need to provide any explanation for withdrawal.

- If you wish to have your responses removed from the study, please email the researchers and provide your MTurk Worker ID number. After one week, results may have been written up and analyzed, making data removal impossible.
- Should you wish to withdraw, simply close your internet browser tab or window that is connected to the survey website. Any tasks will be cancelled, and your data may be removed upon request.
- Your right to withdraw data from the study will apply until one week after you have participated. After this date, results will have been analyzed, written up and/or presented, and it may not be possible to withdraw your data at that time.

**Follow up:**

- If you wish to learn about the results of this study once it has been completed, you may email the principal investigator, his supervisor, or the AIBL research coordinator at anxiety.lab@uregina.ca.

**Questions or Concerns:**

- If you have any questions or concerns, feel free to contact the researchers using the information above
- This project has been approved on ethical grounds by the University of Regina Research Ethics Board on November 3rd, 2017. Any questions regarding your rights as a participant may be addressed to the committee at 306-585-4775 or research.ethics@uregina.ca.

**Consent**

Clicking “Yes, I agree to participate” below constitutes a digital signature, and will have the same effect as a physically signed document. To save a copy of this form for your records, click here.

Clicking the e-select option below indicates that you have read and understood the description provided.

I have had an opportunity to ask questions and my questions have been answered (please email the principal investigator, Isaac Hahn, if you have any questions). I consent to participate in the research project. A copy of this Consent Form has been given to me for my records.
Appendix K: MTurk internal study advertising descriptions

Description targeted toward control participants

This is a study looking for individuals who have never had chronic pain. We are looking for participants to answer questionnaires and complete a short computer task. The purpose of the study is to better understand how psychological factors, like anxiety, may be related to pain.

Description targeted toward participants with CLBP

This is a study looking for individuals with chronic lower back pain. We are looking for participants to answer questionnaires and complete a short computer task. The purpose of the study is to better understand how psychological factors, like anxiety, may be related to pain.
Appendix L: Demographic survey

1.) What is your age? _____
2.) What is your sex?
   a. Male     b. Female     c. Other (please specify)
3.) What is your gender?
   a. Man      b. Woman     c. Other (please specify)
Appendix M: Screening Survey

Do you experience chronic lower back pain (i.e., pain more days than not, lasting longer than 3 months)?

- Yes
- No

Have you received a formal diagnosis for your pain condition from a doctor?

- Yes
- No

Have you ever experienced any other type of chronic pain (i.e., pain more days than not, lasting longer than 3 months)?

- Yes
- No

Do you experience ongoing acute (i.e., less than 3 months) pain other than lower back pain?

- Yes
- No

Do you experience irritable bowel syndrome?

- Yes
- No

Do you experience chronic headaches (e.g., lasting at least 15 days per month for 3 months or more) of any kind?

- Yes
- No

Do you have fibromyalgia?

- Yes
- No
Appendix N: Ethical Approval Certificate

University of Regina

Research Ethics Board
Certificate of Approval

PRINCIPAL INVESTIGATOR
Isaac Hahn

DEPARTMENT
Psychology

REB#
2017-157

SUPERVISOR: Dr. Nick Carleton

TITLE: Anxiety and Experience of Pain

APPROVED ON:
November 2, 2017

RENEWAL DATE:
November 2, 2018

APPROVAL OF:
Application for Behavioural Research Ethics Review, MTurk Study Descriptions, Chronic Pain Survey, Pain Characteristics Survey, BART Scripts for Participants, Intolerance of Uncertainty Scale – Short Form, Intolerance of Uncertainty Scale – Situation Specific Version, Anxiety Sensitivity Index, Pain Anxiety Symptoms Scale – Short Form, Patient Health Questionnaire, Short Form McGill Pain Questionnaire, Informed Consent Form, MTurk Internal Study Advertising Description and Screening Survey.

Full Board Meeting ☐
Delegated Review ☑

The University of Regina Research Ethics Board has reviewed the above-named research project. The proposal was found to be acceptable on ethical grounds. The principal investigator has the responsibility for any other administrative or regulatory approvals that may pertain to this research project, and for ensuring that the authorized research is carried out according to the conditions outlined in the original protocol submitted for ethics review. This Certificate of Approval is valid for the above time period provided there is no change in experimental protocol, consent process or documents.

Any significant changes to your proposed method, or your consent and recruitment procedures should be reported to the Chair for Research Ethics Board consideration in advance of its implementation.

ONGOING REVIEW REQUIREMENTS
In order to receive annual renewal, a status report must be submitted to the REB Chair for Board consideration within one month of the current expiry date each year the study remains open, and upon study completion. Please refer to the following website for further instructions: http://www.uregina.ca/research/for-faculty-staff/ethics-compliance/human/forms1/ethics-forms.html.

Laurie Clune, PhD
Chair, Research Ethics Board

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