Investigating the interaction between pain intensity and time perception and whether anxiety is a moderating factor on this relationship

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Abstract

Research directly investigating the interplay between Time Perception and Pain Intensity has been sparse and biased toward clinical studies following the retrospective paradigm while consistently citing anxiety as confounding results. This study investigated the relationship between Pain Intensity and distortions in duration-estimation in a Cold-Pressor Task to clarify whether Anxiety mediated the relationship. This is the first exploratory laboratory study in this area to use the prospective paradigm of time estimation in a non-clinical sample. The main outcome variables were State Anxiety, Pain Intensity and Time Distortion. Twenty Participants were included in the analysis in this between subjects study, randomly allocated to an Anxiety Condition or no-Anxiety (Control) Condition. Participants in the Anxiety Condition underwent a stress induction protocol and all participants were subject to a Cold-Pressor to induce pain. Given both Time and Pain are cognitively modulated perceptual abilities, it is likely these phenomena not only influence each other but may also be impacted by pain-related mood factors such as Anxiety. Results confirmed the hypothesis that a relationship exists between Pain Intensity and Time Perception with most participants experiencing time as “dragging”. The main hypothesis that Anxiety acts a mediator in this relationship was mostly supported.

KEY WORDS	TIME	PAIN	ANXIETY	TSST	COLD-PRESSOR

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Introduction

Both State and Trait Anxiety have been implicated in deficits in cognitive performance (Eysenck, 1992), particularly in attention-reliant tasks (Bishop, 2009). This is pertinent as recent research has looked, in particular, at whether deficits in temporal processing, that occur during a pain experience, could act as a parameter of pain severity (Somov, 2000). However, although these studies have demonstrated a relationship between Pain Intensity and Time Perception exists, Anxiety has often been cited as majorly confounding many findings in this area. This present study sought to clarify the role of anxiety and whether it is a mediator in this relationship.

Pain Perception

Pain is defined as "an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage"(Merskey et al., 1994). Conceptually it is an attention-demanding perceptual stimulus (Eccleston, 1994) competing with and impacting upon other cognitive tasks utilizing finite attentional resources (Eccleston & Crombez, 1999). Melzack & Wall's (1965) Gate Control Theory of Pain (GCT) describes how psychological or sociological factors, not just biological factors, facilitate or inhibit the perception and transmission of pain. This occurs via reciprocating inputs to/from the brain modulated by dorsal horn neuron mechanisms in the spinal chord (Melzack, 1999). This supports the rationale suggesting emotional states such as anxiety modulate the perception of pain as the brain sends affect information down peripheral fibres to the gate determining a perceptual output of pain (Koestler & Myers, 2002). Melzack (2001) later introduced the Neuromatrix Theory, further clarifying a role for cognitive and affective factors. The neuromatrix comprises parallel processing loops, consisting: sensory-discriminative, affective-motivational, and cognitive-evaluative. It results in a unique and personalised pattern of signals in the body: the neurosignature, arising from the synaptic architecture (Trout, 2004).

Pain perception, occurs in the context of temporal experience, encouraging an aversion to injury (Loeser & Melzack, 1999) and harm avoidance (Evans et al, 2011; Melzack & Katz, 2012). However, chronic pain is pathological and linked to impaired cognitive functioning (Ashburn & Staats, 1999; Moriarty et al., 2011) such as working memory (Park et al, 2001), psychomotor speed (Hart et al., 2000), and executive function (Apkarian et al., 2004). However, Hart et al., (2003) has argued that such cognitive deficits are a result of pain-related stress or anxiety and not the pain itself. Chronic pain is characterised by feelings of uncontrollability and loss of situational control which are specific contexts known to increase Anxiety (Chapman & Gavrin, 1999) often leading to a viscious cycle whereby Anxiety exacerbates Pain (Ploghaus et al., 2001), which in turn increases Anxiety (Fordyce & Steger, 1979).

Time Perception

Temporal processing is not always accurate and often affected circumstantially such as when in pain (Somov, 2000) and with different mood states (Droit-Volet et al., 2004) .

Given " psychological time", like pain, is a perception moderated by cognitive-affective factors and explainable by cognitive processes justifies the rationale that Anxiety may directly impact upon the accuracy of an individuals' temporal processing (Block, 1990; Ogden, 2007) . As an experimental variable, psychological "time" (Grondin, 2008) includes the constructs of "Duration" estimation (Fraisse,1978) and "Subjective Time" - the experience of how rapidly or slowly time passes. These two constructs define "time" as referenced in this study. "Subjective time passage" has infrequently been investigated (Wearden, 2005). "Temporal Distortion" refers to the under or over-estimation of 'Duration'.

Investigating time involves two distinct methodological paradigms, which result in different cognitive processes and outcomes (Wearden, 2005) depending on which is followed: a) the prospective paradigm, where participants are made aware in advance that they will need to estimate an "experienced" duration (Block, 1990) and b) the retrospective paradigm, where participants are simply asked to estimate a "remembered" duration (Brown, 1985) and not made aware in advance (Zakay & Block, 2004). Typically, retrospective estimates engage memory processes and can be explained by the Contextual Change Model whereby the a) the more data stored, b) the level of intensity of information (Ornstein, 1997) or c) amount of contextual changes encoded (Block & Reed, 1978), the longer the "remembered" duration (Zackay, 2012). In contrast, the prospective paradigm is based on attentional processes (Zakay, 1993) and on arousal (Zakay et al., 1983). Task demands influence the division of attentional resources between non-temporal (e.g. stimuli or task) and temporal information (e.g. Zakay, 1992), and can be explained by the Attentional gate model (AGM; Zakay & Block, 1997), an internal clock model based on Scalar Expectancy Theory SET). The component processes involved are a) a pacemaker that autonomously emits consistent pulses and is only influenced by arousal; b) an attentional gate that opens when a person attends to time c) a switch that opens or closes to allow pulses through and d) an accumulator which accumulates a pulse count where more pulses equal greater time estimation (see Figure 1).There are two major determinants of attentional allocation 1) Temporal relevance and 2) arousal. Droit-Volet & Meck (2007) suggests patterns of subjective time experience and behavior in prospective timing varies depending on what level of temporal processing is impacted: "attentional time sharing" or "clock speed". Substantial evidence now indicates redirection of attention due to affective (e.g. anxiety) or non-temporal (e.g. pain) events can divert temporal processing resources away from the timer as well as delay the latency of the switch resulting in loss of pacemaker pulses (Meck, 2013). The result is time would be experienced as shorter than objective time (Lejeune, 2000). Conversely, arousal increases the rate of the pacemaker and more pulses are accumulated resulting in a longer perceived duration (Allely, 2011). However, understanding the role of arousal and attention in temporal processing remains incomplete and findings are not always fully explainable using current models (Wittmann, 2009).

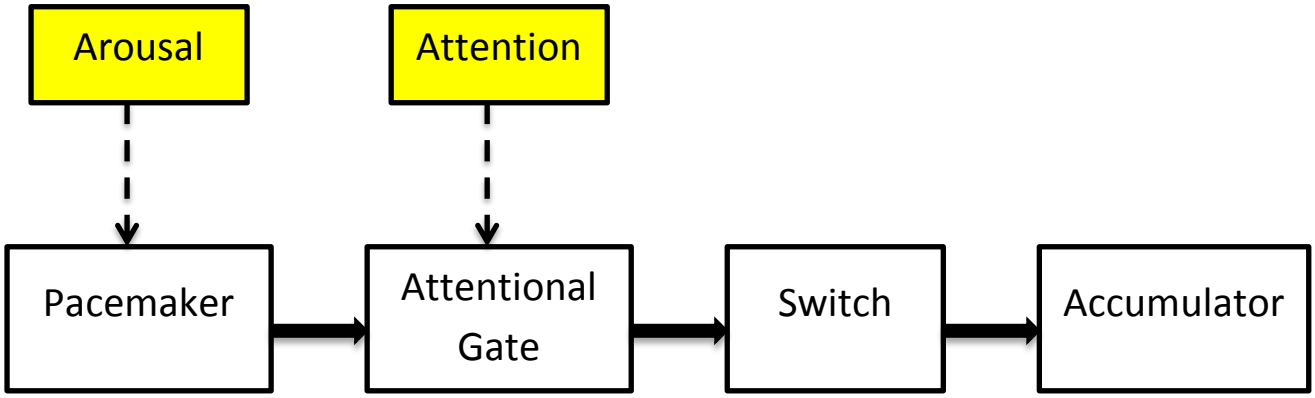

Figure 1: The Attentional-Gate Model of prospective time estimation (Zackay & Block,1997)

Stress and Anxiety

"Stress" and "anxiety" are operationally different but interactive constructs. Stress is defined as an adaptational process initiated in response to, and in order to reduce the effects of, an external "stressor that threatens the wellbeing of an organism, for instance the "fight" or "flight" response (Cannon, 1932). Selye, (1936) outlined a process of coping or exhaustion inherent in a resulting stress response. Psychological stress responses include varying changes in mood, cognition and behaviours while the biological stress response is modulated by cortisol release and includes autonomic arousal and hypothalamic-pituitary-adrenal (HPA) axis and sympathetic activation (McEwen, 1998) and linked to higher blood pressure (James et al., 1986) and heart rate measures (Núñez-Rodríguez et al., 2008). Lazarus (1975) highlighted the role of appraisal where how threatening the stressor is "appraised" and whether the individual has necessary resources to cope, will affect the degree of the stress response. Stress is linked to acute cognitive deficits such as reduced performance on attention tasks (Scheufele, 2000), and if prolonged can lead to excessive sympathetic nervous activity and dysregulation of the HPA axis linked to longer term physiologic and cognitive deficits.

Lewis, (1970) and Endler (1997) conceptualise anxiety as an emotional state – likely to occur as a symptom of and psychophysiologic indicator of a stress response (Robinson, 1990; Basowitz, 1955). A construct used in pain studies is "Pain Distress" which in this study is defined as a pain-related "anxiety" (Best et al., 2001). Spielberger (1966) later distinguished between Trait Anxiety: an individual's pre-dispositional response, and State Anxiety: a transitory emotional state, characterised by feelings of dread and apprehension (also: Lake & LaBar, 2011). References to "Anxiety" in this paper refer to "State Anxiety" unless otherwise stated. High Neuroticism on the Big Five Personality scale is associated with higher tendencies to experience anxiety (Wade et al.,1992). Studies on healthy persons show subclinical anxiety can negatively impact working memory (Ikeda et al.; 1996) and information processing while Post traumatic stress disorder (PTSD) was reported by Bremner, (1999) to result in impairment in divided attention and executive function. The extent

to which perceptual systems depend on biological and psychological processes affected by HPA axes activation and other associated stress responses, is the extent to which perceptual processing may be impacted (Chavez, 2003). Anxiety increases physiological arousal (Hoehn-Saric & McLeod, 2000) but Anxiety also impacts attention-related task performance (Mathews & MacLeod, 2002), therefore the negative impacts on cognition by Anxiety may result from an interaction of attentional processes and arousal. Tipples (2008) showed how negative emotionality was associated with over-estimation of time due to arousal and speeding up of the clock. Droit-Volet et al. (2004) and Effron et al. (2006) argue arousal, more than attention explain over-estimation effects during negative affect. However, findings are mixed with both over and under estimations due to arousal being found (Burle & Casini, 2001)

Batteries of cognitive tests and self-reports given by pain patients show cognitive deficits occur mainly in the areas of attention (Gimse et al.,1997) and memory (Kreitler & Niv, 2007). Memory and attention are domains central to models of both pain and time perception (Block & Zakay, 1997) suggesting these are the processes likely to be affected resulting in time distortion. Rat studies have demonstrated that acute pain accompanied by pain-related anxiety will result in cognitive disturbances and hyperalgesia (Low et al., 2012). Two explanations for this exist: first, explanations that link pain onset directly to cognitive deficits and second, explanations that see these deficits resulting from the concomitants of pain such as anxiety or depression (Hart et al., 2003; Pais-Vieira, 2009). The present study hypothesizes the latter. This is supported by Pincus et al. (1998) who argues chronic-pain attentional biases are more aptly explained by the affective states of anxiety and depression rather than pain itself. For instance, Kewman et al. (1991) found the correlation between pain ratings and cognitive performance were no longer significant when psychological distress (a composite score including anxiety, depression) was used as a covariate. Also, Grace et al. (1999) found trait anxiety (but not depression) and pain intensity covaried and that when mood effects were partialled out, pain intensity no longer correlated with cognitive test performance. Anxiety, however, did correlate when pain intensity was partialled out. Moreover, Keogh & Mansoor, (2001) reported higher anxiety correlated with greater affective responses to cold-pressor pain suggesting a significant anxiety mediated negative response to pain in healthy people. Jones et al. (2002) in a cold-pressor test showed anxiety-induced participants had significant increases in pain intensity relative to non-anxiety group. There is also neurobiological evidence that pain exacerbation during thermal stimulation is due to anxiety (Ploghaus et al., 2001).

Studies investigating the interplay between pain and time perception directly have favoured the retrospective paradigm using predominantly clinical (chronic pain) patients. Zhang et al. (2012) found impaired time perception in 27 migraine patients using a temporal reproduction task of short durations (milliseconds range). Zhang et al. found State Anxiety was higher for Migrainers', but this did not significantly correlate with over-estimation. Zhang cited imaging evidence of deficits originating in the cerebellum, an area implicated in sub-second time processing as well as mood regulation(Schubotz, 2000). Subsecond (< 1sec) processing intervals are known to be affected by automatic, sensory or neural mechanisms while supra-second (>1sec) intervals tend to be explained by cognitive mechanisms (Lewis & Miall, 2003). Recently Anagnostou & Mitsikostas, (2005) found no significant temporal

distortion effects in migraine sufferers in an auditory duration task except with those diagnosed with co-morbid depression thus suggesting mood disorders might better explain temporal abnormalities. In fact, many studies, such as those investigating effects of body temperature on temporal processing often cite stress, anxiety or depression as a major confound muddying interpretation of results (Hancock, 1993).

Bilting, et al. (1983), for instance, found mentally healthy headache patients over-estimate the retrospective duration of a reading task compared to normal pain-free controls that slightly under-estimated. The study sought to investigate whether time-distortion could be used as a pain-related parameter reflecting degree of pain-magnitude. Bilting et al., reported a reasonable correlation of r=0.88 between clinical assessment of severity and average time distortion. Interestingly, patients responding positively to their treatment also showed a normalization of time perception. However, Bilting et al. criticised their results as having confounds affected by anxiety citing Cohen & Mezey, (1961) paper which suggests anxiety can variably lead to either over or under estimations. It is unclear how much anxiety contaminated Bilting et al's findings. On the other hand, Isler et al. (1987) found headache patients in pain underestimated retrospective time estimates during a respiratory biofeedback session described as having "relaxing properties". Explanations were rooted in Ornstein's (1969) Storage Size - memory based model, which involves a Filled-Time Illusion whereby the more events encoded to memory and the more mental processing, the longer the duration experienced. The rationale was that headache patients were tested in an environment of "incomplete sensory deprivation" being in a dark room with ears covered and less mental stimuli to "fill the time interval" resulting in an underestimation of duration. Isler et al importantly noted that these conditions together with the respiratory breathing exercises may have had the effect of "neutralizing anxiety" and so it cannot be determined whether the pain experience per se or the nature of the task lead to the underestimation. Isler's 'condition' could thus be redefined as "underestimation of time whilst in pain during reduced anxiety or relaxation". Cortisol measures would have been helpful as a measure of anxiety and HPA axis activation.

Somov, (2000) criticised earlier studies, particularly Isler et al. for ignoring mood factors and controlled for both Anxiety and Depression. Somov reported that higher pain intensities in migraine patients were associated with duration over-estimation of an experimental task (filling in questionnaires). The majority of patients also either experienced time as "standing Still" or "Dragging" when in pain. Results were interpreted in terms of Ornstein's (1969) model whereby an increase in information processing due to pain resulted in more "Filled Time" leading to longer duration estimations. The role of anxiety is not clear, however, Somov finding was opposite to that of Isler et al's.

Two studies have used laboratory methods to directly investigate the interaction between time and pain perception with non-clinical participants. Hellström & Carlsson, (1997) found healthy participants underestimated retrospective time estimates of short durations (120 seconds, 300 seconds) after immersion in a Cold Pressor Test. Time was also experienced as being "long and slow" by 40% of participants. Ornsteins (1969) Storage Size Hypothesis and "Filled Time Interval" was used to explain the results wherein participants were so engaged in the pain experience that other sensory stimuli were not registered, reducing information

processing and consequently resulting in an underestimation of time. Pain, in this study, was seen as a dull, sensory deprived event. Hellström & Carlsson reported that the pain condition was a highly stressful event while the control condition was experienced as “meditative”. Anxiety and mood states were cited as confounds. However, it attempted to rationalize “stress” as aiding the focus of attention to the monotony of pain resulting in less “filled time”. The study took the view that mood changes are incidental and potentially facilitative of duration overestimation due to pain factors, however the author takes the view that stress/anxiety in this study may be directly mediating the effect of underestimation.

Thorn & Hansell (1993) also used a laboratory study finding participants underestimated retrospective time estimates of duration in a cold pressor Test to induce pain. In contrast to Hellstrom and Carlsson, pain was described as an event that fills participants interval of time and therefore Orstein’s (1969) model was seen as contradicting the researchers findings. Thorn and Hansell suggested pain experience distracts focus from external time cues, however, if a time goal was given the degree of underestimation would be mitigated as more attention would be allocated to a temporally relevant time cue (time goal) improving temporal judgment accuracy. Although the results indicated time goals mitigated under-estimation, the fact that anxiety was not considered raises a concern given other studies have explicitly cited Anxiety as a potential confound. Overall the literature highlights the contradictory explanations and models given to explain different or even the same results whilst also revealing the problem of anxiety as a confound. See Table 1 for a summary of the main research studies in this area.

Table 1
Summary of studies directly investigating the relationship between pain intensity and temporal duration

Study	Type	Paradigm	Task	Result	Anxiety Confounded or Covaried
Zhang et al (2012)	Clinical	Retrospective	Temporal reproduction	Overestimation (< 3sec)	✔
Anagnostou & Mitsikostos (2005)	Clinical	Retrospective	Auditory Task	None	✔
Bilting, Carlsson, Menge et al (1983)	Clinical	Retrospective	Reading Task	Overestimate	✔
Isler et al (1987)	Clinical	Retrospective	Respiratory Feedback Session	Underestimate	✔
Somov (2000)	Clinical	Retrospective	Experimental Task	Overestimate	✔
Hellstrom & Carllsson (1997)	Laboratory	Retrospective	Cold Pressor Test	Underestimate	✔
Thorn and Hansell (1993)	Laboratory	Retrospective	Cold Pressor Test	Underestimate	Not considered

The main aim of this study was to directly investigate the role of Anxiety on time perception but in healthy patients in induced pain. To date no study has done this yet. The specific aims were 1) to establish whether a relationship between Pain Intensity and time perception exists, 2) to clarify and directly investigate whether Anxiety is a mediator given this relationship, 3) to be the first exploratory laboratory study in this area using healthy participants following the prospective paradigm. Since Prospective Timing is influenced by both attention and arousal, this is arguably

a more suitable paradigm by which to investigate the interaction between attention, arousal and temporal processing.

The researcher has several hypotheses. **Firstly**, it is hypothesized that there would be a relationship between time perception and pain-intensity. **Secondly**, based on Somov (2000) it was expected that time would be experienced as "extending" or "slowing" while in pain. **Thirdly,** if Anxiety is a mediator in the relationship between time perception and pain perception then it would be hypothesized that correlations would be exist between Anxiety and Pain Perception as well as Anxiety and Time Distortion. **Fourthly** it is presumed that Anxiety accounts for most the variance in the relationship hence a greater time distortion would be expected to occur in an Anxiety Condition. **Fifthly**, Given individual differences in traits, it was hypothesized that higher Trait Anxiety, higher Perceived Stress Scale (PSS, "tendency to appraise events as stressful) and high neuroticism would predict higher levels of reported State Anxiety. **Sixthly**, Higher State Anxiety is expected to positively correlate with autonomic measures (Heart Rate, Blood Pressure). Given perceptual systems reliance on biological processes, higher physiological response measures (Heart rate [HR], Diastolic Blood Pressure [BP]) would predict greater time distortion.

Additionally, other exploratory analyses were conducted.

Method

Participants

27 Students from the University were recruited. Exclusion criteria were diabetes, circulatory disorders, chronic and pre-existing pain conditions, smoking, medical high and low blood pressure, anxiety disorders, having previously experienced the cold pressor task (Birnie et al., 2012).

Design

A Mixed subjects design was employed with Condition as the between subjects design (2 conditions: Anxiety, No-Anxiety) and Testblock (2 levels: Pre-Manipulation [Baseline], Post-manipulation) as the repeated measures. A computerised randomization schedule was produced to pre-assign participants to one of two conditions, the software available from: http://www.randomization.com.

Materials

Circulatory Water Bath (Pain Induction Technique): A JeioTech circulatory waterbath (RW-3025G) was used for pain inducement, which cooled circulating water to 0 °C. Water temperature was standardized for reliability (Mitchell et al, 2004). For safety, a limit of 230 seconds was the maximum duration of immersion allowed, within the limits of other studies (Von Baeyer et al, 2005).

Thermometer: A digital thermometer (Omron Smart Digital) was used to record hand temperature in degrees Celcius.

Heart Rate (HR): An Omron M6 Sphygmomanometer was used to record Heart rate (HR), and Blood Pressure (Martin, 1961).

Questionnaires and Inventories

Demographic information: Participants completed a 3-item demographics questionnaire consisting age, gender, and ethnicity.

IPIP Big-Five Factor Markers (Goldberg, 2001): The 50-item IPIP Big-Five Factor Marker questionnaire was used, freely available online (Goldberg, 2001). It consisted 10 items for each of the Big-Five Personality Factors, namely: Extraversion, Agreeableness, Conscientiousness, Emotional Stability, and Intellect/Imagination. The Emotional Stability/Neuroticism is scored towards the Emotional stable pole in the IPIP. It has good internal consistency and comparability to other big 5 inventories (Gow et al., 2005).

Perceived Stress Scale (PSS-10): The Perceived Stress Scale (PSS-10) is a 10-item self-report questionnaire, which measures the degree to which an individual appraises life events as stressful – "Trait Stress" (Sheldon Cohen, 1988). It uses a 4-point Likert scale of ratings from 0 =Never to 4 = very often.

Short Form State Trait Anxiety Inventory (SF-STAI): State Anxiety was assessed using the six-item short form of the STAI. Participants evaluated statements such as in the last month " I felt calm" on a 4-point Likert scale with end points of "not at all" to "very much" with higher scores associated with higher Trait anxiety. Originally developed by Spielberger (1983), the STAI has good reliability and validity (Marteau & Bekker, 1992).

Short Form McGill Pain Questionnaire (SF-MPQ) 2: This SF-MPQ-2 (R Melzack, 1987) consists of 22 descriptors of pain (11 sensory, 4 affective, 7 neuropathic) measured on a 11-point Likert intensity scale for ratings from 0 = none to 10 = worst possible. The SF-MPQ-2 has demonstrated to be highly reliable (Dworkin et al., 2009).

Numerical Rating Scales:

Three 11-point Likert-type numerical rating scales were used:

NRS - Pain Intensity (NRS – PI): The NRS-PI scale evaluated Pain Intensity with points from 0 indicating "No pain at all" to 10 indicated "Worst Pain Imaginable" (McCaffery, 2001).

NRS – Pain Distress (NRS–PD): NRS-PD scale evaluated Pain Distress with points from 0 indicating "No pain" to 10 indicating "unbearable pain" (Williams et al., 2000).

NRS – Anxiety (NRS – A): The NRS-A scale evaluated State Anxiety with points from 0 indicating "No anxiety" to 10 indicating "Worst Imaginable Anxiety" (Clarke et al., 2013).

Performance Measures

Pain Threshold: Measured by the time-interval (seconds) from participants' immersion of their hand into the water and the point at which pain is just perceived (i.e. first report of pain). (Keogh et. al, 2005; Pöntinen, 1998)

Pain Tolerance (T_{Actual}): Measured by the time-interval (seconds) from participants' initial immersion of hand into the water, to the point when participants can no longer tolerate the pain resulting in hand withdrawal, (as in Dahlquist et al., 2009). This measure is also the "Actual Duration Time".

Verbal Estimate – Duration ($T_{Estimated}$): This was the participants' Verbal Estimate of the "Actual Duration Time". Raw Verbal Estimate scores were transformed and computed as a percentile difference from the Total Actual Time, indicating "Time Distortion" [TD], in line with previous research in this area, TD = ($T_{Estimated}$ - T_{actual})/ T_{actual}) expressed as a percentile (Angrilli et al., 1997). This transformation gives information about the extent and duration of the mis-estimations (Negative values = underestimation, Positive values = overestimation).

Subjective Time - Multiple Choice: This was a 4-item multiple-choice question requiring participants to respond to the question "When in pain, time a) Stands Still b) Drags on, c) goes as usual, d) flies?".

Procedure

Participants were individually tested in a single session lasting 40minutes in the psychology laboratory. Upon arrival participants were required to read and sign an informed consent form (Appendix A), which included an outline of the study. The experiment was scripted from beginning to end (Appendix I).

Participants began by completing the demographics and IPIP Inventory, SF-STAI, and PSS in the questionnaire booklet followed by the SF-MPQ, NRS-PI, NRS-A, NRS-S to ensure no participants in any pain. Next participants were instructed to remove all watches and jewellery and be seated near the cold pressor (CP). The researcher asked participants to submerge their non-dominant hand in the water for as long as they could until they needed to withdraw and to verbally indicate when they first feel any pain (Pain Tolerance). The first CP task acted as a baseline. A stopwatch recorded Pain Tolerance as well as Pain Threshold. Immediately after hand withdrawal the following baseline measures were recorded: all NRS measures, SF-MPQ, Blood Pressure (BP) and Heart Rate (HR). Participant's hands were then warmed back up to baseline temperature. Next, the manipulation was implemented which involved leading the participant into a small adjacent room.

Manipulation Tasks

Anxiety Condition: Trier Social Stress Test

The Trier Social Stress Test (TSST) is a standardized laboratory stress induction protocol effective for activation of biological stress and anxiety, in particular the hypothalamus-pituitary-adrenal (HPA) axis Kudielka (2008). It was developed by Kirschbaum, et al., (1993) and shown to be a reliable and valid tool in both clinical

and healthy populations (Gassling et al., 2012; Kudielka & Kirschbaum, 2005). An adapted version of the TSST was used with one interviewer instead of three. It consists of a note-making preparation period (5 minutes), followed by a free speech (5 minutes) and a mental arithmetic task (5 minutes) given in front of an interviewer with a voice and video recorder operating. It contains both an 'uncontrollable' and 'social-evaluative' threat which meta-analysis have shown to contribute the greatest HPA axis stress response (Dickerson & Kemeny, 2004).

No – Anxiety Control Condition

This is based on a placebo version of the TSST (P-TSST) developed by Het, et al., 2009, where the main stress-inducing social-evaluative and uncontrollability elements have been removed. No recording equipment and no interviewing audience are present with the participant giving a speech and counting in the room alone. This is a reliable protocol suitable for use as a control condition to the TSST (Klopp et al., 2012).

Immediately after the manipulation, the following '*Post manipulation* measures were taken: NRS- Anxiety, NRS – Stress, BP and HR. The participant was then asked to do the final CP (2) task with the same instruction as CP 1 but this time informed they would be asked to give a verbal estimation of the total time of immersion to withdrawal of the hand. Following withdrawal on CP2, further Post-manipulation measures taken were SFMPQ, NRS-PI, NRS–PD as well a verbal estimate of time duration, and subjective time - MC**.** HR and BP readings were also taken again.

Ethical Considerations

Ethical approval was granted by the University of Buckingham Ethics Committee and conformed to the ethical guidelines for pain research in humans outlined by the International Association for the study of Pain (IASP). Each participant gave their informed consent, told they could withdraw from the study at any time without penalty. Additionally the demographics form included the list of exclusion criteria, which required participants to confirm did not apply to them. Full debriefing (Appendix H) was done and care was taken that participants were allowed to fully recover when distress was noticed and, in some cases, asking if they would like to see the counsellor.

The cold pressor test has been found to cause short-term laboratory-induced pain, with no lasting effects, and no long-term damage when exclusion criteria are upheld. Participants were informed slight discomfort may be experienced but that the discomfort was temporary. Participants were asked to withdraw their hand from the water after a 3 minutes 50 seconds ceiling had been reached for safety reasons. A first aider was on alert and on call throughout the cold pressor test. The participant was made aware that the researcher was not qualified to feedback on any measures taken. The Trier Social Stress test has been used in well over 4000 studies (Kudielka, et al., 2007).

Statistics and Analysis

The primary outcome measures were Pain Intensity (NRS-PI), Anxiety (NRS-A) and Time Distortion [TD]. Secondary outcome measures included Pain Perception Ratings (Sensory, Affective, Neuropathic ratings from SFMPQ), Pain Tolerance (in seconds) with Blood pressure and Heart Rate used as physiological measures of Anxiety. The data was scored, loaded and analysed in SPSS v.20. Significance level was set at $p < .05$.

Results

27 participants (range = 18-29 years) took part however, 7 participants requested or were withdrawn (4 female, 3 males) due to concern about distress levels or discomfort with task. Participants were randomly allocated to either the anxiety (n = 10, 6 Males, 4 Females, mean age = 22.6 years) and no-anxiety (n = 10, 3 males, 7 females, Mean age = 22.3 years) conditions. One participant in each condition was left hand dominant. T-Tests confirmed, participants in both conditions were comparable in measures of Perceived [State] Stress (PSS), $t(18) = 1.417$, $p = .174$; Trait Anxiety (STAI), $t(18) = 1.252$, $p = .174$; and Neuroticism, $t(18) = -1.535$, $p = .142$ having no significant differences.

Analysis of Covariance (ANCOVA) were employed to test differences between main outcome measures controlling for baseline anxiety. Pearson's Product Moment Correlations assessed relationships between measures. Table 2-4 gives Descriptive Statistics showing mean scores of Outcome Variables used in the analysis. (Table 2 are means for trait variables, Table 3 shows baseline and Table 4 shows means of Post-manipulation measures)

Table 2
Mean values and standard deviations of inventories and measures of trait anxiety and trait stress (Perceived Stress)

	Experimental Condition			
	Anxiety N = 10		*No-Anxiety N = 10*	
	M	*SD*	*M*	*SD*
Trait Stress (PSS)	17.90	7.40	13.60	6.10
Trait Anxiety (SF-STAI)	9.70	2.30	8.40	2.60

Table 3
Mean baseline values and standard deviations of measures of state anxiety, pain intensity and pain distress

	Experimental Condition			
	Anxiety N = 10		*No-Anxiety N = 10*	
	M	*SD*	*M*	*SD*
State Anxiety (NRS–A)	2.00	2.10	2.00	2.90
Pain Intensity (NRS-PI)	5.80	1.60	5.60	2.20
Pain Distress (NRS-PD)	3.40	2.10	4.00	2.90

Table 4
Mean post-manipulation outcome values and standard deviations for measures of anxiety, pain intensity/distress and time perception

	Experimental Condition			
	Anxiety N = 10		*No-Anxiety N = 10*	
	M	*SD*	*M*	*SD*
State Anxiety (NRS–A)	4.60	3.60	0.70	1.10
NRS – Pain Intensity	5.30	2.10	5.50	2.60
NRS – Pain Distress	2.90	3.50	2.90	2.70
Pain Tolerance [secs]	126.70	97.40	111.0	103.80
Verbal Estimate of Duration	121.70	124.70	95.60	91.90
Subjective Time	2.20	.6320	2.30	.82
Post-Test Calculated Measures:				
* Time Distortion	-28.00	39.60	-12.90	28.70

**negative = underestimated, Positive = overestimated*

Manipulation Check

A mixed-design 2 x 2 Analysis of Variance (ANOVA) with Condition as the unrelated independent variable (2 levels: Anxiety, No-Anxiety) and Testblock as the related independent Variable (2 levels: Baseline, Post-Manipulation) was carried out on the dependent variable Anxiety scores (NRS-A). The interaction between the two conditions and the change over time was significant, $F(1,18) = 10.643$, $p = .004$. The Baseline mean Anxiety score did not differ significantly, $I(18) = .000$, $p = 1.0$ but the Post-Manipulation mean Anxiety for the Anxiety Condition ($M = 4.60$), was significantly higher, $t(18) = 3.370$, $p = .003$, than the Control Condition ($M = .70$). This confirms the manipulation significantly increases levels of reported Anxiety in the Anxiety Condition as shown in Figure 2.

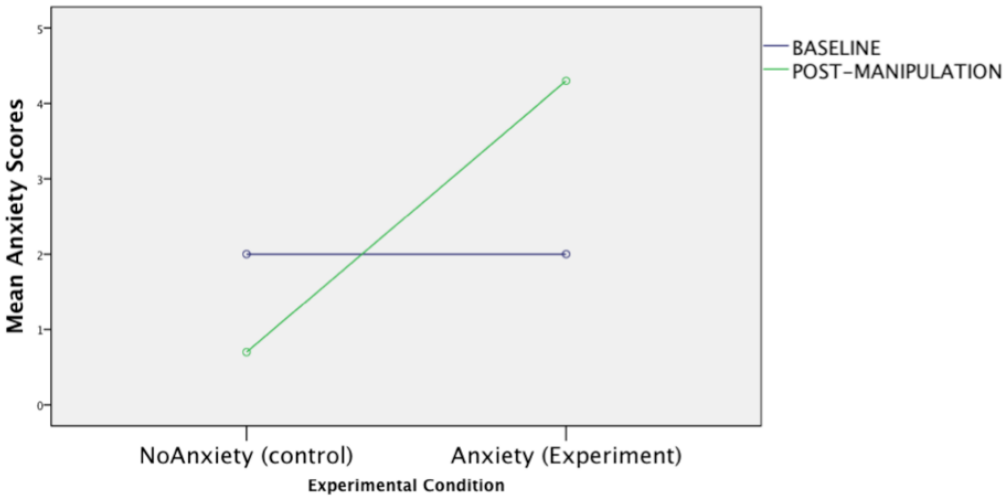

Figure 2: Interaction plot showing baseline and post-manipulation Anxiety

Testing the relationship between Post-Manipulation Time Distortion and Pain Intensity, a significant correlation was found between Time Distortion and Pain-Intensity, $r(18) = -.431$, $p = .045$. See Table 5 and Figure 2. A moderately negative relationship between Pain-Intensity and Time Distortion exists where higher Post-Test Pain-Intensity ratings were associated with lower duration estimations of time (greater Time Distortion). Further when a Partial Correlation was run, controlling for Post-manipulation Anxiety, this relationship no longer correlated significantly, $r(18) = -.263$, $p = .277$.

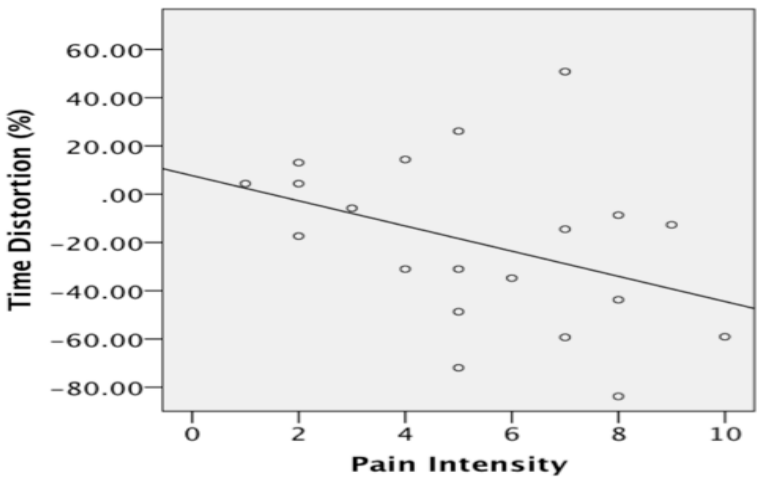

Figure 3: Scatterplot showing relationship between time distortion and pain intensity

Table 5
Bivariate correlations between post-manipulation measures: time distortion, anxiety, pain intensity/type, trait, and physiological measures.

	Time Distortion (%)	Anxiety (NRS-A)	Pain Intensity (NRS-PI)
Emotional Stability (Low Neuroticism)	.14	-.36	.20
State Anxiety (SF-STAI)	-.30	**.51***	-.01
Trait Stress (PSS)	-.080	**.43***	-.01
Systolic Blood Pressure [bpm]	**.48***	-.24	**-.61****
Diastolic Blood Pressure [bpm]	.25	.12	-.30
Heart Rate	.13	**.40***	.08
Anxiety (NRS–A)	**-.38***	1	.32
Pain Intensity (NRS-PI)	**-.43***	.32	1
Pain Distress (NRS-PD)	**-.38***	**.52****	**.60****
Pain – Sensory (SFMPQ)	-.01	.17	.**50***
Pain - Affective (SFMPQ)	-.11	**.52****	.32
Pain – Neuropathic (SFMPQ)	-.04	.27	**.58****
Time Distortion (%)	1	**-.38***	**-.43***
Subjective Time	.11	-.32	-.**46***

** Correlation is significant at the 0.05 level.*

*** Correlation is significant at the 0.01 level.*

A Spearman's correlation showed a significant moderate negative association between Subjective Time Experience and Post-manipulation Pain Intensity Scores, $r(18) = -.457$, $p = .021$, 1-tailed. Higher pain-intensity scores were associated with an experience of time as "dragging". Table 6 shows 70 % of participants indicated that when in pain time "slows down" ("Stands Still" or "Drags"), with only 1 feeling as though it "flies".

Table 6
Frequencies - subjective passage of time reported experiences while in pain (Multiple choice question format)

Response	*No. Participants (Freq)*	*Percent %*
"When in pain, Time Stands Still"	2	10 %
"When in pain, "Time Drags"	12	60 %
"When in pain, Time Goes on as usual"	5	25 %
"When in pain, Time Flies"	1	5 %

A one-way ANCOVA using Time Distortion as the dependent variable and Condition (2 levels: Anxious, non-Anxious) as the independent variable controlling for Baseline Anxiety. Showed the main effect of Anxiety on Time Distortion was not significant; *F(1,18)* = .956, *p* = .171, 1-tailed. The unadjusted mean Time Distortion for the Anxiety Condition (*M* = -28.0) was not different from the mean Time Distortion for the Non-anxiety Condition (*M* = -12.9). However, the mean Time Distortion for the Anxiety Condition was double that of the No-Anxiety Condition as shown in Figure 4

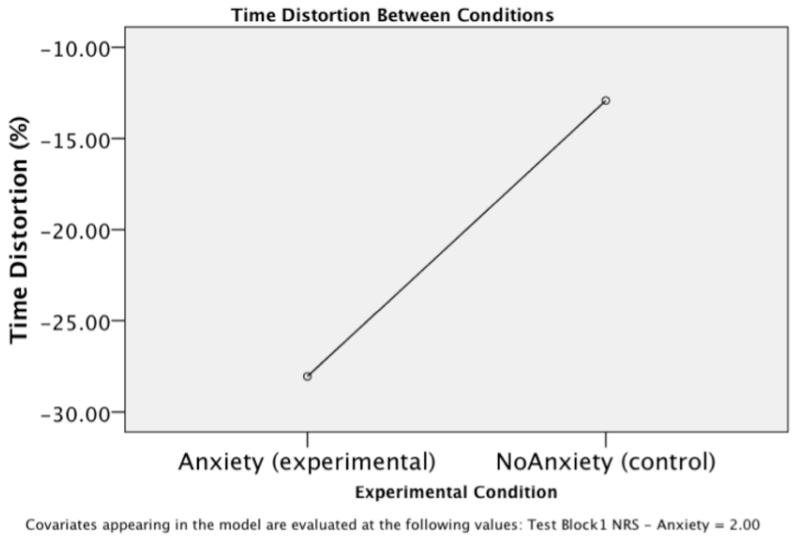

Figure 4: Mean percent time distortion between conditions

A moderate negative correlation was found between Anxiety and Time Distortion, *r*(18) = -.381, p = .049. Higher Anxiety scores significantly predicted greater Time Distortion (underestimation). No significant correlations were found between Anxiety and Pain Intensity. However, when separate correlations were computed *within* each condition a strong positive correlation was found in the Anxiety Condition between Pain Intensity and Time Distortion as shown in Table 7 & Figure 5, *r*(8) = .752, *p* = .016. Participants in the Anxiety condition that reported higher Pain Intensities significantly estimated time as shorter (underestimated). No association between Pain Intensity and Time Distortion was found for the No-Anxiety condition, *r*(8) = -.017, *p* = .481. Similarly a strong positive correlation between Anxiety and Pain Intensity was only found in the Anxiety condition, *r*(8) = .752, *p* = .006 (Table 7), and not in the No-Anxiety Condition (Table 8, Figure 6). This meant higher Pain Intensity ratings followed high Anxiety scores in the Anxiety condition but not in the No-Anxiety Condition.

Table 7
Post-manupulation bivariate correlations for the anxiety condition between time distortion, anxiety, pain intensity

	Time Distortion (%)	Anxiety (NRS-A)
Pain Intensity (NRS – PI)	**.75***	**.75***
Time Distortion (%)	1	.11

** Correlation is significant at the 0.05 level.*

*** Correlation is significant at the 0.01 level.*

Table 8
Post-Manipulation bivariate correlations for the no-Anxiety control condition: between time distortion, anxiety, pain intensity.

	Time Distortion (%)	Anxiety (NRS-A)
Pain Intensity (NRS-PI)	-.017	.43
Time Distortion (%)	1	-.25

** Correlation is significant at the 0.05 level.*

*** Correlation is significant at the 0.01 level.*

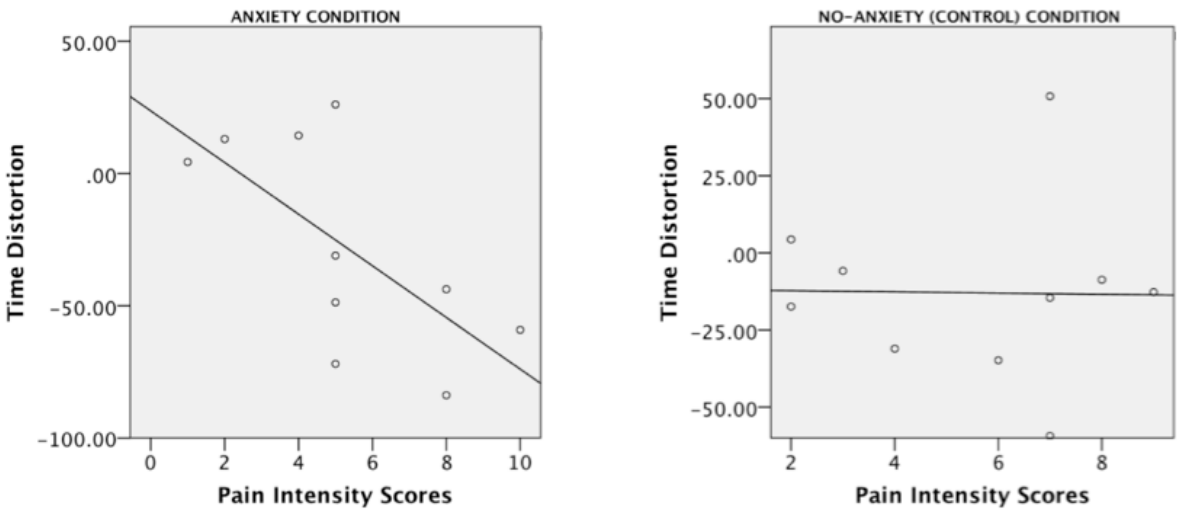

Figure 5: Scattterplot showing correlations between pain intensity and time distortion in anxiety (left) and no-anxiety (right)

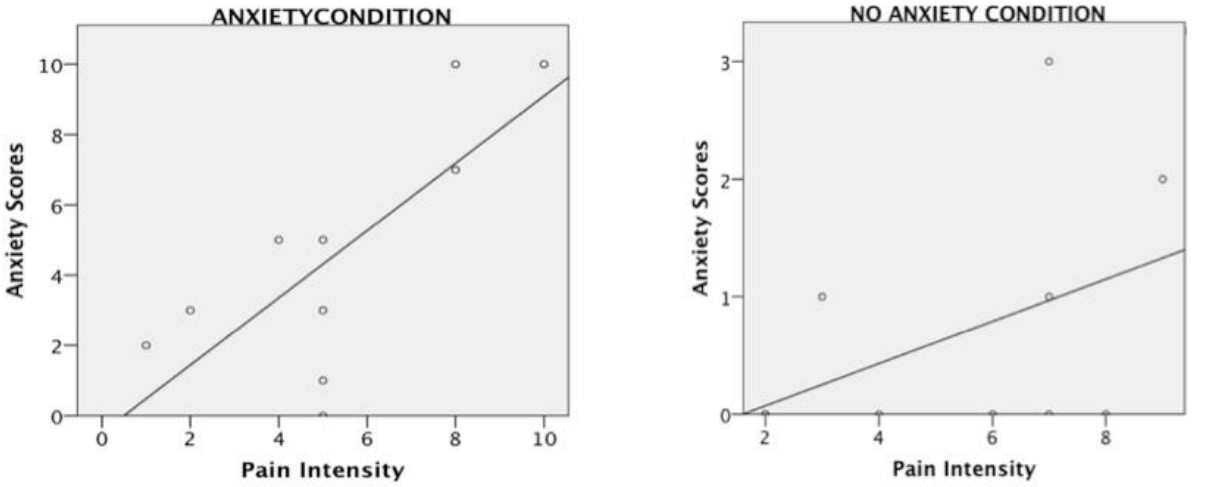

Figure 6: Scatterplot showing correlation between pain intensity in the anxiety (left) and no-anxiety (right) condition

One Sample T-Tests against "0" (absolute accuracy value) showed participants significantly under-estimated duration in the Anxiety Condition (*M* = -28.1), *t*(9) = -2.237, *p* = .050. An non-significant underestimation was evident in the No-Anxiety Condition (*M* = -12.9) but was not significant, *t*(9) = -1.425, *p* = .188.

High State Anxiety scores (Post-manipulation) were significantly associated with higher PSS scores, *r*(18) = .435, *p* = .028, 1 tailed; higher SF-STAI scores *r*(18) = .510, *p* = .011, 1 tailed; but not with Emotional Stability Scores (High Neuroticism), *r*(18) = -.359, *p* = .060, although it approached significance.

Post-Manipulation Anxiety Ratings correlated positively with Heart Rate, *r*(18) = .400, *p* = .040, 1-tailed; but not with Systolic Blood Pressure, *r*(18) = -.214, *p* = .182,1-tailed or Diastolic Blood Pressure, *r*(18) = -.115, *p* = .315, 1-tailed. A fairly strong positive association was found between Time Distortion and Systolic Blood Pressure, *r*(18) = .481, *p* = .049, that is higher Systolic Blood Pressure readings were significantly associated with more positive Time Distortion (Less under-estimation). No other correlations were found for autonomic measures.

Other exploratory analysis revealed a significant positive correlation between Post-manipulation Anxiety scores and scores on the Affective Dimension of the SFMPQ , *r*(18) = .515, *p* = .010. Higher Anxiety Scores predicted higher SFMPQ-Affective ratings. No other associations with Pain Type were found. Also, Pain Distress positively correlated with Post-manipulation Anxiety, *r*(18) = .521, *p* = .009; Pain Intensity, r(18) = .638, *p* = 001 and negatively with Time Distortion, *r*(18) = -.384, *p* = .047 and Subjective Time, *r*(18) = -.472, *p* .036. Higher levels of Pain Distress were associated with high higher levels of Anxiety, Pain Intensity and greater Time distortion (Underestimation) and associated with the experience of time "slowing down".

Discussion

The results of this research offer the first exploratory insight into prospective temporal processing distortions that occur in healthy participants in induced pain of varying severity. The findings do suggest this relationship is mediated by anxiety. Pain Intensity was significantly associated with Time Perception supporting the hypothesis and in line with previous findings. The relationship indicated participants with higher Pain Intensity were prone to greater negative Temporal Distortion or "underestimation". Participants induced with Anxiety significantly underestimated time duration compared to the control group that only slightly underestimated duration. However, when Anxiety was controlled for, this relationship was no longer significant showing that higher pain intensities and greater underestimation were only correlated if Anxiety was also higher. Subjective Time Experience correlated highly with Pain Intensity supporting the second hypothesis that time would be experienced as "extending or slowing" while in pain. Two thirds of participants had reported that time "stands still" or "drags".

The finding of a relationship between pain and time perception is consistent with previous studies but the finding of underestimation contradicts that of Somov (2000) (Zhang et al., 2012) and Bilting et al., (1983). This finding appears more consistent with previous laboratory studies investigating the interaction between Pain Intensity and Time Perception namely, Thorn & Hansell (1993) and Hellström & Carlsson (1997). However, these results are not fully comparable. This is because theoretical underpinnings are expected to be different given the present study explicitly used a prospective timing approach. Any comparison must therefore account for different underlying cognitive processes. Somov (2000) retrospective estimation findings were framed in the perspective that increased information processing due to pain being "engaging" resulted in overestimation. Whereas, in prospective timing duration, studies suggest intervals which are the least eventful are generally perceived longest highlighting (Block & Zakay, 1997). Interpreting the results using the Attentional Gate Model (Zakay, 1992) suggests "attentional time sharing" appears to be affecting temporal processing more than "arousal". Pain (a non-temporal stimulus) 'captures or grabs attention' resulting in either less allocation of attention to time or the delaying of the opening/closing of the "Switch" amounting to less pulses accumulating and time perceived as shorter (underestimated). This interpretation fits with the definition of pain as an "attention-grabbing event" that engages and competes for attentional resources and drawing attention away from "time"(Eccleston et al., 2001). It is also consistent with arguments by Angrilli et al., (1997) that prospective studies in general are "underestimated" (Thomas & Weaver, 1975; Zakay, 1993b). Angrilli et al suggest underestimations increase in tasks that require more non-temporal attention such as a more complex, interesting or negative stimuli (Sawyer, 1994). Angrilli et al demonstrated this by showing durations whilst observing low arousal negatively valenced pictures (using International Affective Picture System, IAPS) were prospectively judged as shorter. A similar effect on prospective temporal processing may be occurring when in pain. It is possible to therefore conclude that, the prospective method produced a set of findings that are different both in outcome and explanation to the retrospective findings of Somov (2000) and Bilting et al., (1983). However, the laboratory findings of underestimation of retrospective durations by Thorn & Hansell (1993) and Hellström & Carlsson (1997) or the clinical findings of (Isler et al., 1987) are not consistent with this

conclusion and may be due to methodological differences that may be clarified if the current study is replicated using a retrospective paradigm. A notable comparative finding across studies however, was that Subjective Time is experienced as "slowing down" or "dragging" is consistent irrespective of whether prospective or retrospective paradigms are used as this was similarly reported by retrospective studies including, Somov's (2000) and Hellström & Carlsson, (1997).

A second aspect of this study partially confirmed the hypothesis that if Anxiety mediated the relationship between time perception and pain perception then it would correlate highly with both Pain Intensity and Time Distortion. This is only 'partial' support as the correlation between Anxiety and Pain Intensity was only found among the anxiety-induced participants. This does indicate Anxiety mediates this relationship. However, the hypothesis that Time Distortion would be different between groups was not supported hence despite the degree of Time Distortion between groups being different by double (underestimation by participants after an anxious event (TSST) was more than double that of controls), Anxiety may not be the only mediator.

These results suggest that greater time distortion occurs when a person's Pain Intensity and Anxiety are higher but that this distortion is lessened when Anxiety is low. In Chronic pain a pattern is found whereby Anxiety exacerbates pain which in turn increases anxiety (Gaskin et al.,1992). Also, anxiety has been shown to predict pain severity in both acute and chronic pain (Kain et al., 2000). Perhaps, then the mediation effect of Anxiety can be understood in the following way in the light of this research: Anxiety enlarges the "pain experience" increasing its severity and intensity resulting in the pain becoming even more "attention grabbing". This leads to even more attentional demand of resources allocated to pain and less to time therefore leading to a greater underestimation of time. However, the findings of Somov (2000) that retrospective estimates of time continued to be overestimated while in pain when anxiety and depression were controlled is not consistent with the present findings. That is, Somov (2000) found that over and above the variance due to Anxiety and Depression, a relationship between pain and time perception was still found. Whether this is a methodological issue as a result of different cognitive mechanisms involved with the differing methods (retrospective versus prospective paradigms) or arising due to differences from clinical versus laboratory pain or conditions is not clear. It might just be that headache patients have a more ingrained neurological condition or disorder affecting temporal processing at a cerebral level (O'Bryant et al., 2005). The lack of clarity in this area is highlighted by the lack of research hence much further work needs to be done.

Thorn & Hansell, (1993) and Hellström & Carlsson's (1997) are the only two laboratory studies on healthy participants but both are retrospective so not fully comparable to the present study. However, it is of interest whether these studies would have reported under-estimations had anxiety been controlled for. In fact Thorn and Hansell found that giving participants a "time goal" mitigated the effect of underestimating retrospective time durations. The researchers interpreted this as having the effect of increasing focus to a time cue therefore normalizing distortion. However, the author argues this might have reduced anxiety. A well-known factor in anxiety is that situations of uncontrollability lead to stress and anxiety. By giving a time-goal, this might have had the effect of reducing the uncontrollability element" as

the participant knows when the pain will end and may assume the experimenter has instructed a “safe” time limit. A similar effect can be seen in Pomares et al., (2011) showing intensity of pain induced by noxious stimulation can be altered by perceived duration. Participants were told that two thermal stimulations would be given, one longer, and another shorter in duration. The first stimulus went for a full revolution of the clock (i.e. 1 minute) but the second stimulation would only go for less than a full revolution. However the clock on the second trial was manipulated to still run for a full minute (move slower) despite the minute hand not making a full revolution. The perception by participants of the time while in pain being “shorter” lead to a reduction in Pain Intensity. This study lends evidence to the authors argument that time goals draw focus away from pain with the effect of reducing anxiety and thereby reducing time distortion.

The cumulative findings of this study best conceptualise Anxiety as a mediator in the relationship between pain and time perception, however as time distortion was not significantly different between conditions, other smaller factors may account for the variability. Cohen & Mezey, (1961) for instance, argue depression is a significant predictor of altered time perception in clinical studies. However it is considered by the author that depression is more likely to occur in clinical samples, hence is less of a factor in non-clinical healthy participants. However, it may be important to include depression as a covariate so as to factor out all potential confounds which should be done in a future study.

Findings also partially supported the hypothesis that participants with a higher Trait Anxiety and a predisposition to appraise events as more stressful would report higher State Anxiety. Neuroticism was, however, not found to be a predictor. Effects of Trait influence time perception including on mathematics tasks (Dubey & Sharma,1978) and measures of performance and memory while correlating with pain severity (Grace et al., 1999). This highlights the role of individual differences in Anxiety that are important considerations in Anxiety research.

Findings are unclear in respect to the hypothesis that certain physiological (autonomic) measures correlated with Anxiety. Only Heart rate (HR), not blood pressure, was associated with higher State Anxiety. This fits with previous research (Núñez-Rodríguez et al., 2008), but contradicts others where blood pressure is linked to Anxiety (Knight & Rickard, 2001), others also link Anxiety to low blood pressure (Hildrum et al., 2007). The general lack of clarity in the literature suggests Anxiety only weakly correlates with physiologic measures. Temporal distortion should occur given the extent that physiological systems are relied upon by perceptual systems which might be changed by autonomic nervous system activation (Chavez, 2003). However, only higher Systolic Blood Pressure was linked to time distortion. Again, the literature is mixed with HR linked to time estimation but not with blood pressure (Hawkes et al., 1962) and no link with HR in another recent study (Schwarz et al., 2013) or no links with any physiological measures (Shaefer & Gilliland, 1938).

However, the present study did not measure cortisol, which is a major limitation as this is a key hormone released in association with a biological stress response. It is a much more accurate unbiased measure and indicator for Anxiety. Cortisol has been implicated in impairments to cognitive functioning in Chronic pain patients (Lupien et

al., 2002) as well as healthy adults (Kirschbaum et al., 1996). A measure of cortisol in future studies would help substantiate a biological interpretation for the results of anxiety mediation in the relationship between pain and time perception. Hart et al., (2003) argues that cognitive deficits result from the concomitants of pain such as anxiety or depression, rather than being a direct result of pain (Pais-Vieira, 2009). The current study, fits with this idea as the findings are suggestive that a large proportion of the variation in time distortion is due to Anxiety itself. Also Pain-distress correlated highly with all measures of Anxiety, Pain intensity and Time-distortion suggesting Pain-distress may be a sub-factor of the "Anxiety" construct. Anxiety also appeared to result in a strong affective dimensional response to pain as greater affective pain correlated with higher anxiety.

Although the Cold-Pressor Test (CPT) itself has been shown to induce Anxiety (Liao, & Craske, 2013; Deuter et al., 2012), the Trier Stress test has been found to be more effective (Kirschbaum et al., 1993). The CPT produces only low to moderate stress and anxiety and the HPA axis is not always activated (Schwabe et al., 2008). This is because CPT precludes elements of "uncontrollability" and "social-evaluation" particularly relevant in situations of high stress. In the present study baseline CPT anxiety levels dropped in the No-anxiety group suggesting the experimental cold-pressor did not have a long-lasting anxiety-inducing effect.

An issue with the study design was the very demanding emotional impact it had on the researcher and confederates. The TSST resulted in 7 participants not completing the task due to withdrawal or due to the researcher or confederate stopping the Task. It may have been that both the researcher and confederate were in a couple cases unable to remain objective throughout the tests but it also may have resulted in the most highly stress disposed and stress-induced individuals being excluded from participation. On the other hand, at least 2 of the participants were not stressed at all in the TSST as both were business students accustomed to giving presentations every week. This means that program of study was a possible confound and should have been recorded for analysis.

A major shortfall of this study was the small sample size of only 10 participants in each condition (total – 20) with a sampling bias of 7 females to 3 males in the no-anxiety condition. This would have weakened statistical power and confidence where analysis might have found Time Distortion to be significantly different. Future studies should aim for sample of at least 60 participants. Participants were also told to " keep their hand in the cold pressor for as long as they could". This resulted in very short durations (5 seconds) and very long durations (230 seconds), which could be confounding results causing extremes of over or underestimations. Angrilli et al., (1997) argues differences could result as longer durations allow for more elaborate cognitive processing such as comparison and individuation of timing cues. Hence, shorter fixed successive intervals should be chosen. Despite these limitations, this was suitable as a preliminary exploratory study yielding noteworthy findings that will be useful to future research ascertaining the role of anxiety in prospective estimations while in acute pain.

Previous research has favoured the retrospective paradigm in clinical studies. However. in order to further understanding of temporal processing in conditions of pain, future research should seek to expand the research in both prospective and

retrospective designs within laboratory conditions for controlled experimental isolation of the underlying variables involved. Such studies might aim to clarify the role of attention and arousal. Dual-task designs that vary levels of distraction (attentional factors) or stress reduction (arousal), using for instance Progressive Muscle relaxation or International Affective Picture System (IAPS) to induce emotional valence may help to help reveal the nature and clarify and refine The Attentional Gate model.

The clinical implications of this research becomes especially prominent when considering a major component for treatment and diagnosis of migraines and similar conditions often with co-morbid anxiety is the reported durations of attacks and intervals between drug intake and relief (Hancock & Weaver, 2005) . Suitable treatment for such conditions may be Anxiolytic drugs, which have been shown to mitigate many of these effects (Narita et al., 2005). Schneider et al. (2011) describes a recent intervention using Virtual Reality (VR) Computer games that specifically targets pain-related distress and anxiety in cancer patients through distraction methods. Anxiety was found to explain a significant proportion of the variability of altered time perception, finding VR was effective at normalizing altered time and when anxiety was lowered patients also reported time as “passing quicker”. With further research in this area using experimental designs, theoretical models of perception can be tested and refined within the context of pain which may in turn inform clinical interventions for pain and pain-related deficits.

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