Selective Attention, Resilience and Perceived Stress in The Arabic-Speaking Population with Chronic Pain

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List of Common Abbreviations

CP Chronic pain

IOR Inhibition of return

SA Selective attention

SOA Stimulus onset asynchrony

ABM Attentional bias modification

CLBP Chronic low back pain

FM Fibromyalgia

PPIE Patient and public involvement and engagement

Abstract

Chronic pain (CP) is one of the most common conditions worldwide. The prevalence of CP is even higher among the Arabic population. CP adversely impacts different aspects of the sufferer's life. Previous literature found that attentional biases in people with CP affect the link between CP and attentional bias, which has not been explicitly investigated among the Arabic population. Further, the findings have been inconsistent in the wider literature, so the evidence should be re-examined. Thus, three studies were conducted to strengthen the evidence in this field. All studies included in this thesis were preregistered and used open-science tools. Furthermore, the current evidence was first investigated through a systematic review and meta-analysis that included only studies with relatively large sample sizes (Chapter 3). The systematic review also included a table mapping processes onto models, which specify the different attentional processes and how these are interpreted by existing theoretical models in this space.

The second experimental (Chapter 4) study was conducted due to the absence of previous evidence in the CP-attention field in the Arabic population. Attentional biases were assessed among CP individuals compared to healthy controls using two selective attention tasks; the Posner spatial cueing task and the Emotional Stroop task using pain-related words. Also, resilience and perceived stress levels were measured. Examining a later time point in the cueing task meant that the experiment revealed differences between the groups in *when* they disengaged their attention from different cue types. The results showed that individuals with CP disengaged early from sensory pain-related information relative to other cue types, as revealed by the inhibition of return (IOR) effect. Resilience extreme values moderated attention performance on the Posner task. Participants with CP who gave extra consent for a semi-structured interview were engaged in a one-to-one exploration of their daily attention experiences, experiences of exposure to pain-related information in the experiment, and opinions about possible coping and managing strategies (Chapter 5). Participants provided rich data and suggestions involving personal CP-related attention experiences, coping experiences and more public policymaker-related recommendations.

In conclusion, the studies conducted enhanced re-organising the evidence available around reaction time tasks in the general CP-attention field. Together, the outcomes provided preliminary evidence that attention difficulties and related biases are important in maintaining CP among Arabic individuals.

Declaration

No portion of the work included in this thesis has been submitted in support of an application for another degree or qualification of this or any other university or other institute of learning.

Copyright Statement

Dedication

To my mum, my dad, Raed, my sisters, my wife, Aryam, Nabeel, Maryan, my wife's family, my brothers and all who believed in me and supported me in pursuing my academic dream.

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CHAPTER 1

Introduction

1.1 Selective Attention and Chronic Pain: Contextual Overview

Over the last two decades, the cognitive consequences and causes of chronic pain (CP) that persists for a long period that exceed three months (Merskey, 1986) have received growing attention. CP is a common and challenging condition because, in addition to its biological nature, it interacts with psychological and social factors. Thus, the deterioration in function is associated with the psychological situation of the individual suffering from CP (Luber, 2019). Persistent pain potentially lowers the voluntary internal ability to manage pain and could increase the possibility of developing other disorders (Bushnell, Čeko, & Low, 2013). Śweiboda and her colleagues pointed out that reduced functional abilities, sleep disturbance, eating disorders, sexual disorders, and lower pain threshold are frequently co-morbid with CP (Świeboda, Filip, Prystupa, & Drozd, 2013b). CP also contributes to mental and emotional problems and has a negative impact on brain functions (Clark & Cox, 2002).

The seriousness of CP for society comes from its effect on disability as illustrated by the biopsychosocial framework (Bursch, Walco, & Zeltzer, 1998; Turk, Wilson, Swanson, Ebert, & Kerns, 2011) and related prevalence rates. Internationally, despite the heterogeneity of research studies, it is estimated that the prevalence rate of CP is around 20% (Mills, Nicolson, & Smith, 2019; Phillips, 2009; Souza et al., 2017), and in Europe, it is about 19% (Breivik, Collett, Ventafridda, Cohen, & Gallacher, 2006). In a country like Brazil, this rises to 39% (Souza et al., 2017). A recent systematic review found that the prevalence of CP ranges between 33% and 50% in the UK (Fayaz, Croft, Langford, Donaldson, & Jones, 2016). These differences could be attributed to the absence of a standardised definition for CP, lack of validated and culturally sensitive measures for CP, and inequitably burdened populations across regions (Jackson et al., 2016). The cost of CP management attributes the economic burden on patients, their caregivers, and health systems globally (Phillips, & Schopflocher, 2008) and was affected by the Covid-19 pandemic and its consequences on the health systems (Lacasse et al., 2021). Since CP is affected by psychological and sociocultural factors, evidence is needed from different cultures, such as high, middle, and low income settings (Bates, Rankin-Hill, & Sanchez-Ayendez, 1997; Turk, & Monarch, 2002). Considering the high prevalence of CP, which ranges between 20% and 46.4%

in the Arabic population (Elzahaf, Johnson, & Tashani, 2016; Almalki et al., 2019, Mills, Nicolson, & Smith, 2019), it becomes clearer that examining the mechanisms contributing to the development and/or maintenance of CP among Arabs in both low, and high-income countries like Jordan and the UK is needed. To date, very few studies have examined CP among Arabs in the UK or other European countries.

Several factors and mechanisms contribute to the experience of CP. Factors "influence but not alone sufficient to cause change" (Evans, Li, & Whipple, 2013), whereas mechanisms are cognitive or biological processes that cause change and are linked with causation (Siegler, 1989). Key psychological processes were viewed as causal mechanisms (i.e. Mediators) in the relationship to a threat. These processes involved in the stress-CP relationship include; attention, perception, motivation, and action (King, Keil, & Sibille, 2016).

Evaluating the processes and their contribution would help individuals with CP to cope with this long-term condition (Jensen, Turner, Romano, & Karoly, 1991; Edwards, Dworkin, Sullivan, Turk, & Wasan, 2016; Meints, & Edwards, 2018). Because CP is associated with different mechanisms and comorbidities that could affect the quality of life for CP individuals as well as levels of anxiety (Zhuo, 2016) and depression (Holmes, Christelis, & Arnold, 2013), thus, understanding the cognitive resources available is essential for dealing with associated issues such as reduced behavioural activity, altered pain perception, and avoidant coping styles related to attention (Eccleston, 1994).

However, there is very little empirical evidence in the literature explicitly focusing on the cognitive mechanisms which contribute to the development and/or maintenance of CP among Arabic speaking population. Specifically, targeting this population with a culturally adapted experiment is needed because there is preliminary evidence that health-related behaviours (such as having a less healthy lifestyle when being in their home country) are different among the Arabic-speaking population from other (e.g. western) populations (Al-Awadhi et al., 2004, Alzain et al., 2022). Further, the specific linguistic Arabic language metaphors related to pain words would give a culturally sensitive dimension (Al-Abdullah, 2019). Such a cultural-sensitive understanding of pain experiences in an experimental study is essential for the exploration and development of a specific list of words to be evaluated by future research.

In the next section, the definition of CP and its relationship with perceived stress and resilience will be considered. After that, the theoretical models that link attention processes and CP will be explained, followed by an illustration of common tasks used to measure attentional performance in individuals with CP. The aims of the thesis and the structure will then be introduced in Chapters 1 and 2.

1.2 Chronic Pain (CP): An Overview

1.2.1 Definitions

Pain has received significant research attention due to its major impact on a person's life and functionality. According to the Kyoto protocols and the International Association for the Study of Pain (IASP), pain is defined as *''an unpleasant sensory and emotional experience associated with actual or potential damage, or described in terms of such damage''* (IASP, 1979, as cited in Raja et al., 2020). Pain can be classified using different dimensions such as intensity, body part(s) affected, and duration. Regarding duration, pain is usually divided into acute or chronic (Świeboda et al., 2013b). Acute lasts less than three months, while chronic persists for three months or more (Merskey, 1986).

CP *"may arise from psychological states, serves no biologic purpose, and has no recognizable end-point"* (Grichnik & Ferrante, 1991, p.217). This definition suggests that this form of pain does not serve the chief role of pain as a warning signal and defence mechanism. Acute pain is defined as *"pain provoked by a specific disease or injury. It serves a useful biologic purpose, is associated with skeletal muscle spasm and sympathetic nervous system activation, and is self-limited"* (Grichnik & Ferrante, 1991, p.217). Sometimes, the term 'sub-acute' is used to describe a sub-type of pain lasting from 6 weeks to 3 months (Van Tulder, Koes, & Bouter, 1997). Pain is considered a disease state if it lasts beyond the normal time of healing associated with a disease or injury. Another way of classifying pain is according to its site, whether it is localized or general widespread pain. Finally, the classification of pain according to specific aetiology is used when the cause is known. This includes different kinds such as pathophysiological or anatomical causes (Świeboda, Filip, Prystupa, & Drozd, 2013a). Unfortunately, some kinds of pain are idiopathic, meaning their causes are still unknown (Malfliet et al., 2015). Additionally, as the ICD-11

classification implies, a proper differential diagnosis between sub-types of CP is essential in case management (Nicolas et al., 2019).

According to the eleventh revision of the International Classification of Diseases (ICD-11), CP can be divided into two main subcategories, Primary CP and Secondary CP. The former is defined as

"*pain in one or more anatomic regions that persists or recurs for longer than three months and is associated with significant emotional distress or significant functional disability -interference with activities of daily life and participation in social roles- that cannot be better explained by another chronic pain condition*" (Treede et al., 2015, p.1003).

The nature of primary CP is multifactorial; different biological, psychological and social factors contribute to its development (see below), but its aetiology is unknown. This definition encompasses several conditions, such as Fibromyalgia (FM), Complex Regional Pain Syndrome (CRPS), Chronic Migraines and other disorders (Treede et al., 2015). However, secondary CP is explained or related to another medical condition (i.e. chronic cancer-related pain, chronic postsurgical or posttraumatic pain, chronic neuropathic pain, chronic secondary headache or orofacial pain, chronic secondary visceral pain, and chronic secondary musculoskeletal pain) (WHO, 2019).

1.2.2 Brief explanation of pain mechanisms

Three main categories characterise pain occurrence. First is nociceptive pain, which results from the inflammatory reaction process to infection or tissue damage (Koltzenburg, 2000). This mechanism plays a crucial role in survival as it pushes the person to attend to the pain caused as a source of distress. Because nociceptive pain is related to noxious stimuli, it works like an early alarm system essential for survival (Woolf, 2010). The second category is neuropathic pain, in which damage to nerves occurs (Colloca et al., 2017). For instance, when a person loses a leg, a neuroma could develop at the end of the stump, causing pain from the signals of the damaged nerve, which could be due to pathology or injury to the nervous system[1] (Williams, 1984; Campbell, & Meyer, 2006). The third category is related to the more recent nociplastic pain

[1] This is different from phantom pain, in which the person with an amputated limb feels pain as if it is occurring in the lost part of the limb.

concept introduced by the International Association for the Study of Pain (IASP) is neoplastic pain, in which a collection of vague symptoms exists and affect the person's quality of life despite the absence of apparent physical causes (Fitzcharles et al., 2021). Nociplastic pain mechanisms are understood in the light of the biopsychosocial model (Figure 1.1). One example of nociplastic CP is the nociplastic fibromyalgia features, which include physical (e.g. hyperalgesia, which is the increased sensitivity to painful stimuli) and psychological (e.g. marked affective pain component) factors, compared to symptoms-based fibromyalgia which is characterised by a generalised somatic pattern of pain (Bidari, & Ghavidel-Parsa, 2022).

Despite criteria identifying different mechanisms contributing to the development and maintenance of pain, the overlap between pain categories is common (Maixner, Fillingim, Williams, Smith, & Slade, 2016; Slade et al., 2020). Because CP mechanisms are prominently related to sensory processing in the central nervous system, it becomes essential to study the overall attention processes and related attentional experiences of individuals with CP (Phillips, & Clauw, 2011).

1.3 Stress and Resilience In Chronic Pain

1.3.1 CP and Stress

In the field of psychology, stress had been thought to be a negative factor that affects mental health, denoting a psychosomatic component that is linked to physiological reactions (Bienertova-Vasku, Lenart, & Scheringer, 2020). Recently this view has changed, and growing evidence suggests that stress is rather a reaction that prepares the body for a potential challenge, so if a person has a positive perception of stress, this will improve health and age expectancy for him/her (Richardson et al., 2012; McGonigal, 2013). In other words, the way an individual perceives stress has a direct effect on his/her body and determines to a large extent how it affects health status, including pain sensations. Similar to self-fulfilling prophesy, if a person believes that stress will harm him/her, there will be a higher chance for actual harm to happen (Szabo, & King, 2000). Psychological distress and eustress are terms used in the stress literature to differentiate between the negative and positive meanings of stress (Bienertova-Vasku, Lenart, & Scheringer, 2020). Psychological distress is an "unpleasant subjective stress responses" that denotes a negative meaning of stress that is related to negative emotions such as anxiety or depression (Matthews, 2016). In contrast,

eustress is seen as an adaptational positive cognitive appraisal when responding to stress (Lazarus, & Folkman, 1984). Perceived stress is related to how the person interprets either the external situations from the surrounding environment and related stress or the internal stress triggered by various cognitive, emotional, or physiological factors (e.g. thoughts, illness, pain), which are perceived as unpredictable and uncontrollable (Cohen, Kamarck, & Mermelstein, 1983).

Because CP is a long-term condition, the link between CP and perceived stress plays a crucial role in the development and maintenance of CP (King et al., 2016). Understanding how perceived stress can be affected by contextual situations could inform a deeper understanding of the effect of cognitive processes and neural mechanisms in interpretation biases that maintain stress and chronic stress-related CP (Abdallah, & Geha, 2017), and potentially cause cognitive impairments (Hart, Wade, & Martelli, 2003). To the best of our knowledge, previous literature has not explored these mechanisms between stress and CP using experimental approaches. Such exploration is important because stress could play a role in enhancing selective attention (Chajut, & Algom, 2003). As I will be discussing further below, shifting attention away from the source of the threat information (pain-related information) that causes stress-related behaviour (i.e hypervigilance, avoidance) would help dismantle mechanisms that maintain this vicious cycle between CP and distress (i.e. negative stress interpretation vicious cycle).

1.3.2 Chronic Pain and Distressing Events

The concept of pain is tightly linked with chronic stressors. The link between exposure to prolonged stressors and developing CP is well-established in the literature (Asmundson, Coons, Taylor, & Katz, 2002; Brennstuhl, Tarquinio, & Montel, 2015; Sharp & Harvey, 2001). Both psychological distress and CP have similar symptoms, such as hyperarousal and attentional bias to somatic signs (Shutty, DeGood, & Schwartz, 1986; Dworkin, 1994). On the other hand, CP is thought to be biologically connected with chronic stress by sharing the activation of similar biological networks (Abdallah & Geha, 2017; Blackburn-Munro & Blackburn-Munro, 2001). Stress-related CP can result from the way one perceives life events. This could lead to reactions that affect the individual's biological homeostasis. Unlike acute stress, the increase of stress hormones (i.e. epinephrine, norepinephrine, and cortisol) persists in a chronic condition, which in turn, attenuates the individual immunity, affecting his/her general health and increases the chances of experiencing CP (Hannibal & Bishop, 2014; Pruessner, Hellhammer, & Kirschbaum, 1999).

Fortunately, there is some evidence that ameliorating stress is associated with a decrease in CP intensity (Blackburn-Munro & Blackburn-Munro, 2001; Rosenzweig et al., 2010). Community and social interventions can improve both distress symptoms and CP. One study found that providing CP sufferers with socially supportive environments reduced CP, distress, and disability symptoms (Ashton-James, 2022). These findings suggest that social involvement and easy access to social services may reverse the negative consequences of distress and CP.

The bio-psychosocial model and attentional bias interpretative models (which will be explained later in this chapter and chapter three) are useful theoretical frameworks for understanding the associations between CP and psychological distress (Gatchel, Peng, Peters, Fuchs, & Turk, 2007; Pincus & Morley, 2001). The theoretical basis and the different dimensions of the bio-psychosocial model are illustrated in Figure 1.1 (Gatchel, 2004). The biological dimension highlights the predisposition for physiological responses and pathophysiological reactions to psychological distress. The psychological aspect includes cognition/thoughts, emotions, and behaviours such as distorted beliefs, biased attention, altered memory, learning, current coping methods, attribution, and psychological distress. Lastly, the social aspect involves socio-economical, socio-environmental, and socio-cultural elements such as social support, family support, economic status, and work (Gatchel et al., 2007). The interaction between these dimensions is dynamic and should be considered simultaneously to understand the association between distress and CP.

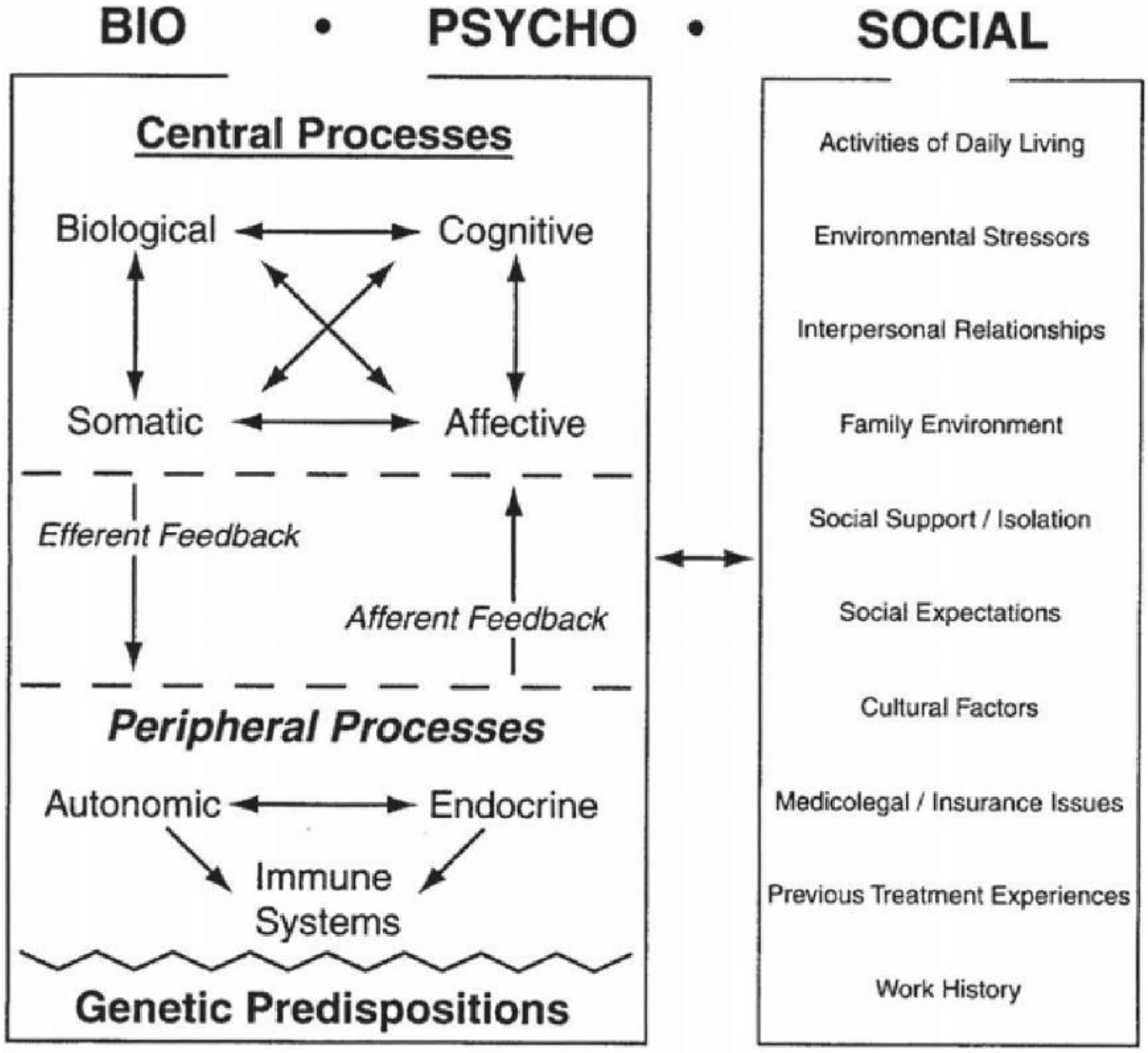

Figure 1.1: A conceptual model of the bio-psychosocial interactive processes involved in health and illness. Adapted from "Comorbidity of Chronic Mental and Physical Health Conditions: The Biopsychosocial Perspective" adapted from Gatchel (Gatchel, 2004).

1.3.3 The Importance of Resilience in Dealing with Chronic Pain

Chronic pain is usually associated with negative consequences such as depression (Brown, G. K., Nicassio, & Wallston, 1989). Therefore, there is a need for a counter-effect that can help CP sufferers to regain balance in their life. One of these potential processes is resilience. Resilience refers to "the ability to successfully adapt to stressors, maintaining psychological well-being in the face of adversity" (Haglund, Nestadt, Cooper, Southwick, & Charney, 2007). Different studies show that resilience and stress have an inverse relationship. Individuals with a high level of

resilience are less likely to be affected by stressful life events (Bitsika, Sharpley, & Bell, 2013; Loprinzi, Prasad, Schroeder, & Sood, 2011; Shatté, Perlman, Smith, & Lynch, 2017). Although some studies describe resilience as a trait and link it to genetic predisposition (Feder, Nestler, & Charney, 2009; Haglund et al., 2007), other studies propose that resilience is affected by the environmental surroundings and cultural differences, and that resilience could be an adaptation process to extreme stress, through building coping strategies that help to ameliorate stress-related distress (Masten, Best, & Garmezy, 1990; Neftci & Çetrez, 2017).

There is evidence that resilience can be modified and improved using positive psychology techniques such as the broad-minded affective coping procedure (BMAC) (Panagioti, Gooding, & Tarrier, 2012). Likewise, different studies used positive psychology and mindfulness to improve resilience which also could advance cognitive functions, including memory and attention control (Jha, Rogers, & Morrison, 2014; Seligman, 2011; Staal, Bolton, Yaroush, & Bourne Jr, 2008). In their book "Handbook of Adult Resilience", the authors argued that resilience could only be assessed for those individuals who went through a stressful or threatening experience because, in such situations, adaptation and growth could express by overcoming that experience and, as a result uncovering a "resilient" individual. This means that resilience determines to a great degree, the capacity to recover from ordeals (Reich, Zautra, & Hall, 2010). Resilience may have an adaptive, protective and mitigating role against the impacts of CP and related psychological distress (Sturgeon, & Zautra, 2010; Yeung, Arewasikporn, & Zautra, 2012). Therefore, resilience was assessed as part of a comprehensive mixed methods study (i.e. the studies covered in Chapters 4 and 5).

1.4 Understanding the context of CP in the Arabic population

There is accumulating research evidence linking CP with stressful events or environments. Yet, such continuous and persistent adverse consequences could affect health and well-being. It has also been found that the interactions between CP and stress-related psychological factors play a crucial role in the well-being of people with CP (Hart et al., 2003; Heidari, Hasenbring, Kleinert, & Kellmann, 2017). CP sufferers usually experience psychological symptoms for several years after exposure to those events (Priebe et al., 2013), although this has not been investigated thoroughly in the Arabic population. However, understanding the context of CP development and maintenance and how it is affecting basic functionality for many CP sufferers is a cornerstone in

taking further steps to unravel this issue and also proposing culturally sensitive solutions. To address this gap, this thesis tried to contribute to building these foundations that are mainly related to attention, distress, and resilience.

The chronic precipitating factors could affect how people perceive stress and appraise their life situations in a way that exceeds the effect of the current stressors on shaping a person's lifestyle. This exaggerated way of perceiving stress is more likely in CP because CP implies that an intersection between situational stress and actual or perceived damage to one's body occurred (McGonagle & Kessler, 1990; Cohen, Kamarck, & Mermelstein, 2021). Accessibility to effective treatments is one of the most prominent challenges for Arab speaking population with CP because they often face multiple and costly needs for health care services, including surgical, medical, and psychological services (Kronfol, 2012). This issue is salient in the CP population because of the dysfunctional effect of CP that makes them unable to afford the cost of treatment in their countries, increases poverty, and limits their ability to engage in social activities due to the poor disability-friendly infrastructures (Abu-Bader, & Gottlieb, 2009; Peters, 2009). Additionally, there is little information in the literature about the cognitive mechanisms related to CP among Arabic-speaking populations in different contexts (including Jordan and the UK).

Because pain is a very subjective experience, the possible solutions vary (El Sount et al., 2018). Existing interventional approaches which may be used to mitigate CP symptoms include Attention Bias Modification (ABM) (also known as "Attentional Retraining") (Kuckertz et al., 2014), Inhibition Control Training (Allom, Mullan, & Hagger, 2016), Eye Movements Desensitization and Reprocessing (EMDR) (Mazzola et al., 2009), Cognitive Behavioural Therapy (CBT) (Morley, 2011), Problem Management Plus (PM+) (Dawson et al., 2015), and Acceptance and Commitment Therapy (ACT) (Hughes, Clark, Colclough, Dale, & McMillan, 2017). Most of these therapies were tested previously in general CP population and proved their effectiveness. While some of these approaches have been used with CP, they have not yet been used for ameliorating CP symptoms among Arabic speaking population in Jordan and the UK. Current treatments focus mainly on chemical medications, which are frequently misused, and physical modalities (Al-Shareef, Omar, & Ibrahim, 2016; Al Maharbi et al., 2019). Additionally, it is crucial to address the need for culturally adapted Arabic interventions that meet the specific cultural needs of this population.

The lack of a culturally standardised pain-related words list adapted for the Arabic population made it essential to prepare such a list for future experimental studies (refer to Appendix 4.H). This list would consider the cultural differences and benefit from previous experimental studies' word lists and pain-related words translated into the Arabic language, such as the study by Harrison (1988). However, it is worth noting that because the Covid-19 pandemic lockdown time was not known when the studies included in this thesis were conducted, a significant challenge was encountered to redesign the experiment according to remote delivery. This needed to move from the local experimental setting to an online compatible supervised platform setting.

In addition to the points mentioned above, previous literature that explored the cultural influence on pain experiences (Peacock, & Patel, 2008; Sharma, Abbott, & Jensen, 2018), and how individuals perceive the pain (Callister, 2003) formed a theoretical motivation for focusing on the Arabic-speaking population. For instance, a systematic review explored the socioeconomical factors related to pain in sub–Saharan Africa, and found that the culture is a main key that influences pain maintenance and contribute to choosing how to manage it (Dompreh, Lynch, & Longworth, 2022). The role of language is another factor that need to be taken into consideration when exploring pain related phenomenon. A recent systematic review concluded that (Bacco et al., 2022). An interesting paper titled *"when words burn"*, authors argued about the effect of using language (i.e. words as cues) in electing responses in CP population different than a neurotypical individuals, which is related to semantic comprehension and linguistic context that provide the meaning rather than the attentional bias explanation that attribute the attending to pain-related information due to additional experiences they went through (Vukovic, Fardo, & Shtyrov, 2018). Together, cultural and linguistic factors could shape how individuals make sense of pain experiences and influence attentional processes.

1.5 Selective Attention

1.5.1 Cognitive Processes in CP Condition

1.5.1.1 Definitions

Cognitive processes are essential in understanding CP. Cognitive processes are a set of functions that encompass controlling different aspects of intellectual functions and processes such as attention, knowledge formulation, working memory, long-term memory, evaluation, higher

reasoning, problem-solving and decision-making, and comprehension and production of language (Diamond, 2013). Cognitive processes such as attention and memory play a critical role in the development and maintenance of CP because they affect the processing of sensory stimuli, pain and perceived threats (Higgins, Martin, Baker, Vasterling, & Risbrough, 2018).

The dramatic shift between early scientific claims and recent studies of attention demonstrates the difficulties that hinder the efforts to produce an organised and structured understanding of attention. The early understanding of attention as expressed by William James (as cited in Styles, 2006) remarked that "everyone knows what attention is". However, later we tended to have a more humble views. For example, three decades ago, there was a general view that attention cannot be "defined" (Johnston, & Dark, 1986). One of the explanations of attention is to see it as a *"*variety of psychological phenomena*"* (Styles, 2006). These multi phenomena imply that we need to go beyond the superficial understanding of attention as shifting interest -toward or away from a particular stimulus- and decompose the elements that affect this shifting. Yet, it is worth mentioning that the American Psychological Association (APA) define attention as *"*a state in which cognitive resources are focused on certain aspects of the environment rather than on others, and the central nervous system is in a state of readiness to respond to stimuli" (American Psychological Association, 2013a, p.133).

Attention has been split into various types that affect how we attend to different stimuli in the surrounding environment. Still, the complexity of the "attention" term means that it is challenging to have a precise definition of attention and referred to as "umbrella-term for a general topic, subsuming a host of questions about selective processing" (Allport, 1993; Driver, Davis, Russell, Turatto, & Freeman, 2001; Petersen & Posner, 2012). Although there are different types of attention (e.g. sustained attention, executive attention, …etc.), and because it is a huge topic, this thesis focused on the selective attention that is thought – from previous literature- to be the main attentional sub-type to be affected in the CP population.

Selective attention is defined as *"*concentration on certain stimuli in the environment and not on others, enabling important stimuli to be distinguished from peripheral or incidental ones" (American Psychological Association, 2013b). Another definition of selective attention is "Focusing concentration on a single stimulus or class of stimuli to the exclusion of others" (Colman, 2015). In other words, selective attention is the process of being able to choose between

two (or more) different stimuli, prioritise and attend (or not) to them. Although these different stimuli might occur simultaneously, the person decides to attend to some of them and prioritise them over other stimuli (i.e. stimuli can be visual, auditory, tactile, ... etc) (Lavie, 2000). Selective attention is considered *"an intrinsic component of perceptual representation in a visual system that is hierarchically organized"* (Yantis, 2008). In his book about cognition, Revlin explains selective attention further by suggesting that

"In order to sustain our attention to one event in everyday life, we must filter out other events…we must be selective in our attention by focusing on some events to the detriment of others. This is because attention is a resource that needs to be distributed to those events that are important." (Revlin, 2012).

In other words, selective attention involves shifting the focus toward or away from a particular internal or external stimulus by reprioritising the existing stimulations.

Different studies and related theoretical models propose that in CP, patients experience disability and distress that could partially- at least- be explained by attentional biases (Pincus, & Morley, 2001; Eccleston, & Crombez, 1999; Van Damme, Legrain, Vogt, & Crombez, 2010; Crombez, Van Ryckeghem, Eccleston, & Van Damme, 2013; Todd et al., 2015). Attentional biases are "automatic tendencies to shift attention towards a specific stimulus or set of stimuli" (Carleton et al., 2020). Attentional bias is considered one of the prominent factors affecting the quality of life in the CP population, and studies suggest that people with CP excessively direct attention towards distressing symptoms (Pincus & Morley, 2001; WHO, 2019).

Usually, attentional bias is investigated in association with a perceived threat (Schoth, Nunes, & Liossi, 2012). Indeed, several biased processes of attention, memory, and interpretations impact on the emotions and actions accompanying pain-related experiences. Similarly, attentional bias toward threatening emotional and cognitive information is common among people with anxiety and acute stress and may maintain core symptoms such as hypervigilance (McHugh, Behar, Gutner, Geem, & Otto, 2010). In the context of chronic stress, the symptoms of pain are interpreted as a threatening stimulus. Then, pain leads to more severe and persistent stress-related symptoms, affecting the individual's functioning (Lazarus & Folkman, 1984).

One type of attentional bias is the visual-spatial attention bias, which tends to be seen as a covert orienting rather than an overt process guided to a specific spatial area (Styles, 2006). This type relies on the fact that an individual can attend to stimulus without moving eyes. This process was further explained by Posner (1980), who identified two main mechanisms linked to attentional shifting; the first one is the endogenous attention related to inner-directed goals such as having a pointing arrow. This internal motivation is also related to the top-down attention process that guides and controls attention allocation related to expectations and anticipations. Thus, this makes the person ready to react to a stimulus even before the appearance or occurrence of the stimulus itself. This explains biases related to inner motivations (e.g. thoughts, fear, anxiety, pain) based on these internal cognitive-related interpretations, emotions or physical sensations (Figure 1.2) (Disner, Beevers, Haigh, & Beck, 2011; Katsuki, & Constantinidis, 2014). Further, eye tracking cannot catch the attention to peripheral visual stimuli (Mazidi et al., 2019), which are usually involved in capturing exogenous (external) stimuli (Berger, Henik, & Rafal, 2005). The second type is the exogenous orientation mechanism, in which the attention is affected by an external trigger presented as a cue in the person's surroundings. The trigger does not have to be neutral, but there is an automatic orienting to the stimulus (Berger, Henik, & Rafal, 2005). This type of attention is related to the bottom-top mechanism of following a solely external stimulus salient in a person`s environment (Katsuki, & Constantinidis, 2014). Visual attentional biases, related theoretical interpretative model of CP and the main relevant experimental tasks are explained in the following sections.

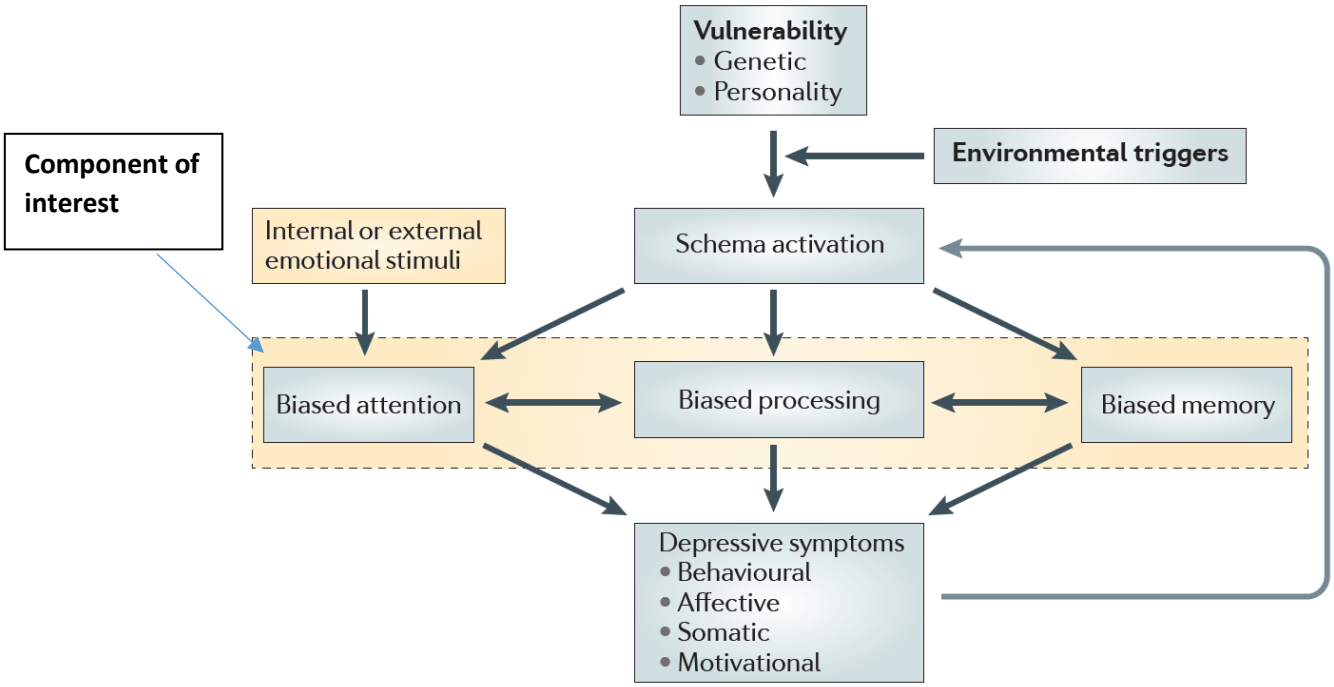

Figure 1.2: Information processing in the cognitive model of depression as adapted from (Disner, Beevers, Haigh, & Beck, 2011).

1.5.1.2 Selective Attention toward Pain-related stimuli

Pain-related functionality is impeded within a goal-oriented context. Often, pain is not only irrelevant to the person's intended goals, but it also interferes with these goals and interrupts them, meaning that pain affects the achievement of goals. Further, because pain plays a crucial role in determining the amount of attention needed to control it (i.e. the more the pain the more attention paid to manage it), this leads to increased attentional processing of pain-related information. As such, it becomes clearer how attentional control is being affected by different factors like pain or by other disorders that often overlap with CP, such as anxiety or depression (Van Damme et al., 2010; Verhoeven et al., 2010; Crombez, Heathcote, & Fox, 2015). Pain-related information can be either painful bodily sensations or pain-related stimuli such as words or pictures that carry pain-related meaning.

Experimental selective attention tasks/paradigms are of increased interest as they can be used to distinguish between the effects of various stimuli on people with CP. These stimuli reflect different types of triggering stressors that could be faced in real life. Attention disruption by pain contributes

to distress by decreasing the ability to concentrate on fruitful, productive tasks (Attridge & Niederstrasser, 2018; Crombez, Eccleston, Baeyens, & Eelen, 1998; Vancleef & Peters, 2006; Veldhuijzen, Kenemans, de Bruin, Olivier, & Volkerts, 2006). Studies that have investigated attentional performance in CP populations are split in their results, one part found "attentional bias" toward pain-related stimuli, while other studies found "attentional avoidance" away from pain-related stimuli. This attendance towards/away from stimulus can change over time (Crombez et al., 2013). These results were significant mainly for CP but not acute pain groups, and the reliability of some tasks was poor (Cisler, Bacon, & Williams, 2009; Crombez et al., 2013). Despite this, research on selective attention in CP is advancing. For example, researchers have used modern neuroimaging like fMRI and event-related potentials (ERPs), as well as eye-tracking techniques for more in depth investigations of selective attention (Duchowski, 2007; Yantis, 2008).

1.5.1.3 Theoretical Interpretative Models of Selective Attention Processes in CP Condition

Pain captures attention and functions as a survival mechanism. The cognitive system integrates this warning sign to control the reaction to a threat, which includes attention to pain as a salient stimulus (Blöchl, Franz, Miltner, & Weiss, 2015). Various attention models were developed to explain attentional processes in CP patients. They also relate to general models of pain being prioritised in healthy participants. These models propose different interpretative frameworks that could be used to explain the attention-CP relationship. However, there is an overlap between these models, which will be explored further in a systematic review (see chapter 3).

The ***schema enmeshment model***, which Pincus and Morley (2001) suggested, is one of the leading models that explain the attention-CP relationship. This model proposes that the three cognitive schemata, pain, illness, and self, are over processed and enmeshed, resulting in information processing biases in CP. This model also predicts that most of the patients with pain show attentional biases toward sensory pain information, due to the heightened personal relevance of pain and illness, which becomes enmeshed over time (Pincus & Morley, 2001; Rusu, Vogel, Van der Merwe, Pither, & Pincus, 2009). The enmeshment of schemas may become problematic when a disproportionate amount of attention is directed toward pain-related stimuli, implicating hypervigilance (i.e. actively seeking pain-related information) as the primary mechanism of

maladaptive processing of pain-related information, i.e. the experience of pain causes attentional bias toward pain-related information (Crombez et al., 2013; Rusu et al., 2009).

Interestingly, Eccleston and Crombez developed another model to interpret the pain-attention schematic relationships. ***The misdirected problem-solving model***, also known as the pain-related worries model (Christopher Eccleston & Crombez, 2007), postulates that being concerned about pain is correlated with hypervigilance toward pain and pain-related cues. In this model, CP patients can be imagined as stuck in a "perseverance loop", in which patients try vividly to solve the wrong problem (A Khatibi, Sharpe, Jafari, Gholami, & Dehghani, 2015).

The cognitive–affective model of the interruptive function of pain is another interpretative model for selective attention in CP by Eccleston and Crombez (Eccleston & Crombez, 1999). This model proposes a different part of selective attention, in which the difficulty of disengagement (i.e. difficulty moving attention away) from pain stimuli increases under threatening circumstances. This difficulty leads to the inability to engage in other more goal-oriented functional actions, which in turn heightens the risk of additional disability. The aggravated disability is explained as a result of engaging in pain palliative behaviours at the expense of other life functions, such as staying at home instead of going to work or not doing regular housekeeping tasks. The concept of "dynamic mechanism of selection for action" included in this model illustrates the association of various factors with pain and attention, including environmental factors, stimulation type, sensory system, action programs, focal task usage and threat mediation and moderation factors (Eccleston & Crombez, 1999).

Vlaeyen and Linton suggested the fear of pain model (Vlaeyen & Linton, 2000), to illustrate the relationship between pain-related stimuli and shifting the attention away from the stimulus. Later, Vlaeyen and Linton evolved this model to establish ***the fear-avoidance model of musculoskeletal CP***, which focuses on the persistent experience of pain and attentional readjustment according to this condition (Vlaeyen & Linton, 2012). Such alteration in attention leads to attentional hypervigilance, which could occur in anticipation of pain (Crombez, Eccleston, Van Damme, Vlaeyen, & Karoly, 2012). The model presumes that fear of pain is an essential element in the development and maintenance of CP. The basis of this model lies within prior works on avoidance learning and the subsequent development of the fear-avoidance model (Fordyce, Shelton, & Dundore, 1982). Unlike other models, the fear-avoidance model hypothesises that catastrophic pain-related thoughts associated with distorted beliefs about the consequences caused by the

stressful severe event could lead to attentional avoidance of pain cues. Thus, pain behaviour is classified as phobic behaviour (Lethem, Slade, Troup, & Bentley, 1983; Linton & Shaw, 2011). Recent works still show support for the fear-avoidance model, which implies that avoidance is a primary factor in maintaining CP existence (van Heck, 2019).

The motivational account of attention to pain model put by Van Damme and his colleagues suggests that when individuals prioritise a pain-related objective such as seeking pain treatment, which occurs due to heightened attentional processing of pain and pain-related information (Schoth & Liossi, 2016). This increased attentional processing is attributed to variations in pain perception, which in turn cannot be explained by biological causes, but rather as a dynamic motivational mechanism that could be better understood using a bio-psychosocial perspective (Van Damme et al., 2010).

A more recent model for selective attention in CP patients is ***the threat interpretation model***. This model proposes that for an individual to be biased towards attending to a threatening stimulus, this stimulus should be first categorised as such. The model also predicts that the relationship between the interpretation of a threatening stimulus (e.g. pain-related stimuli) and the attention toward that particular stimulus will be stronger under circumstances of excessive threat. The threat interpretation model differs from other models because it postulates that *avoidance* rather than difficulty disengaging is the key factor in high-threat situations (Crombez et al., 2015; Todd et al., 2015). In this model, attentional bias is an influential factor of pain. Attentional bias takes place because pain activates threat mechanisms response rather than because of attentional differences (Van Ryckeghem & Crombez, 2014). Interpretation is thought to be the mechanism responsible for the impact of threat on attention. Further, there is growing evidence that threat level and hypervigilance toward pain-related stimuli are positively related (Todd et al., 2015).

Differences between attentional processes measured by the previously mentioned models are illustrated in Table 3.1 (Chapter 3). This was a general overview of the models that link attention with CP. However, because not all experimental tasks measure the same variables and attentional processes, the literature is quite inconsistent regarding attention in CP. In the next section the main experimental tasks use for measuring attention in CP will be introduced.

1.5.2 Visual Selective Attentional Processing Tasks: A Chronological Perspective

1.5.2.1 The Stroop Task

Various types of experimental paradigms/tasks have been developed to measure selective attention and have been applied to CP populations. Early works in the selective attention field included the development of the Stroop task by John Stroop in 1935. The Stroop task assesses the person's ability to constrain his/her cognitive processing of one stimulus (or attribute) in order to allow room for another process to take place (Golden & Freshwater, 1978).

The Stroop phenomenon illustrates the difficulty in naming the ink colour of a coloured word if there is a conflict between the ink colour and the semantic meaning of the word. The popularity of the Stroop task is attributed to its ability to assess the fundamental operations of cognition, especially attention, in addition to the strength of this phenomenon (MacLeod, 1991). This effect is often used in pain research by measuring the time needed to detect the colour of a word that carries a pain-related semantic meaning, such as the word "sharp" with red ink colour (Snider, Asmundson, & Wiese, 2000). The Stroop task can be introduced in two ways; masked or unmasked. In the masked Stroop task, a stimulus is presented for a very short time (e.g. < 100 ms) and replaced by a reversed mask, which has the same colour as the first stimulus. This allows for assessing the preconscious recognition of the pain-related stimulus, which is known as "automatic processing". Nevertheless, in a traditional unmasked Stroop task, the presentation of the stimulus is unlimited (i.e. until the participant responds), which allows for assessing strategic processing (Cisler et al., 2009; Daza, Ortells, & Fox, 2002).

There are many variations on the original Stroop effect, such as spatial Stroop task (Wühr, 2007), reverse Stroop task (Durgin, 2000), numerical Stroop task (Henik & Tzelgov, 1982), and manual Stroop task. For instance, in the manual version of the Stroop task, the individual was instructed to press a key instead of naming the word, as this way is easier for recording (Andersson & Haldrup, 2003; Asmundson, Wright, & Hadjistavropoulos, 2005). An example of a computerised version of the Stroop task is demonstrated in Figure 1.3, in which the Stroop task follows the presentation of a prime stimulus (Kalanthroff, Henik, Derakshan, & Usher, 2016).

The Emotional Stroop task is a paradigm that focuses on the effect of emotional information (e.g. the pain-related information) interference with cognitive processes. Bias is indicated by comparing

a neutral condition to a condition with emotional information (Laméris, Verspeek, Eens, & Stevens, 2022). A recent systematic review of the emotional Stroop task confirmed its validity for assessing selective attention among the CP population (Amaro-Díaz, Montoro, Fischer-Jbali, & Galvez-Sánchez, 2022).

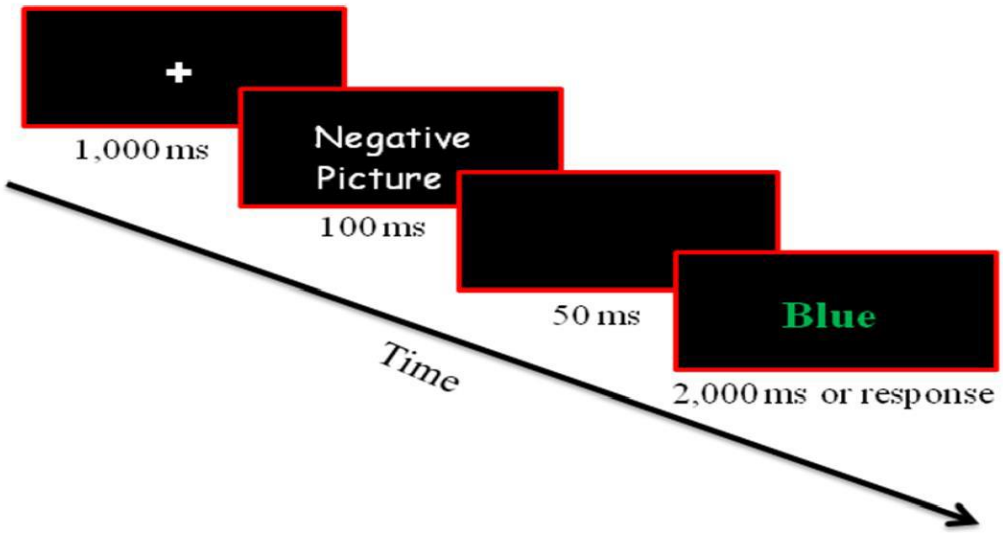

Figure 1.3: An example of a negative emotional distractor incongruent Stroop experimental trial adapted from Kalanthroff et al. In this task, participants are required to identify the colour of the incongruent word "Blue", which is written in green colour after being exposed to the cue "negative picture" (Kalanthroff et al., 2016).

1.5.2.2 The Dot-Probe Task

Another key selective attention task is the dot-probe task, which Macleod, Mathews and Tata developed in 1986 (MacLeod, Mathews, & Tata, 1986). Although this method was initially used to examine attentional biases to threatening auditory information, it was then adapted to the visual modality and became known as the visual probe task (Haggman, Sharpe, Nicholas, & Refshauge, 2010; Ali Khatibi, Dehghani, Sharpe, Asmundson, & Pouretemad, 2009; MacLeod, Mathews, & Tata, 1986). Figure 1.4 shows the dot-probe task, which measures the differences in reaction time between congruent trials, where the dot replaces the target/threatening stimulus and incongruent

trials, where the dot replaces the neutral stimulus (van Heck, 2019). Like the Stroop task, a dot-probe task can be used to investigate the automatic preconscious responses and strategic conscious responses (through measuring the reaction time) to a stimulus such as pain-related information. Unlike the Stroop task, the dot-probe presents two stimuli simultaneously to measure biases related to emotions or pain-related information. These stimuli could be words or pictorial (van Rooijen, Ploeger, & Kret, 2017).

Although widely used to measure attentional bias, both the dot-probe and Stroop tasks have poor test-retest reliability (Schmukle, 2005; Strauss, Allen, Jorgensen, & Cramer, 2005; Kappenman, Farrens, Luck, & Proudfit, 2014). Some studies have reported inconsistent findings, and replication and validity difficulties for the dot-probe task (Dear, Sharpe, Nicholas, & Refshauge, 2011; Thigpen, Gruss, Garcia, Herring, & Keil, 2018), in addition to fleeting reliability (Chapman, Devue, & Grimshaw, 2019). Further, the dot-probe task does not usually include a baseline measurement. This means that it can be challenging to measure the facilitation of attention or to separate it from disengagement without combining it with other procedures, such as having a neutral-neutral stimulus as a baseline measurement (see Fashler & Katz, 2014, but also Blicher et al., 2020 questioned the use of neutral-neutral trials), or adding an eye-tracking task (Cisler et al., 2009).

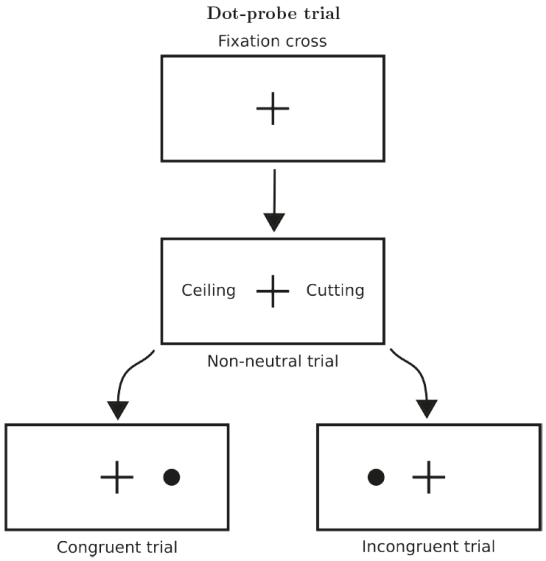

Figure 1.4: Dot probe task adopted from Van heck, 2019. Participants are required to determine the location of the dot (van Heck, 2019).

1.5.2.3 The Posner Cueing Task (Posner Paradigm)

Michael Posner suggested the concept of exogenous (involuntary) and endogenous (voluntary) orienting of attention (Posner, 1980). Exogenous attention is "stimulus-driven, automatically activated by the sudden onset of a stimulus in the visual field. Its effect on perception is fast and transient, peaking at approximately 100–120 ms and decaying again quickly", while endogenous attention is "conceptually driven, voluntarily allocated to a location in the visual field within approximately 300–500 ms and can be sustained for several seconds" (Barbot, Landy, & Carrasco, 2012). Posner also investigated the effect of spatial visual cues through using a task that was named after him. Posner cueing task (also known as spatial cueing task) assesses the individual's ability to perform an attentional shift (Posner, 1980). An example of computerised version of Posner cueing task is illustrated in Figure 1.5, in which the spatial cue is shown on screen, in endogenous (i.e. dependent internal cue) or exogenous (i.e. independent external cue) presentation form. This presentation is followed by the target appearance, either in the same place of the stimulus (also called cued or valid trial), or in the opposite place to the stimulus (also called uncued or invalid trial). The time between the onset of the cue and target presentation is referred to as the stimulus onset asynchrony (SOA) (Shevrin, 1996). At short SOAs facilitation process can occur, while at longer SOAs the inhibition of return (IOR) that may emerge later in time can observed, which means a delay in responding to a target that replace cue (congruent replacement) compared to uncued target (Hu, Samuel, & Chan, 2011).

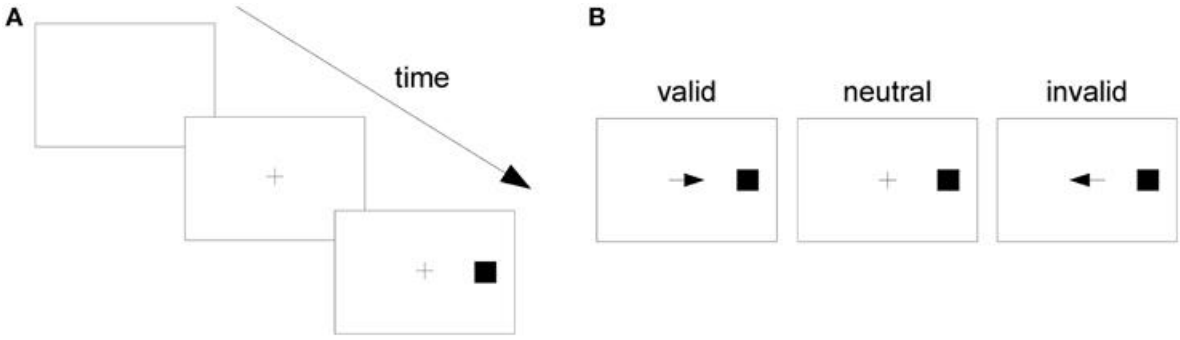

Figure 1.5: A computerised version of Posner cueing task adopted from Feher de Selva and Blado. In an endogenous task there would just be a central arrow and in an exogenous task just a peripheral cue.
A) A trial in the Posner cueing task. **(B)** From left to right, valid, neutral, and invalid cue, which are related to whether cue and target are at the same location or not (Feher da Silva & Baldo, 2015).

Various modified versions of Posner cueing task have been used to assess spatial attention across different disorders such as pain, insomnia and brain injury. These modifications were done through manipulating the cue type, cue presentation time, cue validity, and changing stimulus type (Kim et al., 2009; Van Damme, Crombez, & Eccleston, 2004; Woods, Marchetti, Biello, & Espie, 2009). In emotional Posner cueing task, an emotion-related cue is presented at one of the peripheral locations before a neutral target appears (Mulckhuyse, & Crombez, 2014). This modified version of Posner task can be used to assess the vigilance-avoidance pattern of attention and strategic characteristic of it (Ellenbogen, & Schwartzman, 2009). In a study by Imhoff and his colleagues, they found that using 50% cue validity (i.e. cued versus uncued) would reduce the cue validity effects in location tasks more than in identification tasks. This occurs because response biases influence cue validity effects in location tasks; the cue tells the participant which response to prepare in advance (left or right). At the same time, cue validity effects in identification tasks reflect changes in the time to process (and identify) the target due to attention to the cued location. Therefore, using identification tasks would help minimise the possibility of response biases (Imhoff, Lange, & Germar, 2019). This observation would help in choosing methodologies that add a differentiation layer component to the task designed.

1.5.2.4 The Visual Search Task

In the visual search task, the individual is asked to find a particular visual stimulus (i.e. target) among distractors (i.e. cues) (Wolfe, 2015). Similar to the Posner cueing task, the visual search task is used to detect facilitated attention and/or difficulty of disengagement from a stimulus (Cisler et al., 2009). In this task, the individual is instructed to detect a target stimulus that is hidden among a number of distracting stimuli. This can reveal facilitated attention if the detection of threatening stimulus (e.g. pain-related stimulus) is quicker than a neutral stimulus. The other possibility is revealing a difficulty in disengagement if time needed to detect neutral stimulus (target) embedded among threatening stimuli (distracters), compared to time needed to detect neutral stimulus among other neutral distracters (Öhman, Flykt, & Esteves, 2001; Rinck, Becker, Kellermann, & Roth, 2003; Cisler et al., 2009). Mostly, this task is combined with eye-tracking technology (explained below) to allow for the measurement of an intentional goal-oriented task. This searching task can be either a bottom-top or top-down process (Figure 1.6).

While attentional biases produced using visual searching task are usually assessed using eye-tracking device, it is important to notice that the contextual factors interaction play a crucial role in determining the search performance and thus in the outcomes of the biases assessed (Frischen, Eastwood, & Smilek, 2008). Having specific demands of the task determine the search performance according to the contextualised process of the individual`s expectations (e.g. location, identification). For instance, finding a yellow rectangle (i.e. target) among red (i.e. distractors) can have a similar speed for vice versa task unless the target was adopted in a strategical way to find the specified target (Yantis, & Egeth, 1999). Thus, visual searching does not assess pure biases per se even if an eye-tracking device is used to monitor gaze fixations. However, the visual search task clarifies the conflict of bottom-up and top-down processes that occur simultaneously while trying to find the "target" and helps in measuring the guidance in searching when reaction time is correlated with the size of the set to be searched (Wolfe, 2015).

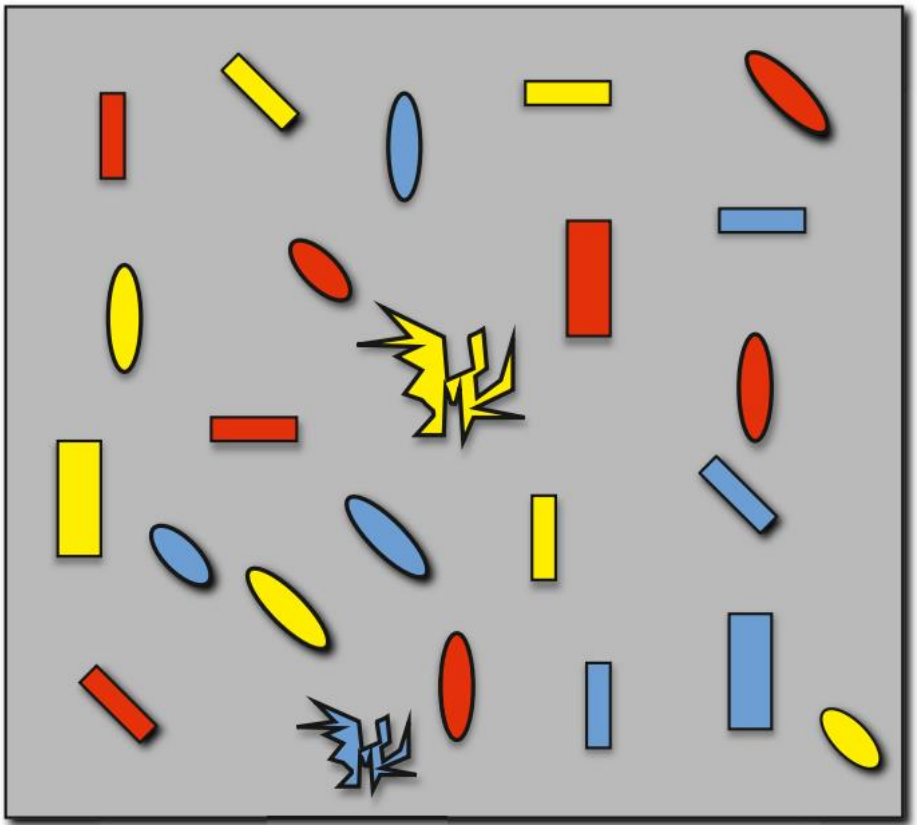

Figure 1.6: Visual search task in which the large yellow irregular shape (in the middle) grabs the attention using through the bottom-up processing. The top-down process can re-direct the attention toward the small blue oval shapes at the edge (Wolfe, 2015).

1.5.2.5 Eye-tracking technology

Eye-tracking technology has been used frequently in attention bias-CP related studies in recent years, which helped researchers to overcome some limitations related to intentional reaction time tasks that need the response of the participants (Jones et al., 2021). Eye-tracking can be used with reaction-time tasks or without. The idea of eye-tracking is to capture the eye-movements and gaze duration on different spatial locations in the scene which can potentially produce a large amount of (continuous) information related to attentional biases. One can measure bias towards or away from the location of stimuli (Yang, 2013).

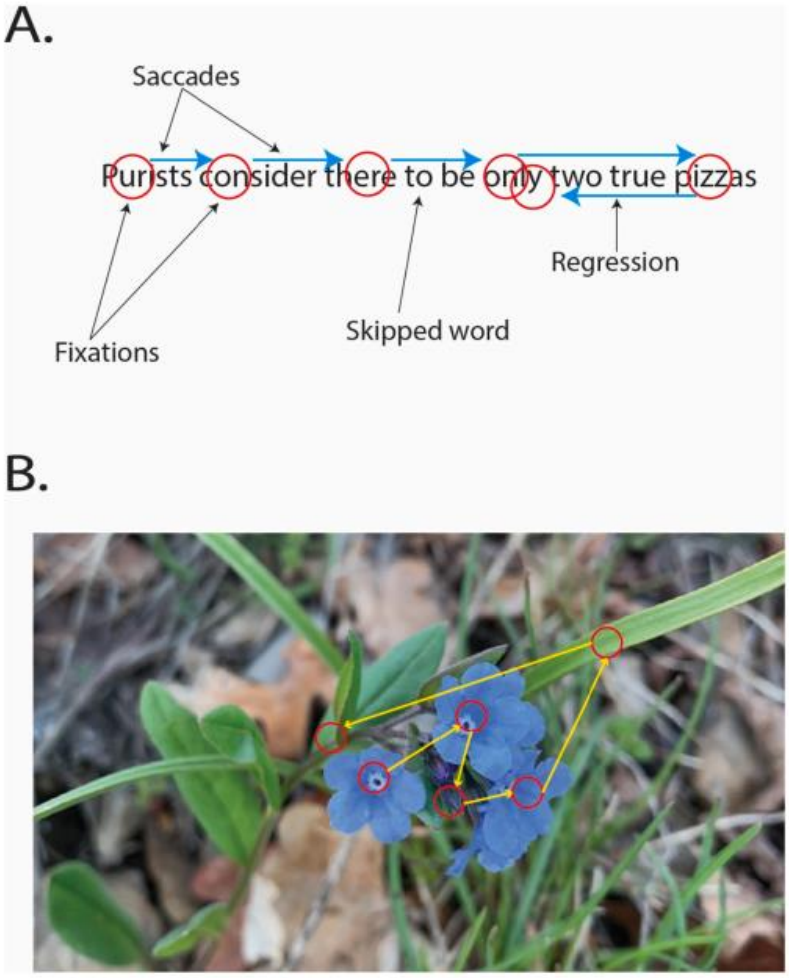

Figure 1.7: Basic eye-movements saccades (A) blue arrays, (B) yellow arrays that move between fixations (the red circles) (Carter, & Luke, 2020).

The eye tracking contains the saccades and fixations components (Figure 1.7). While the saccades are the quick movements of the eye when moving from one stimulus to another, fixations represent the period of time in which the eye gaze stopped at one particular stimulus (e.g. word in a paragraph, an object in a scene). These fixation times are essential for inputting and processing visual information (Carter, & Luke, 2020). However, despite its ability to capture processes associated with attention biases, eye-tracking is not inherently better than other reaction-based tasks. This is because an individual can attend to stimulus without moving eyes.

Both gaze behaviour (i.e. not measured by reaction time) and intentional goal-oriented tasks (i.e. intentional response tasks) have internal psychological motivations affected by cognitive schemas related to specific issues (e.g. CP, anxiety, depression) (Beck, & Clark, 1997). However, intentional goal-oriented tasks carry a different mechanism, in which, the intentional voluntary will of the participant plays a crucial role in interacting with the idiosyncratic meaning of the cues. This could partially explain the previously published studies that found that people with CP tend to have strategic attentional biases rather than automatic attentional biases (Snider et al., 2000). It is worth mentioning that if the previous studies used 75% valid peripheral cues in the tasks, then they are also encouraging strategic attention (Combez et al., 2013). Thus, using 50% will be the ideal way for assessing attentional biases from theoretical perspective as it does not predetermine and reinforce the biases that might occur. Comparing between these factors was overlooked in some previous literature. This can be observed clearly in eye-tracking free viewing "task" that does not include an intentional goal-oriented procedure in their methodology (Jones et al., 2021). However, goal driven motivating task requires an explicit action related to a stimulus, whether that task is assessed by an eye-tracking device or not (Addleman, Tao, Remington, & Jiang, 2018; Jiang, 2018). Additionally, studies that combine two or more tasks in the same experiments are still scarce. Using more than one task would be of value because it may generate a better understanding of which processes are involved in different tasks.

1.6 Thesis Organisation

Because this thesis contained different methodologies and studies, it was organised in journal format to improve the workflow. The journal format enables presenting the papers (i.e. published or submitted for publication) as one unit that integrates and completes the work parts. I am the first author in all manuscripts presented in this thesis.

This thesis was built based on hierarchical scientific evidence. To illustrate the hierarchical evidence in this thesis, a pyramid of evidence was built (Figure 1.8). This figure aims to clarify the level of evidence gathered and through which methodology this was achieved during the PhD work. At the bottom of the pyramid, one can see the general literature review and clinical observations that informed the research questions and main aims of this thesis (Chapter 1).

In the next level, I introduce the methodological decisions and considerations (Chapter 2) specific to this thesis and how they guided the approaches used in each study. This chapter outlines the methods-related decisions of each study and provides some details, including research aims, research questions, and hypotheses. Additionally, further information about recruitment and research setting are mentioned.

As shown in the pyramid, the systematic review and meta-analysis (Chapter 3) influenced and shaped the methodological construction of the subsequent research. This study was conducted before other studies but continued to be updated in parallel while conducting experimental and qualitative research. This parallel work helped a lot in keeping the research work updated and influenced by recent advances, yet with the preserved original methodological approach as pre-registered on the PROSPERO database, open science framework (OSF), and according to the available resources for conducting an online remotely supervised experiment due to Covid-19 restrictions, to guarantee the transparency of this work.

This project aimed to understand the current evidence available in the literature about selective attention in the CP population and explore the different types of tasks and stimuli used to assess CP subgroups. By understanding the processes and the interpreted models used, I learned how to conduct an empirical study using these reaction-based tasks. Thus, in the fourth level of the pyramid of evidence, which is reflected in Chapter 4, I made an experimental application of the knowledge gathered from previous levels.

The fifth level of the pyramid is the qualitative study, which is an important addition to the experiment. In Chapter 5, I describe the experiences, perceptions, and suggestions of participants about the study conducted and their daily attentional experiences.

The General Discussion (Chapter 6) discusses the evidence gathered from different studies, integrates them, and tries to reach evidence-based conclusions and implications for both experimental and clinical research.

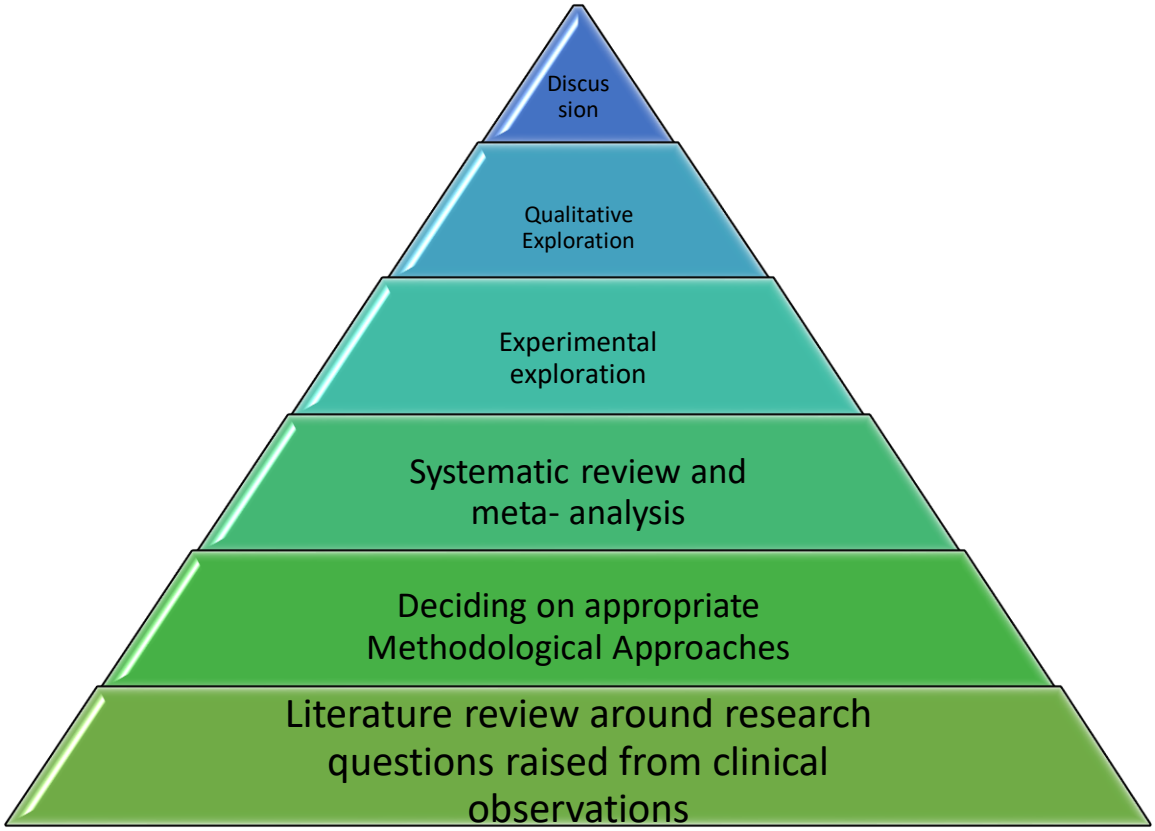

Figure 1.8: Pyramid of evidence included in this thesis

1.7 Conclusion

CP is a disabling condition which is common among distressed Arabic-speaking individuals. Cognitive processes such as selective attention are potentially key causal mechanisms implicated in the development and maintenance of CP. However, robust evidence for these associations is scarce. Research to examine these mechanisms using the lens of the bio-psychosocial model, in addition to other interpretative models of attentional performance in CP condition, has great potential to advance the scientific understanding of the development and maintenance of CP symptoms. Furthermore, understanding the attentional processes in Arabic-speaking individuals with CP is essential in acquiring a deeper insight into the complex context of CP and potential

ways to deal with it. Such understanding could produce recommendations for developing a culturally sensitive intervention targeting this cognitive mechanism. Additionally, adapting an experimental task to the Arabic culture that uses an easy access and cost-effective approach would be the first step toward further future research among this population. The next chapter will introduce the thesis aims and explain the methodology of the studies included in this thesis.

Chapter 2

General Methodological Decisions, Challenges, and Reflections

2.1 Introduction

This chapter will present the rationale for the methods chosen and outline the organising of the studies included in this thesis. This chapter will elaborate on the decisions related to research questions, the pre-registration process, ethical applications and amendments where applicable, recruitment, and power calculation. The details of the methods, procedures and their critical analysis are described in the methods sections of Chapters 3, 4, 5 and 6.

The research questions that led to this work came from the clinical background of the researcher, who worked with individuals with chronic pain (CP). There was a clinical observation that Arab individuals with CP tend to show less attentional abilities than individuals without CP. For instance, they faced difficulty paying attention and following instructions during the progressive muscle relaxation procedure group intervention compared to those without CP (Abudoush, & Breik, 2017). These observations helped form the research questions to explore this phenomenon further using scientific methods. Mixed methodology research was chosen to explore this phenomenon while considering and understanding the opinions of individuals with CP. However, the available evidence in this field was limited because of conflicting results in the literature. Further, the search of the literature did not reveal any relevant studies in the Arabic populations, and thus, the main idea came from synthesising the evidence available. To do so, the first study aimed to conduct a systematic review and meta-analysis using a robust methodology (i.e. including only studies with sufficient sample size). To synthesise the work in this field, the researcher explored the main theoretical models that include selective attention and how they map onto different attention processes in previous literature. This evidence synthesis helped confirm the methodological approach in experimental research, including using two attentional tasks in the same study.

In the second study, the main goal was to convert the knowledge gathered from conducting the systematic review and meta-analysis into practical experiments, including tasks that could assess attentional biases with a new population (i.e. Arabic population). The research included using open source technology (i.e. Psychopy) to measure the reaction time of the participant, which is the variable that can allow for comparison of the spatial attentional biases. The experimental study used between groups design for conducting the main data collection with identical experimental tasks procedures. The design benefited from previous studies, using two different tasks: the

Emotional Stroop task (Ben-Haim et al., 2016) and the Posner task (Van Ryckenghem et al., 2012). However, significant modifications were added to this novel design as it attempts to logically compare two tasks that both include presenting one stimulus at a time. Although the two tasks measure different processes (Cisler, & Koster, 2009, see also Chapter 3), this comparison was chosen to assess a range of processes in the Arabic population. Experimental tasks have not yet been used with this CP population.

Another vital addition to this design was using a colour degree identification task as a target. Choosing an identification task prevents response bias that could occur when the target relies solely on the target's spatial location. For instance, if participants are pressing left/right to indicate the location of the target that the location of the cue can bias them towards the correct response for the target rather than making them quicker to detect the target (Driver, & Spence, 1998; Aspell, Lenggenhager, & Blanke, 2011). Another significant difference related to the sample characteristics was using Arabic words as a stimulus with 1000 ms presentation time. Presentation times varied across studies (200 ms to 3000 ms), with 500 ms presentation time being the most common (see Chapter 3). Because there is some evidence that Arabic language comprehension is relatively longer than English, the presentation time was set to 1000 ms (Bentin, & Ibrahim, 1996; Farghaly, & Shaalan, 2009). Another novel aspect of this study design was using a hybrid data collection method (i.e. participants were monitored in both remote supervised and in-person supervised sessions) that allowed for a more flexible yet controlled experimental application. Together, these essential differences in the experimental design created a unique chance to explore attentional biases in the Arabic CP population for the first time through accessible methods.

Further, this exploration was of importance because; I) Few studies used two tasks comparison in the same study that is essential for assessing specific attentional processes (e.g. engagement, disengagement) and comparison of tasks performance in the Arabic population, II) the lack of previous studies in this population, III) Enabled exploring language differences when using Arabic words as a stimulus, IV) It opened a new stream of research that is more comprehensive and cross-cultural. V) It developed a standard list of stimuli for future research. VI) It Explored the perceptions about the attention–CP experiences within the context of the experimental research and daily experiences.

To ensure a high-quality study, I used the patient and public involvement and engagement (PPIE) principles of the Centre for Engagement and Dissemination (previously known as INVOLVE) by engaging and consulting an individual with CP along the process of designing, building, piloting, and applying the experiment (Lamont, & Maxwell, 2023). This was important for getting insightful feedback about some needed modifications (e.g. ensuring clear instructions for the experimental part, the number of breaks during the data collection session, suitability of semi-structured interview topic guide questions). This study was being carried out during the Covid-19 period, which prevented me from having a larger PPIE group. However, the experience of having one individual with CP was of great benefit. The overview of the general aims of the thesis will be outlined in section 2.2, the impact of COVID-19 on the methodological approaches and decisions in section 2.3, and further details for each study will be covered in sections 2.4, and 2.5 of this Chapter.

2.2 Overview of The General Aims of The Thesis

This thesis explores the selective attention experiences among Arabic-speaking individuals with CP. Cognitive processes such as attention are potentially critical mechanisms implicated in developing and maintaining CP. Understanding these attentional mechanisms is essential. However, robust evidence for these associations is scarce.

Understanding the mechanisms behind CP could inform the development of interventions to improve patients' quality of life and their families and healthcare providers who may find themselves caring for persons with this chronic illness. The PhD thesis is presented in an alternative (journal article) format.

The overall aims of the thesis are to i) Evaluate the current evidence on selective attention tasks used in identifying CP (i.e. by conducting a systematic review and meta-analysis), ii) Explore the cognitive attentional processes associated with CP, and build a core list of culturally adapted words that could be used in future experimental studies, iii) Understand the relationship between attentional performance and the level of psychological resilience, iv) Assess the impact of experimental tasks on participants' perceived stress and v) Qualitatively explore participants' experiences in research involving attentional tasks and their views on coping strategies with CP.

2.3 Impact of COVID-19 on The Methodological Approaches

The Covid-19 pandemic restricted face- to face interactions, which limited researchers' ability to conduct direct experiments. Not being able to conduct an in-person experiment shifted my efforts to conduct a remotely supervised experiment with the potential of returning to face-to-face experiments when possible (i.e. an ethics amendment was made accordingly). The original plan included a mix of eye-tracking and reaction-based technology usage. The ethics approval took extra four months. Further, using technologies such as eye-tracking with reaction-time tasks was not possible from a practical point of view because this technology needs a device to be installed and calibrated for each participant. The current remote eye-tracking options (e.g., a web camera or phone camera) are not accurate and give low-validity data. To align with the methodological limitations encountered, I based the analysis of the systematic review (Chapter 3) on the reaction time-based studies instead of gaze fixation to have a homogeneous sample to inform the experimental study.

2.4 Study One: Systematic Review and Meta-Analysis

2.4.1 Review questions:

The primary aim of the systematic review and meta-analysis was to evaluate the effectiveness of various common tasks and stimuli to identify potential differences in selective attention processes among CP populations. This review addressed the following research questions:

A) What experimental tasks measure selective attention processes in patients with CP?

B) Do commonly used tasks measure differences in selective attention processes across subgroups of patients with CP (e.g. fibromyalgia (FM), Chronic low back pain (CLBP), complex regional pain syndrome (CRPS), Headache…etc.)?

C) Do commonly used tasks identify differences in selective attention processes in CP patients when using different stimuli?

2.4.2 General comments on the methodological approach

One of the main steps in preparing the systematic review was the pre-registration of the protocol (CRD42019159121; Abudoush et al., 2019). This pre-registration process ensured the high quality

of the work done. The benefits of pre-registration include avoiding HarKing (i.e. hypothesising after having results) by separating the hypothesis generation from the hypothesis testing phase (Kerr, 1998). This preplanning allows for transparent data analysis and minimises the post hoc analysis unless justified. It also helps avoid duplication of the same work from different researchers and saves efforts. Furthermore, pre-registration helps avoid bias in the published results and enhances data interpretation through clear preplanning when conducting a systematic review in experimental psychology. The review was updated on different points between November 2019 and August 2022. These updates were important to monitor the recent advances in the field and see whether any related review was published. All previous publications were specific to one task or one subtype of CP.

Another important point was the collaboration with authors from different universities worldwide. In addition to collaborating with some researchers at the University of Manchester, I collaborated with other researchers from Modern languages at the University in Pakistan and Maastricht University in the Netherlands to bring expert opinions in the CP-attention field and improve the rigour of the review.

The most novel feature of this systematic review is that it explores all reaction time-based attention tasks that were used previously in the CP-attention field. This exploration aimed to understand the pros and cons of their use in comparison with gaze behaviour studies. Although gaze behaviour (see Chapter 1) provides some information about attentional processes, mixing reaction time studies with gaze behaviour studies can affect the overall interpretation of the results. One could argue that the reflected gaze behaviour is the by-product of the cognitive schema, while on the other hand, attention cannot be judged only based on non-goal-oriented tasks. Further, since a recent meta-analysis explored specifically the eye-tracking studies (Jones et al., 2021), replicating such a review was of little value. Instead, I wanted to understand the tasks that demand intentional participant-recorded responses as a standard way of comparison. Additionally, it was not possible to add eye-tracking technology besides the reaction time tasks because of the nature of the hybrid experimental study (Chapter 4) at the beginning of data collection. The difficulties in applying eye-tracking technology for hybrid or remote experiments are due to the calibration and device installation needed for each participant.

When data were missing from the papers, I contacted the authors to obtain this data. For most studies, authors did not reply or could not share the data for different reasons (e.g. lost access to data, not working in the field anymore). Thus, it is crucial to use the open science framework (OSF) for pre-registering experiments and other reproducibility tools that enhance tracking studies data. I collaborated with Dr Dimitri Van Ryckghem from Maastricht University to have an additional expert opinion on the CP-attention field. Dr Van Ryckghem provided part of the data for the meta-analysis gathered previously.

2.4.3 Building extraction descriptive templates

Depending on the variables targeted in this review, the template of the descriptive characteristics and a template of target variables were built. These templates were piloted to ensure they are accurately extracting the data. This was in collaboration with different authors of the review (see Chapter 3).

Agreement and discussions between authors were important in deciding on the tools, templates, and studies included. It is worth noting that experimental quality assessment tools are scarce, this is important considering experimental research design for assessing CP individuals differs from randomised control trials (RCTs). It was important to review earlier studies to decide which tool could be used. An adapted quality assessment tool developed by Crombez and colleagues (2013) and cited by Todd and colleagues (2018) was further modified and used in my study for easier measurement and interpretation of the results (Appendix 3.B).

2.5 Mixed Methods Project

2.5.1 Introduction

Because of the context of conducting this research during and post the pandemic, there was a need to create an experimental design that can be delivered remotely while ensuring the experiment setting is appropriate and the participants are engaged and follow the instructions. Thus, I used online technology to conduct the experimental study, namely Pavlovia.org (Peirce, n.d), and Zoom software (Zoom Video Communications Inc., 2022). The Zoom software was used to deliver the experiment link after ensuring that the experiment setting was appropriate. It enabled me to monitor the participants while answering and responding to the experiment parts, such as monitoring the experiment, including eye fixation on the screen while answering the experimental

tasks. Zoom was also used for conducting and recording the qualitative interviews. Audio-only files were kept in a secure server after the interview for coding.

The PsychoPy software is one of the prominent open-access psychophysics software used for various experimental studies with and without hardware devices (e.g. eye-tracking devices). I will be able to share the task design, stimuli evaluated list, and related code via OSF for other researchers to use in future studies. Open-access tools encourage the re-reducibility of the research methodology through repositories saved for each project (Peirce, 2007). The experiment (Chapter 4) was built by the researcher using PsychoPy software (Peirce et al., 2019, MacAskill, Hirst, & Peirce, 2022) and then pushed to the Pavlovia website. The PsychoPy software was used to take participant consent, collect demographic data, apply the experimental tasks and answer the questionnaires. These steps were piloted, and suggestions were taken from a member of PPIE.

For the main data collection, data were initially collected through supervised remote data collection sessions, then –with the ethical amendment- through hybrid in-person and supervised remote data collection sessions. This hybrid flexible methodological design allowed for an easier, cheaper, safer, quicker and more accessible experiment. Data collected were stored on a secure server with anonymised participant list identification that can only be accessed by the main researcher. Other procedures related to data handling and experimental procedures are explained in Chapter 4.

2.5.2 Study two: Selective attention, resilience, and perceived stress in the Arabic Speaking Population with Chronic Pain: An experimental study

2.5.2.1 Experimental study aims

Aim 1: Examine whether individuals with CP show different patterns of attentional processing of pain-related information compared to individuals without CP.

Aim 2: Assess whether psychological resilience is affected in individuals with CP and whether this is associated with attentional processing of pain-related words.

Aim 3: Examine whether the self-reported stress level of participants increases following participation in the attentional tasks that involve pain-related information and whether there are any experimental group differences (CP participants versus controls). I am interested in how the

groups differ after the task because this would allow assessing the suitability of using reaction time tasks in the Arabic population.

2.5.2.2 Reaction time techniques

Reaction time is one of the most widely used measurements of attentional biases (see Chapter 1). Different experimental methodologies have been used, including visual, somatic, auditory and many others, although some recent studies used gaze fixation only. Others used reaction time and eye-tracking technologies simultaneously to monitor participants' reactions. Thus, it was important to build the experiment and design it in a supervised session for tracking the eye location directly by the researcher during the data collection session and having an identification task to avoid response biases. Among the four main reaction time tasks (i.e. Ponser spatial cueing task, Emotional Stroop task, Dot-probe task, and Visual searching task) that were used in previous literature to assess the visual selective attention biases, the current research used Posner cueing task and Emotional Stroop task. Both tasks used one cue at a time, with differences in the dynamic spatial attention between them. They measure relatively different processes that enable researchers to compare attentional tendencies in new populations (Cisler et al., 2009). Further, the Posner cueing task has several advantages over the dot-probe task due to probability issues with the latter (Schmukle, 2005). Furthermore, using the Emotional Stroop task would be more practical due to the relatively shorter time needed than the dot-probe task, which is important with vulnerable populations such as individuals with CP. Together, these reasons contributed to the methodological decision of recruiting these particular tasks.

Attentional bias modification (ABM) is one of the recent technologies investigated for the potential of helping attention re-allocation of individuals with CP. ABM uses reaction time-based tasks with a different design (i.e. cue only replaces neutral stimulus instead of random replacement of pain and neutral information). However, results are still preliminary in this field and thus need further research (Carleton et al., 2020).

2.5.2.3 Power calculation

To ascertain the sample size of the study, the literature was explored, including studies in the systematic review. A number of high-quality studies were reviewed to build the equation for the required sample size (Chapter 3). I found that the average sample size for each group would be 50

participants for each group (i.e. 100 participants in total). Then the number of main variables was added to the equation. The general sample size equation for the final multiple regression model was 50+8K=50+8*3 with a 25% estimated dropout ratio to avoid losing power.

2.5.2.4 Experiment building, piloting, and pre-registration

Ethical approvals from the University of Manchester Research ethics committee (UREC) and the Jordanian Ministry of Health (MoH) were obtained. I built the experiment using Psychopy software (Pierce et al., 2019). This took 10 months to complete, mainly since coding experiments in the Arabic language is still not fully supported technically. To address this technical problem, a picture of the words was created, typical of the word presentation. Further, in addition to using the builder version, coding was essential to allow for looping and allocating breaks during experimental tasks.

Since the Arabic language "Fusha" is the formal language used by Arabs, its worth mentioning that, according to some views, this language has a different processing time. It seems that Arabic words need more processing time depending on their comprehension (Bentin, & Ibrahim, 1996). This could be because Arabic words are usually written without diacritics that could clarify the exact meaning directly. While it is interesting to search the response to words with and without diacritics, I focused on the main form of Arabic words (without diacritics) for practical reasons and because my initial literature search showed that Arabic processing is slower than English. To its uniqueness, Arabic language processing is thought to take longer time than English (This is also reflected in the methodological approach as explained in Chapter 4).

Once the experiment building was finished, piloting was the next step for modifying and reviewing its appropriateness. While most studies used 500 ms (stimulus presenting time varied between studies), I used 1000 ms for the stimulus time in piloting before the main experiment. To assess the basic effect of cued and uncued trials created, a pilot study was conducted with ten non-Arabic-speaking healthy volunteers. Then the means of the reaction time (RT) responses were collected for the neutral, affect and sensory words. Piloting results showed significant differences between cued and uncued trials (M = 64 milliseconds), which proved the basis for building the experiment. Then, testing with one Arabic speaking individual with CP was done to ensure the experiment's flow, instructions, and process were appropriate. The PPIE member suggested using a single link

for the whole procedure, allocating break points and helped in improving the clarity of the instructions, These, minor suggestions were made and applied to the experimental design.

The pre-registration process on the OSF was essential for planning the experimental methods and the data analysis plan. The pre-registration was done at the beginning of data collection and before any human observation of the data (1st of November 2021). A minor modification was added for the pre-retractions regarding the slight over-recruitment, the amendment of in-person sessions, and adding the mixed effect analysis (full details in Chapter 4).

2.5.2.5 Additional details on recruitment and hybrid settings

When a potential participant contacted the researcher, a quick check for the inclusion /exclusion criteria was made, and the participant information sheet was sent to the potential participant with the opportunity to answer questions related to participation in the study. Once the participant agreed, the appointment slot was reserved. On the day of the appointment via Zoom, I introduced myself and ensured that the participant was in a private, quiet place and ready to start the experiment. All distractions, including noise and light levels, were controlled to a minimum during the experimental tasks. Later, when the data collection occurred face-to-face (i.e. for part of the UK sample), participants were invited to a specific pre-reserved room at the University of Manchester to conduct the data collection session. To ensure safety, Covid-19 guidelines were followed carefully, and all other instructions were exactly the same as the remote session. No reports of an adverse effect from the experiment were made except occasional distress, as expected in CP cases. The distress reported was minor in all cases, and later follow-up with those participants revealed that it was only temporary. Because the whole project was conducted online, I designed all experimental work and questionnaires in one place. Hence, participants needed to use only one link to access the experiment on the Pavlovia website. Further, I provided support and clarification when needed.

2.5.3 Study three: Exploration of the attentional experiences of Arabic individuals with CP: A qualitative research

2.5.3.1 Introduction to study aims

This study aimed to assess the attentional experiences of individuals with CP. To the best of my knowledge, this is the first study that used qualitative interviews related to participating in

experimental attention tasks in the CP-attention field. It is also the first experimental task in the Arabic population and one of a few studies that used two experimental tasks to compare processes in this field. The main objectives included understanding participants' perceptions of the experimental tasks and their daily attentional experiences. The qualitative semi-structured interviews were conducted directly after the experiment. Participants were given a break between the experiment and the interview. The researcher ensured that participants felt comfortable sharing their thoughts and feelings about daily attentional experiences and experimental tasks. Participants were offered to rest during the interview if needed and reassured that they did not disclose any information they did not want to share.

2.5.3.2 The topic guide

A topic guide was developed and reviewed first within the supervisory team, and then the PPIE member gave feedback on the questions. The topic guide was a living document in this research and was updated and modified as the researcher progressed in conducting interviews. The topic guide contained four main parts:

1) Identify and elicit details on how the daily attentional experiences are affected by CP.
2) Identify and elicit details on the experience of exposing to pain-related information.
3) Identify and elicit details on participants' perspectives about coping with CP.
4) Explore opinions about possible interventions that could be of benefit from the participant's perspective.

2.5.3.3 Methodological approach

Because of this project's mixed methodology nature, there was an optional choice for participants of the CP group to participate in the interviews. For practical reasons, the consent was part of the written experiment tasks instead of separate verbal consent. Because it was impossible to transcribe and code the interviews during the time period the data was being collected, the researchers decided to take and analyse all interviews while monitoring when the saturation level will be reached. Reaching saturation would mean that no themes are emerging from the analysis of the transcripts. There is a debate in the literature about the situation concept and whether it should be always followed (Braun, & Clarke, 2021). The recommendation is that it depends on the context of the study conducted.

The interviews were conducted in a private environment where the participants could express their feelings and reflect on the questions being asked. The interviews were recorded using the Zoom application, using the audio option only, anonymised and saved on the UoM server. The Transkriptor web tool (Transkriptor, 2022) was used to transcribe the Arabic interviews as this tool is compatible with this language. Once transcriptions were finished and there was no further need for the interviews, these were deleted. An inductive framework thematic analysis approach (i.e. NatCen approach) was used (Ritchie, Lewis, Nicholls, & Ormston, 2013). For the coding phase, the first seven interviews were translated into English and coded by two researchers in word software and then moved to an excel spreadsheet and colour coded according to the category they follow. Researchers discussed and agreed on framework codes, and then coding was completed. A template was made for translating the verbatims from Arabic to English and reviewing them by two authors (i.e. AA and KA). This approach enhanced the conducting of the analysis and eased the extraction of the themes and sub-themes. Framework analysis is a flexible systematic thematic analysis that allows the exploration of differences within and between participants (Srivastava, & Thomson, 2009). The researcher used this approach because it allows for mapping large data gathered by generating a structured summary of the data (Gale, Heath, Cameron, Rashid, & Redwood, 2013).

CHAPTER 3

This is a modified version of a paper accepted for publication in the PAIN journal

What Can We Learn About Selective Attention Processes in Individuals with Chronic Pain Using Reaction Time Tasks? A Systematic Review and Meta-Analysis

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3.1 Abstract

Information-processing biases such as attentional, interpretation, and memory biases are thought to play a role in exacerbating and maintaining chronic pain (CP). Evidence suggests that individuals with CP show attentional bias toward pain-related information. However, the selective attentional (SA) processes that underpin this bias are not always well outlined in the literature. To improve current understanding, a systematic review was performed using a descriptive synthesis of reaction time-based studies. A random-effects meta-analysis was added to explore whether the results of previous meta-analyses would be confirmed using studies with larger sample size. For this review, 2008 studies were screened from four databases, of which 34 (participant n= 3154) were included in the review and a subset of 15 (participant n=1339) were included in the meta-analysis. Review results were summarised by producing a descriptive synthesis for all studies. Meta-analysis results indicated a mild significant attentional bias toward sensory pain-related information (k = 15, g = 0.28, 95% CI [0.16, 0.39], I^2=43.2%, p = .038), and preliminary evidence of significant moderate bias towards affective pain-related information (k = 3, g = 0.48, 95% CI [0.23, 0.72], I^2 = 7.1%, p = .341) for CP groups compared to control groups. We explored the main tasks, stimuli, and CP subtypes used to address attentional biases and related processes. However, variation across studies did not allow for a decisive conclusion about the role of stimulus, task type, or related attentional processes. Additionally, a table of CP attention-related models was produced and tested for reliability. Finally, other results and recommendations are discussed.

3.2 Background

Chronic pain (CP) is characterised by distress and unpleasant sensations that last beyond three months (Loeser, & Treede, 2008). CP has a high prevalence worldwide, with around 20% of the world population suffering from CP at some point in their life (Mills, Nicolson, & Smith, 2019). Because of its nature, CP can lead to secondary complications, including attentional dysfunction (Aronoff, 1991). Difficulties in emotion processing add to the development and maintenance of CP (Davis, Zautra, & Smith, 2004; Kökönyei, Urbán, Reinhardt, Józan, & Demetrovics, 2014). Theories concentrating on attentional processing have suggested that dysfunctional attention toward emotional information (i.e. attentional biases towards negative emotions) might be one potential developmental and maintenance factor of CP (Giel et al., 2018). Cognitive biases such as attention to interpretation and recall of pain can lead to maladaptive strategies and the exacerbation of pain (Rusu, Gajsar, Schlüter, & Bremer, 2019).

Different developments and technologies have been used in the Selective attention (SA)-pain field since the first related experiment by Pearce and Morley (Pearce, & Morley, 1989). The use of the attentional bias concept became more common throughout the literature on SA in CP individuals after being adopted from earlier literature about biases in the context of anxiety (Lundh, & Eysenck, 1994; Beck, & Clark, 1997). Attentional bias towards pain-related information is thought to be crucial in developing and maintaining the fear of pain in individuals with CP (Vlaeyen, & Linton, 2000; Todd et al., 2015). Different mechanisms are thought to be involved in CP symptoms maintenance (Eccleston, Crombez, Aldrich, & Stannard, 1997; Vlaeyen, Morley, & Crombez, 2016). The key processes and characteristics that may be involved (illustrated in Table 3.1) include; *hypervigilance*, in which the individual has a high level of alertness toward environmental triggers. Although still under-specified as a process (and is sometimes used as an alternative general term for SA), hypervigilance contains the component of the "predisposition" to search for information actively and, thus, differs from the general concept of SA (Asmundson, Wright, & Hadjistavropoulos, 2005; Crombez, Van Damme, & Eccleston, 2005; Richards, Benson, Donnelly, & Hadwin, 2014). The other somewhat similar process is *facilitated attention*, which means a faster orienting of attention towards a stimulus compared to another when it appears and being grabbed by it, especially for people of more "attention sensitive" nature (Cisler, Bacon, & Williams, 2009). The *difficulty of disengagement* means being slower to disengage from a

threatening stimulus and attend towards another stimulus. Other studies differentiate this process from *avoidance*, which is faster disengagement from threatening information; Brown, Danquah, Miles, Holmes, & Poliakoff, 2010; Todd et al., 2015). An important distinction is that attentional deployment can be s*trategic* that takes longer, like deliberately paying attention to where you expect someone to appear or *automatic* - the quick and unintentional processing of information (Snider, Asmundson, & Wiese, 2000). However, there is still some argument about the particular mechanisms and the role of earlier engagement or differences in disengagement in developing attentional bias and whether it is strategic or automatic (Schoth, Nunes, & Liossi, 2012; Mahmoodi-Aghdam, Dehghani, Ahmadi, Banaraki, & Khatibi, 2017). For example, if people with CP aim to control their pain, then pain-related cues become goal-relevant for them. Therefore, they are deliberately (i.e. strategically) allocating more resources to them (Van Damme, Legrain, Vogt, & Crombez, 2010).

All of these processes have been introduced in the literature based upon evolution in theoretical models in the field of pain. The main interpretative models were used to explore attentional processes in individuals with CP (Table 3.1). They try to describe what happens when individuals with CP are exposed to pain-related stimuli. The aim of producing a table with attention-CP related models is not to argue that the role of attention is distinctly different in the different models, but rather closely examine the dominant models and depicts how attention is characterised in them. This is especially important since the tasks chosen for testing attentional biases are an essential criterion which determine the processes involved. For instance, hypervigilance or facilitated attention could be followed by avoidance (faster disengagement) or slower disengagement (Mogg, Bradley, Miles, & Dixon, 2004; Todd et al., 2015). Specifically, these models propose theoretical accounts of how the relationship between CP and attention might work, in which, attention might lead to greater awareness or processing of pain-related stimuli. The interpretative models (Table 3.1) agree that biases in attention to painful or pain-related stimuli in people with CP are key in the development and maintenance of CP or related disability. Yet, although all these models point at the role of attention, only a few specify the attentional processes they predict to be involved in biased attention for pain information. Furthermore, there are overlapping processes between some models, which differ from the interrelated and interacting varied cognitive biases (Van Ryckeghem, Noel, Sharpe, Pincus, & Van Damme, 2019). Because the exact processes are often left unspecified, in current study we aimed to indicate which processes are suggested to play a role

and how they differ according to different models. It is worth emphasising that the attention part often forms only part of these models. Additionally, it is worth noting that different attentional processes might be relevant at different time points in the development and maintenance of CP (Todd et al., 2015). To help understand, we coded the attentional processes specified by the different interpretative models (Table 3.1).

Table 3.1: Attentional processes measured by attentional bias tasks in main chronic pain interpretative models and hypotheses (Colour coded).

Attention Process / **Interpretative Model**	Content	Hyper-vigilance (General predisposition)	Facilitated attention	Avoidance (Faster disengage)	Difficulty of disengagement	Automatic (As a general characteristic)	Strategic (As a general characteristic)
Schema enmeshment model (Pincus & Morley, 2001)	Stimuli related to pain, self and illness (affective)		✓			✓	
The misdirected problem-solving model (Eccleston & Crombez, 2007)	Pain and pain-related cues	✓					✓
The cognitive-affective model of the interruptive function of pain (Eccleston & Crombez, 1999)	Pain and pain-related stimuli	✓	✓		✓	✓	
The motivational account of attention to pain model (Van Damme et al., 2010)	Pain and pain-related stimuli	✓				✓ (when pain is goal-irrelevant)	✓ (when pain is goal-relevant)

The threat interpretation model (Todd et al., 2015)	Pain-related stimuli interpreted as threatening	✓	✓	✓ L.T and H. T	✓ M.T		
Vigilance-avoidance hypothesis (Mogg et al., 2004)	Threat cues	✓	✓	✓			
Fear avoidance model in chronic musculoskeletal pain (Vlaeyen & Linton, 2000)	Bodily sensations	✓					

Following these theories, research in the domain has grown exponentially. Yet, research investigating attentional biases toward pain-related information in individuals with CP shows mainly either small to moderate, focusing on specific tasks, or having a mixed findings (Schoth et al., 2012; Crombez, Van Ryckeghem, Eccleston, & Van Damme, 2013; Todd, Van Ryckeghem, Sharpe, & Crombez, 2018; Jones et al., 2021; Amaro-Díaz, Montoro, Fischer-Jbali, & Galvez-Sánchez, 2022). Although most of these meta-analyses outlined the nature of some attentional processes, they did not particularly emphasise the different processes and how related models interpret them. Further, there is no gold standard task to assess attentional processing in this population or to produce reliable individual differences (Hedge, Powell, & Sumner, 2018). Available meta-analyses have shown the existence of attention bias in CP individuals while processing pain-related information (Schoth et al., 2012; Crombez et al., 2013). However, one potential source of heterogeneity relates to the small sample size in some studies included in these meta-analyses. Thus, conducting a meta-analysis that includes studies with relatively large sample sizes would give a reliable and clearer picture of the processes involved. Another potential source of heterogeneity relates to the paradigm used to research attention bias. The most used task to assess attentional bias in CP populations is the dot-probe task (Todd et al., 2018). Dot-probe task assesses attentional biases by presenting a pain-related cue and a neutral cue simultaneously in two different locations followed by a target (i.e. dot-probe) that appears in the place of either the pain-related cue (congruent), or the neutral cue (incongruent; Baum, Schneider, Keogh, &

Lautenbacher, 2013). The usual measure of attentional bias includes a combination of facilitated attending towards (faster responses to the probe that replaces the pain-related cue) and difficulty in disengagement (higher response latency to the probe when it replaces the neutral stimuli) from pain-related information (Cisler et al., 2009). In the emotional Stroop task, both automatic and strategic SA characteristic processes are assessed, in which, attention is drawn to the meaning of the word (e.g. sensory, affective, neutral) and the participant must strategically attempt to ignore the meaning, which slows down the reaction time (Snider et al., 2000). These processes are assessed through measuring the differences in reaction time needed to name colours of words with neutral or pain-related semantics printed in different colours (Cisler et al., 2009). Some researchers moved to use pictorial stimuli rather than words to access related affective information (Lavy, & Van den Hout, 1993), and to overcome cross-language barriers to help pooling data from different studies on the long term. However, the cross-cultural barriers cannot be simply removed by the mere use of images, because differences could be attributed to the differences in the cognitive cultural schemas of images meaning (Bove, 1996; Kimmel, 2005). Also, different meta-analyses found that using words produce large effect size comparing to pictorial stimuli (Crombez et al., 2013; Mogoaşe, David, & Koster, 2014). For the dot-probe task, some studies have reported inconsistent findings, and replication and validity difficulties (Dear, Sharpe, Nicholas, & Refshauge, 2011[b]; Thigpen, Gruss, Garcia, Herring, & Keil, 2018). Further, the dot-probe task does not usually include a baseline measurement. This means that it can be challenging to measure the facilitation of attention or to separate it from disengagement without combining it with other procedures, such as having a neutral-neutral stimulus as a baseline measurement (see Fashler & Katz, but also Blicher and colleagues who questioned the use of neutral-neutral trials; Fashler, & Katz, 2014; Blicher et al., 2020), or adding an eye-tracking task (Cisler et al., 2009). The study by Fashler and Katz is an example of including the measurement of a neutral-neutral condition (Fashler, & Katz, 2014). Sometimes, manipulation of the stimulus onset asynchrony (SOA) is used to look at the automatic and strategic elements of attention (den Heyer, K., Briand, K., & Smith, 1985). Different tasks have advantages and disadvantages. For instance, the dot-probe task measures the competition between stimuli, however, as discussed above this can lead to difficulties with interpretations of the results. Meanwhile, the Posner cueing task does not measure competition, but can be used to look at the time-course of attention and can be set up to examine strategic or automatic attention (Cisler et al., 2009). It uses covert orienting of attention, in which

an individual is paying attention without moving eyes. Reaction times are measured toward different cues, which are presented singly (Hoofs, Grahek, Boehler, & Krebs, 2022). In the Posner cueing task, pain-related cues are either valid (i.e. congruent presentation of the pain-related cue and the target) or invalid (i.e. incongruent presentation of the pain-related cue and the target), in which the cue is presented first, followed by the target. This allows the separation between the processing of different cue types (Schmukle, 2005; Cisler et al., 2009; Hayward, & Ristic, 2013). However, it is worth mentioning that because Stroop and Posner cueing tasks present only one cue in each trial, the measuring can include response bias in addition to the attentional bias. This limitation can be resolved by including a discrimination task, in which, the task would include distinguishing the target type (e.g. colour degree) rather than determining only its spatial location. Further, this limitation was one of the factors that led to the development of the dot-probe task (MacLeod, Mathews, & Tata, 1985). A brief description of the main reaction time tasks can be found in Table 3.2.

Recent reviews in the CP field have focused on only one specific task, such as the dot-probe task (Todd et al., 2018), eye-tracking (Jones et al., 2021), or emotional Stroop task (Amaro-Díaz, 2022), or one specific CP subtype (O'Hara, Sharpe, & Todd, 2022). Moreover, for reviews that did explore different tasks, the lack of consistency between experimental results is still one of the most common barriers toward understanding the SA processes in this population (Crombez et al., 2013). However, since the publication of this review, many novel studies have been published in this domain. Therefore, understanding the similarities and differences between SA tasks and their interpretative theoretical models is crucial (Mangun, & Hillyard, 1995; Cisler et al., 2009). Another major pitfall noticed in previous studies was the heterogeneity of CP samples. The nature of the SA processes affected could differ between subtypes of CP (Grisart, & Plaghki, 1999; Darnall, 2019).

Table 3.2: A brief description of the main reaction time tasks used in assessing attentional biases in individuals with chronic pain.

Task	Brief Description
Modified Posner (spatial) cueing task	An emotion-related cue is presented at one of two possible locations in the visual periphery before a neutral target appears. The participant is then asked to identify the target type or spatial location as quickly as possible. The cue may be predictive (indicate the likely location of the upcoming stimulus) or non-predictive (location unrelated to the target location).
Emotional Stroop task	An emotion-related coloured word (stimulus) is presented against a grey background. The participant is asked to identify the colour of the word regardless of the word's semantic meaning as quickly as possible, and reaction time is recorded.
The dot-probe task	Two cues (one neutral and one emotion-related) are presented at opposite locations in the visual periphery and then a target appears. The participant is asked to identify the target type as quickly as possible. Differences in reaction time between congruent trials, where the dot replaces the emotion-related stimulus and incongruent trials, where the dot replaces the neutral stimulus are recorded.
The Visual Search Task	The individual is asked to find a particular visual stimulus (i.e. target) among distractors (i.e. cues) as quickly as possible. Two conditions are usually presented; in the first one, the distractors are pain-related, and the target is neutral, and in the second, the distractors are neutral, and the target is pain-related. Reaction time for both conditions is recorded.

We conducted a systematic review, and a meta-analysis which aimed to examine whether: 1) Different experimental tasks identify differences in SA processes between individuals with CP and healthy controls; 2) Different tasks and stimuli are more likely to detect differences in SA processes between CP individuals and healthy controls.; 3) Patterns of differences in SA processes differ across subgroups of individuals with CP (e.g. chronic low back pain (CLBP), fibromyalgia, complex regional pain syndrome (CRPS) and headache).

3.3 Methods:

The systematic review protocol was prepared and registered on PROSPERO (CRD42019159121), and the systematic review was conducted and reported according to the PRISMA 2020 guidance (Page et al., 2020).

3.3.1 Searches

Four databases were searched from inception to 17th August 2022, including the Ovid platform (title and abstract), MEDLINE, PsycINFO, and PsycARTICLES full text (via Ovid), and the Web of Science. The searching strategy is included in Appendix 3.A. Furthermore, the Open Grey database was searched for relevant grey literature. Medical subheading heading (MeSH) terms were used where available (i.e. Medline, and PsycINFO databases) using CP as a sub-heading. Journal articles and PhD theses were included, but not conference abstracts and MSc theses. Backward citation tracking was conducted by searching reference lists of included studies. Related systematic reviews were hand-searched with forward citation tracking involving searching the references of any relevant systematic reviews.

3.3.2 Study selection

The study selection was completed in two stages. First, we started with titles and abstracts screening, followed by full-text screening for eligible studies at the title/abstract screening stage. The two stages of screening were done independently by two researchers (AA and AN). The interrater agreement (κ) on searching the titles and abstracts and full-text screening reached 97.38% and 85.83%, respectively.

3.3.3 Eligibility criteria

We had the following eligibility criteria using the PICOS framework:

- **Population**: CP group: Individuals with CP for three months or more, aged 18 years or older, and have normal or corrected to normal vision.

  Control group: Healthy individuals without CP, aged 18 years or older, and have normal or corrected to normal vision.
- **Intervention**: These included experimental conditions such as (i) Tasks that assess attention bias for pain-related information or (ii) Any experimental pain-related stimulation such as auditory, visual, or somatosensory.

- **Comparison**: Baseline, neutral condition, or no comparison.
- **Outcome measures**: Reaction times were the primary outcome measure used to compare tasks and stimuli used. Attentional biases of participants with (i.e. at least 50% of the sample size) and without CP were compared. This was done by comparing the reaction time differences between participants with and without CP. Between-group differences and within-group differences were calculated. Some studies used an equation to calculate the bias score (i.e. attentional bias index) instead of the reaction time. The bias score relied on the differences between the CP group and the control group (Some other studies that only included one group were excluded only from the meta-analysis part). The magnitude and orientation of these scores were used to infer the SA process that might occur.
- **Study design:** For the systematic review, we included studies with experimental or quasi-experimental designs using any reaction time based experimental task that assessed attentional biases and had at least 20 participants. For the meta-analysis, a further condition of having a control group with at least 20 participants for comparison purposes.

We excluded studies that were non-experimental (e.g. qualitative studies), used questionnaires measures only (e.g. cross-sectional using questionnaires only), were not focused on CP or were focused on drugs (e.g. pain killers, opioids). Because previous meta-analyses reported a high level of heterogeneity (Crombez et al., 2013; Todd et al., 2018), we excluded studies that had less than 40 participants (i.e. at least 20 participants in each arm) in order to improve the reliability of this review. Thus, based on the inclusion criteria, non-reaction time-based eye-tracking studies were excluded from this review. Such eye-tracking studies were explored in a recent meta-analysis (Jones et al., 2021). Other exclusion criteria were tasks not including attention bias toward pain-related stimuli and studies not written in English.

3.3.4 Data extraction

Two researchers (AA and AN) completed the data extractions independently using a standardised excel spreadsheet piloted before its use. We extracted information on studies, populations, experimental tasks, comparisons and outcomes, and quantitative data that were amenable for the meta-analysis (Appendix 3.C). Demographic information (i.e. age, gender, ethnicity, education, socio-economic status) of the participants, pain characteristics (i.e. duration, intensity, location(s)),

and measurement tools used in the studies were summarised in Appendix 3.D. When these values were not presented separately in the journal articles, we gathered them through contacting the authors of these articles or authors of previous meta-analyses. If the experimental study had more than two groups, we chose the group with the least comorbid symptoms to increase the homogeneity of the overall sample (Beck, Freeman, Shipherd, Hamblen, & Lackner, 2001; Haggman, Sharpe, Nicholas, & Refshauge, 2010; Mohammadi et al., 2012; Franklin, Holmes, Smith, & Fowler, 2016). When there was a discrepancy between the two researchers involved in the data extraction, it was resolved by discussions or the involvement of the wider team of reviewers.

3.3.5 Quality Assessment

We assessed the included studies' quality using a tool adapted from Crombez and colleagues, which involved assessing the internal and external validity of the eligible studies (Crombez, 2013). Although we used the tool as it is, we changed the scoring system to better interpret the overall quality of scoring (3.B). The score on each item ranged from 0 to 3 (expect one item ranging from 0 to 4), then this score was converted to a percentage ratio for a more straightforward interpretation. Two researchers (AA and AN) completed the quality assessment independently, and disagreements were resolved by discussion.

3.3.6 Data analysis:

The results were initially narratively synthesised according to the research aims with a focus on different tasks, stimulus types, and CP subgroups. For the subset of studies with amenable quantitative data, meta-analysis was conducted using Stata-16 software (Ho, Huynh, Jacho-Chávez, & Rojas-Baez, 2021). Hedges' g was used to calculate the effect size because it is better with smaller sample sizes compared to Cohen`s d. The values of Hedges' g can be interpreted similar to those of Cohen's d, which range between 0.01, 0.2, 0.5, 0.8, 1.2, and 2.0, indicating very small, small, medium, large, very large, and huge effect size respectively (Cohen, 2013; Brydges, 2019). When quantitative data were not available, we twice contacted the authors of the eligible studies included. Subgroup analyses were executed to examine the effect of different tasks, stimuli, and CP-subtypes. A sensitivity analysis was performed to examine whether effects remain robust when only studies with low risk of bias scores are retained in the analyses (3.E). All analyses were conducted using the DerSimonian-Laird random-effects model to account for between-study

heterogeneity. Heterogeneity was quantified using the I^2 statistic. Conventionally, I^2 values of 25%, 50%, and 75% indicate low, moderate, and high heterogeneity (Higgins, Thompson, Deeks, & Altman, 2003). Provided we identified more than ten studies per every outcome (Sterne, Gavaghan, & Egger, 2000), a formal assessment of slight study bias (publication bias) was performed by constructing funnel plots (with the use of metafunnel command) and examining the value and significance of the Egger's test (using the metabias command; Egger, Smith, Schneider, & Minder, 1997; Sterne, & Harbord, 2004; Harbord, Harris, & Sterne, 2009).

3.4 Results

3.4.1 Studies selection

The systematic searches revealed 1657 studies. After removing duplicates (284 studies), 1373 studies from four bibliographic databases and two studies from grey literature were retained for titles and abstract screening. Out of these studies, we identified 126 studies for full-text screening. Another two search updates revealed 361, 143, and 131 studies, respectively, totalling 2008 studies for screening. A total of 34 studies were included in the review, and of these, 15 studies were included in the meta-analysis. The details of the systematic review process are illustrated in Figure 3.1 using the PRISMA flowchart.

3.4.2 Descriptive characteristics of studies and outcomes

The overall sample size of 3154 individuals across the studies included 2057 CP individuals and 1097 healthy participants. The sample size for CP groups ranged from 20 to 170 and from 20 to 200 for the control groups. The mean age of the samples for CP groups (M=42.61, Sd=7.19) and healthy groups (M=33.85, Sd=10.35). The samples predominately consisted of females, mean ratio of females (65.0%) in CP groups and (64.6%) in control groups. Most studies were conducted in high-income countries (29 out of 34 studies, 85.3%). The average pain duration was 95.02 months (Sd = 55.22; range, 6.7 to 220.32), and the average pain intensity (i.e. out of ten degrees) was 4.62 (Sd = 1.27; range, 2.5 to 6.4) (See 3.D for the pain characteristics and 3.F for the included studies' full list). The majority of experiments k= 21 were conducted in the English language. The first study was published in 1998 by Pincus and colleagues, and the last was published in 2020 by Carleton and colleagues (Pincus, T., Fraser, L., & Pearce, 1998; Carleton et al., 2020). The descriptive characteristics of all studies included in the systematic review are summarised in Table 3.3.

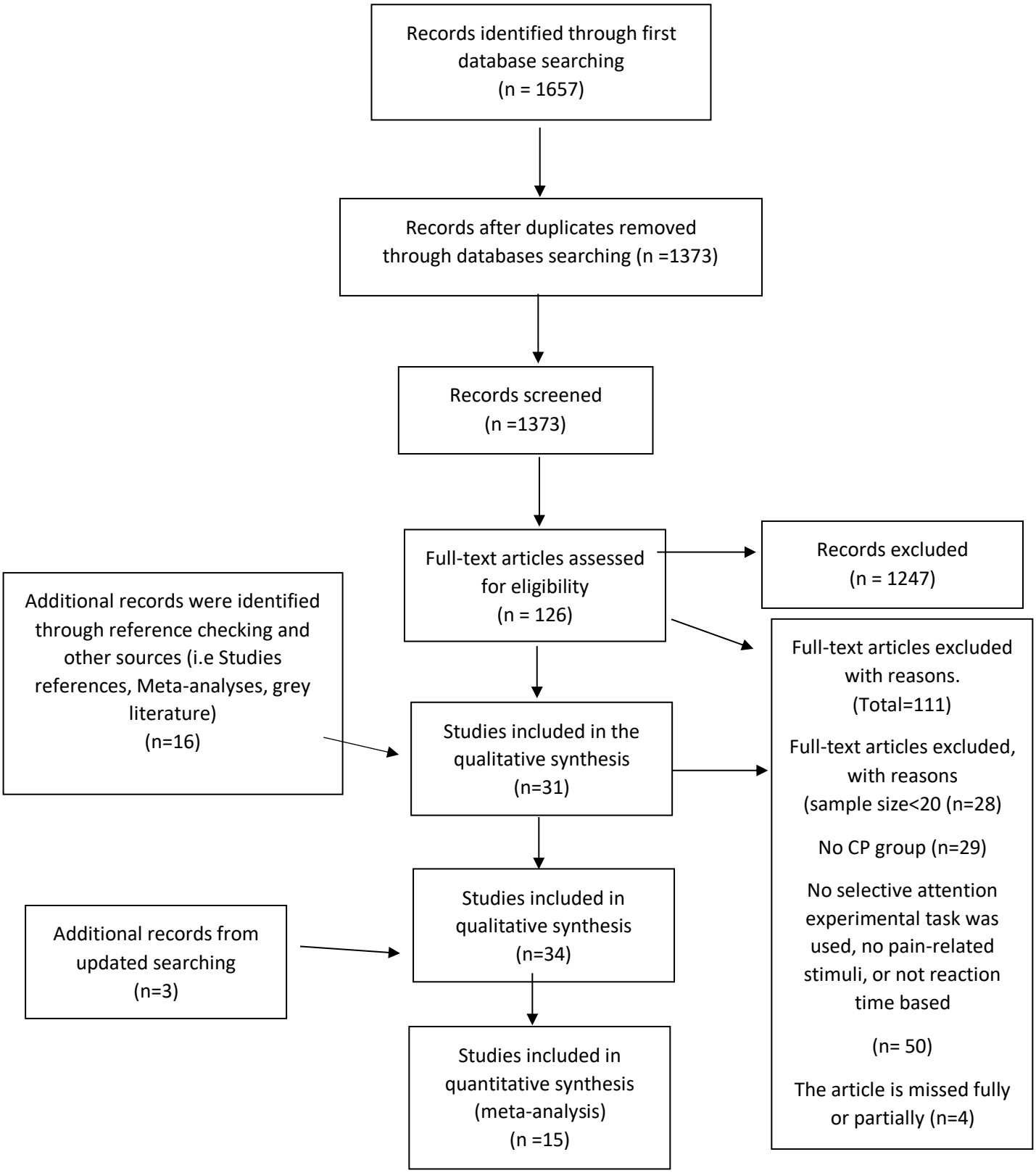

Figure 3.1: PRISMA Flow Chart

Performance related to attentional biases of participants with CP was compared with healthy participants (25 studies out of 34 have a control group, 73.5%). This was conducted by comparing the reaction times toward sensory pain-related information and affective pain-related information with reaction times toward neutral information. When we had mixed types of pain-related stimuli in the same study, we explored each of them separately. Across the studies, different SA processes were implicated by the authors. Although the majority of studies that used dot-probe task predicted hypervigilance process, they linked this process to a range of models, mainly the fear-avoidance model (Vlaeyen, & Linton, 2000), fear of re-injury model (Vlaeyen, Kole-Snijders, Rotteveel, Ruesink, & Heuts, 1995), and the vigilance-avoidance hypothesis (Mogg et al., 2004). On the other hand, not all studies linked a particular model to the same attentional processes; instead, different findings were occasionally used to support the same model depending on how they were interpreted. The fear-avoidance model was linked with combinations of hypervigilance, avoidance, and difficulty of disengagement processes when using the dot-probe task (see Table 3-A in 3.C; Vlaeyen, & Linton, 2000). For instance, some studies using eye-based reaction times found that CP individuals tend to be hypervigilant to, and then avoidant from painful facial expressions, which supports the vigilance-avoidance hypothesis (Yang, Jackson, & Chen, 2013; Fashler, & Katz, 2014; Mazidi et al., 2019). The main task characteristics of all studies, including the attentional processes, are listed in Table 3-A, Table-3-B, and Table 3-C in Appendix 3.C.

Table 3.3: The descriptive characteristics of all studies included in the systematic review (Studies references full list in Appendix 3.F).

First Author	Study setting (country)	Research design	Pain Intensity M (SD)	CP subtype	Procedure language	Comorbid symptoms of EG	Sample size (EG)	sample size (CG)
*Andersson, & Haldrup (2003)	Sweden	Quasi-experimental/ Two matched groups	NPRS 0-10 6.25 (1.3)	FM, whiplash, and LBP	Swedish	Anxiety and depression	20	20
*Asmundson et al. (2005)	Canada	Quasi experimental/ 2 groups design	MPI-pain subscale 4.1 (1.2)	83% BP	English	Anxiety and depression	36	29
Asmundson, & Hadjistavropoulos (2006)	Canada	Quasi-experimental/ Two matched	-	83% (n= 30) BP	English	Anxiety, FOP, and depression	36	29

		groups (2ndry re-analysis)						
*Beck et al. (2001)	USA	Quasi-experimental /3 groups design	PTSD with CP 4.33(1.17) CP 3.80 (1.44)	Musculoskeletal	English	PTSD and other non-specified psychiatric diagnoses	26	21
*Carleton et al. (2020)	Canada	Quasi experimental/ 2 groups design	-	FM	English	Anxiety, depression, and stress	26	29
Chapman, & Martin (2011)	UK	Quasi experimental/ 2 groups design	51.35 (19.21)	IBS	English	Anxiety and depression	20	33
Crombez et al. (2000)	Belgium	Quasi experimental/ one group design	48.72 (24.88)	LPB	Dutch	Anxiety	25	NA
Dear et al. [a] (2011)	Australia	Quasi experimental/ 2 groups design	Not-specified	44% LBP and limbs, 17% upper shoulder and cervical region	English	-	139	200
*Dear et al. [b] (2011)	Australia	Quasi-experimental/ 2 groups design	Not specified	LBP 43%, upper shoulder and cervical 17%	English	Depression, stress, and anxiety	129	50
Dehghani et al. (2003)	Australia	Quasi-experimental/ one group design	MPI 4.07 (1.13)	LBP (37.5%), upper limb pain (15%), lower limb pain (14%) and 6% cervical pain	English	Moderate disability, depression, anxiety, , FOP, and severe stress	168	NA
Dehghani et al. (2004)	Australia	Quasi-experimental/ one group pre-test-post-test design	MPI 4.25(1)	CLBP (38.1%), Upper limb pain (12%), Lower limbs (12%), Cervical pain (12%).	English	-Moderate disability, FOM, and FOP -Severe stress, clinical depression, and anxiety	42	NA
*Duschek et al. (2014)	Germany	Quasi experimental/ 2 groups design	MPQ 53.8 (16.5)	FM	German Deutsch	Depression, and anxiety.	27	34
Fashler, & Katz (2014)	Canada	Quasi experimental/ 2 groups design	Mild (15.7%), Moderate (74.5%), severe (9.8%)	Neck or BP (30), headache/ migraine pain (22), ankle/knee (21), shoulder (15) stomach (12) hip (5), arm (2), eye (1), and jaw (1).	English	Severe disability, and anxiety	51	62

*Fashler, & Katz (2016)	Canada	Quasi experimental/ 2 groups design	Mild (15.7%), Moderate (74.5%), severe (9.8%).	Neck and/or BP (30), headache/ migraine pain (22), ankle/knee (21), shoulder (15) stomach (12) hip (5), arm (2), eye (1), and jaw (1).	English	Severe disability, and anxiety	51	62
*Franklin et al. (2016)	UK	Quasi-experimental design/ 4 groups design (defensive high-anxious, high-anxious, repressor, non-extreme, and control)	-	CBP	English	Anxiety	70	20
Garland, & Howard (2013)	USA	Pre-allocation assessment/ 2 groups RCT	MORE 5.82±1.27 Support 5.94±1.59	Lumbago (58%), FM (19%), arthritis (13%), and cervicalgia (3%)	English	MDD GAD Substance use PTSD	92	NA
*González et al. (2010)	Spain	Quasi experimental/ 2 groups design	-	FM	Spanish	Anxiety	25	25
*Haggman et al. (2010)	Australia	quasi experimental/ 4 groups design (CLBP-PT/CLBP-tertiary referral pain clinic/acute LBP/control)	PT 2.61 (2.25) Tertiary 4.85 (2.81)	LBP	English	Depression	107	50
Harvold et al. (2018)	Denmark	Quasi experimental/ 2 groups design	CP no PTSD 6.4±1.6 CP and PTSD 7.4±1.5	RTA related non-cancer CNP	Danish	PTSD	20	NA (CP+PTSD group less than 20)
Jackson et al. (2019)	China	Quasi experimental /one group sample design	CPGS 12.66 (4.82)	Neck or shoulder (46%) LBP (28%) Extremity (13%) Head or face (10%) Other (3%)	Chinese	-	89	NA
*Khatibi et al. (2008)	Iran	Quasi experimental/ 2 groups design	VAS (100 mm) 54.6 (13.6)	Not specified	Persian	Anxiety, depression, stress, FOM, and FOP.	170	40

Liossi et al. (2010)	UK	Quasi experimental/ 2 groups design	2.5 (1.1)	CH (tension type)	English	Anger trait, angry temperament, angry reaction, and anger out	40	40
Mazidi et al. (2019)	Iran	Quasi experimental/ 2 groups design	VAS current week 5.34(2.24)/ VAS currently 2.7 (2.17)	17.85% upper limbs, 21.43% lower limbs, 10.71% BP	Persian	Anxiety, depression, and stress	28	29
Mohammadi et al. (2012)	Iran	Quasi experimental/ 3 groups design (CP, caregivers, and control)	VAS – 100 mm CP 51.41 (30.71) caregivers' estimation 53.71 (28.43)	20.7% upper limbs, 23.7% lower limbs, 43% BP, and 12.6% more than one location	Persian	Non-sig. on Anxiety, depression or stress	135	52
Peters et al. (2000)	Netherland	Quasi experimental/ 2 groups design	-	FM	Dutch	Non-specific bodily symptoms	30	30
*Pincus et al. (1998) (experiment 1 only)	UK	Quasi-Experimental /2 groups (2*4 factorial design)	NPRS scale 1-101 30 (17)	-	English	Anxiety and depression	20	20
*Roelofs et al. (2005)	Netherland	Quasi experimental/ 2 groups design	Using VAS-100 mm 60.1 mm (26.3)	CLBP	Dutch	Substantial physical disability	49	44
Schoth, & Liossi (2013)	UK	Quasi experimental/ 2 groups design	3.11 (1.22)	CH	English	Depression, state and trait anxiety.	37	38
*Schoth et al. (2014)	UK	Quasi experimental/ 2 groups design	-	-Tension-type headache 19 (83%) -Migraine 4 (17%)	English	Severe disability	23	24
Sharpe et al. (2009)	Australia	Quasi-experimental/ one group design	5.6 (9.9)	-Definite or classic Rheumatoid Arthritis	English	Anxiety	100	NA
Sharpe et al. (2012) (study 2 only)	Australia	Pre-allocation RCT (study 2 only)	ABM+CBT 4.45 ± 2.0 PT+CBT 3.3 ± 2.0	-Benign CP -Arthritis	English	Disability	34	NA

Snider et al. (2000)	Canada	Quasi experimental/ 2 groups design	MPQ-SF 5.6 (2.1)	CBP (23) CNP (10)	English	Depression	33	33
Van Ryckeghem et al. (2012)	Belgium	Quasi-experimental/ one group design	MPI scale 3.86 (SD = 0.98)	CBP (92.8%), CNP (68.1%) Leg pain (66.7%) Arm pain (44.9%)	Flemish	Depression, disability, and anxiety	69	NA
*Yang et al. (2013)	China	Quasi experimental/ 2 groups sample design	Using CPGQ High FOP group 16.85 (4.06) Low FOP group 16.27 (1.90)	Abdominal pain (12) Headache (4) BP (3) Orofacial pain (2) shoulder pain (1) NP (1) Chest pain (1)	Chinese	FOP	24	24

3.4.3 Risk of bias assessment

Internal and external validity was assessed using the tool adapted from Crombez and colleague's meta-analysis (Crombez et al., 2013); the fulfilment of the internal validity between studies reached (79.3%), and the external validity fulfilment reached (78.7%). Detailed information on the quality ratings can be found in Appendix 3.B.

3.4.4 Synthesis of results

The studies included in the analysis varied in the experimental tasks and type of stimulus used. Therefore, we grouped the results for each main task and stimulus type used. For the CP sub-groups, we compared studies related to back pain only due to the heterogeneity of other study samples.

3.4.4.1 Tasks

The main tasks used to assess CP are the modified Stroop and dot-probe tasks, either with or without eye-tracking (i.e. eye-tracking technology was used in k= 6 studies). For the type of tasks used, the main tasks were the modified dot-probe task k=23, which used pain-related stimuli (i.e. pictorial or words) and the modified Stroop task k=8, which used words as pain-related information, with one study (Asmundson et al., 2005) using both tasks consecutively. Other tasks included Posner spatial cueing task k=2, dual-task (i.e. detection of electrical stimulation task and RT for visual stimuli task) k=1, and visual search task k=1.

3.4.4.2 Stimulus

For stimulus type, words were used in k=25 studies, while pictorial stimuli were used in k=11 studies. While two studies used both words and pictorial stimuli in their study separately (Roelofs, Peters, Fassaert, & Vlaeyen, 2005; Dear, Sharpe, Nicholas, & Refshauge, 2011[a]). Other stimuli included using geometric pictorial shapes k=2; first study used a red light as a signal before detecting the location of an innocuous electrical stimulus (i.e. bodily sensation relevant to pain) and determining a geometric object type in a dual task experiment (Peters, Vlaeyen, & van Drunen, 2000). The second study used a pink or blue square and a noxious electrical stimulus (one of the squares was related to pain through classical conditioning; Van Ryckeghem et al., 2012). The results of extraction are shown in Appendix 3.C -Table 3.3.

3.4.4.3 Chronic pain subtypes

Regarding the CP subtypes, the results were heterogeneous. The studies were connected the CP sub-group category with the main diagnosis (i.e., 50% or more of the sample size); back pain k=11, fibromyalgia k=4 chronic headache k=3, irritable bowel syndrome (IBS) k =1, Rheumatoid arthritis (RA) k=1, and road traffic accident (RTA) k =1. In comparison, the rest of the studies (i.e. k=11) recruited samples with miscellaneous subtypes of CP, and not specified in further one study k=1. However, only a few studies were amenable for inclusion in the meta-analysis (i.e. chronic back pain k=4).

3.4.4.5 Attentional characteristics and processes

Different processes were identified to be involved in different phases of the attentional process as stated in studies included. While hypervigilance k=20, avoidance k=5, and facilitated attention k = 1 attention processes were linked to the initial phase of the attentional process (i.e. <200-300ms), the difficulty of disengagement process k=8 and strategic characteristics were related to later processing (i.e. >200-300ms; Berger, Henik, & Rafal, 2005; Nguyen, Watanabe, & Andersen, 2020; Fernández-Calderón, Lozano, Moraleda-Barreno, Lorca-Marín, & Díaz-Batanero, 2021). Although the strategic characteristic was reported in k=9 studies, automaticity was not explicitly discussed but was implied through descriptions of facilitated attention. All attentional processes and their related models are summarised in Table 3.1. Ratings in Table 3.1 were done by two

independent reviewers (AA and EP), and the inter-rater reliability was medium (kappa coefficient=0.53).

For the presentation time of the stimulus, many studies, k=14, used 500 ms. While some studies used shorter presentation time (i.e. 100 -300 ms) k=3, others used longer presentation time (1000 ms to 4000 ms) k= 9, and some studies k = 4 used both short and long presentation time. Also, in the Stroop task some studies used unlimited presentation time k =5, with two of them contained also masked presentation of 14.3 ms that then replaced by a string.

3.4.4.6 Main comorbid symptoms

Regarding comorbid psychological symptoms, depression and/or anxiety were the main comorbid symptoms of individuals with CP k=24, post-traumatic stress disorder k =2, anger trait k =1, miscellaneous sample symptoms k =2, unspecified symptoms k=2, in addition to general comorbid disability k=3. Where possible, the results of the studies not included in the meta-analysis, including sub-group analysis, were described in Appendix 3.C - Table 3.3.

3.4.5 Meta-analysis

The pooled effect size across the 15 studies was small and significant (g=0.28, 95% CI [0.16, 0.39], I^2=43.2%, p = .038); see forest plot in Figure 3.2, suggesting that CP groups have a greater bias towards sensory pain-related information than healthy groups. As indicated by the I^2 statistic, there was moderate heterogeneity in this meta-analysis. However, we found no evidence of publication bias (p = .98, 95% CI [-3.26, 3.18]), as shown in Figure 3.3. Sensitivity analysis was conducted using the highest ten studies' quality score, and the effect size was moderate and significant (g=0.39 95% CI [0.24, 0.54], I^2=15.4%, p = .301). This supports the primary results that the CP population have a greater attentional bias toward sensory pain-related information. For assessing the effect size of the affective pain-related information, data from authors were obtained from only three studies, which were found to be moderately significant (g=0.48, 95% CI [0.23, 0.72], I^2=7.1%, p = .341) (Appendix 3.E).

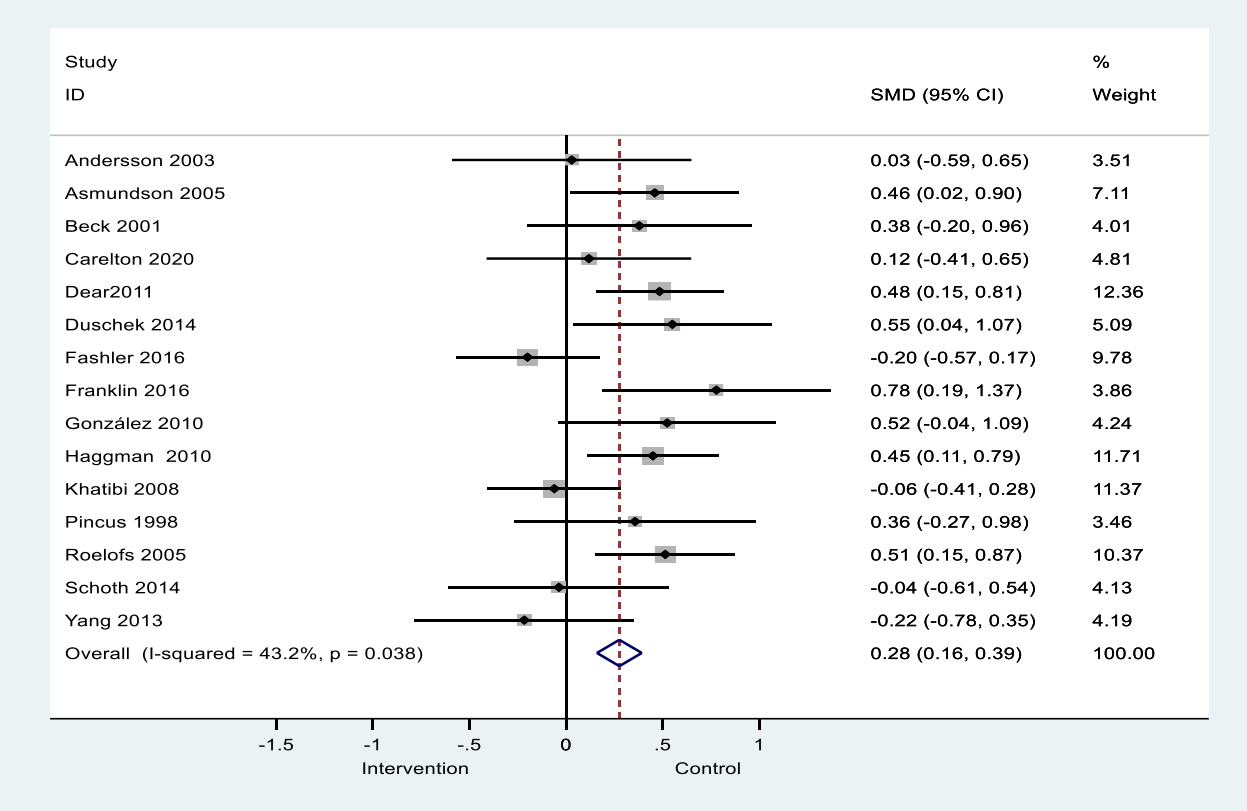

Figure 3.2: Forest plot to assess the effect size between CP and healthy controls groups for the sensory pain-related information.

3.4.5.1 Effect of Task

For the task comparison, six studies used the dot-probe task, and the revealed pooled effect size was small and significant (g=0.22, 95% CI [0.06, 0.38], I^2=67.4%, *p* = .009), while the pooled effect size for six studies that used the Stroop task was moderate (g=0.41, 95% CI [0.18, 06], I^2=0%, *p* =.853) (Appendix 3.E).

3.4.5.2 Effect of Stimulus Type

Regarding the type of stimulus, the pooled effect size across 10 studies that used words was moderate and significant (g=0.44, 95% [0.28, 0.60], I^2=0%, *p* = .681), while the pooled effect size across 5 studies that used a pictorial stimulus was small and non-significant (g=0.09, 95% [-0.10, 0.28], I^2=61.3%, *p* = .035) (Appendix 3.E).

3.4.5.3 Effect of Chronic Pain subtypes

For the CP sub-groups, we found a significant and moderate effect size (g=0.51, 95% [0.31, 0.71], I^2=0%, *p* = .810) (Appendix 3.E), related to chronic low back pain in 4 studies. Other CP subtypes could not be analysed using meta-analysis due to heterogeneity and lack of studies focused on CP subgroups.

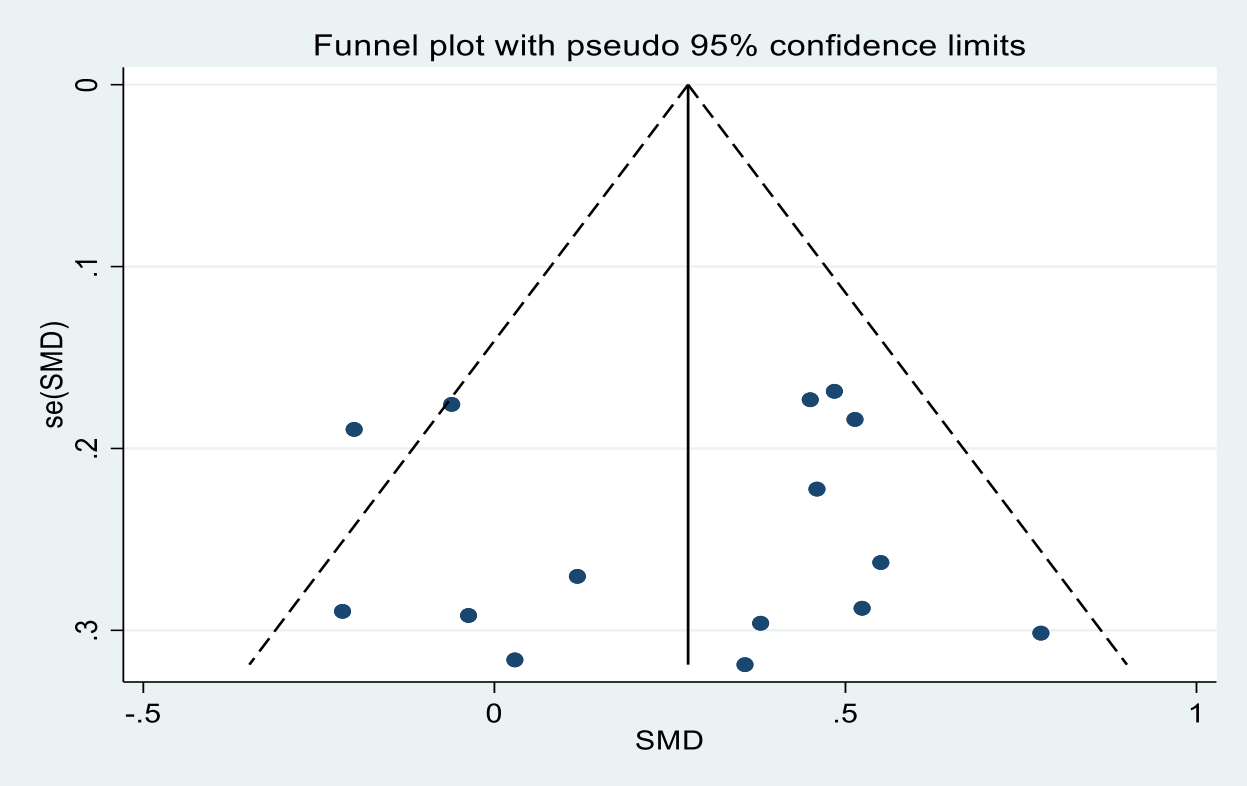

Figure 3.3: Funnel plot used assess publication bias of studies included in the meta-analysis. Non-significant publication bias found among the studies included.

3.5 Discussion

In this systematic review we explored reaction time-based studies and synthesised a descriptive analysis that shows overlapping and variations between tasks, stimuli, CP sub-groups, attentional processes predicted, and interpretational models used in these studies. For the meta-analysis, we found that using relatively larger sample size confirmed that compared to healthy controls, individuals with CP show an attention bias towards sensory pain information of relatively small to moderate effect size. Further, different from previous reviews that looked within groups (i.e.

compared congruent and incongruent within groups) we found a moderate effect size for affective pain-related information when assessing studies with large sample size. However, only limited affective pain-related data (i.e. k=3) were amenable for the meta-analysis, and therefore we recommend caution in interpreting these findings. The low number of included studies is mostly attributed to either low sample size or poor data reporting. Thus, there is a need for more studies with robust methodology to be conducted using affective pain-related cues. We also found a moderate heterogeneity level, which is expected given the variation in methodologies and outcomes of the studies. Therefore, we followed this up with subgroup and sensitivity analyses to explore key sources of the detected heterogeneity. The main tasks used were the dot-probe task and the emotional Stroop task. The emotional Stroop task identified greater attentional biases in the CP groups compared to controls. However, this might be due to the involvement of different attentional processes in the tasks, or even other non-attentional processes, such as higher-order processes, when the tasks are not purely measures of attentional biases. Therefore, further studies are needed to confirm such differences. The main stimulus types were words and pictorial stimuli; however, we could not determine whether there was greater variability in the type of pictures used than the words used because many studies did not include the actual stimuli list used in the experiment, and thus, a transparent reporting of stimuli is needed.

Our findings concur with previous reviews, which also observed high inconsistency across studies (Crombez et al., 2013; Todd et al., 2018). In comparison to other recent reviews which investigated only dot-probe task (Todd et al., 2018), eye-tracking studies (Jones et al., 2021), or pain-related and bodily somatosensory stimuli (Crombez et al., 2013; Broadbent, Liossi, & Schoth, 2021), this review explored all existing reaction time based tasks. It should be noted, however, that our strict inclusion criteria meant that some of these reviews included more studies. This exhaustive review of assessment tasks and stimuli provides an overview of SA processes in the CP population and the associated attention processes (See Table 3.1). For instance, our review has found that some previous studies claimed that individuals with CP show *strategic* attention toward pain-related stimuli rather than *automatic* attention (Snider et al., 2000; Mazidi et al., 2019). This claim was consistent across different experimental tasks (i.e. Stroop, dot-probe and eye tracking). The vast majority of studies that looked at automatic versus strategic processes chose a similar time point (i.e. 500 ms) in the dot-probe task to assess the strategic or hypervigilance attention processes. Interestingly, it was noticed that this choice was mainly based on earlier research that found

significant results for strategic but not automatic attention (Sinder et al., 2000; Pincus, & Morley, 2001). Choosing such a time point implied that attention in the CP population is widely accepted as more related to strategic than automatic processes. However, having an agreed format to facilitate comparability of time presentations among studies from different countries would need to run a more global study that takes into consideration the cross-cultural differences. Such cultural variations could be related either to the cultural sensitivity (e.g. type of stimulus, the appropriateness of the stimulus) or language specificity of that culture (e.g. language comprehension, language processing, language expression speed, stimulus interpretation; Price-Williams, 1974; Mazari, A., & Derraz, 2015). Further, this review indicates that studies using words more consistently found differences than those using pictorial stimuli (Appendix 3.C). Although words might be less effective at eliciting memories or schemata, they have been used more often in studies of CP. Furthermore, another novel feature of this systematic review is that it explored the general SA processes in light of their relation to the different tasks and the interpretative models (See Table 3.1). By doing so, we tried to link SA processes with the theoretical models to understand how attention is characterised in them, taking into consideration the psychometric parameters from the different tasks, and stimuli.

We found from the descriptive analysis that the same task was often used to support different models. This is unsurprising given that there is an overlap in the SA processes implicated by the different models. This process-model relation could be a priori specified through the pre-registration in future studies as recommended by the literature on the open science (Mirowski, 2018). Thus, the key importance of pre-registration is that it prevents HARKing (i.e. hypothesising after results known; Köckerling et al., 2019). Specifying the exact effects predicted in advance of collecting data through pre-registration of the experiment is crucial for having consistency between predictions and the arguments made. Thus, effects might be overestimated without such pre-registration.

This review has several research implications. First, we found a larger effect when using the Stroop task over the dot-probe task in measuring the bias toward (or away from) pain-related information, suggesting that bias toward-pain related information is greater when using the Stroop task rather than the dot-probe task. However, we need to be careful when interpreting these results because it is difficult to determine the exact driving factors due to the relatively small number of studies in

subgroups with potential overlap between moderators, such as the type of task and the type of stimuli. Further, it is not because the effect is smaller that the task is less good in detecting the attentional bias and related processes. The larger effect may be due to other processes (e.g., higher-order processes) that have an effect. While a general argument about attentional bias can be made that it does not matter which task we are using because we should have an attentional bias effect. On the other hand, it is worth noting that the Stroop task calls upon many attentional processes (such as automatic and strategic processes characteristics as well as inhibitory mechanisms; Brueggemann et al., 2021), and the effect may be larger because they are added together, so it is hard to tease them apart. We recommend that future research use more than one task, which would allow for more robust results, such as the study by Asmundson and his colleagues (Asmundon et al., 2005), use the task that is more reliable to detect the hypothesised SA process or use repeated measurements. Further, in this study, authors correlated findings between the tasks and found that only affect pain-related and health catastrophe words were significant. These findings raise questions about whether these tasks are distinguishable from each other, given that they were correlated. Because only a few studies investigated other tasks and due to data reporting problems, these were not included in the meta-analysis. However, using other tasks such as the Posner cueing task might allow future researchers to focus on specific attentional sub-processes (Van Ryckeghem et al., 2012). Furthermore, few studies used actual bodily or painful stimuli, such as the study by Bulcke and her colleagues that discuss hypervigilance for somatosensory signals in CLBP individuals (Bulcke, Van Damme, Durnez, & Crombez, 2013). This could be a future direction compared to most studies that mainly used words or pictures.

Second, as expected, we found that many studies used the dot-probe task, which has also been used in studies investigating attentional bias modification as a potential intervention for some subtypes of individuals with CP (Carleton, Richter, & Asmundson, 2011). However, the psychometric properties of dot-probe tasks, such as reliability, have been questioned, and alternative tasks such as using the Posner cueing-target task have been recommended, which have more reliable psychometric properties, especially when controlling for the *across* and *within* trial parameters (Hayward, & Ristic, 2013). However, the Posner cueing task has only been used in a small number of studies. It should also be noted that the limitations of the chosen task affected what attentional processes could be specifically measured and therefore used in interpretations. Also, recent developments in this field suggest using technologies such as eye-tracking -which

given the continuous measurement- has pros and cons compared to relying on reaction time. However, eye tracking cannot be used to measure attention to stimuli in the periphery (Mazidi et al., 2019), which is usually involved in capturing exogenous (external) stimuli (Berger et al., 2005). Further, we cannot directly measure processes through eye-tracking (i.e. a person can pay attention to a location without moving eyes), so they are not inherently better than other tasks. Further information about the advantages and disadvantages of the eye-tracking technology were discussed in the study by Chan and colleagues (Chan, Suen, Jackson, Vlaeyen, & Barry, 2020). It was obvious that many studies did not agree on which attentional processes involved even when using same tasks (Appendix 3.C). This could be partially explained by the specific methodological approach used, or due to the different theoretical framework of interpretations. Further, a careful interpretation is recommended concerning processes mentioned in different studies because of the various potential meanings used by different authors. As an alternative, an agreed global format would facilitate future research.

Third, we found that using words as a stimulus, either sensory or affective pain-related information, produced a larger effect than pictorial stimuli. This suggests that using words as a stimulus produces more potent effects than a pictorial stimulus, which is also aligned with the findings of the previous meta-analyses (Crombez et al., 2013; Mogoaşe et al., 2014). However, it is worth noting that this finding might be driven by the greater use of words in the Stroop task, which also produced stronger effects, and that fewer studies used pictures overall. In addition, unlike most studies that focused on the sensory pain-related information and resulted in a small significant effect size, we found that the effect size for using affective pain-related information was moderate (Appendix 3.E). Yet, finding a consistent confirmation of attentional bias toward sensory pain-related information from fifteen studies with relatively large sample sizes could help future studies using attentional bias related approaches, such as recent studies trying to manage CP through using attentional bias modification (ABM) approach (Carleton et al., 2020). Further, as expected, including studies with larger sample size reflected in a relatively better-quality assessment outcomes comparing to previous meta-analyses (Appendix 3.B).

Fourth, the systematic review illustrates how different CP sub-types were linked with patterns of attentional processes. For instance, all studies that included fibromyalgia samples were found to have a faster reaction time toward pain-related information compared with the control group,

which may reflect hypervigilance or facilitated attention (Table 3.3, Appendix 3.C-Table 3A, 3B, and 3C). Because this is an association and due to heterogeneity between samples recruited, it is not possible to know whether the differences between the patient groups are due to the type of task or stimuli being used or if these are genuine differences between CP sub-types populations. Due to the heterogeneity of the CP samples or low sample size used, we could only include the chronic low back pain (i.e. the most common CP) samples in the meta-analysis. More studies are needed to compare CP populations directly on the same type of task. This comparison would allow exploration of the possible links between the sub-type of the CP populations and the correlated attentional processes. One possible explanation is that individuals with fibromyalgia have more widespread pain without an apparent physical cause, which triggers hypervigilance. This aligns with nociplastic pain mechanisms that explain the nature of fibromyalgia symptoms in light of the biopsychosocial perspective (Fitzcharles et al., 2021). Conversely, more localised CP that arises from a specific trigger (e.g., arthritis, injury) is related to avoidance. Another possible reason could be that a broad range of pain words is more relevant for individuals with fibromyalgia than for people suffering from a specific pain problem. Although the main comorbid disorders were depression and anxiety, which linked to the development and maintenance of pain (de Heer et al., 2014), the symptoms were subclinical in some studies suggesting an association rather than being causal factors in the development and maintenance of the CP. For instance, one study found that anxiety symptoms in individuals with fibromyalgia do not mediate the hypervigilance process (González et al., 2010). Further, not all studies explored the comorbidity of anxiety and depression symptoms, so we were not able to examine comorbid symptoms in this review. For instance, the effect of depression on attention and other cognitive processes was explored in a previous systematic review and meta-analysis (Rock, Roiser, Riedel, & Blackwell, 2014). Thus, we recommend future studies should examine and report how comorbid symptoms interact with CP and attentional processes. Further, some studies showed that attentional biases among individuals with CP were related to daily activities and, thus, are likely to be linked to processes that maintain or exacerbate CP symptoms and disability (Vlaeyen, & Linton, 2000; Todd et al., 2015). However, a previous meta-analysis did not find a link between CP and preattentive processes, which may not always be the case (Crombez et al., 2013). Based on the current state of the art, there is no clear evidence that attentional biases are related to the level of disability in individuals with CP,

the development of CP, or pain disability. Therefore, future studies are encouraged to test these relationships as well as potential solutions.

This is the first review that explored particularly the SA processes and their links to tasks, stimuli types, and interpretative models. Key strengths are the use of state-of-the-art systematic review and meta-analysis methods and the inclusion of studies with the most robust evidence by applying quality assessment criteria. However, there are also some limitations. Many studies were excluded from the meta-analysis because either they did not have a healthy control group (i.e. We did not look at within-group bias), had a small sample size, including some recent eye-tracking studies that did not use goal-oriented reaction time, or the data reporting was poor. Poor data reporting was recognised across a considerable number of studies which did not improve after contacting study authors and therefore precluded the inclusion of these studies in the meta-analysis. For instance, one important additional meta-analysis would be examining the differences between congruent and incongruent reaction times. However, we could not do this comparison in the meta-analysis for two reasons; first, the number of papers that reported congruent-incongruent data was relatively small, and second, the studies that provided data used different equations to calculate the indices. Thus, using meta-analysis would result in a biased result. This could have been avoided if raw data were shared alongside the article, which aligns with the open science recommendations related to data sharing (Munafò, 2016). We encourage future studies to use more standardised indices calculations that can be used in meta-analysis. In turn, having limitations in the ability to include studies in a meta-analysis decreases the ability to generalise the findings or produce more robust evidence about the attentional bias tasks, stimuli, or processes. Thus, we strongly recommend the use of open data. Moreover, the studies varied in their results considerably even when the same task and parameters (e.g. dot-probe, cue duration equal 500 ms) were used, which did not allow us to explore the impact of additional factors such as time-points (Appendix 3.C). This would have been valuable to understand the dynamics of attention towards pain-related information. We recommend conducting an individual participant data meta-analysis to assess comprehensively various factors to detect differences in attentional biases between individuals with CP and healthy controls. Further, when we included the studies in the meta-analysis and had a design with more than two groups, we chose the experimental group with the least comorbid symptoms to increase the homogeneity of the overall sample as much as possible. Finally, we tried

to build the descriptive tables through careful extraction; however, the models and processes were not always presented clearly, due to reporting variations across papers.

3.6 Conclusion

This systematic review in the field of SA-CP, explored reaction time-based studies with relatively large sample size and compared their different components descriptively. The meta-analysis confirmed that individuals with CP show a relatively small to moderate bias towards sensory pain-related information when conducting a meta-analysis through studies with large sample sizes. Further, unlike previous reviews, we found that exploring studies with large sample size gave preliminary evidence that individuals with CP may show a moderate bias towards affective pain-related information. The evidence regarding attentional bias in people with CP was more substantial when using the Stroop task as well as word stimuli. However, more rigorous studies are still needed to gain robust evidence regarding attentional bias towards affective pain-related information. Exploring the main models that characterise attention among CP individuals can give a deeper understanding of the potential mechanisms around processes involved in the phenomena of their attentional biases. Additionally, there are significant variations across the studies, which do not allow definitive conclusions about the role of types of stimuli and tasks, as well as whether these findings are valid across subgroups of individuals with CP. Overcoming such variation would help in comparing attentional processes found across different experiments. To do this, we strongly encourage open access data availability to overcome data reporting problems, enhance methodological quality, and enable universal use of meta-analysis in the future.

CHAPTER 4

THIS IS THE TITLE OF A PAPER INCLUDED IN THE THESIS

Selective Attention, Resilience and Perceived Stress in the Arabic Speaking Population with Chronic Pain: An Experimental Study

Ahmad N. Abudoush, Ellen Poliakoff, Maria Panagioti, Alexander Hodkinson, Nusrat Husain

4.1 Abstract

Introduction: Previous studies have explored attentional biases in individuals with chronic pain (CP). However, such attentional biases have not been explored in the Arabic-speaking population. The current study used two experimental tasks to investigate different attentional processes related to exposure to pain-related information. Further, associations with perceived stress and resilience were explored for the first time. **Method:** Two matched groups of Arabic-speaking participants with (58) and without (58) CP were recruited from Jordan and the United Kingdom. They completed emotionally modified versions of Posner cueing and Stroop tasks in a counterbalanced order alongside questionnaires. **Results:** Significant group differences were found for the Posner task for sensory pain-related cues, with the CP group exhibiting early disengagement (inhibition of return) compared to other cue types. The control group showed similar disengagement across cue types. No differences were found on the Stroop task. The CP group had lower resilience scores than healthy controls, and resilience moderated performance on the Posner task. **Discussion:** The study provides preliminary evidence that the CP group show early disengagement for sensory pain-related information (i.e. faster uncued RT), but slower for affect pain and neutral stimuli. Resilience might play an important role in attentional performance. Thus, future research should further explore the role of resilience and compare different time points in relation to the attentional behaviours of this population.

4.2 Introduction

Chronic pain (CP) is pain that persists or reoccurs for three to six months or more despite treatment (Treede et al., 2015). Different theories and hypotheses have tried to explain the psychological factors contributing to the development and maintenance of CP (Kuch, 2001). Attention-CP related models explain that attention might play a role in maintaining pain symptoms (Abudoush et al., In publication). Previous meta-analyses confirmed that people with CP exhibit attentional biases related to pain-related information that differs with mild to moderate strength from those without (Crombez, Van Ryckeghem, Eccleston, & Van Damme, 2013; Todd, van Ryckeghem, Sharpe, & Crombez, 2018; Jones et al., 2021). However, despite recent advances in the field of CP-selective attention (SA), such CP-SA related experiments were not adapted or replicated in the Arabic population to assess its cultural and linguistic appropriateness. Despite the scarcity of studies, available literature suggested that the prevalence of CP in the Arabic population range between 20% and 46.4% (Elzahaf, Johnson, & Tashani, 2016; Almalki et al., 2019). Thus, to expand our understanding of the relationship between attentional biases and CP, these methods and tasks in this field need to be adapted and replicated in the Arabic population.

Different models explore the CP-attention association and related processes and introduce different interpretations. These involve attending towards or away from pain-related information (Abudoush et al., In publication) and may be modulated by the level of threat. For instance, the vigilance-avoidance hypothesis asserts that hypervigilance is linked with attending more strongly initially when a threat appears for a short duration (< 500 ms), and then avoidance at a later stage (> 500 ms) (Mogg, Bradley, Miles, & Dixon, 2004). The threat interpretation model (Todd et al., 2015) asserts that individuals with CP exhibit hypervigilance toward pain-related information that is positively correlated with the threat level at the early stage of attention. However, in the sustained attention model, low and high levels of interpreted threat result in avoidance while moderate level results in a difficulty of disengagement of attention from the threat (Todd et al., 2015).

The socio-cultural factors can influence the performance on selective attention-related tasks (Caparos, Linnell, Bremner, de Fockert, & Davidoff, 2013). These factors were especially explored in young children (Jurkat, Köster, Yovsi, & Kärtner, 2020). For instance, Senzaki and colleagues (2018) found differences in performance on selective attention-related tasks

between Eastern and Western children depending on their socio-cultural context. However, investigations of CP-attention did not explore the culturally specific factors among the Arabic population. Further, the neural structure and functions are influenced by sustained cultural experiences (Park, & Huang, 2010). Thus, understanding these potential differences is essential among different populations. Some studies have taken place in different countries that brought up cultural context factors, such as meanings of terms used, yet there is no clear evidence about the effect of such factors on attentional bias processes (Mohammadi et al., 2012; Abudoush et al., 2023). As there are no previous similar studies in the Arabic population, it is essential to understand these selective attention processes in the adult group before exploring them in other more vulnerable age groups (i.e. children, teenagers, and older adults).

Researchers have used different tasks to try to objectively measure attentional biases towards or away from a threatening stimulus (i.e. words or pictures) using reaction times in visual tasks such as the cue-target task (Posner, 1980), the Dot-probe task (MacLeod, Mathews, & Tata, 1986), and the emotional version of the Stroop task (Williams, Matthews, & MacLeod, 1996). The Posner task can be used to measure faster orientation of attention towards the cue (facilitation) and faster (or slower) disengagement of attention from the cue and at later time points inhibition of return (IOR) can be found where people are slower to reorient to a previously attended location (Klein, 2000). The Stroop and Posner tasks involve different attentional processes (Cisler, Bacon, & Williams, 2009), and the Stroop task calls many processes (e.g. automatic, strategic, facilitated attention, disengagement) into play when used (Snider et al., 2000; Wright, 2017). Yet, both tasks share some properties, such as using a single cue presentation approach. This made them appropriate for assessing the salient phenomenon of attention biases. To assess this phenomenon among Arabic speaking population, we used the emotional Stroop task where the threat-related information (i.e. pain cue) is in the middle of the visual field and compared that to the cues at the periphery of the vision using a modified Posner cueing task. The Posner cueing task involves different spatial locations and the engagement or disengagement of attention with these cues. Further, because this is the first study in the Arabic population, using the general CP concept (i.e. not specifying CP sub-type) and comparing different tasks that measure relatively different processes was essential to identify potential processes that generally prevailed in this population.

Language comprehension processing is another challenge in experiments in different cultures. Although images have been used to overcome cross-cultural barriers, using words has been

found to be more effective than pictorial stimuli (Crombez et al., 2013; Carleton et al., 2020). Thus, it would be essential to assess the word stimuli in Arabic. While a considerable number of previous reaction-time-based studies used 500 ms to present pain-related cue words, some literature suggests that the Arabic language processing might take a longer time to process (Bentin, & Ibrahim, 1996; Farghaly, & Shaalan, 2009). Thus, it seems that a longer cue exposure would be essential to ensure sufficient processing time for Arabic words in the context of CP. Further, assessing linguistic differences is more relevant than pictorial stimuli in the Arabic population because it would allow for a deeper understanding of the attention-related biases in this specific population when exposed to Arabic pain-related information. In turn, such exploration can help researchers understand how attention-related biases are driven by the linguistic factors that characterise the Arabic culture.

The current study also explores resilience levels and perceived stress among individuals with CP. Resilience is the ability to adapt positively or to preserve or reach mental health again despite facing calamity (Herrman et al., 2011). Resilience involves coping with undesired chronic circumstances (i.e. CP tolerance) (Sturgeon, 2016). Despite the role that resilience plays in alleviating CP (Yeung, Arewasikporn, & Zautra, 2012), the potential moderating role of resilience has not previously been explored in relation to experimental attention tasks. Further, because stress can be linked to developing negative consequences (i.e. the internal feeling of distress) or as a source of a positive, motivating factor (i.e. eustress) (Brulé, & Morgan, 2018), this study investigated perceived stress following the experimental tasks. This was particularly relevant because tasks similar to the research tasks can be used for attentional bias modification that has the potential to improve the management of CP by training people to reorient their attention away from pain cues (Sharpe et al., 2012; Carleton et al., 2020).

This current study tested the attention-CP link using two tasks (i.e. Posner cueing task and emotional Stroop task) that involve assessing different processes, in a new population recruited across two countries. As introduced earlier, the emotional Stroop task measures selective attention (i.e. participants must ignore the threat and attend to the colour), while the Posner task measures the dynamics of attention. Regarding the current study aims, the first aim of this research was to examine whether individuals with CP show different patterns of attentional processing of pain-related information compared to individuals without CP using different experimental tasks (i.e. Posner cueing task and modified emotional Stroop task). A non-directional hypothesis was used because the evidence is scarce in the Arabic population. The

second aim involved assessing whether psychological resilience moderates the attentional processing of pain-related information in individuals with CP. Finally, the third aim explored whether the perceived stress level of participants differs between groups following participation in the attentional tasks that involve pain-related information while controlling for baseline measurements. Additionally, this study aimed to develop a list of pain-related and neutral words stimuli that could be used in future research with the Arabic population.

4.3 Methods

4.3.1 Participants

One hundred and sixteen participants were recruited through online advertisements and posters hung at pain clinics, physiotherapy centres, hospitals, and community centres in Jordan and the United Kingdom (UK). Interested individuals contacted the researcher through a project account or email and were sent the participant information sheet (PIS). Potential participants who identified themselves as having CP were contacted and checked for inclusion criteria. Participants gave informed consent at the start of the supervised experimental session (online or in person). The research project was approved by the university of Manchester ethics committee (UMEC) (ethics approval number; 2022-11074-21987) and the Jordanian ministry of health (MOH) (ethics approval number; Moh/REC/2021/233). Recruitment stopped once the target sample was reached.

The sample size was calculated according to two references; A) Multiple regression model general sample equation; and B) Sample size in other high-quality studies from a systematic review and meta-analysis conducted by the research team (i.e. 50+8k) (Abudoush et al., 2021). Then, the sample size was confirmed using G*Power software based on medium effect size f^2, three predictors, and 0.8 power. A twenty five percent dropout ratio was added to the sample totalling a hundred participants (i.e. 50 for each experimental group arm). The participant groups consisted of fifty-eight individuals with CP and fifty-eight healthy controls matched for age, gender and country of residence (Table 4.1). Only one participant was excluded from the healthy control group due to exceeding the 30% threshold of wrong answers on both experimental tasks.

The groups did not differ significantly in age; CP group and the healthy group ($W = 1887.5$, $p = .190$). Groups were matched for gender and country of residence (i.e. CP and healthy control

groups matched with slightly higher recruitment from Jordan (N =33) compared to the UK (N=25) per group). There were no significant differences between groups in education X^2 (3, N = 115) = 1.33, p = .722, and income level X^2 (2, N = 115) = 2.13, p = .345, while significant differences were found between groups on marital status X^2 (3, N = 115) = 13.85, p = .003.

Table 4.1: Demographic characteristics of the chronic pain group and healthy control group.

Demographic variable		Chronic pain group (N=58)	Healthy Control group (N=57)
Age		M = 42.03, SD = 13.40	M = 39.32, SD = 14.46
Gender	Male	60.35% (N=35)	60% (N=34)
	Female	39.65% (N=23)	40.35% (N=23)
Education	Primary level (equivalent to high school level UK)	8.62%	12.28%
	Secondary school level (equivalent to college level UK)	29.31%	22.81%
	Undergraduate level	44.83%	42.11%
	Postgraduate level	17.24%	22.81%
Income level	High	5.17%	5.26%
	Medium	63.79%	75.44%
	Low	31.03%	19.30%
Marital status	Single	17.24%	47.37%
	Married	72.41%	50.88%
	Widow	8.62%	1.75%
	Divorced	1.72%	0.00%
Country of residence	Jordan	56.9% (N=33)	57.89% (N=33)
	United Kingdom	43.1% (N=25)	42.11% (N=24)

The inclusion criteria for the CP group were a self-reported primary diagnosis of any CP subtype, 18 years or older, identifying themselves as having Arabic as their native language, can read and write in Arabic, being able to use a laptop, having normal or corrected to normal vision, and living in either Jordan or the UK. The exclusion criteria were participants who had pain for less than three months or were medically unstable. The healthy control group were participants who did not report pain or only had mild pain on the day of the experiment.

4.3.2 Questionnaires

An online version of self-reporting tools was embedded in the experimental procedure. Participants in both groups answered the Arabic versions of the following scales presented according to their chronological appearance in the session.

4.3.2.1 Pre-experiment questionnaires

a. The Perceived Stress Scale (PSS-14) pre-test

The PSS-14 comprises 14 items that measure perceived stress, with seven positive items (i.e. 4,5,6,7,9,10, and 13) and seven negative items. The score on the seven positive items is reversed then the total score is calculated out of 56 possible points. No cut-off point is used for this scale (Cohen, Kamarck, & Mermelstein, 1994). The scale uses the 5-point Likert scale ranging from “Never” to “Always”. This scale has been translated into different languages, including an Arabic-validated version, with the Cronbach's alpha coefficients reached 0.80 (Almadi, Cathers, Mansour, & Chow, 2012). This scale was also used post-experiment.

b. The Short-form McGill Pain Questionnaire (SF-MPQ)

SF-MPQ is a common tool that measures qualitative and quantitative pain characteristics. This tool consists of a 15-item checklist, divided into 11 items that assess sensory pain (throbbing, shooting, stabbing, sharp, cramping, gnawing, hot-burning, aching, heavy, tender, and splitting), and four items assess the affective dimension of the pain (tiring-exhausting, sickening, fearful, and punishing-cruel). The 15 items are rated on a 4-point pain Likert scale, where (zero) means “no pain” and (3) means “severe pain” (Melzack, 1987; Terkawi et al., 2017). This questionnaire was applied to the CP group only using the Arabic-translated version with the Cronbach's alpha coefficients reached 0.85 (Terkawi et al., 2017).

4.3.2.2 Post-experiment questionnaires

In addition to the PSS-14 (post-test), the following scales were applied.

a. Connor-Davidson Resilience Scale-10 (CD-RISC-10)

The CD-RISC (Connor, & Davidson, 2003) has an excellent psychometric rating that measures psychological resilience with the Cronbach's alpha coefficients reached 0.85 (Campbell-Sills, & Stein, 2007; Windle, Bennett, & Noyes, 2011). It has ten items with a Likert scale. A higher score on this scale indicates a higher resilience rate, with forty points as the maximum possible points. An Arabic-validated version of this scale is used in this research (Toma, Guetterman, Yaqub, Talaat, & Fetters, 2017).

b. Patient health questionnaire (PHQ-9)

The PHQ-9 is composed of 9 items that are used to assess depression severity (Kroenke, Spitzer, & Williams, 2001). The scale has very good validity and reliability (Costantini et al., 2021). The Arabic version of this study was translated and tested for validity and reliability by Sawaya and her colleagues (2016), with the Cronbach's alpha coefficients reached 0.86 (AlHadi et al., 2017). The score of this scale range between "0" which means "never", and "3", which means "almost every day". The maximum score is 27, with 5, 10, 15, and 20 cut-off points reflecting mild, moderate, moderately severe, and severe depression symptoms.

c. Generalised anxiety disorder (GAD-7)

The GAD-7 scale contains seven items that assess the severity of the anxiety symptoms, which has high validity and reliability rates (Spitzer, Kroenke, Williams, & Löwe, 2006). The Arabic version of this scale was translated and validated by Sawaya and her colleagues (2016), with the Cronbach's alpha coefficients reached 0.76 (AlHadi et al., 2017). The score of this scale range between "0", which means "never", and "3", which means "almost every day". The maximum score is 21, with 5, 10, and 15 representing the cut-off points for mild, moderate, and severe anxiety symptoms.

4.3.3 Stimuli

The list of pain-related words was obtained from the study by Harrison (1988) to ensure the validity of these translated pain-related words (i.e. sensory (e.g. sharp) and affect (e.g. exhausting) pain-related words). We used 10 sensory pain-related words and ten affect pain-related words for this study. Neutral words were adapted from the study by Fashler and Katz (2014). The neutral words were translated using the Oxford Arabic dictionary (Arts, 2014). Two independent researchers who speak Arabic and English reviewed the translations of the

10 neutral words and agreed. In the Posner task, words were presented in white colour against a black square (10 x 10 cm). While presented in either green, red, yellow, or blue in the Stroop task against a black square background. The screen background was grey in both tasks.

4.3.4 Piloting experimental tasks

Before data collection, the prepared experiment was piloted through a non-Arabic speaking sample (N = 10) to ensure that it captured the basic differences between cued and uncued trials. The cueing effect direction (uncued minus cued) was negative. Further, an Arabic-speaking PPI person with CP was invited to give comments, opinions, and feedback about the experimental session. Their feedback and comments helped improve the experience of the experiment (e.g. the instructions, the number of breaks and their allocation).

4.3.5 Modified Posner cueing task

Participants received detailed instructions before completing the practice trials (N = 10) using a neutral word to ensure they were familiar with the task. In the Posner task, a cross fixation "+" first appeared in the middle of the screen for 1000 ms. Then this fixation was replaced by two black squares presented horizontally, with the cue appearing in the middle of one of them for 1000 ms. The cued (i.e. Target appeared in the same place as the cue word) trials formed half of the trials, and uncued (i.e. Target appeared in the opposite place of the cue word) for the other half, with the order of all trials being randomised. Participants were told that the cues were not predictive of the target location. Next, the target, a green-coloured frame, appeared on the outer edge of either the right or left black square. This resulted in six possible conditions (i.e. cue condition (cued, uncued) x word type (sensory, affect, neutral). Twenty trials were presented per experimental condition. Thus, each word appeared four times (i.e. appeared in two conditions). For each of these conditions, there were four possibilities Target location (left, right) x Target colour (dark, light) that were occurred the same number of times in each of the experimental conditions.

Participants were asked to determine as quickly and accurately as possible whether the colour of the green frame is light green using the up arrow or dark green using the down arrow on the laptop keyboard, while concentrating on the middle of the screen and not moving their eyes or body towards the target stimulus. The target remained on the screen until a response was given. An interval of a grey background, two black boxes and a black cross was presented for 500 ms before the next trial began. An optional break was offered before starting the task, after

finishing half of the trials in each task (i.e. after 60 trials), between tasks, and after finishing the second task (i.e. presentation of tasks was counterbalanced between participants; Figure 4.1).

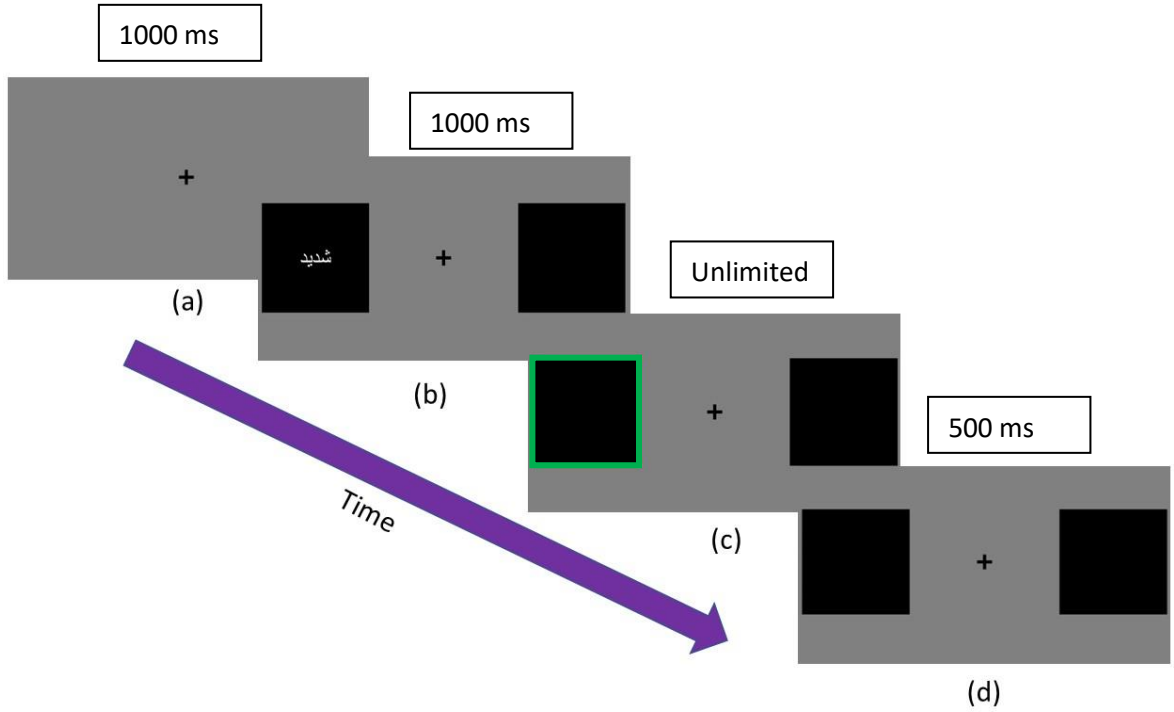

Figure 4.1: The Arabic version of the modified Posner task; (a) central fixation (1000 ms), (b) cue (1000 ms), (c) target (unlimited time), and (d) inter-trial interval (500ms). Participants were told to respond as quickly as possible according to degree of the colour of the target box frame (i.e. pressing "up" key for light green and "down" key for dark green).

4.3.6 Modified emotional Stroop task

Following instructions participants completed practice trials (n=20) using a neutral word to ensure being oriented and familiar with the task. A modified design of the emotional Stroop task by Ben-Haim and his colleagues (2016) was introduced to the participants. Each trial started with a single black square in the middle of the screen, with a coloured cue word in the middle. This square appeared on a grey background. Participants were instructed to respond to the colour of the cue word by pressing either the up arrow for red colour, the down arrow for green colour, the right arrow for yellow colour, or the left arrow button for blue colour. The square and word stayed on the screen until the participant responded. Then, the subsequent trial started immediately. In total, there were 120 trials in which each of the thirty words (i.e.

sensory, affect, neutral) was presented in all four possible colours. The presentation of the trials was randomised for both word types and colours (Figure 4.2).

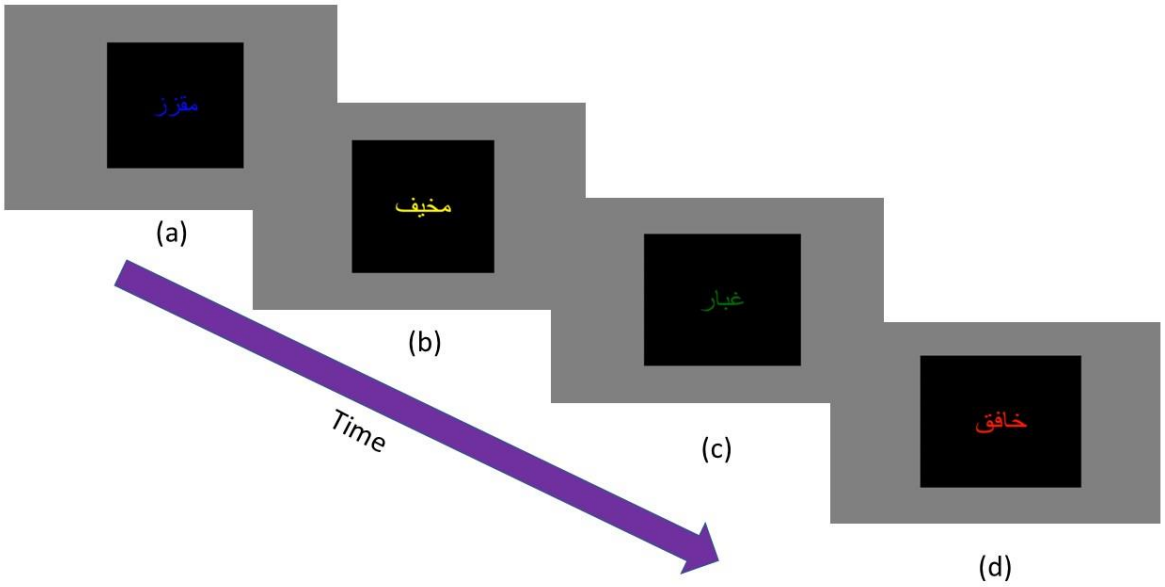

Figure 4.2: The Arabic version of the modified emotional Stroop task, (a) Sickening, (b) Fearful, (c) Dust, and (d) Throbbing. This shows an example of the temporal progression between randomised trials for word types and colour presented. Participants were instructed to identify and respond to the colour of the word as quickly as possible.

4.3.7 Procedure

The study was pre-registered on the open science framework (OSF) (Abudoush, Poliakoff, Panagioti, Hodkinson, & Husain, 2021). Pre-registration occurred at the beginning of the data collection and before any human observation. The research was conducted using a hybrid approach, that is, remote supervised sessions and face-to-face research sessions. Both approaches used the same experimental research and the same software to run the experiment on the Psychopy-Pavlovia website (Peirce, 2007). Because the experiment was already coded and fully automated, the setting type was not recorded as part of the experiment. An online remote data collection session was offered to begin with, especially at the beginning of the recruitment process due to Covid - 19 restrictions, then in-person sessions were added to the recruitment process while offering a remote data collection session to begin with. All participants were encouraged to use a screen with a standard size of 15.6 inches and a 1920 x

1080, 80 Hz display when possible. For the face-to-face sessions, the Covid- 19 regulations were followed carefully to avoid contamination or infection, including using personal protective equipment. Participants were encouraged to bring their laptops, when possible, to decrease the possibility of infection. Otherwise, an Acer laptop was used with 15.6 inches screen, with a windows 10 operation system, 1920 x 1080 pixels, 80Hz.

After ensuring that all regulations were met and setting the device for the experiment, the participant started the experiment with the examiner behind the participant. A pre-prepared mirror helped the examiner monitor and ensured that the participant's eyes focused on the middle of the screen. Participants were also instructed to minimise their head movements during the experimental tasks. After finishing the experiment, a qualitative interview was recorded (with participants who consented to do so) using the Zoom application with the camera turned off to maintain the consistency of the methodological approach used in the remote sessions.

For the remote sessions, one day before the experiment, the researcher sent an invitation link to the participant and ensured the appropriateness of the place where the research session will be conducted. Participants were instructed to use a laptop with a Windows operating system (version 7 or later), with the Zoom application installed on it (Zoom Video Communications Inc., 2022), and to choose a suitable place which has only the participant at the time of research, limit noise as possible, and reduce light and/or sits away from the window to avoid glare on the laptop screen.

At the beginning of the research session, the researcher welcomed, explained and checked that the setting was appropriate (i.e. minimize light, avoid glare on the screen, quiet and private room, and ensure that the device is around 60 cm distance from the participant) for the research session to start. Then, the researcher turned off his camera and muted the mic to avoid distractions while the participant was completing the experimental session. The participant camera stayed on, so the researcher supervised and ensured that the participant is engaging in the experiment and that participant`s eyes were focusing on the middle of the screen during the experimental tasks. Using the zoom chat box, the researcher then put the experiment's link and instructed the participant to use it to start the experiment. From there, the instructions embedded in the experiment guided the participant using the PsychoPy software pushed to the Pavlovia website (Peirce, 2007, Peirce et al., 2019). Regular breaks were offered to participants

during the research session, and the researcher checked that participants were comfortable or had anything they wanted to mention or ask about.

The chronological order of the experiment started with an automated consent form, then taking some demographic data (i.e Age, gender, education, social status, marital status, and country of residence). The CP group also answered the MPQ-SF at this point. Then, this was followed by answering the PSS scale and then the two experimental tasks (i.e. Modified Posner cueing task and Modified emotional Stroop task). The order of the presentation of the tasks was counterbalanced, and the trials in each task were randomised. After the experiment, the PSS-14 was presented again, assessing the pain severity using a numeric pain scale (i.e. as a sub-scale of the MPQ-SF scale). Next, the CD-RISC-10 scale was used to assess the resilience level, followed by the PHQ-9 to assess the depression symptoms level and the GAD-7 to assess the anxiety symptoms level. At the end of the experimental tasks and questionnaires, the last task was to evaluate on a Likert scale out of five degrees (i.e. from "1", which means not appropriate to "5" were very appropriate) whether the words used in the experimental tasks were appropriate and understood from the participant's point of view to be used in similar future experimental studies related to pain in general.

After finishing the experiment, the participants from the CP group who provided additional consent were interviewed to explore their opinion about the experiment and CP-attention-related experiences. Due to the large number of interviews conducted (N=51) and for practical reasons, this data were analysed and presented separately in the next chapter of this thesis. The total time of the research session lasted around 60- 90 mins for the CP group and around 60 to 70 minutes for the healthy control groups. Participants were compensated for their time according to the guidelines of UoM for reimbursement.

4.3.8 Analytical plan and data handling

No participant data was lost or missed due to the direct supervised one-session methodological approach for collecting data. The data was collected and stored securely on the Pavlovia server until the researcher downloaded it and stored it on a secured server provided by the University of Manchester. Then, data were cleaned and tidied using the R software version (Team, 2022) following the pre-registered analysis plan on the OSF and deviations from this are noted in the results section. All analysis were done using Rstudio software (RStudio Team, 2020). Data trimming steps are explained in Appendix 4.A. One participant from the healthy group had

more than 30% wrong answers on both experimental tasks and was consequently excluded from further analysis as planned in the pre-registration. Outliers were removed according to the pre-planned range (i.e. > 3000 ms or < 250 ms) since responses outside this window would indicate anticipation or a lapse in concentration.

Trimming of data was done using the interquartile data normalising equation (i.e. Q1 – 1.5*IQR, Q3 + 1.5*IQR) for each condition separately; then, participants' data with more than 30% data loss on all conditions in a particular task or 50% from a particular condition were excluded. This rule was developed after the pre-registration when looking at overall error rates but prior to any statistical analysis. The data were checked for normality using plotting (QQ-normal and density plots) and the Shapiro-Wilk test and log transformed when normality was violated. Because of the nature of the data collected (i.e. different levels of variables), an additional analysis of a multiple linear random mixed-effect regression model was used.

4.4 Results

For comorbid symptoms, anxiety symptoms were mild in the CP group (M = 7.40, SD = 5.05), and healthy controls (M = 5.54, SD = 4.58), with a significant difference between groups W = 2029, p = 0.035. Depression symptoms were also mild in the CP group (M = 9.55, SD = 5.61) and healthy controls (M = 7.33, SD = 5.53), with a significant difference between groups W = 2046.5, p = 0.028. On the SF-McGill pain questionnaire, the average pain intensity was severe in the CP group in the pre-experiment measurement (M = 5.83, SD = 2.04) and consistent with the post-experiment measurement (M = 5.79, SD = 2.03). The CP group described their pain mainly as being "distressing" to "horrible" (M = 3.64, SD = 1.02), which was consistent with post-experiment re-measurement (M = 3.53, SD = 1.17). The duration of the pain ranged between 4 months and 24 years (M = 7.11, SD = 6.41). Ratios of CP subtypes are summarised in Appendix 4.B. Healthy controls reported minimal pain levels both pre-experiment (M = 0.79, SD = 1.37) and post-experiment (M = 0.76, SD = 1.41). The overall mean response on the severity of subscales of the pain words (i.e. subscales words in the McGill questionnaire) for the CP group was moderate on both sensory (M = 1.50, SD = 1.18) and affect words (M = 1.86, SD = 1.16). Mean responses for each word were summarised in Appendix 4.C. The results from the analysis addressing each study aim are described in the next section.

4.4.1 RESEARCH HYPOTHESES

In this section, the results of testing different research hypotheses are explained. Because the investigations in this thesis included a new population (i.e., the Arabic population), some hypotheses needed more evidence to support using directional hypotheses, and thus, some hypotheses were non-directional.

4.4.1.1 Do individuals with and without CP show different patterns of attentional processing of pain-related information using different experimental tasks?

4.4.1.1.1 Hypothesis one: Assessing between-groups differences on the Posner task

For hypothesis one, the dependent variable was the reaction time, while the independent variable was the experimental group type, cue condition, and word type three-way analysis of variance (ANOVA) test revealed a significant main effect of group $F(1, 671) = 19.97$, $p < .001$ with the CP group being slower overall. However, no significant differences were found between word type and cue condition. Because ANOVA analysis cannot reveal the specific differences between different stimuli and word types necessary to explore the interaction on the words and cues levels, a random linear mixed effect model was used, which was an addition to the planned analysis. Analysis revealed significant overall differences between groups $t(140) = 2.43$, $p = .0166$, and significant differences between groups on sensory stimuli compared to neutral stimuli $t(580) = 2.61$, $p = .009$. The overall cueing effect was significant $t(583) = 3.22$, $p = .001$. The cueing effect direction (uncued minus cued) was negative. No significant differences were found between groups on the affect stimuli compared to neutral stimuli $t(581) = 0.52$, $p = .606$. Regarding the covariates, there were overall significant effects of age $t(101) = 5.99$, $p < .001$ (i.e. longer reaction time for older participants) and gender $t(102) = 3.00$, $p = .003$, (i.e. longer reaction time for males) but not on education, income level, marital status, or country of residence (Appendix 4.D). The CP group took more overall time to react to a neutral stimulus compared to sensory stimulus $t(112)=2.44$, $se = 0.022$, 95%, $p = .016$ with mean of difference $m = -0.054$, CI [-0.098, -0.01] reflecting a longer response to neutral stimuli (i.e. mean sensory-mean neutral = -54 ms), and compared to healthy controls $t(109) = 2.\ 9$, $se = 0.022$, $p = .019$ with mean of difference $m = 0.052$, 95% CI [0.009, 0.096] reflecting a longer response in CP group (mean CPG - mean HCG = 52 ms).

Between groups and within groups means comparisons using cueing effect (i.e. uncued minus cued reaction time) are illustrated in Figure 4.3, and summarised in Appendix 4.E. Figure 4.3 illustrates that the control group shows IOR (i.e. faster uncued than cued RTs) with all word

types, whereas the CP group shows IOR only towards sensory words. The key finding was the sensory-neutral difference for the CP group. The overall model R squared (0.88). The best-fit model was used according to the Akaike information criterion (AIC) value of -1063.52, and the Bayesian information criterion (BIC) value of -950.36 (Burnham, & Anderson, 2004).

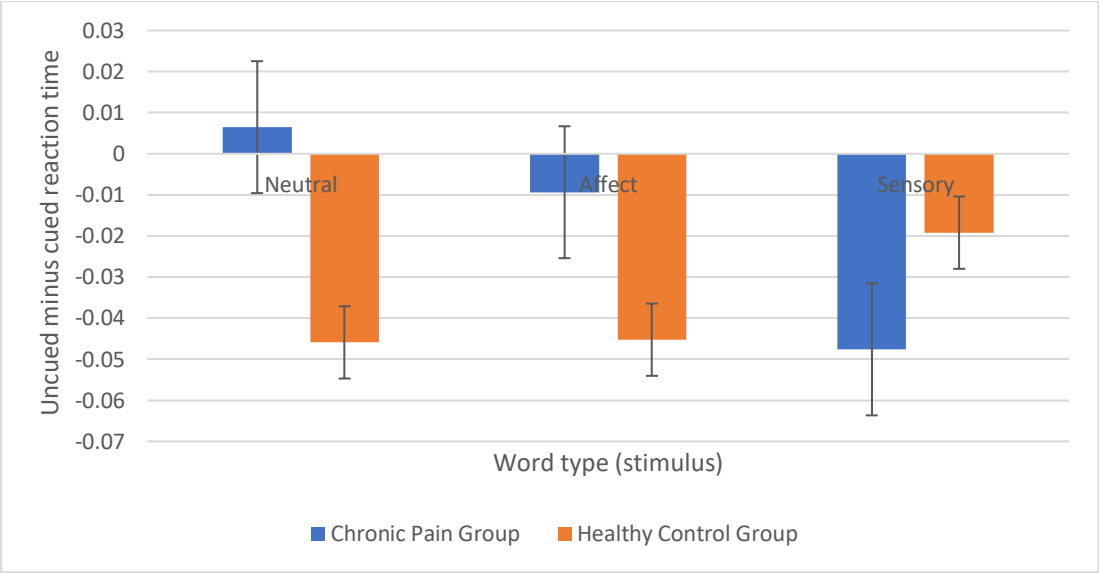

Figure 4.3: Mean (standard error of the mean) of the uncued minus cued reaction time difference for the chronic pain and healthy control groups in the sensory, affect, and neutral words conditions.

4.4.1.1.2 Hypothesis two (Assessing between-groups differences on the Stroop task)

The dependent variable was the reaction time, while the independent variable was the experimental group type and pain-related information condition. An ANOVA revealed significant differences between groups $F(1, 312) = 8.00$, $p = .005$, with CP group had a slower overall reaction time compared to healthy controls (Appendix 4.D). Non-significant differences between word types $F(2, 312) = 0.21$, $p = .812$, and non-significant group*word interaction $F(2, 312) = 0.05$, $p = .954$ confirmed the null hypothesis that there are no significant differences between-group or within groups detected.

4.4.1.1.3 Hypothesis three (Correlation of performance of CP group on Posner and Stroop tasks)

Pearson correlations were used to explore correlations between different stimuli used among both the Posner and Stroop tasks in the CP group. Pearson correlation coefficient between CP individuals' performance on the Posner task (i.e. using cueing differences uncued - cued) versus emotional Stroop task (i.e. reaction time) revealed a non-significant weak negative

correlation between affect words $r(51) = -0.16$, $p = .258$. Non-significant correlations were found for sensory words $r(50) = 0.07$, $p = .617$, and neutral words $r(51) = -0.08$, $p = .550$ (Appendix 4.F).

4.4.1.2 Assessing whether psychological resilience moderates the attentional processing of pain-related information in individuals with CP.

3.1.2.1 Hypothesis one (Assessing between-group resilience differences)

An independent samples t-test revealed a significantly lower resilience level in the CP than the healthy control group $t(111) = -2.56$, 95% *CI* [-4.95, -0.63], $p = .012$ (Figure 4.4).

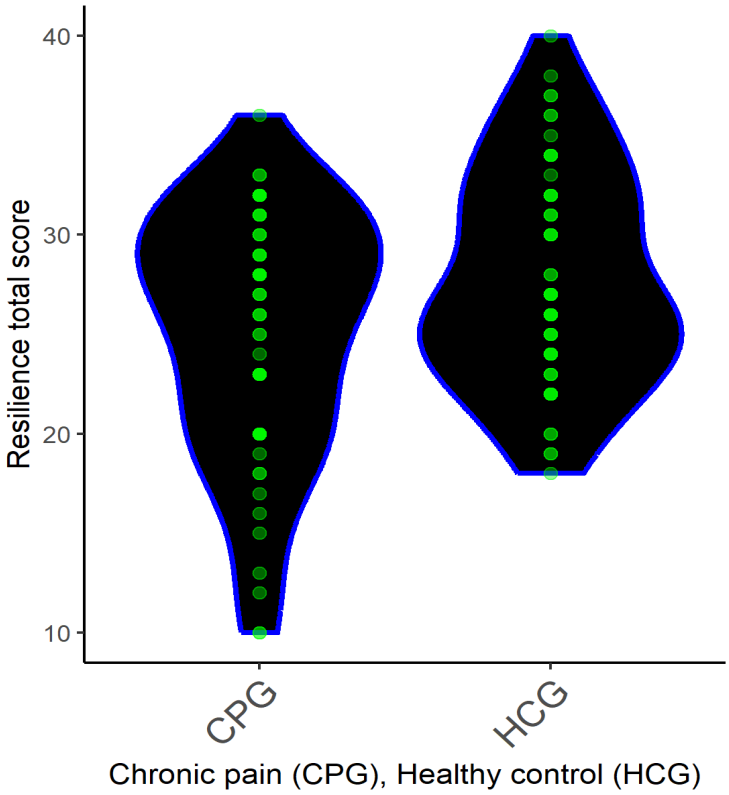

Figure 4.4: Violin plotting of the spread of resilience total score for the chronic pain group (CPG) versus the healthy control group (HCG).

4.4.1.2.2 Hypothesis two (assessing the moderation effect of resilience differences between groups on Posner and Stroop tasks)

A multiple linear random mixed-effect regression model was used to tackle this hypothesis. An interaction factor term (i.e. group type*word condition*resilience score) was made for assessing the moderation effect of the psychological resilience level on participants' performance on the Posner task (i.e. using cueing differences between uncued minus cued

condition as the dependent variable) and revealed a significant between groups effect $t(217) = -2.17$, $se = 0.003$, $p = .031$ for sensory words compared to neutral words. Overall, the CP group showed lower cueing effect differences and lower resilience scores compared to the healthy group. Healthy controls showed an overall positive association between the level of resilience and cueing effect, while this was less obvious in the CP group (See scatterplots in Appendix 4.G). while non-significant $t(214) = -1.77$, $se = 0.003$, $p = .079$ for the affect words. R squared =0.49, AIC = -471.86, and BIC = -418.34. For the emotional Stroop task, the interaction with resilience was not significant for either sensory $t(204) = 0.503$, $se = 0.003$, $p = .616$ or affect words $t(204) = -1.106$, $se = 0.003$, $p = .915$.

4.4.1.3 Effects of participation in the attentional tasks on perceived stress levels

4.4.1.3.1 Hypothesis one (Assessing post-experiment between-groups differences in perceived stress)

The perceived stress levels of both experimental groups were normally distributed. Data were compared using the analysis of covariance (ANCOVA) test to assess between groups post-experiment assessment points while controlling for pre-experiment baseline measurement and other covariates. Differences between experimental groups were significant $F(1,100) = 7.40$, $p = .008$, with the CP group having higher perceived stress scores than healthy controls. However, when assessing the post-test results, the interaction between group type*pre-test revealed non-significant differences $F(1,100) = 0.27$, $p = .604$. The effects of all other covariates controlled for (i.e. age, gender, education, country, income level, and marital status) were non-significant.

4.4.2 Evaluation of word stimuli

Both groups evaluated the words used in the study at the end of the experiment for the CP group (M = 4.28, SD = 1.60) with mean appropriateness of 85.6% (i.e. 4.28 out of 5), and the healthy control group (M = 4.26, SD = 1.66) mean appropriateness of 85.2% (i.e. 4.26 out of 5). The descriptive statistics for the words are listed in Appendix 4.H.

4.5 Discussion

This study examined the attentional biases and processes in the Arabic population, the role of resilience on attentional performance, and the perceived stress among this population. Regarding the first aim of the study, the analysis of results based on the overall reaction times from the Posner task showed that the CP group did not respond more quickly to words related

to sensory pain-related stimuli than the control group. However, they responded more quickly following sensory cues than to neutral cues, which has not been reported in the previous literature (Crombez et al., 2013; Abudoush et al., 2023). This difference might have resulted from the tendency of CP participants to disengage early from sensory information through responding to it quickly.

Because the presentation time was relatively long, a negative cueing effect was observed – the *"inhibition of return"* (IOR) effect (Li et al., 2017). While healthy controls showed IOR across the different cue stimuli, the CP group exhibited IOR only for the pain-sensory stimuli. In IOR, participants disengage from the cued location and become faster in responding to the uncued location. IOR usually occurs when an exogenous sensory stimulus is presented at the periphery of the visual-spatial location of fixed eyes due to a delay in attentional response to the cued stimulus (Klein, 2000). Thus, the CP group showed delayed disengagement for the neutral stimuli and faster disengagement (i.e. IOR emerged) for the sensory stimuli. This suggests that the nature of the cue affected the dynamics of the disengagement process, as seen for participants with non-clinical somatoform dissociation in a study using tactile stimuli (Brown, Danquah, Miles, Holmes, & Poliakoff, 2010).

This study applied a slightly later time point than most other studies and found an IOR effect, which reflects the fact that the findings in this study differ from previous hypotheses related to the vigilance-avoidance pattern stemming from experiments in the anxiety field (Mogg, & Bradley, 1998; Mogg et al., 2004; Todd et al., 2015). Also, by using 50% valid cues we were more likely to observe IOR. Previous studies that explored long presentation time points using non-predictive cues (i.e. 50%) did not report IOR effect (Liossi et al., 2010; Schoth, & Liossi, 2013; Garland, & Howard 2013; Fashler, & Katz 2014, Mazidi et al., 2019). Because there were no similar previous studies in the Arabic population, a comparatively longer presentation time (i.e. 1000 ms) was chosen due to language processing differences (Bentin, & Ibrahim, 1996; Farghaly, & Shaalan, 2009). However, the fact that an IOR effect was produced in most conditions in the control group indicates that the Arabic language might not need longer processing time as previously thought. Thus, future research should aim to replicate a similar study with more than one presentation time (i.e. >500 ms and < 500 ms) to explore both earlier and later components of attentional orienting.

Regarding between-groups differences in the emotional Stroop task, the CP group had a slower overall reaction time compared to healthy controls, but these differences were non-significant. It might be that such differences relate to general cognitive or dexterity issues, which merits further investigation. Because participants in the CP group were overall slower, this might mean that the inclusion of pain-related stimuli in the experiment might was slowing participants down. This could be due to the nature of this task, which calls upon different processes, especially since the Stroop task presentation time is unlimited until the response is given. The results of the correlations similarly revealed differences for the Posner but not the emotional Stroop task. This is expected given that these experimental tasks measure different attentional processes (Cisler et al., 2009). While participants` IOR observed suggested a pattern of early disengagement in the Posner cueing task, there was an overall slower response in the CP group in the Stroop task yet non-significant differences between the word types. From these results, it appears that looking at the dynamics of spatial attention is where there are group differences.

The emotional Stroop task relies on the interference of the meaning of the stimulus with the performance of the task. The participant needs to respond to the colour of the word; thus, the meaning could form a "cognitive slap" that hinders executing the task instead of grabbing attention (De Ruiter, & Brosschot, 1994). The development of fear stems from a basic survival instinct when a person faces a threat that might cause them sensory harm (e.g. lion). However, it is unclear why affective pain-related information did not have a similar effect in the Posner task, given that affective experiences trigger the same areas in the neural system. The somatic experiences generated by the sensory pain words might explain this difference (Satpute et al., 2015). The evidence around the affective pain-related information is much related to idiosyncratic cognitive reasoning and still at a preliminary evidence level which could partially justify the more salient effect of the sensory information (Patterson, Rothstein, & Barbey, 2012; Abudoush et al., 2023). Thus, further experimental research is needed to explore this phenomenon in different paradigms and different stimuli.

The second aim of the study focused on the role of resilience. As expected, the CP group had significantly lower resilience than healthy controls. This aligns with the notion that CP is associated with low resilience and higher distress levels (Goubert, & Trompetter, 2017). Interestingly, resilience was found to moderate participants' performance in the Posner task. Healthy controls showed an overall positive direction of effect for the level of resilience and cueing effect (i.e. sensory and affect words). This means higher resilience was associated with

a lower magnitude of (more positive) IOR and potentially later disengagement. However, the direction of the effect was not clear for the CP group regarding the affect pain-related cues but showed that extreme resilience levels (i.e. very low or high) were associated with higher magnitude of (more negative) IOR for sensory pain-related cues (Appendix 4.G). The results show that individuals with CP may avoid (or disengage early from) distressing information instead of facing them because of either high avoidance pattern (i.e. low resilience) or flexible management (i.e. high resilience) when exposed to threat (Crane, & Searle, 2016). Although the distress avoidance pattern is usually found in people with lower resilience, it is also salient in individuals with CP (Ramírez-Maestre, Esteve, & López-Martínez, 2014). Future studies should further explore the spatial cueing-resilience association over several time points. Furthermore, integrated interventions that include using attentional bias modification (Sharp et al., 2012; Carleton et al., 2020) could be promising in re-orienting attention when exposed to distress related situations.

Because this is the first study in the Arabic population, we explored the potential effect of experimental tasks on the overall perceived stress levels between groups. Although significant differences were found between groups at baseline, perceived stress levels did not differ significantly between groups after the experiment while controlling for baseline measurements. These results indicate that exposure to pain-related information within a research study is not unduly distressing in the Arabic population, setting the scene for potential future studies with this population. This suggests it is reasonable and ethical to use these approaches, and it suggests that attentional bias modification tasks would also be reasonable to use within interventions.

Piloting the experiment with non-Arabic speakers ensured the practical design of the experiment. Another strength of this study was the involvement of an individual with a CP in the research development who provided vital comments and feedback that enhanced the presentation of the experiment and improved the overall experience of the participants and made them feel comfortable during the experimental session. Public involvement became a more common practice in recent research studies in the cognitive neuroscience field (Sullivan, & Poliakoff, 2023). Additionally, participants evaluated the words used in the experiment. The results of word evaluation revealed a high appropriateness of the words used from both experimental groups. This Arabic word list is essential for future research on this population.

For these reasons, this study is a pioneer project in the SA-CP field and would allow a deeper understanding of SA mechanisms in the Arabic population.

The design of this hybrid experimental study provided a flexible approach that overcame health restrictions, and distance barriers enabling recruitment from two countries. Controlled experiments can be accessible, and feasible with this methodological design. The advantages, disadvantages, designing, and implementation of online behavioural experiments, such as easy access and cost-effectiveness versus difficulties related to controlling the experimental environment, have been discussed within the broader experimental psychology literature (Sauter, Draschkow, & Mack, 2020; Zaadnoordijk, & Cusack, 2022). Future research should consider the controlled hybrid and remote application of the experiments done in this study as an effective, cost-efficient, and more accessible option to CP individuals, especially those living in the distant, less fortunate area. Such methodologies ensure that experiments are controlled yet can be accessible by the target population.

Despite the promising approach used in this study, there were several limitations; first, the ability to control the setting of participants was challenging and the researcher had to apply extra checks. Second, limitations on the duration of the experiment meant that we could only look at one-time point post cue. Third, a limitation is that the group differences were observed in additional rather than pre-planned analysis, so replication will be essential. Fourth, the similar experimental approach between groups and participants' awareness of the nature of the study and supervision might increased their feelings of being observed, which encouraged participants to maintain focus on the task. However, it might have also increased the potential competition between groups. Such competition could contaminate the results if the control group changed their behaviour because of the feeling of being under observation. This effect is also known as the Hawthorne effect (Sedgwick, & Greenwood, 2015). Fifth, for practical reasons using eye-tracking technology was not possible in this study. Eye-tracking technology would help overcome the potential response bias that can occur in spatial reaction-time-based tasks (Jones et al., 2021). Although response bias was avoided in the Posner task by using a discrimination response that prevented responses from relying solely on spatial location (i.e. through identification of the cue type), eye tracking would be a possible next step in the research with the Arabic population.

In addition to the recommendations mentioned above, it is important to assess the attentional biases of Arabic individuals with CP through other types of stimuli, which would give a further understanding of the attentional tendencies and processes in this population. For instance, combining reaction time tasks with words or pictorial stimuli, along with other potential easy-access technologies, can be an advanced step that helps link findings with other studies from different cultures. Further, because attentional biases appear to be involved in the difficulties that affect the functionality and quality of life of individuals with CP (Todd et al., 2015), developing easy access, and reliable assessment procedures is crucial. This would enhance establishing an agreed cross-cultural format of experiments and settings. Finally, the pre-registration of this study ensured the high quality of the methods used. It also recruited open-access technologies that made the experiment reproducible. Many previous studies needed a similar approach, which affected data availability and reproducibility (Abudoush et al., In publication). Thus, we recommend that future studies use such open-access reproducible designs.

4.6 Conclusion

This first experimental study of attentional biases in the Arabic-speaking population with CP revealed the importance of the cross-cultural experiments that involve participants from low and middle-income countries. The healthy control group showed IOR across all conditions and were not significantly influenced by the condition, while the CP group was influenced by the condition with the IOR effect only evident in sensory pain-related information condition. This suggests that the timing of disengagement of attention is affected in CP. Resilience levels in the CP and control group moderated the performance on the Posner task, suggesting that resilience might play an important role in attentional performance. Yet, completing the experiment did not affect their perceived stress levels, implying that using such experimental tasks is ethical in this population. This paves the way for future research in the field of SA-CP among Arabic participants, which could benefit from the findings and recommendations made.

Chapter 5

THIS IS THE TITLE OF A PAPER INCLUDED IN THE THESIS

Exploring Chronic Pain Related Attentional Experiences, Distress and Coping Strategies, Among Arabic-Speaking Individuals in Jordan and The United Kingdom: A Framework Analysis

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5.1 Abstract

Introduction: The patient experience of chronic pain (CP) has rarely been explored in the literature among Arabic-speaking populations. Understanding the experiences, impacts on attention, coping mechanisms, and perspectives of individuals with CP about existing treatment options would help to find better ways to support this population in managing their CP. **Method**: Using a qualitative descriptive design, one-to-one qualitative interviews were completed with fifty-one participants with CP following the completion of an attention experiment. Interviews were conducted using a semi-structured topic guide, transcribed verbatim and translated from Arabic to English before agreeing on the coding framework. Theme and subthemes were extracted using a framework analysis approach. **Results**: Six main themes were identified; (1) Factors contributing towards developing or exacerbating CP, (2) the impact of CP, (3) perceptions about available treatments, (4) the perceived role of social support, (5) strategies to cope with CP and (6) patient-led recommendations for interventions. The relationship between attentional experiences and CP was reciprocal and affected by different contextual and cultural factors. **Discussion**: CP impacts several physical and psychosocial functioning areas, including attention. Despite using various approaches to manage their CP, none of the participants used psychological interventions or counselling. It is crucial to understand the diverse impacts of CP and the coping strategies employed to develop culturally sensitive interventions, review current policies, and improve the healthcare services.

5.2 Background

Chronic pain (CP) affects more than 30% of people globally, and hence is a significant contributor to personal and economic burden (Cohen, Vase, & Hooten, 2021). Two CP conditions (neck pain and back pain) are amongst top leading causes of years lost to disability (Vos et al., 2017). International studies and a few studies among Arabic populations concur that the prevalence of CP is high; 20% - 46.4% in Arabic populations (Elzahaf, Johnson, & Tashani, 2016; Almalki et al., 2019). Attentional biases are one of the factors found to be linked with CP (Crombez, Van Ryckeghem, Eccleston, & Van Damme, 2013). The main focus of the previous literature has either been the quantitative scaling of CP-related symptoms or exploring the experience of CP and its subtypes (MacNeela, Doyle, O'Gorman, Ruane, & McGuire, 2015). There is established evidence that the psychological impact of CP can affect the well-being of individuals and have a multifaceted impact (Tanaka, Okita, Jenkins, & Kozu, 2022). However, the subjective experiences of attention in daily life have not been explored in the Arabic population (Crombez et al., 2013; Abudoush et al., In publication). In addition to attentional experiences, exploring different factors contributing to maintaining CP and related dysfunctionality among Arabic individuals is essential.

Because of its chronic nature, coping with CP is a key component in understanding how positive or negative strategies are used to survive on a daily basis (Dysvik, Natvig, Eikeland, & Lindstrøm, 2005). Autonomy-driven approaches encourage individuals with CP to be more independent and resilient, which helps active engagement in therapy and life (Gittell, 2016; Gorman-Badar, 2020). Thus, exploring the available options for managing CP and related difficulties among Arabic individuals is essential.

Using a mixed-method approach (i.e. conducting a qualitative study alongside the experimental task and quantitative questionnaires) to explore CP and attention-related experiences can balance out the limitations of each method and provides a deep insight into the perspectives of the individuals on challenges accompanying CP and their views about possible interventions. (Kelle, 2006; Ritchie, Lewis, Nicholls, & Ormston, 2013). Further, exploring the experiences of Arabic individuals with CP can help to explore the sociocultural factors (e.g. social values, religious believes, and language) that might be specific to this population. The sociocultural perspective is important to understand the CP because of its multidimensional impact on shaping how individuals respond and cope with their CP. Understanding how CP-related difficulties affect individuals is essential in understanding how attention-related intervention

might be developed through patient-driven options, considering a culturally sensitive approach. To address this research gap, this study aimed to explore the attentional experiences, coping mechanisms and suggestions for treating CP among Arabic-speaking individuals in Jordan and the United Kingdom (UK).

5.3 Methodology

5.3.1 Design

A qualitative study nested within an experimental study. All the participants in the CP group (experimental group) of the study were invited to participate in the qualitative part of a larger empirical study.

5.3.2 Setting

This was a hybrid study with participants recruited from pain clinics, physiotherapy clinics, community centres, and hospitals from two study sites (i.e. Jordan and The United Kingdom). For complete information about the design, see the original experiment by Abudoush and his colleagues (Chapter 4).

5.3.3 Eligibility criteria

5.3.3.1 Inclusion criteria

Arabic-speaking individuals with CP (i.e. pain for 3 months or more) who were aged 18 years or above, have a normal or corrected to normal vision, have a native speaking, reading, and writing of the Arabic language, resident of either Jordan or the United Kingdom at the time of the experiment, can complete experimental tasks with 70% or more of accuracy assessments, have access to a laptop or desktop with an internet connection for at least 90 mins for one time, willing to participate in the study, and can provide informed consent.

5.3.3.2 Exclusion criteria

Individuals were excluded if they were having any severe or uncontrolled mental or medical disorders that would affect their participation and/or having a current acute or subacute pain.

5.3.3.3 Description of the experiment

The main experimental study was pre-registered on the open science framework (OSF) (Abudoush, Poliakoff, Panagioti, Hodkinson, & Husain, 2021).

5.3.4 Recruitment

The study was approved by the University of Manchester Research ethics committee (UREC) (2022-11074-21987) and the Jordanian Ministry of Health (MoH) (Moh/REC/2021/233). A total of 116 participants (N = 58 in the CP group and N = 58 in the healthy control group) matched for age, gender and country of residence were recruited through online advertisements and posters at pain clinics, physiotherapy clinics, community centres, and hospitals. Interested potential participants directly contacted the researcher for participation and were screened against study eligibility criteria, followed by sending and explaining the participant information sheet (PIS). Participants received reimbursement for their time.

For the qualitative nested study, participants from the CP group who gave additional consent for the interview were included. All 58 individuals with CP who participated in the main experiment were invited for a one-to-one interview. Seven of them did not consent to participate. A total of fifty-one participants formed the final sample and completed the interview.

Although there are no specific limits for the sample size in the qualitative interview, it is worth mentioning that our sample is considered within a reasonable sample size range (Dworkin, 2012). A reasonable sample size would ensure that all possible themes and subthemes are covered in the study and that there is no new data generated when conducting additional interviews. Dworkin (2012) suggest a sample size that range between -but limited to- 5 and 50 participants.

5.3.5 Data collection

A semi-structured interview was conducted directly after the experimental study. A semi-structured topic guide was developed to facilitate the interview. The topic guide aimed to explore four main areas to identify and elicit details on the following;

1) How the daily attentional experiences affected by CP,

2) Attention experiences related to exposure to pain-related cues,

3) Participants' perspectives on coping with CP, and

4) Participants' views about possible interventions that could be of benefit.

The topic guide was developed by two authors (AA and TK) and reviewed by the other co-authors. To ensure the suitability of questions included the topic guide was reviewed by the

PPIE member and modified according to their feedback. It was also updated during the period of data collection phase according to the feedback from participants. The first section included the questions around the daily attentional experiences affected by the CP, which is essential to understand the impact of the CP on their attention especially those related to the tasks that require attention. The second section explored the included the attention experiences related to the exposure to pain-related cues, which is essential to understand the effect of participating in experimental study that contains pain-related cues in the Arabic population. This is essential for future research in this population. The third section included the different perspectives related to coping with CP, which is essential to understand the patterns of adjusting to attention-related difficulties and what coping strategies might helped in overcoming such difficulties. The last section in the topic guide was about the possible interventions, which explore the participants opinions about what could help them to overcome the challenges related to the CP and related attentional difficulties.

The interviews were conducted by the first author (AA), who is bilingual (i.e. Arabic and English), an experienced clinical psychologist who has worked with patients with CP for many years. All interviews were conducted using the Zoom application (Zoom Video Communications, 2022), audio recorded and saved on a secure server until the transcription phase was done. All interviews were transcribed by two authors (AA and KA) and reviewed for accuracy. Initial seven interview transcripts were translated into English and coded by (AA), and these coded transcripts were discussed with a senior qualitative researcher (TK). Both AA and TK agreed on an initial coding framework. For the remaining interviews, Arabic transcripts were coded using the coding framework by (AA) and only coded verbatim were translated from Arabic to English. To minimise the loss of meaning, the authors followed the recommendations of Van Nes and her colleagues (Van Nes, Abma, Jonsson, & Deeg, 2010). For example, the authors used fluid descriptions of meanings when necessary, rather than relying only on the direct translation to allow for an accurate contextual meaning of the verbatims. The mean duration of the interview was around 25 minutes.

5.3.6 Analysis

An inductive framework thematic approach was used to analyse the results (Gale, Heath, Cameron, Rashid, & Redwood, 2013; Ritchie et al., 2013). The first author conducted the familiarisation stage (AA) and reiterated through transcripts to fully understand the data. Then, researchers independently coded seven interviews (AA &TK), discussed the code resulted and

agreed on the framework themes and sub-themes. Next, the first author (AA) completed coding and categorising the other forty-four interviews independently. Then, TK reviewed all interview codes, and translated verbatims to ensure accurate coding and categorisation. A discussion between all authors was held to agree on the analytical decisions and then on the final codes matched to the verbatim list.

To ensure the quality of the analysis and the reasonableness of the sample size, researchers by considered the data saturation concept during the analysis process (Braun, & Clarke, 2021). Further, because of the numerous subtypes of CP a large sample was essential to ensure covering different aspects of CP related experiences. The resulted large data was manged by the researchers (AA and KA) under the supervision of a senior qualitative researcher (TK). Using framework analysis helped in organising such data in a structed way for easier interpretations. The auditability of analysis was ensured through re-iteration of the transcripts, agreeing on the code book (i.e. framework identification), and regular review of the progress of data analysis. Further, despite the potential effect of the prior experience of the researcher on shaping the findings, the researcher bias was avoided through ensuring that different co-authors involved in all steps and decisions related to data analysis.

5.4 Results

The demographic characteristics of all participants are described in Table 5.1. All participants have Arabic ethnicity. The average pain intensity (i.e. out of 10 points) between interviewed participants was moderate to severe (M = 5.67, SD = 2.07). The pain duration ranged between 4 months and 24 years (M = 7.21, SD = 6.53). Ratios of the pain subtypes are summarised in Table 5.2.

Table 5.1: Demographic variables of the overall sample and between countries

Demographic variable		Chronic pain group-Jordan (N=33) 64.71%	Chronic pain group -UK (N=18) 35.29%	Total chronic pain group (N=51)
Age		M = 43.67, SD=14.60	M =39.56, SD = 12.06	M= 42.22, SD= 13.77
Gender	male	(N = 19) 57.58%	(N = 12) 66.67%	(N = 31) 60.78%

	female	(N = 14) 42.42%	(N=6) 33.33%	(N =20) 39.22%
Education level	Primary	(N =1) 3.03%	(N=1) 5.56%	(N = 2) 3.92%
	High school	(N =16) 48.48%	(N=0) 0.00%	(N = 16) 31.37%
	Undergraduate	(N =15) 45.45%	(N= 9) 50.00%	(N = 24) 47.06%
	Postgraduate	(N =1) 3.03%	(N = 8) 44.44%	(N = 9) 17.65%
Income level	High	(N =2) 6.06%	(N=1) 5.56%	(N = 3) 5.88%
	Medium	(N =21) 63.64%	(N =11) 61.11%	(N = 32) 62.75%
	Low	(N =10) 30.30%	(N =6) 33.33%	(N = 16) 31.37%
Marital status	Single	(N =6) 18.18%	(N =3) 16.67%	(N = 9) 17.65%
	Married	(N = 22) 66.67%	(N = 15) 83.33%	(N = 37) 72.55%
	Widow	(N = 4) 12.12%	(N=0) 0.00%	(N = 4) 7.84%
	Divorced	(N = 1) 3.03%	(N=0) 0.00%	(N = 1) 1.75%

Table 5.2: The ratio of participants across CP subtypes

Type of chronic pain	low back pain	Neck pain	Back pain	Headache (including migraine, tension headache, cluster headache, sinus headache)	Post-injury chronic pain (musculoskeletal, burn,	Ulcerative colitis	Epigastric reflux acidity // Acid reflux and GERD	Non-injury related limb pain (Osteoarthritis, overuse, ..)	Rheumatoid arthurites (RA)	Irritable bowel syndrome (IBS)	Planter fasciitis-bone spur
Ratio Jordan	**7**	**4**	**-**	**5**	**4**	**1**	**2**	**5**	**1**	**1**	**3**
Ratio UK	**5**	**2**	**1**	**4**	**5**	**-**	**-**	**1**	**-**	**-**	**-**
Ratio total	**12**	**6**	**1**	**9**	**9**	**1**	**2**	**6**	**1**	**1**	**3**

5.4.1 Framework analysis themes

The findings were synthesised into six main themes. The formation was driven by the related topics discussed with the participants and the agreed-on set of codes made after analysing the first seven interviews. Several iterations were done to ensure that all additional codes that emerged during analyses of the rest of the transcripts were fully reflected in the final coding framework. A framework was created comprising fifty-one interviews and six main themes representing the main study's objectives around lived experiences of CP, reciprocal impact between CP and attention on daily attentional experiences and exposure to pain cues, available treatments and perspectives about coping strategies with CP. Because currently qualitative software cannot analyse Arabic text (e.g. Nvivo) or cannot capture the specific verbatims words as assessed by authors (e.g. Atlas.ti), the data were manged using Excel sheets (Niglas, 2007; Hwang, 2008; Dhakal, 2022).

5.4.1.1 Factors contributing towards developing or exacerbating CP

Different factors were identified as contributing to developing, exacerbating, or maintaining CP among Arabic-speaking individuals. These factors were explained through five subthemes.

A) The impact of psychological status on CP

Participants perceived that the severity levels of CP were related to their psychological conditions. A couple of participants from both study sites highlighted the connection between their mood and the pain they experienced, and one participant shared as

"*I feel that if I'm emotionally tired and I have pain, the pain can also increase, but if I have pain and my mental health is good, the pain does not decrease, but I think of it less."* (P44).

Many participants firmly stated that the pain intensity went in tandem with stress at home or work. Psychosocial pressure, such as stress at work, the tension of assignments, and family pressure, intensified the pain. One female participant reported;

"*If I increased my concentration more than what was needed, the pain increased because I would have been in stress, but if my concentration was normal and moderate, which is a regular day, for example, that you work during the day in the normal hours, so that is fine*" (P49)

B) *The impact of work/job related factors on CP*

Work behaviours were one of the sources that exacerbated the CP. Nature of work, such as *sedentary* (P43), or having worked in a prolonged fixed position, e.g., *long screen time in one position* (P35), or *excessive standing* (P32), had an effect on the degree of pain suffered. Participants realized their pain increased with *specific postures at work, mainly when they had a deadline* (P49). One female student participant expressed how her routine at the study workstation was connected to the pain.

"I feel that the pain increases when I work a lot on a computer or when I am stressed, I mean, lots of things to do on that day. It is not a requirement that it be related to study, (but) it means that it is related to my normal life. You know, this is what happens when I feel that it is a period of tension, a period of pressure." (P1)

C) The impact of environmental factors on CP

Participants identified that lifestyle factors such as diet, obesity, *"not exposing enough to sunlight"* (P3), *"cold weather"* (P13), and *"lifestyle stress"* (P12) had an effect on CP. Food

quality or the type of food influenced the development of CP in a few participants. Some kinds of food, for instance, ready-made food, were perceived as inappropriate for their illness, and that *"food is not giving benefit"* (P3), which made their pain worsened. Therefore, they tried to follow a healthy diet. For one particular housewife, *"weight gain"* (P42) made her CP persistent.

D) ***The relationship of attention with CP*** is consistent with the notion that focusing on pain intensifies it, whereas diverting attention towards something else decreases the pain (P12), and one participant described it as a "*paradoxical effect*" (P17):

"I continue feeling the pain when I focus on the pain, I mean if I did not distract myself (to something else)." (P11)

Participants also mentioned other ways in which attention can contribute to exacerbating pain. They reported that tasks requiring greater attention could increase pain intensity. Pain became noticeable when they focused on specific functions, e.g., reading or working at home. This experience was also related to body posture while concentrating on computer-related tasks. Student participant experienced it and shared:

"When I am concentrating on something, or I have something, the pain increases, yeah, exactly it increases if I read or study or work at home, all of these increase the pain". (P16)

E) The Impact of exposure to pain-related information in experimental tasks

Some participants highlighted that conducting attention experimental tasks needed concentration and extra effort to keep focusing on the task, which made them a *"little exhausted"* (P13). One participant explained the pain-related information:

"It is possible some words for me, they are, as I told you, big. For example, such as kicking out and stabbed" (P42).

Nevertheless, other participants saw this attentional exposure as a source of *"excitement"* (P1) or as *"brainstorming*" (P9). One participant explained the experience of attention during the experimental task as follows:

"If I focus on the thing that they told you to, on the cross, you will find it easy, great, if I start to oversight and look at the words, I forgot once or twice, and so I realised that I got mixed up…if I focused on the information that I have, the cross sign, and focus on the colours and answer fast with focus, but if you scattered the words you cant" (P32).

Positive feedback on the experiment was also reported by the participants. Participants highlighted that the activities included in the task were enjoyable. *The "rehearsal"* (P42) part helped them to be prepared for exposing to pain-related information and conducting the experimental tasks. Comments from participants included the importance of the interaction with the task during the experiment. One male participant highlighted that the good thing about the attention tasks was that they *"made one reflect on themselves in relation to the topic of attention, sometimes we do tasks, or we carry out tasks without concentrating or with partial concentration" (P50).*

5.4.1.2 Impact of Chronic pain (CP)

Three subthemes that explain the impact of CP were identified from the interviews as follows:

A) ***The impact of CP on attention*** was frequently mentioned in different forms, including *"If pain is severe, I have to stop doing the task because it affects my concentration ability"* (P2) and that *"focusing tires and exhausts me when I am in pain"* (P20), and *"it distracts my attention"* (P21). Interestingly, some participants linked the severity of pain (P49) with the attention they had throughout the time of the day, which one participant reported as follows:

"*It depends; sometimes, when the pain is severe, my concentration becomes scattered depending on the degree of pain during the morning, noon and afternoon. In the afternoon, the pain is very intense."* (P23).

Moreover, the interruption caused by CP on attention can be seen in different dimensions of life. The pain made it difficult for the participants to focus on their surroundings or work. They were required to put more effort when they tried to remain focused on what they were doing, such as communicating with others (P50). One participant shared his experience:

"All of your focus is on your pain, so you are not conscious about what is happening around you, like, when you are in a certain gathering, you won't be aware of some things there, who is there, who is praying, who is working, what is required from you. All your concentration, body and senses are focused on the pain" (P33).

B) Impact of CP on psychological status was evident among some participants, such as CP perceived as "*distressing*" (P26) and "*psychologically irritating that increases negativity"* (P31). Participants were usually angry and frustrated (P19) as they had to live with CP, under pressure (P18), or feeling trapped, and they perceived that they could not have a normal life (P20). One participant reported;

"Some days, you could find that I stopped bearing it (pain); I become nervous from it. I get angry that way, and why (I have pain)? I want to get rid of it, I want to get out of this thing. I want to live like any other normal person." (P12).

Participants mentioned pain as being associated with suffering, and their experience of CP created ***pessimistic*** views. Most of them explicitly described how CP negatively affected their mental status, such as *desperation* (P25), *hopelessness, disability* (P45), *having a bad mood or being secluded* (P36):

"*When I get a pain episode, I get isolated, and I feel the world is black. It causes me much sadness. Then depression creates (further) depression. Yeah, sometimes I cry, become nervous, and tense. I isolate myself to avoid getting anyone angry. It's the hardest thing, I get a psychological condition when I got a pain episode"* (P10).

A couple of participants expressed the ***fear*** and being *"careful and scared"* (P22) related to the CP. They were fearful or anxious about escalating CP (P8) or of developing imminent pain in other parts of the body. One participant also shared her worries about getting a proper diagnosis, so she tried to procrastinate seeking medical checks. Also, self-blaming and *"internal conflict"* (P50) arose after the pain had been exacerbated.

"*I am living with the illness, but I still have that fear that it will increase, that it will spread to my hands. I remain scared because it is in the neck and shoulders to radiate down to my hands. The fear, the worry. I am scared that it will spread to my hands.*" (P11).

C) The Impact of CP on the quality of life was described as having a *"great negative effect"* (P22). Participants reflected on the chronicity of pain through the necessity for "*adapting to the situation*". Some participants were *forced to give up what they liked* (P39) and *to navigate life without having any (self) control* (P42). They became dependent and relied heavily on their families or friends, even for certain routine chores such as taking out clothes from the wardrobe or getting a sofa (P50). Participants compared their life before and after having the CP, and one of them reported:

"It influences everything, sleep, work, studies, everything, like, it's tiring. That's it your head hurts, you become unable to do anything like before." (P36). Pain also limited the participants' quality time, mainly with family; they became secluded and pushed away family members to avoid being seen in pain or tried to avoid recreation. Some participants also explained how CP negatively affected social relations and social engagement. Under the effect of pain, they could

not interact with others, leading them to *"less participation in society"* or *"avoid people"* (P42) eventually.

Participants with CP also suffered sleep disturbance or lack of quality sleep (P12). They repeatedly woke up during the night due to pain, which was even harder for participants with certain types of CP, such as chronic back pain (P43) or in patients whose symptoms got worse at night time (P38), and sometimes, they required sleeping pills.

Participants also faced *"challenges"* (P2) in daily life due to CP, including *"work"* (P18), *"house chores"* (P18), *"praying"* (P19), "*studying"* (P21), *"cooking"* (41), *"driving"* (P45), and *travelling far distance"* (P50). Some participants described this impact as an *"actual disability"* (P9) that required staying home for a long time

5.4.1.3 Perceptions about available treatments

Three subthemes were identified explaining perceptions related to available treatments.

A) Perceptions about medications and surgeries

Participants had varied experiences and opinions about medications, which is one of the first-line interventions for dealing with CP. Some participants perceived that oral medicines significantly reduced CP, and therefore, they felt comfortable (P24). Nonetheless, participants perceived that the effect of some medications was notably decreased over time, and they were required to switch to another type (P41). One participant reported:

"*I tried painkillers that are Paracetamol exclusively. it is the only one that works for me. After many years of using it, its effect has diminished a little*" (P46).

Most participants used different treatments to relieve the symptoms, including oral medicines, topical applications, injections, and surgery. For some participants, using one (e.g., pain killer alone) or a combination of medicines (e.g., muscle relaxants and injections) was effective and they had *a positive perspective on medications* (P6). However, some participants thought *medications produced only temporary pain relief* (P38). One young participant reported

"CP medications merely cure the symptoms, not the underlying reason." (P37).

Some participants reported being unable to adhere to medications due to fears of side effects in the long term. One participant reported:

"Surely it (overuse of CP medications) will multiply diseases. I mean, for me, the medicine, in particular the medicine, I mean, I do not take it as a patient I have at home, does not take it, but only with caution. There is a need for someone (to supervise), and there is a need for a specific time for it (the medication)." (P12).

Many participants were pessimistic about available treatments. They *took the pain medication because of its availability* (P33), and *to manage and prevent (pain episodes) temporarily* (P19) *rather than cure the pain* (P27). One participant reported

"*There is nothing that I have come across that has helped me as I've felt*" (P18)

Few participants did not like the idea of *"going to the hospital or clinic"* (P8) regularly for pain management and possible side effects. One participant explained:

"If one continues to use these (medications), it can have an effect negatively on your organs in your body. So this is what, uh, in my opinion, has, to be honest, one should stay away from them as much as possible." (P3).

In addition to their side effects (e.g. drowsiness, kidney problems, liver problems, stomach aches), some medicines for CP were also considered expensive, which usually frustrated them. One participant noted:

"Very tiring (the treatments). Uh really, really tiring and annoying and expensive. And I mean you get the frustration, I mean, I can't take (medication) every day. The problem of medications also is that it has side effects." (P10).

B) Perceptions about non-medication treatments

Participants mentioned using non-medication treatments such as herbs, physiotherapy, and psychotherapy. Participants' experience with physiotherapy was positive. They used physiotherapy in conjunction with other types of treatment, mainly medications. Participants felt comfortable while doing the exercises, and they perceived it was helpful in subsidising pain and reducing discomfort. Some perceived that physio-related medical equipment such as "*back belt*" (P4), "*leg band"* (P17), "*bandage*" (P44) "*warm device*" (P50) was beneficial. One participant reported

"I must strengthen my muscles, so the exercises are important, ice combined with the physiotherapy was better than taking medicines" (P47).

They also appreciated the specialist treatment of physiotherapists because they could do exercises with appropriate techniques, especially when they did their sessions with a physiotherapist. Some provided reasons for not following home physiotherapy as *"unable to manage their time at home"* (P43) or worried of worsening pain while doing exercises themselves. One participant revealed:

"*Physiotherapy just requires a long time because when I come home I get the pain, now it moves my fingers fine and lowers them well, but when I come home and I get the pain. I stop, I say to myself that I don't want (to do exercises), because I don't want to be in more pain. So I let myself like this, just when I go to her (physiotherapist) she will work instead of me and I can tolerate that."* (P41).

A few participants complained that the benefits of physiotherapy were temporary and that their pain returned after one to two sessions. Other participants differentiated between physiotherapy and exercises. For them, physiotherapy was not effective but the exercises, stretching and carrying heavy things and resistance training were extremely helpful in reducing the pain.

Despite mentioning these treatments, none of the participants had undergone any type of psychotherapy or counselling for managing their CP.

C) Perceptions about using alternative/complementary medicine

A few participants had tried alternative/complementary medicine to relieve CP, including *"Chinese needles*" (P1), "*Arabic medicine*" (P5), "*herbs",* and *"cupping"* (P6). Their belief in religion, together with alternative/complementary medicine had a positive effect on the pain management although they did not last for long. However, one participant regretfully shared his negative experience with alternative/complementary medicine since he perceived that the treatment could have ended up with him being in paralysis.

"A month ago, I lost hope that I could go back to walking normally again or doing my daily routine. I tried a (traditional) prescription, and others suggested prescriptions for more than a month. I tried two or three (traditional mixes), and also I did not get any benefit. They took me to a person who treats traditional Arabic medicine for that. I also didn't benefit. I benefitted one day, I mean, let's say when he cracked (my back), he almost paralysed me" (P9).

5.4.1.4 Perceived role of social support

Participants with CP acknowledged the positive role of having social support and being treated with empathy. Many participants regarded families, friends, colleagues, and neighbours as very helpful (P45) in terms of soothing the pain or even helping distract their attention from the pain. The psychological aspect of treatment was considered more important than painkillers or other medical-related interventions, and social support could represent *"collaboration, cooperation and sensitivity"* (P31). A few participants also shared their experience of receiving positive psychosocial support during severe pain episodes. The role of family support was explained by one participant:

"The most important thing is the family, like, this affects me very very much from a psychological point of view and gives me, like, a push to keep going, like, how should I say this, positivity in my mental health. I feel much better emotionally when you have people around you, your family" (P40).

Participants perceived the *encouraging and caring words* (P14) as mental support which made them feel compassion and security. They particularly mentioned that *chatting* with someone, including colleagues or friends (P48), reduced their pain intensity and made them more comfortable. They greatly acknowledged the power of words from others such as *"don't give up, resist, try moving"* (P10). Some viewed social support as an essential key element in pain management, and other treatments came later (P33). A participant enthusiastically shared as;

"The relief is more psychological than if it is physical. The second thing is it possible, just because the people around me, I mean, social support in general, they talk to me, I mean, they ask me about my pain and if I am getting better, oh, it helps, I mean, I don't know how to say it to you, but I mean, I feel a connection, I mean the social (bonds)." (P1)

One important distinction participants made is that social support is not the mere number of people around them but the *quality of support* they receive from them (P42). Support by people who also experienced pain was also reported as beneficial.

However, a few participants also mentioned that *too much involvement from family members made them feel uncomfortable* (P13).

5.4.1.5 Strategies to cope with chronic pain

Participants shared their coping strategies related to managing their CP, which resulted in six main subthemes.

A) Coping with the CP by developing an understanding of the nature of the CP

Some participants developed a detailed "*understanding of the nature of CP"* (P6), the *"reasons*" (P51) behind its persistence and coping strategies to achieve maximum functionality and minimise the impact of pain.

One participant reported:

"(through) the person himself and his mentality and his understanding can know the nature of the pain, and the concept of creating pain inside the human and how to control this pain and cope with it, this has a huge role in human (life)…Let's say your closest friend, would you harm your closest friend? The same thing with pain" (P5).

B) Coping with the CP through medically related behaviours

Aligning with the previous theme on the perceptions about the available treatment options, participants tried different treatments to manage their CP. These options included *"Physiotherapy" (P1, 11, 12, 14), "vitamins" (P4), "muscle relaxants and neck collar" (P11), "injections to reduce pain" (P9), "painkillers" (P15), "medical corset and creams" (P17), "painkillers and sleeping pills" (P21), "medications" (P30), "comfortable (medical) shoe" (P32), eyeglasses" (P34).* Participants also did some actions such as *"going to the hospital" (P9), "going to the doctor (P31), "following the instructions that could increase the back pain" (P33) "going to chiropractic to check the body alignment" (P48).* However, none of the participants tried psychological therapies to manage the CP.

C) Coping with CP through behavioural-oriented changes

Participants used a range of behavioural activities to cope with existing CP, including physical activities such as *"sports exercises"* (P47), *"swimming"* (P32), *"going to the gym"* (P48), *"immediately stopping what I am doing"* (P1), *"go to a warm swimming pool"* (P50) and *"walking when the sun is out"* (P4). Other participants tried to change the way of performing tasks to find a "*better and easier"* (P2) way, such as *"monitoring"* their pain location (P20). Coping through a *"changing lifestyle"* (P42) and daily routine were reported as strategies that help keep pain at minimal levels, as well as following a *"healthy diet" (P3) or "drinking herbs and ginger" (P5).*

Other participants related coping through organising their time, *"doing everything in chunks"* (P14), *"following a programme every week"* (P17) and having *"enough sleep"* (P24). Work-related behaviours included being cautious when doing work tasks so that it would not affect

their injury negatively. Two participants reported that they tended to change their posture while working or reduce the working hours to avoid exacerbating the pain. One middle-aged female reported her coping behaviours as follows.

"Searching about any article or video and listening to my body… listens to something that relaxes them whether it is Qur'an or music calmness somewhat can relax, reduce the pain, yes, turning the lighting for example, like, if one takes a relaxation session" (P7),

D) Coping with CP through attention shifting or re-orienting

Participants shifted their attention away from pain, such as changing the task they were doing or *"distracting"* (P10) themselves from pain by *"ignoring the pain"* (P27). To compensate, participants engage in other activities that *"preoccupy*" (P25) their attention and keep themselves *"busy as much as possible"* (P33), *"working on something useful, sat down and working or reading help forgetting or not forgetting but paying less attention to pain, overlook pain"* (P40).

Participants were trying in their daily life activities to focus on other more functional tasks, which, in turn, makes *"the sense of pain becomes lighter"* (P1). Some participants reported the reciprocal effect of taking care and attention to what a person should do and then ignoring the pain itself. One participant summarised this attention reprioritisation experience as follows:

"I am (Having) attention because I am too arranging things and know how to manage it. Attention and focus will improve, and attention and focus are (good) from a lot of what I am (doing). On the contrary, (because) I am paying attention and concentrating it made my illness improve." (P42).

E) Coping with CP through faith or belief system

Some participants mentioned their faith or belief as a source of "hope" (P45), which kept them "*positive and hopeful, and being patient"* (P2) and that supplication and *"spirituality"* (*P13) helped* to relax them (P13). Others saw the CP as a *"test"* (P5) that they must live with it*.".* Some faith-related behaviours included reading *"the Qur'an or doing Tasbeeh (remembering god)" (P10), "supplicates a lot" (P26), or "pray to Allah that he calms me" (P20).*

F) Psychological coping with CP

Some participants focused on optimism and resilience-related mentality to adjust to the CP experience. Using these psychological resources to *"pay attention to the positive things"* (P42) and increase acceptance was an essential feature in some participants' perspectives as they reported *"attempting to accept the suffering*" (37) and "*adapting to pain*" (P40). However, other participants highlighted the need to normalise pain, such as *"act as if I don't have pain*" (P29), and *"not giving up"* (P20). Further, participants mentioned the importance of motivating and *"energising"* (P3) themselves by *"remaining encouraged"* (P8). This positive perspective and persistence, in turn, helped some participants to preserve their attention while doing different tasks. One male participant reported:

"I do not let anything prevent me from focusing on anything I do, whether it is simple or complex" (P46).

Participants reported that *"psychological readiness"* (P51) is essential in dealing with CP and that it is a crucial factor, so *"the first thing is to do something that will lift your mood"* (P29) because "*good mental health and that's it*" (P21). One male explained that accepting that this is a chronic condition and dealing with it with a positive attitude is crucial:

"I can't refuse, I can't change what happened, but I can change what is about to come" (P8).

5.4.1.6 Patient-led recommendations for interventions and related policies

Participants provided ***recommendations related to their physical activity for managing the CP***. These suggestions focused on outdoor activities such as doing *"sports"* (P12) or *"going on a trip"* (P42). Other participants gave suggestions ***related to the faith and belief system.*** Some participants suggested that having spiritual life or religion would enhance *"inner peace"* (P6). ***Treatment-related suggestions to manage CP*** varied among participants, but they agreed that awareness of the factors that maintain the CP symptoms and *"understanding the reasons"* (P6) behind CP would be important in being *"self-sufficient"* (P1). A common advice from participants was to seek proper medical treatment and commit to it. However, one participant warned that individuals should avoid excessive use of *"heavy painkillers"* (P30) and seek other options.

Adaptation to CP was one of the leading ***suggestions for managing CP through psychological willpower.*** Some participants thought that being able to *"adapt"* (P41) and *"tolerate pain endurance"* (P30) are essential to have a well-balanced life and keeping motivated for future

planning. Interestingly, some participants linked hope to *"making others who also have pain happy"* (P6). One old male highlighted the role of psychological status as *"You can enhance your psychological potential so that you are satisfied with the situation that you are in so you can continue with life"* (P31).

Participants agreed that the quality of services they receive from the health systems has a major impact on their well-being. The importance of increasing awareness about CP interventions. For example, via media was mentioned by one participant through "*the role of TV and advertising" (P6).* Some participants highlighted the need to involve policy-makers, media, and other influencing parties *to "support the use of recognised methods for pain management"* (P5) and provide proper *"training for professionals"* (P37). One older male highlighted (with a frustrated tone) the lack of support he received to manage his CP and the necessity to improve the services given to this population as

"*There has to be special care. it is the right of the people by the government, that it takes care of their matters and provides them with services via their power, ability and their various ministries or specialities, ……..They should not leave people like on margin, and in their very limited financial situation, suffering until they lose their life, they have to, uh, care for us and maintain our dignity and provide us with everything that we need….. we need their ability to recruit all possible resources to cease suffering. ……you go to the hospitals and find them to be overcrowded, both in the outpatients and inpatients*" (P31).

5.5 Discussion

This study explored the impact of CP on the lives of Arabic-speaking individuals and their attentional experiences, their coping strategies, views about available treatments and how they manage CP daily, as well as recommendations for future interventions to improve the management of CP. Factors contributing towards developing or exacerbating CP varied and included psychological (mood disturbance), contextual (job/work requiring attention) and social factors (social support). This aligns with previous studies which emphasised the link between CP and mental well-being (Turk, & Okifuji, 2002). Further, previous literature highlights that negative affect is the most commonly assessed psychological factor associated with CP (Meints & Edwards, 2018), and the tolerance rate of individuals with CP is low when their mood is low (Tang et al., 2008). Evidence also exist on association between availability of social support and improvement in CP (Turk, Fillingim, Ohrbach, & Patel, 2016). The majority of participants in this study preferred having supportive people around them, however,

some participants preferred to be left alone. Having people in their close circle helped most participants manage their CP and maintain their optimism. It has been seen as a source of motivation to keep going in life.

Rich information from participants reflected the various mechanisms of CP persistence and aggravation. Despite not being explored in detail before, the role of attention in exacerbating CP was clearly observed. Mainly, participants highlighted that focusing on pain (whereas distraction was a solution) as well as a task requiring attention (such as performing experimental tasks during an experiment) as exacerbating factors. They also described difficulty focusing or concentrating when their pain was bad. A recent systematic review has highlighted that individuals experiencing CP find it difficult to complete tasks that require attention, such as driving (Vaezipour et al., 2022). Further, exposure to pain-related information enhanced the embodiment of the pain sensations. However, the experience of being exposed to pain-related information during the attention experiment was comfortable for most of the participants, which reflects the safety of such exposure. This suggests that attention bias training is likely to be acceptable to this group.

In terms of the impact of CP on survivors' life, it made some participants feel hopeless with self-defeated opinions and behaviours related to suffering for a long period. They felt "forced" to live with pain, but the suffering is "optional", as reported, so the psychological situation differs significantly. In addition to the psychological consequences of CP, CP-related attentional difficulties affected other aspects of the participants' life, such as not being able to concentrate on their daily tasks and minimised their productivity, which aligns with previous literature (Graziosi, Yaden, Clifton, Mikanik, & Niemiec, 2022), adversely affecting physical and psychological health (Kawai et al., 2017). There is established evidence of the impact of CP on the overall quality of life of this population, including physical functioning, and interference with professional life (Hadi, McHugh, & Closs, 2019).

The perception of the available treatments varied among the participants, some of whom indicated that the treatments were temporary and did not cure the pain. Of course, it is not possible to guarantee that there is a definitive treatment for everyone, but it seems that some of participants did not benefit from the available treatments. The pessimistic view of some of the participants prevented them from trying different alternatives. Further, it seems that some participants had misconceptions about the safety of medications and surgeries, and therapeutic exercises as part of physiotherapy, which raise concerns about the quality of services, or the

quality of the information provided. High expectations of some participants contributed to them being trapped trying to achieve a cure and perfect results which are not possible because CP is a chronic situation.

Participants mentioned several coping strategies with CP, and most were able to adjust their lifestyles and cope with CP. However, some participants were unable to manage their CP, either because of a lack of awareness or high severity of pain; they tended to focus on pain and could not reorient their attention to other functional tasks. Participants who had the ability to develop coping strategies appeared to be more resilient and had better mental health. A review by Burke and her colleagues found that individuals focused on physical-psychological factors of CP tended to experience greater fear of pain and depressive symptoms (Burke, Mathias, & Denson, 2015). However, no studies related to the Arabic population were included in this review.

Some participants overcame these CP difficulties by being psychologically resilient and having a spiritual-faith belief system. This psychological status helped increase acceptance and coping and enhanced behavioural solution-focused approaches. Those participants were generally able to manage their pain and achieve tasks in their daily life and work despite persistent pain. Dealing flexibly with the persistent state of pain reflected higher resilience features among participants. It is noteworthy that some participants had the ability to use psychological capacities to adapt and recover from the impact of persistent pain. Psychological resilience is considered one of the healthy ways to face difficult circumstances (Newton-John, Mason, & Hunter, 2014). None of the participants had used psychological interventions or counselling and this seems a missed opportunity. It is worth exploring the availability of culturally sensitive services and any cultural reasons that participants have not accessed these services. In a Cochrane database review, there were 75 randomised control trials included about the available psychotherapies for the CP population, yet non-involved Arabic population (Williams, Fisher, Hearn, & Eccleston, 2020). Several suggestions were given by the participants regarding dealing with CP daily. For instance, one of the important factors was related to willpower. Ridson and colleagues explained how willpower is linked with higher levels of coping and tolerance of CP (Risdon, Eccleston, Crombez, & McCracken, 2003). Additionally, some participants mentioned the importance of establishing policies and improving health services for CP.

Despite its several strengths, this study also has important limitations. First, the sample size was shaped by the linked experimental study and did not depend only on the saturation level

of the qualitative data study, resulting in repeated data. Second, despite offering breaks before the interviews, participants had to do the interview after the experiment, which they might have found tiring. However, this study succeeded in unfolding the factors associated with CP maintenance, especially those related to the CP-attention relationship. Future studies are recommended to build on the results of this study and examine in more depth what changes are needed in policies and improvements in health services to meet the needs of people who experience CP and have attention difficulties.

5.6 Conclusion

This is the first qualitative study that explores the attentional experiences in the Arabic population with CP and found that participants' everyday function, including attention, is affected by their CP. Further, coping strategies can ameliorate the adverse consequences of CP, including attentional difficulties. Patient-led suggestions were exceptionally important and reflected the need for better policies and improved services for CP. Researchers, practitioners and policymakers are encouraged to use the findings of this study to benefit people with CP.

Chapter 6

General Discussion

6.1 An Overview

The main aim of this thesis was to explore the selective attention processes in Arabic individuals with CP. Because this is the first experimental exploration of selective attention processes in the Arabic population with CP, this thesis established a baseline understanding which can guide future studies to further assess attentional processes among people with CP and potentially inform the development of interventions. To achieve this goal, two experimental tasks (i.e. Posner spatial cueing task and emotional Stroop task) used words (i.e. sensory, affect, neutral) as a stimulus. The use of an open-access approach, pre-registration, and reproducibility will enable future researchers to replicate and advance this research.

The secondary aims of this thesis were (i) to synthesise the available evidence around the reaction time tasks and the theoretical interpretative models related to the attention-CP relationship, (ii) to explore the role of resilience in the attentional performance in individuals with CP (iii) to assess the perceived stress levels of the CP individuals compared to the healthy control group. (iv) to build and evaluate a list of Arabic word stimuli that can be used in future experiments with this population, and (v) to explore the daily attentional experiences of Arabic individuals with CP.

The first study aimed at collecting the available evidence around experimental task types, stimuli used, models used to explain the selective attention processes in the CP population, and other important variables, including the characteristics of populations and settings (Chapter 3). The second study examined quantitatively selective attention, resilience, and perceived stress (Chapter 4). The third study explored the attentional experiences (Chapter 5) of the CP individuals from the Arabic population in Jordan and the United Kingdom qualitatively. The key theoretical and methodological contributions will be discussed below before the researcher explain the clinical implications and future directions.

6.2 Theoretical and Methodological Contribution

This section includes a discussion around the contribution of the studies included in this thesis and how the findings fit into the broader literature and related topic areas.

6.2.1 Chapter 3: Different tasks to measure attention CP

Chapter 3 study found that the reaction times tasks used in assessing selective attention used varied methodologies and relied on different theoretical framework models to interpret the results achieved. A table that arranges the attention-related models was produced to clarify this

relationship. Furthermore, this study also confirmed that no previous studies were conducted with Arabic CP individuals. Producing a table with attention-CP related models that examine the dominant models and depict how attention is characterised is important because the tasks chosen for testing attentional biases determine the processes involved. Further, this table can be used as a guideline for future studies to choose appropriate tasks according to the processes and matched theoretical models. Using a relatively large sample size allowed to draw a robust conclusion in relation to the general patterns of selective attention in CP populations. The study filled in the gap around the reaction time tasks in comparison to recently emerging solely use of eye-tracking studies (Jones et al., 2021). Furthermore, it gathered information about the comorbidities in this population, which mainly were related to anxiety, fear and depression symptoms. This was important to reveal where the studies had poor data reporting or in available data. The meta-analysis included 15 studies and confirmed with relatively larger samples that individuals with CP have small to moderate biases toward sensory pain-related information. Unlike previous meta-analyses, this review showed preliminary evidence that individuals with CP have a moderate bias toward affect pain-related information. The overall conclusions of this study form a guide for future studies using reaction time tasks with individuals with CP to measure attentional biases. Recommendations included using pre-registration and open-access tools that allow transparent sharing of study data, using more than one task that helps in gaining robust results, testing associations between attentional biases and the level of disability in individuals with CP, the development of CP, or pain disability, using good sample size in each experimental arm, and developing a gold standard global format tool that takes into consideration the cultural differences that would make organising evidence and reviewing experiments much more accessible. However, variations across non-preregistered studies did not allow decisive conclusions about the role of stimulus, task type, and related attentional processes.

Further, Chapter 3 rearranged the evidence on the CP-selective attention field. This was essential for future experiments, given that the dot probe and emotional Stroop task dominated investigations in previous reaction time studies. The field is shifting gradually to involve eye-tracking technology; in Chapter 3, we illustrated that using reaction time tasks has many benefits and that response bias can be avoided by adding a layer of complexity to the reaction time task (e.g. cue differentiation task instead of using the identification of cue location) (Spence, & Driver, 1994). The evidence that confirms the attentional biases toward sensory pain-related information can be attributed to the nature of the physical problem associated with

having CP and the priming of such information. In contrast, findings from the meta-analysis confirmed significant evidence regarding the affect pain-related information (i.e. a moderate effect size of attentional bias toward affect pain-related information) using a relatively large sample size. However, this evidence needs cautious interpretation and more research because of the few number of studies involved. Because the CP field is large, the review tried to cover the different subtypes of CP, but it was not possible at this stage, and for the purposes of this thesis, to explore every task with every subtype of the CP.

6.2.2 Chapter 4: Time-Course of Attentional Bias Using Posner Spatial Cueing Task

Chapter 4 described the selective attention, resilience and perceived stress study, in which, the reaction times to stimuli presented (i.e. sensory, affect, neutral words) in two experimental tasks (i.e. Posner spatial cueing task and Emotional Stroop task) were recorded and analysed to assess and determine the processes involved in attention orienting in Arabic individuals with CP compared to a healthy control group. Some previous literature claims that the Arabic language might need a relatively long time for comprehension (Bentin, & Ibrahim, 1996; Farghaly, & Shaalan, 2009). According to the findings of the systematic review and meta-analysis (Chapter 3), and due to the potential longer processing of the Arabic language, the researcher was interested in late points of attention using longer Stimulus onset asynchrony (SOA; i.e. 1000 ms). Further, information was collected about the clinical symptoms of depression and anxiety, as the systematic review and meta-analysis recommended. Interestingly, results showed that the CP group were slower to disengage their attention (i.e. no IOR) for the neutral and affective pain conditions but disengaged more quickly for the sensory pain condition as revealed by the presence of IOR. On the other hand, the controls exhibited IOR in all conditions, which could mean that Arabic language might not need longer processing time as thought before. Thus, there is preliminary evidence that Arabic individuals with CP were slower to disengage than healthy controls except for sensory conditions. Reaction time results implied that Arabic language processing does not differ from previously explored languages regarding response speed. Early time points of attention explain processes such as the facilitation of attention or vigilance, while later points are related to other processes, such as disengagement. Unlike the preliminary evidence found in the meta-analysis, individuals with CP did not have more biases toward affect pain-related information. The CP group had a lower resilience score than healthy controls, and resilience moderated performance on the Posner task. Moderate levels of resilience were associated with slower disengagement from sensory-

related information in the CP group, while extreme values were associated with faster disengagement.

Further, there were significant differences in resilience between the CP group and the healthy control group, with the CP group having lower levels of resilience. Resilience moderated the attentional performance on the Posner task when comparing the CP group with the healthy groups (i.e. CP group showed more IOR with higher resilience than moderate resilience levels, and to a lesser extent, the low resilience level). High resilience score was associated with earlier disengagement of attention from the location of potentially threatening information compared to healthy controls. Thus, resilience might play a moderation role in the attentional biases that CP individuals have toward pain-related stimuli compared to the healthy control group. Despite differences between groups at baseline, with the CP group having higher perceived stress, participating in the experimental tasks did not affect these levels.

Variation in results found between attentional processes in the general literature (as explained in Chapter 3) compared to IOR related to sensory pain-related information revealed by the experimental study (as explained in Chapter 4). For the previous studies, findings related to both earlier and later time points were mixed between vigilance, avoidance, the difficulty of disengagement and strategic characteristics of attention. While the current study found early disengagement, as revealed by the existence of the IOR effect in relation to sensory pain-related information. Similarly, the results varied between the review that found a preliminary effect of the affect pain-related words compared to no effect of affect pain-related words in the experimental study. These differences may be due to differences between populations that the studies investigated. The other reason is that the preliminary evidence in the systematic review used a relatively large sample but relied on a few available studies (N=3). Thus, such variations were expected. In this research, the cue length was 1000 ms in Posner spatial task with non-predictive (i.e. 50% valid) cues and unlimited time for the emotional Stroop task. While in the other three studies, two of them had a cue presentation time of 500 ms with non-predictive cues using a dot-probe task (Roelofs, Peters, Fassaert, & Vlaeyen, 2005; Haggman, Sharpe, Nicholas, & Refshauge, 2010), while the third one had an unlimited time using Stroop task (Pincus, Fraser, & Pearce, 1998). Future research needs to explore these differences at different time points using open research tools. The emotional Stroop task measures strategic and automatic characteristics of attention but also involves many cognitive processes due to the semantic emotional load of the words, despite being irrelevant to the ink colour of the stimuli (Snider, Amundson, & Weise, 2000; Cisler, Bacon, & Williams, 2009). Using two tasks within

the same study allowed for assessing relatively different processes in the same sample. This helped provide preliminary evidence about attentional tendencies in Arabic individuals with CP (i.e. early disengagement). Thus, future research would benefit from using a similar approach to explore other time points, stimulus types, or tasks.

6.2.3 Chapter 5: Understanding the attentional experiences of the individuals with CP from the qualitative study

Chapter 5 explored the attentional experiences of the Arabic participants with CP from the experimental study (i.e. study in Chapter 4). The study gathered information about the perspective of participants about available treatments and coping strategies with CP and their suggestions about CP management. The exploration involved all participants who consented from the main sample of the experimental study (i.e. Chapter 4). The vast majority of participants were using painkillers and other physical coping strategies. Some participants reported the importance of the psychological interventions, but surprisingly, none of them undertook any psychotherapy or psychological support for their CP. This finding need further investigation in future research to explore the reasons behind such lack of access to mental health services.

The current state of art assures that adopting positive coping strategies and improving resilience levels could be achieved through psychological support and resilience strategies (Yeung, Arewasikporn, & Zautra, 2012). Being able to face psychological distress increases psychological flexibility and ameliorates the consequences of CP persistence (Gentili et al., 2019). Such interventions use a holistic approach and consider the context under the biopsychosocial perspective. This study showed the need for such interventions. On the other hand, exposure to stress does not necessarily mean that it will have an adverse effect on individuals. Although many studies explained the stress mechanism as a negative factor, others found that exposure to stress could be even more important for growth. Literature pointed out the importance of the positive evaluative view toward stress that relies heavily on our perceived opinion and how stress is differentiated from distress (McGonigal, 2013). For instance, in relation to the experiences of individuals with CP, perceived stress levels after the experiment (controlling for pre-experiment level) did not differ between groups. Further, the impact of varied factors on developing or exacerbating CP symptoms was essential in exploring the uniqueness of the Arabic population. The psychological impact plays a major role in coping with CP because the experience of having CP may be unavoidable, but the associated

psychological suffering can be avoidable. The impact of functions that require attention was another important factor that summarised the dysfunctionality in this population. For example, reading, studying, or working were reported as functions that required attention and were linked to pain exacerbation. When a cognitive interruption is caused by pain, behaviours are reprioritised to solve the issue that causes the interruption. However, if the strategy used does not succeed, the individuals become trapped in a vicious cycle of negative coping- trying to solve- failing to succeed, as illustrated in Figure 6.1 (Eccleston, & Crombez, 2007; Flink, 2011).

Previous literature also pointed to the potential mediating effect of pain catastrophising between the biomedical problem (i.e. CP) and the medically oriented problem-solving behaviour (Flink, 2011). This aligns with the qualitative results that differentiate between the negative catastrophising, worrying, or ruminations that keep attention on the CP and the positive motivational reorientation of attention that leads to more functional problem-solving. Further, these qualitative results also align with the results obtained in Chapters 3 and 4. This approach of coping can take two directions, the problem-focused approach, in which the individuals with CP become vigilant to any potential threat, or the other direction is solution-focused approach which reprioritises the solving the CP issue with possible available resources and then reorients the attention toward more functional tasks in daily life (Grant, & O'Connor, 2010).

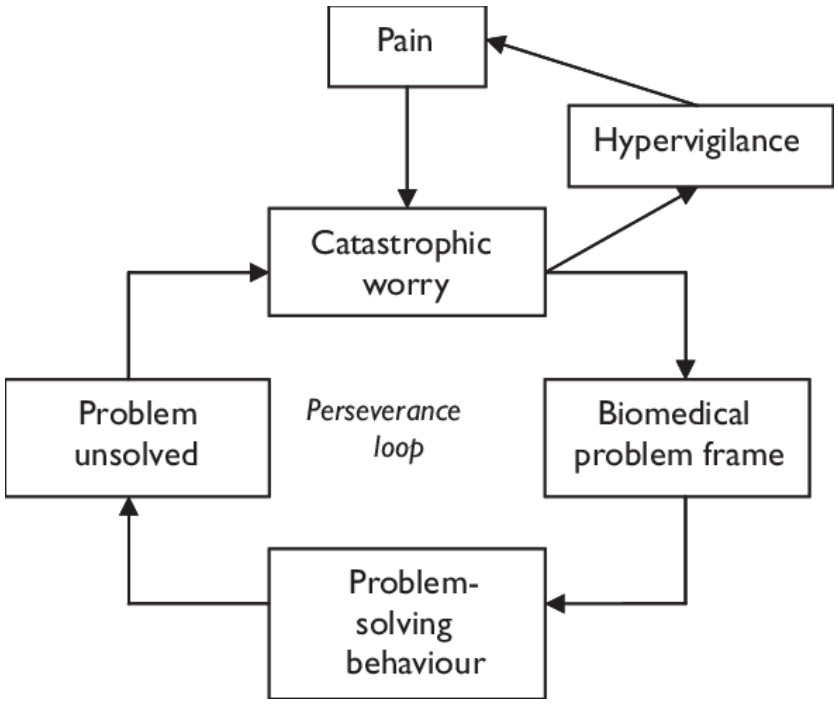

Figure 6.1: The misdirected problem-solving model adapted from Flink (Flink, 2011).

Another main factor that had an impact on the quality of life was CP-related physical disability. There is a longitudinal association between individuals with CP having physical limitations and developing anxiety and depression (Lerman, Rudich, Brill, Shalev, & Shahar, 2015). Anxiety and depression symptoms, in turn, include having less attentional capacity. This was evident in the experimental study, with the CP group having significantly higher symptoms of anxiety and depression compared to the healthy control group. Thus, understanding CP-attention-related difficulties needs to be taken in the wider context of disability. Attentional biases in the context of CP cannot be totally separated from the impact of other psychological symptoms. It was noticed that the reciprocal interaction between factors impacting the CP and vice versa causes a vicious cycle that keeps the individuals preoccupied with their CP, deepens the beliefs of their disability and causes losing control. When such beliefs emerge, feelings tend to be tense, and the "world becomes black".

Suggestions for CP management focused on the temporary effect of the treatments and how individuals with CP can overcome difficulties through willpower. This willpower also reflects a resilient coping strategy in the face of the ordeal of CP. Willpower is essential for exercising the focus of attention (Loewenstein, 2000). Resilience to stress and the ability to preserve willpower coincide with each other (Davis-Laack, 2013). Thus, the moderating effect found in resilience may be related to the ability to focus while exposed to threat stimuli (i.e. pain-related information).

Governments, media, and research organisations have a critical role in the awareness of CP management among the Arabic population. A very important practice in this research is that we avoided "salami" slicing in the qualitative study. Salami slicing means that "artificially segmented articles in which related aspects of the same study were published separately" (Bailey 2012, p. 212 as cited in Jackson, Walter, Daly, & Cleary, 2014). Although we had participants from two different countries, the analysis in the quantitative experimental study was taken as one unit to give the appropriate power. Thus, the qualitative study also took the sample from these two countries as one unit to maintain consistency. Further, direct comparison of the results from different countries is out of the scope of this research.

The main distinctive experiences focused on the role of improving resources that contribute to the attention ability and the reciprocal effect of priming CP cues that distract attention, decrease functionality and increase overall distress. Participants who showed resilient features (e.g. positive perspective about the ability to manage their CP) during the semi-structured interviews

were also able to express positive coping strategies. On the other hand, hopelessness was noticed in participants with fewer resources and less effective coping strategies. The impact of CP was significant in almost every aspect of their daily life. The attentional experiences formed part of this impact, and there were two main points related to attention; first, the inability to focus or concentrate on a task when the CP episode intensity increases, and the other point was the preoccupation with the CP itself that distracts the individual. Generally, participants had minimal stress while doing the experiment. However, the embodiment of some sensations was a source of distress for some participants. Overall, these results encourage conducting future experiments or attentional bias training with this population while taking similar precautions into consideration to ameliorate any potential distress among participants. Some previous studies compared threat levels during the experiment from a quantitative perspective (Jackson, Su, & Wang, 2018) but not from a qualitative personal perspective. The main coping that helped is focusing attention on the solution instead of the problem (i.e. solution-focused approach) and training themselves to keep distracting and ignoring CP. Tolerating both techniques helped some participants to be functional in their life. However, exploring the attention-CP experiences in populations that were not explored before (i.e. Arabic population) needs to consider a large number of factors that develop, interact and maintain CP through considering the biopsychosocial approach. The uniqueness of culture is a key reason for exploring potential differences from other populations.

Different ways have been used to adjust to having CP. However, because of the chronic nature of this problem, the vast majority of these interventions are palliative rather than curative. Thus, coping with CP through finding effective strategies that help adjust to it is essential. This coping was reflected in different attentional patterns that participants reported (i.e. careful vigilance vs distraction or avoidance vs coping with exposure). Because the cognitive predisposition and interpretation precede the strategy the person will use, some avoid it while others become alert and vigilant. Pain tolerance was one of the key factors supporting people in achieving their life goals.

As revealed from the study, participants with CP had different subtypes of the CP. Because CP has numerous subtypes a large sample was essential to ensure covering different aspects of CP related experiences. To address the research question related to finding an overarching patterns across the Arabic population with CP, the framework analysis was used. The framework analysis allowed structuring the large data set resulted from coding and arranging themes according to the patterns found. Future research could benefit from using other qualitative

research methods on this topic to analyse specific experiences of the participants. For instance, the interpretative phenomenological analysis (IPA) can be used to explore a specific CP subtype, which would give a deeper understanding and a detailed examination about how particular chronic illness shaped their lives and attention-related experiences (Eatough, & Smith, 2017). Further, despite the existence of qualitative studies about CP in general, the scares qualitative evidence in the field of CP-selective attention, made it essential to explore such experiences. Future researchers are encouraged to explore these attention related experiences in different CP populations.

6.2.4 Theoretical Implications

In this section, we will discuss how the findings link with the theories that we presented in this thesis. First, I conducted a systematic review that arranged theoretical models and their use in interpreting attentional processes (Chapter 3 Table 3.1). However, the results from the experimental study (Chapter 4) found interesting findings which differed from previously published literature. Most previous studies found attentional biases toward sensory pain-related information (Abudoush et al., In publication). However, the between-groups analysis in the experimental study found an early disengagement from the sensory pain-related information compared to neutral information revealed through inhibition of return (IOR). It is also important to consider that the CP group may have been slower to disengage for the affective and neutral cues (since they did not show IOR in these conditions). However, what we do not know is whether they would have shown a stronger early facilitation effect followed by earlier IOR. Following attention being oriented to the cue in the early phase (i.e. usually identified as >100 ms and < 500 ms), participants are faster to orient to the invalid (compared to the valid) cue location at a late time point (Posner, & Cohen, 1984). The theoretical interpretation of these findings overlaps with the vigilance-avoidance hypothesis within the threat interpretation model. This model explains the change in response to threats over time (Todd et al., 2015). This model shows that compared to the positive association between the level of the threat and vigilance level at the initial attention phase, the later phase of attention will depend on the threat severity (i.e. low, moderate, high) personal interpretation (Figure 6.2). However, in this study, we did not separate the threat level assessed by stimuli introduced, which could be a good avenue to explore in future studies. Further, according to the findings in this thesis, the sensory cue (high threat) is linked to having an IOR effect (early disengagement/avoidance), while neutral and affective cue (moderate threat - perhaps for the CP group even neutral seems moderately threatening) are linked with no IOR effect (difficulty disengaging).

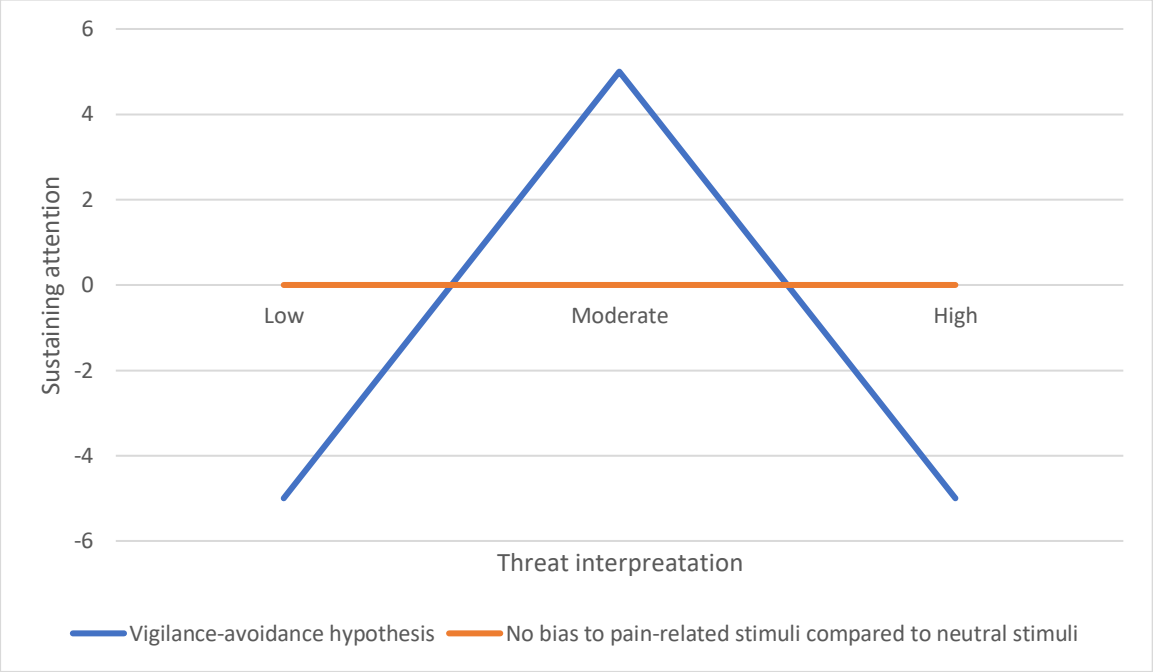

Figure 6.2: The threat-avoidance hypothesis within the threat interpretation model adapted from Todd and colleagues (Todd et al., 2015). Positive numbers mean difficulty of disengagement, negative numbers mean avoidance, and zero means no bias to pain-related information compared to neutral stimuli.

The terminologies used in explaining this model overlap with the IOR concept in which early disengagement could be classed as avoidance when exposed to valid cues, which inhibits response to the exact spatial location compared to uncued conditions. Thus, IOR can be detected using a reaction time that needs a response from participants but also can be seen in preference for eye movements (Pertzov, Zohary, & Avidan, 2010). Despite the Posner cueing task being used in some previous literature (Van Ryckeghem, 2013), IOR has not been found in these studies. This is likely due to the use of shorter SOAs and/or predictive (i.e. 75% valid) cues, which means that IOR appears later (Klein, 2000; Abudoush et al., In publication). Using IOR as a reliable indicator of inhibitory attentional control is common (Li et al., 2020). It also helped us understand the attentional tendencies of the Arabic population using relatively longer presentation time points.

To further explore the theoretical links between the results of thesis studies and previous literature, studies that explored different time points simultaneously were compared to the experimental findings. Three previous studies that compared two different time points (i.e. 500 and 1250 ms; 200 and 2000 ms) found that using the detection dot-probe task resulted in strategic attentional characteristics responses toward pain-related information (Liossi, White,

& Schoth, 2011; Garland, & Howard, 2013; Schoth, & Liossi, 2013). This means that attention was maintained at the threatening location even at the longer time point. However, it is worth noting that IOR is not usually measured using double-cue stimuli (e.g. dot-probe task). Another study that used a discrimination dot-probe task (i.e. using 500 ms and 1250 ms time points) found that avoidance is the main process among participants with CP (Harvold, MacLeod, & Vaegter, 2018). Among these studies, only one study (i.e. Liossi et al., 2011) used a theoretical framework model to interpret the results related to attentional biases and processes. The model used was the cognitive-affective model of the interruptive function of pain. This model explores the association between the pain characteristics, such as the threat level and the characteristics of the environmental demands while doing a task that requires attention, such as emotional arousal related to exposure to threat information (Eccleston, & Crombez, 1999). The main similarity between this model and the threat-avoidance hypothesis within the threat interpretation model is that both rely on the level of the threat, but this model also takes the contextual environmental demands into consideration. Further, it should be noted that avoidance in these models is an attentional process rather than a functional behaviour.

6.3 Need to Address CP and Attention in The Arabic Population

In addition to the twenty-two countries with Arabic as their primary language, Arabic-speaking populations are spread throughout the world, with millions of people ranging in socioeconomic status. A few studies concerned with the epidemiology of CP in the Arabic population found that it ranged between 20% and 46.4% (Elzahaf, Johnson, & Tashani, 2016; Almalki et al., 2019). Despite this high ratio, and although psychological interventions have been explored in relation to chronic illnesses, attentional difficulties related to CP have not been investigated in this population (Hamdan, 2009; Okasha, & Okasha, 2012). The researcher's clinical observations of individuals with CP before commencing his PhD degree reflects the necessity of addressing attentional difficulties associated with CP. These difficulties hindered their improvement, interfered with their functionality, and maintained their dependency on painkillers. These limitations were the basic motivations for conducting the research in this thesis.

The findings from this thesis support the idea that culture is a key factor that might shape attentional processes pain experiences. The experimental study revealed IOR and early disengagement among CP group toward sensory pain-related information. Previous studies did not reveal IOR even when using long time points. However, this study needs to be replicated

to ensure the findings and are consistent and related to the cue time or task used. Further, results from the qualitative study revealed the importance of the social support network in overcoming the psychological burden of the CP condition. This support is more linked to the Islamic cultural background that asserts on the role of the extended family that provide intergenerational support (Sibai, & Yamout, 2012). This could partially explain why none of the participants reported accessing the mental health services for the CP.

Regarding the language, the findings did not support differences in the language processing. The healthy control group showed IOR on all cue types suggesting that there are no language processing speed differences. However, these findings need further investigations at different time points to confirm these findings. It is worth noting that using the "Fusha" (i.e. formal Arabic) language without diacritics formed a baseline that can be compared to words with diacritics, informal accents, or pictorial stimuli in future studies. Such comparisons would help reveal further information and understand the CP-attention deeper in the Arabic population.

6.4 Feasibility of Measuring Attention in CP Remotely and Cross-Culturally

Being the first study on the Arabic population, one of the main achievements of this study was to build a list of Arabic words that could be used in future research with this population. The list of rated words will be made available to future researchers (Appendix 4.H). The investigation was carried out through one data collection session (i.e. hybrid data collection session with the majority of the sample did a remote session) in adults living in Jordan or the United Kingdom at the time of data collection. The remote nature of many data collection sessions in this study aligned with the shifting tendency toward engagement and involvement of a wider population and helped obtain a more representative sample, compared to regular data collection sessions which involve a limited number of settings or places to collect data from.

During and beyond the Covid-19 pandemic, online psychophysics tools (e.g. Pavlovia platform) have become necessary. There is a wide range of open research tools that can help researchers design reproducible research in the psychophysics field. This recent technology allowed for easy access to experiments requiring much effort from researchers and participants (Peirce et al., 2019). The researcher carefully monitored this remote delivery of the experiment to ensure controlling the environment around the participants. Combining the psychophysics tool with the communication platforms (e.g. Zoom application) (Zoom Video Communications

Inc., 2022) made reaching distant participants possible and helped enrich the data collected more than before.

There are several benefits of the online experimental design; first, it gave the researcher a chance to develop an experiment otherwise it was not possible in regular circumstances. Second, it allowed for easy supervision of the participants in the experiment (e.g. ensuring the gaze fixation on the middle of the screen, not moving their head, and being engaged actively in the experiment) and saving the data directly on an approved secure server before moving data to the university server; third and most important, made the experiment more accessible that allowed reaching distant participants in Jordan and the United Kingdom without the need for travelling from both sides. Especially that travel might be particularly challenging for people with CP symptoms. This easy access, in turn, helped in accelerating the recruitment process (i.e. data were collected over four months period) and improved the representativeness of the sample from all over the included countries and regions.

The experience of participating in an experimental study varied, with some participants explaining the embodiment experience when exposed to a pain-related stimulus. For instance, participants reported feeling pain when doing experimental tasks that contained sensory pain-related information (e.g. imagining a painful stabbing sensation). In general, findings from the qualitative study supported the notion that experimental tasks are safe and appropriate to be used with Arabic CP individuals. Feedback on participating in the study was generally positive, with minimal distress reported. However, the field still needs a gold-standard reproducibility approach to conducting the experiments, affecting the ability to interpret the results from previous reviews (Atmanspacher, & Maasen, 2016). However, it is important to consider the cultural variations between populations that could affect the replicability of experiments (Greenfield, 2017). One essential solution was proposing a unified, standardised, reproducible approach that relies on sound theoretical models. Such cross-cultural standards can enhance the understanding of the attention-CP and integrate the use of accumulative evidence in this field.

6.5 Clinical and Practice Implications

Despite the tendency to study the psychological phenomenon in isolation from clinical implications in experimental psychology, this thesis conveys a number of key messages for practitioners and policymakers in the field of attention-CP. From the experimental study, we concluded that the individuals with CP from the Arabic population could be assessed safely for

their selective attention. The word list developed in this research can be used for such an assessment. Second, the dynamics of attending towards and away from the location of the sensory cue differed in the CP group, confirming the need to enhance the responses toward this type of stimuli. This could be achieved through stimuli-related attention training in an intervention in the future (Carleton et al., 2020). Further, the qualitative study supported the evidence gathered from the experiment and asserted that attentional experiences play a crucial role in dysfunctionality through people's inability to do or complete daily tasks. Results also supported the need for psychological therapies to support people with this chronic condition. Thus, including the attention assessment in the general CP routine check-up would be necessary as part of the overall well-being status and functional ability of the sufferers. However, we need to be cautious because the Posner spatial cueing task and the emotional Stroop task are not usually used as clinical measures on an individual. Nevertheless, attention dysfunctionality assessment could be achieved by developing a simple electronic tool that measures biases related to pain information. Developing such tools can benefit from current advances in measuring eye movements and reaction time, along with collaboration with researchers in the biomedical engineering field. Further, the recent interventions in CP that target attention reprioritisation (i.e. attention bias modification) do not persist in the follow-up (Carleton et al., 2020). Thus, the feasibility of using these experimental tasks with the Arabic population could pave the way for investigating whether attentional training could be useful. Developing an integrative intervention that utilises the attentional resources to modify attention and works on cognitive biases related to resilience and perceived stressors would be vital in managing CP-related attentional difficulties. This study conceptualised the different experiences of CP sufferers` including psychological symptoms (i.e. using questionnaires), attention (through experimental tasks), and acquired a holistic understanding of the CP experiences using individual interviews. However, because this is the first experimental study with this population, the current preliminary evidence needs to be supported by further studies that explore different attentional time presentations and stimulus types.

6.6 Future Considerations

The Psychophysics field focuses on the study of behavioural phenomena, that is, the interaction with physical stimuli when triggering one or more of the sensory systems (Gescheider, 2013). Because psychophysics heavily relies on advanced data analysis methods such as mixed models' analysis, enhanced use of open statistics tools (e.g. RStudio) is essential as a complementary step that allows for easy wrangling of the data gathered from psychophysics

software (Prins, 2016; R Core Team, 2022). Such statistical software supports reproducibility and provides a plausible way to share data codes that can be reused in studies.

The open-access nature of psychophysics tools is also promising because of the varied ability to modify and adjust to the specific contextual needs to implement an experiment. The approved servers used by such platforms made saving data much more manageable. The codes and programming used in the research are also available through repositories for transparency and future researchers' use. Scaling up the use of these tools is part of the research reproducibility movements that aim to increase the quality of research produced and published and decrease the chance of malpractice. The replicability and open-source software directly address some of the issues that were picked up on in the systematic review (Chapter 3).

Because the main experiments focused on assessing the attention according to the available literature, it was not possible to gather essential information that would help build a future intervention with this population. For instance, the use of the relatively long presentation time (1000 ms) revealed IOR among participants, but early time points should be included to assess early facilitation of attention. Another recommendation is comparing different types of stimuli (e.g. pictorial, somatosensory) when possible, as this would give further understanding of pain-related information in the context of the Arabic population. The pictorial stimuli have the potential to vividly arouse emotions, with a potential focus on the specific objects in an image if combined with eye tracking. It also could help overcome the language barriers that might exist between populations or among illiterate individuals (Dear, Sharpe, Nicholas, & Refshauge, 2011). The somatosensory stimuli could provide various information such as the mechanical force, speed, direction, trajectory, intensity, pain threshold, proprioception, balance, vibration detection, chemical reaction, temperature change, or shapes distinguishing testing (Macaluso, & Driver, 2001; Mendoza, Foundas, Mendoza, & Foundas, 2008; Hayward, 2018). Measuring somatosensory discrimination could also be explored because there is a possibility of measuring attention towards somatosensory stimuli or assessing whether pain-related words might lead to faster responses to somatosensory stimuli. This is important, considering that attending towards the body is very relevant to CP. Further, experimental tasks can be used as a source of improving dexterity, which is linked to the neural behaviour of individuals with CP (Orosy-Fildes, & Allan, 1989; Shuchang, 2011).

It is recommended that future research use the open-research, pre-registration, and reproducibility approaches to maximise the benefit of research and have the potential of

forming more global standardised formats for evidence-based effective assessing procedures (Open Science Collaboration, 2017). Future studies by the researcher would benefit from minor deviations included in the study, such as using the linear mixed effect models in analysis. However, it seems that non-significant results from the emotional Stroop task imply not recommending it for future research as it calls many processes and represents cognitive interference instead of isolating attentional processes. Further, it would be essential that future studies recruit participants from other Arabic countries to improve the representativeness and understanding of the CP-attention phenomena. Once the evidence around the attention processes and CP in the Arabic population becomes more apparent, a feasibility study that uses mixed methodologies around attention-CP intervention would be the next reasonable step. This would need to take into consideration the complex nature of the CP phenomenon and employ an integrative approach to develop a biopsychosocial spiritual culturally sensitive intervention.

In the broader literature, the behavioural responses could vary when exposed to different triggers, and not only pain-related information. The human reaction time to visual stimuli is related to the choice that can rely on the amount of uncertainty in the experimental task used (i.e. cued and uncued conditions; Proctor, & Schneider, 2018). Measuring uncertainty could help identify the tendencies of the population according to the alternatives chosen and reaction time to these alternatives. Another important point to be considered is manual dexterity. Often, individuals with CP encounter some level of physical disability. Although such a disability did not interfere with the performance on attention tasks because of the screening done for participants, it is important to keep the overall physical performance ability as a factor when considering the reaction time in the context of CP. Including a simple reaction time task can control for this physical ability-related factor. Attentional biases, cognitive biases, and manual dexterity are crucial components that influence the performance of individuals with CP on reaction time tasks. Language processing and cultural differences played an important role in the design of this study; thus, having cultural sensitivity when designing such experiments is a key element in its success.

This thesis provided knowledge that will help future researchers to explore CP in the Arabic population further. The next steps would be assessing different time points after the cue, including earlier attentional patterns, and exploring the possibility of adding an eye-tracking technology to support future assessment of attentional biases patterns. Integrating these methodologies could provide further information about gaze behaviour, such as spatial gaze, fixation time on a target, visual speed, and reaction time (Lange, Hunfalvay, Murray, Roberts,

& Bolte, 2018). Aligning with the considerations mentioned above, the researcher started collecting available information about the possible projects that can be stemmed from this thesis. Assessing different time points simultaneously would help in exploring patterns of processing in earlier time points and confirm the reliability of the results achieved in this study. It is highly recommended that future research would benefit from the words list and experimental programming made within this study and explore the CP in more Arabic populations inside and outside the Arabic world, which would be necessary for the generalisability of the findings, and then feasibility studies would be developed according to the available evidence.

6.7 Final Conclusion

In summary, the evidence generated in this thesis around attention in the CP individuals with an Arabic ethnic background confirmed the importance of attentional biases. The collective evidence gathered from the studies included in this thesis showed the necessity of investigating individuals with CP among the Arabic population and that the individuals with CP tend to have early attentional disengagement from sensory pain-related information compared to the healthy controls. However, replication and further comparisons including both in early and later time points are needed to understand this finding better. Resilience plays an essential role in moderating attention performance. The qualitative study formed an important aspect that provided a further understanding of how attention ability is affected by CP and how voluntary selective attention can help in reprioritisation and improving functionality. The daily attention experiences are heavily connected to the level of coping strategies and the resources available to the person.

Integrating an attention-related intervention (e.g. attentional bias modification with other intervention that targets cognitive biases such as cognitive behavioural therapy) and other complementary treatments could be improved through a resilience-focused approach. The current findings indicate that it would be feasible to deliver computerised training with pain-related words online and remotely. For future research, we highly recommend using open-access, reproducible, pre-registration, smooth online short data collection sessions when possible. For clinicians and policymakers, we recommend that CP-related policies consider including psychological and attentional assessment as part of the routine pain check-up in healthcare settings. Access to psychotherapies related to CP and psychiatric comorbidities as an essential treatment option and increased awareness about it should be prioritised in

healthcare settings through reviewing and improving the policies related to treatment recommendations for CP populations.

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Appendices

Appendix 3.A: Searching strategy

Search terms and phrases:

The strategy used for searching databases (i.e Medline, PsychInfo, PsychArticles, Web of science) is listed below.

(i) Condition: (chronic AND (pain OR ache)) OR fibromyalgia OR complex regional pain syndrome OR CRPS OR migraine OR arthritis OR abdominal OR musculoskeletal OR postsurgical OR post traumatic OR cancer* OR non cancer*

(ii) Cognitive process: attention* OR process* OR attend* OR vigilan* OR detect* OR bias* OR process* OR facilitate* OR disengage* OR orient* OR automatic* OR strategic

(iii) Stimulation: audit* OR pict* OR word* OR visual OR visuospatial OR somat* OR tactile OR cutaneous OR electric* OR pressure OR thermal OR mechanic* OR vibrat*

(iv) Exceptions: chronic pain NOT (acute OR opioid* OR drug*) AND adult* NOT (adolescent OR child*)

Note: Medline and PsychInfo allow for the use of MESH term, in which, the term “chronic pain” was used.

Appendix 3.B: Quality rating tool (Adapted with modifications from Crombez et .al, 2013 as cited in Todd et al., 2018)

External validity components

Criteria	Coding	Description	The overall percentage for satisfying the criterion between studies
Description of inclusion and exclusion criteria	0=not mentioned 1=Cannot tell 2=partially mentioned, 3=Fully mentioned	A study should provide detailed information regarding the inclusion and exclusion criteria in terms of age range, sex, diagnosis or other relevant variables.	**88.24%**
Description of demographics of participants	0=not mentioned 1=Cannot tell 2=partially mentioned, 3=Fully mentioned	A study should provide information regarding the age, gender and socioeconomic status, as often study participants are biased towards the higher educated.	**70.59%**
Description of pain experience in the chronic pain group	0=not mentioned 1=Cannot tell 2=partially mentioned, 3=Fully mentioned	A study should provide a detailed description of the pain characteristics of the participants, in terms of pain severity, type of pain and pain duration.	**81.37%**
Description of pain experience in the non-chronic pain group	0=not mentioned 1=Cannot tell 2=partially mentioned, 3=Fully mentioned	For the control group, a detailed description of pain characteristics should still be recorded, or information provided on how following exclusion criteria no pain was present. It is sufficient to say 'pain-free sample' but not sufficient to say 'excluded those with a history of chronic	**64.10%**

		pain', unless a current pain rating is also included	
Description of the recruitment procedure	0=not mentioned 1=Cannot tell 2=partially mentioned, 3=Fully mentioned	A study should provide information about the recruitment procedure. When participants are students the description should include whether they volunteered for credit points or money. When participants are patients, the description should include the recruitment procedure (advertisement, consecutive patients). When applicable, the study should describe how many patients refused participation. Of less importance are the reasons for refusal.	**84.31%**
Description of the setting or location of the study for the chronic pain group	0=not mentioned 1=Cannot tell 2=partially mentioned, 3=Fully mentioned	The study should provide information about the setting where patients were recruited (general population, pain clinic, multidisciplinary pain centre), type of students (e.g. university undergraduates).	**84.31%**
Description of the setting or location of the study for the non-chronic pain group	0=not mentioned 1=Cannot tell 2=partially mentioned, 3=Fully mentioned	The study should provide information about the setting where patients were recruited (e.g. general population, university students).	**83.33%**

Description of data cleaning, and its criteria (data trimming, outliers, missing values, invalid data)	0=not mentioned 1=Cannot tell 2=partially mentioned, 3=Fully mentioned	Studies must report how data was cleaned, how outlying participants and data were removed and the percentages or number removed. Also, the study should report the percentage of missing values in the final data set. It is not necessary that the study investigates the pattern of the missing values (missing completely at random, missing at random or missing not at random).	**70.59%**

Internal validity components

Criteria	Coding	Description	The overall percentage for satisfying the criterion between studies
Relevance of Pain-related information (min. score 2 to satisfy criteria) (mainly for the dot-probe task and Stroop task)	0=not mentioned 1=cannot tell 2=mentioned but not piloted study (same or another study) 3=mentioned from other piloted study 4=mentioned and piloted (same study)	The study should report that the pain-related stimuli are relevant for the Chronic Pain group of the study. Score 4: Stimuli may be selected in a pilot study in which the participants are identical to the study participants. Stimuli may be rated for relevance by the participants themselves. Score 3: Stimuli may be selected in a pilot study from another study that	**72.06%**

		involves similar participants and context. Score 2: It is not sufficient that stimuli have been shown to be pain-relevant and valid in another study. Validity is not absolute, and is often context-dependent. Pain-related stimuli that are relevant for one setting and one type of patients are not necessary valid for another setting or type of patients. Or when the study reports that pain-relevance has been investigated, but fails to report the data. Score 1: Studies in which the pain-related stimuli are only based upon the experimenter's expertise, or in which the same stimuli are used from previous studies that did not provide data about pain relevance or information provided is not clear. Score 0: No mentioning of an internal check is scored 0.	
Pain and non-pain information (or stimulation) adequately matched	0=not mentioned 1=Cannot tell 2=partially mentioned, 3=Fully mentioned	The pain-related stimuli and non-pain related stimuli are perfectly matched. Pictures should ideally have the same visual complexity, and luminance. Words should be matched for familiarity and word length.	**98.04%**

Participants' engagement with task (from overall error rate)	0=not mentioned 1=Cannot tell 2=partially mentioned, 3=Fully mentioned	Check for outliers, RTs from errors discarded, and exclusion of individuals not conforming to the task instructions, digit trials, or gaze fixations. An assumption is that participants perform the task as requested, and do not use alternative strategies. When a target appears on every trial, one may not focus attention only to one side instead to the middle of the screen. Catch trials in which no reaction times are presented, may allow the investigation of anticipatory errors. Digit trials in which a digit appears for a brief period in the centre of the screen, can help to determine whether participants are focusing at the middle. Registration of eye movements are also possible. Engagement can also be ascertained by the experimenter, with task motivation explicitly targeted.	**67.65%**

Appendix 3.C: The main results of extraction

Table 3-A: Studies used dot-probe task

First Author	Task Type	Stimulus type	main stimulus/ Cue duration	Type of task participants do with the target	Target type	Counter-balancing of stimulation	Attentional process(es) predicted	CP-SA Model/Hypothesis	Dependent variable/response measuring	The time between cue end and target
Asmundson et al. (2005)	Dot-probe	Words	500ms	detection	Dot-probe	Mixed blocks and random words	The difficulty of disengagement / Strategic	Fear-avoidance model	ABS	Immediate
Asmundson, & Hadjistavropoulos (2006)	Dot-probe	Words	500ms	Detection	Dot-probe	Mixed blocks	Hypervigilance	Fear-avoidance model	ABS	Immediate
Carleton et al. (2020)	Dot probe	Words	500ms	discrimination	Letter E or F	Random	Hypervigilance	Different models mentioned	RT	Immediate
Dear et al. (2011) (a)	Dot probe	Words	500ms	Discrimination	letter p or q	Mixed	Hypervigilance	-	RT/ABS	immediate
Dear et al. (2011) (b)	Dot-probe	Pictorial and words	500ms	discrimination	letter p or q	-	-	not consistent with the fear-avoidance model	ABS	-

Dehghani et al. (2003)	Dot-probe	Words	500ms	Discrimination	letter ‘p’ or ‘q’	mixed	Hypervigilance	Fear of (re)injury model of pain.	RT/ABS	immediate
Dehghani et al. (2004)	Dot probe	Words	500ms	Discrimination	letter p or q	Mixed	Hypervigilance	Fear of (re)injury model of pain.	RT/ABS	immediate
Fashler, & Katz (2014)	Dot-probe task with eye tracking	Words	2,000 ms	Detection	Dot probe	Mixed	Hypervigilance /Avoidance	Fear-Avoidance Model	ABS	immediate
Fashler, & Katz (2016)	Dot-probe task with eye tracking	Pictorial	2,000 ms	Detection	Dot probe	mixed (randomised)	Hypervigilance /Avoidance	Fear-avoidance model	ABS	immediate
Franklin et al. (2016)	Dot probe	Pictorial	500ms	Discrimination	: or ..	Mixed	Hypervigilance	Vigilance avoidance hypothesis	RT	immediate
Garland, & Howard (2013)	Dot probe	Words	200ms; 2000ms	Detection	dot probe	-	Hypervigilance/Strategic	-	RT	-
Haggman et al. (2010)	Dot probe task	Words	500ms	Discrimination	The letter ‘‘p’’ or ‘‘q.’’	Mixed	Hypervigilance	not consistent with the fear of (re)injury model.	ABS	immediate
Harvold et al. (2018)	Dot probe	words	500; 1250 ms	Discrimination	“<” or “>,”	Mixed	Avoidance	-	ABS	immediate

Jackson et al. (2019)	Dot-probe task with eye movement tracking	Pictorial	2000ms	Detection	Visual target/ dot probe	congruent and incongruent type	Hypervigilance	-	gaze duration	immediate
Khatibi et al. (2008)	Dot-probe	Pictorial	300 ms	Discrimination	Left-facing arrow or right-facing arrow	Mixed	Hypervigilance	Fear-avoidance model	ABS	fixation presented for 100ms
Liossi et al. (2010)	Dot-probe	words	500 ms and 1250 ms	Detection	small dot	mixed	Strategic	The schema enmeshment model, the cognitive-affective model of the interruptive function of pain, and the content specificity hypothesis	ABS	immediate

Mazidi et al. (2019)	Dot-probe task with eye movement tracking	Pictorial	Faces remained for 1500 ms	Detection (left or right)	dot probe	mixed(pre-randomised)	Hypervigilance/avoidance	Vigilance-avoidance hypothesis	Gaze duration	immediate
Mohammadi et al. (2012)	Dot-probe	Pictorial	500ms	Discrimination	Left-facing arrow or right-facing arrow	mixed	Hypervigilance or difficulty disengaging from painful faces (can't be distinguished because no neutral-neutral stimulation was used)	Fear of (re)injury model of pain	ABS	-
Roelofs et al. (2005)	Dot-probe	Pictorial and words	500 ms	Detection (location)	dot-probe	blocked counterbalanced	The difficulty of disengagement/avoidance	Fear of (re)injury model of pain	ABS	Immediate
Schoth, & Liossi (2013)	Dot-probe	Pictorial	500ms and 1250 ms	Detection	p, q	blocked counterbalanced	Strategic	Not specified	ABS	immediate
Sharpe et al. (2009)	Dot-Probe	words	500ms	Discrimination	letter p or q	mixed	Difficulty of disengagement	Fear of (re)injury model of pain	ABS/RT	immediate

Sharpe et al. (2012) (study 2 only)	Dot-probe	words	500ms	Discrimination	letter 'p' or 'q'	mixed	Hypervigilance / difficulty disengaging	The fear of (re)injury model of pain	ABS	immediate
Yang et al. (2013)	Dot probe with eye-tracking	words	2,000 ms to allow EM measurement	Detection	dot probe	Mixed (randomised)	Hypervigilance	Vigilance-avoidance hypothesis	-RT -Gaze duration -First fixation duration	can't tell

Table 3-B: studies used Stroop task

First Author	Task Type	Stimulus type	main stimulus/Cue duration	Type of task participants do with the target	Target type	Counter-balancing of stimulation	Attentional process(es) predicted	CP-SA Model/Hypothesis	Dependent variable/ response measuring
Andersson, & Haldrup (2003)	Emotional Stroop	Words	unlimited until response	Naming	Ink colour of words	NA	Strategic	Schema enmeshment model	RT
Asmundson et al. (2005)	Emotional Stroop	Words	Unmasked. Unlimited time/Masked 14.3 milliseconds then replaced by a string	Naming	Ink colour of the words	Mixed	Strategic	Fear-avoidance	RT

Beck et al. (2001)	Emotional Stroop	Words	4s	naming	Ink colour of the words	Can`t tell	difficulty of disengagement	Not specified	RT
Crombez et al. (2000)	Emotional Stroop	Words	2 sec	Naming	Ink colour of the words	Randomised	Hypervigilance	The cognitive-affective model of the interruptive function of pain	RT
Duschek et al. (2014)	Emotional Stroop	Words	500 ms	Naming	colour of the words	Mixed	Strategic	Not specified	RT
González et al. (2010)	Emotional Stroop	Words	Unlimited until response	Naming	Ink colour of the words	Mixed	Hypervigilance	Not specified	RT
Pincus et al. (1998) (experiment 1 only)	Emotional Stroop	Words	Unlimited until response	Naming	Ink colour of the words	blocked fixed order	Strategic	Not specified	RT
Snider et al. (2000)	Emotional Stroop (masked and unmasked)	Words	Unmasked (unlimited RT) masked only (14.3 ms)	Naming	ink colour of words	Mixed	Strategic	Fear-avoidance model	RT

Table 3-C: studies used other tasks

First Author	Task Type	Stimulus type	main stimulus/Cue duration	Type of task participants do with the target	Target type	Counter-balancing of stimulation	Attentional process(es) predicted	CP-SA Model/Hypothesis	Dependent variable/response measuring	Time between cue end and target
Chapman, & Martin (2011)	Spatial cueing	Words	100 ms	Detection	Dot probe	Mixed	The difficulty of disengagement and Hypervigilance	Fear-avoidance	ABS	blank masking screen was presented for 50 ms between cue and target
Peters et al. (2000)	Single Detection then Dual-task (Detection of electrical stimulation task and RT for visual stimuli task)	Red light signal, then an innocuous electrical signal + geometric (pictorial)	1 s	Detection of electrical signal and discrimination of the geometric object	-Location of the electrical signal on the schematical representation of the body -Geometric object type intertwined with triangle distractor (non-simultaneous)	Blocked fixed order (trails in each block randomised)	Hypervigilance (non-sig)	Not specified	RT	Half of the trials were immediate (0 sec), and the other half 6 sec delay from light onset
Schoth et al. (2014)	visual searching with eye-tracking	Pictorial	3 seconds	Detection (Target-absent)	Images (pain/happy/anger/neutral)	Blocked counter-balanced	Facilitated attention	A motivational account of attention to pain	RT/accuracy	NA
Van Ryckeghem et al. (2012)	Spatial cueing task	Pink or blue square (pictorial), and noxious electrical stimulus (one of the squares was related to pain through	200 ms	Discrimination	A visual target (: or¨),	Blocked counter-balanced	Difficulty of disengagement	A number of different models	RT/ABS (mainly)	Immediate (0)

		classical conditioning)								

Table 3-A studies used the dot-probe task, 3-B studies used the Stroop task, and 3-C studies used other tasks. That includes the experiment task type, stimulus type, cue duration, action to the target, counterbalancing, an attentional process dependent variable, and timing between cue and target. CP: chronic pain, SA: selective attention, RT: reaction time, ABS: attentional bias score.

Appendix 3.D: Demographic information of the participants, pain characteristics, and measurement tools used in the studies (As reported in the studies)

First Author	Age CP group	Age control group(s)	Gender in both groups (female ratio), if applicable	Ethnicity	Education	Socio-economical status	Duration of CP	Pain Intensity	Number of Pain location(s)	Measurement tools
Andersson et al. (2003)	M=44.5 (SD= 9.82)	M=45.6 (SD= 9.45)	Total 40, CP 20, 16 females (80%), matched control	can`t tell (Swedish)	CP: 15% higher education Control: 40% higher education	Not mentioned	Range 24 to 284	6.25 out of 10, (SD=1.3)	can`t tell	1-Beck Depression Inventory / 2-Beck Anxiety Inventory /3-State Anxiety (STAI-S)/4-Coping Strategy Questionnaire /5-Multidimensional Pain Inventory
Asmundson et al. (2005)	Females M=36.27 (SD=11.76) Males M=40.79 (SD=9.38)	Females M=42.00 (SD=10.64) males M=35.91 (SD=10.30)	Females CP 22/36 (61.1%) Control 18/29 62%	not mentioned	47% higher education	Not mentioned	36.74 months (SD 50.84; range, 4 to 240 months)	4.1 (1.2) on MPI-pain subscale	mainly 1-back pain (83%)	1)Anxiety Sensitivity Index 2) Beck Depression Inventory 3)State-Trait

										Anxiety Inventory 4)Multidimensional Pain Inventory 5) Pain Anxiety Symptom Scale
Asmundson et al. (2006)	Females (36.3, 11.8) males (40.8, 9.4)	Females (42.0, 10.6) males (35.9, 10.3)	CP 22 females 22 (61.1%) Control females 18 (62%)	predominantly white	Higher education or technical school education CP 47% (n = 17) Control 55% (n=16)	Not mentioned	(36.7, 50.8, 4 to 240)	not-mentioned	can`t tell	1)the Anxiety Sensitivity Index (ASI); 2) the Pain Anxiety Symptoms Scale (PASS), a 40-item measure of FOP; 3) the Beck Depression Inventory (BDI), a 21-item questionnaire; and 4) the State-Trait Anxiety Inventory (STAI)

Beck et al. (2001)	CP (M=41.3, SD=8.6)	PTSD+CP (M 42.9, SD=10.7) Control (M=32.5, SD=10.1)	females PTSD+CP 75%, CP 81% Control 48%	PTSD+CP Caucasian PTSD+CP 77%- CP 85%- Control 86% African American PTSD+CP 20%- CP 10%- Control 4% Hispanic PTSD+CP 3%- CP 5%- Control 0%	not mentioned	Not mentioned	91% > 3 months	PTSD +CP 4.33(1.17), CP 3.80 (1.44), control .33 (.66)	not mentioned	1)Fear during motor vehicle accidents (MVA) (0-100) ,Helpless during MVA (0-100) Danger (0-100), Certainty would die 2)BDI 3)the State-Trait Anxiety Inventory 4)PTSD Symptom Scale—Self Report 5)Impact of Event Scale—Avoidance and Intrusion subscales (IES-A and IES-I)

Carleton et al. (2020)	M=47.92(SD=10.75)	M=47.98 (SD 5 11.89)	female only sample	mainly Caucasian	graduating with a college degree (control 37.0%; ABM 39.7%), completing high school (control 24.1%; ABM 22.2%), obtaining a partial college degree (control 20.4%; ABM 17.5%).	homemaker (control 20.4%; ABM 28.6%) being employed full-time (control 18.9%; ABM 30.2%), retired (control 11.1%; ABM 17.5%) or on disability leave (control 14.8%; ABM 4.8%). married (control 57.4%; ABM 65.1%) and Caucasian (control 83.3%; ABM at 90.4%).	> 3 months	not mentioned	not mentioned	1.The Anxiety Sensitivity Index-3 (ASI-364) 2.The Depression Anxiety and Stress Scale 21-item (DASS-217). 3.The Illness/Injury Sensitivity Index-Revised (ISI-R17). 4.The McGill Pain Questionnaire—Short Form (SF-MPQ44) was used to measure pain experience. 5.The Pain Anxiety Symptoms Scale-20 (PASS-20) of the original PASS42.

Chapman et al. (2011)	M=31.20 (SD=11.33)	M=27.64 (SD=11.20)	Females, CP 18/20 (90%), Control 21/33 (63.6%)	not mentioned	not mentioned	Not mentioned	majority met ROME II criteria (12 weeks out of last 12 months of symptoms)	CP 51.35 (19.21), Control 33.00 (20.00)	GI tract	1)The Somatic Symptoms Scale 2) Social interaction anxiety scale 3)Hospital Anxiety and Depression Scale 4)Social Phobia Scale 5)Emotion VAS (emotions intensity)
Crombez et al. (2000)	M=48.36 (SD=14.12)	NA	Females 14/25 56%	not mentioned	not mentioned	Not mentioned	10.44 years (9.37)	48.72 (24.88)	1 LBP	1)Pain Catastrophizing Scale 2) VAS 3)NRS 4) Tampa Scale of Kinesiophobia
Dear et al.[a] (2011)	(M=43.86, SD=11.73)	(M=19.6, SD=2, 3.70)	CP 72 out of 139 females, Control 65/200 females picture-based dot-probe-task, control	can`t tell	Twenty percent had completed a university degree while 31% reported having had less than 10 years of education	Fifty percent of the sample were either married or living in a de facto relationship. Thirty-two percent of the sample was employed full-time, 11% were	6.84 years (SD = 7.46	not-mentioned	34%>= 2	1) STAI 42 2) ASI 16 3)FPQ-III 30 4)TSK 17; 5) the RMDQ 24 6) DASS 42

			71 females-word-based task 34%			employed part-time, and 41% reported being unemployed due to pain.				
Dear et al.[b] (2011)	M=44.02 (SD=11.75)	M=38.18 (SD=11.50)	Females 67/129 (51.9%) Control 28/50 (56%)	not mentioned	Twenty-two percent had less than 10 years education and 19% had a university qualification	Fifty percent were either married or living in de facto relationships. Forty percent reported being unemployed due to pain and 43% were engaged in full-time or part-time work	6.80 years (SD = 7.39)	Can't tell	2 or more locations	1)Depression Anxiety Stress Scales (DASS) 2) the Tampa Scale of Kinesiophobia (TSK) 3) modified version of the Roland and Morris Disability Questionnaire (RMDQ) 4) the Fear of Pain Questionnaire III (FPQ-III).

Dehghani et al. (2003)	M=44.5 (SD=13.4; range:18–80)	NA	Not mentioned	not mentioned	40 participants were educated to University level (23%), 50 completed high school (28%), and less than ten years of education (49%).	Sixty-one percent (n = 103) were married, Fifty four percent were unemployed, 18.5% worked full-time, 9.5% part-time, 11.9% retired, 4.25% casual, and 1.8% were studying. Seventy-five patients (43%) were receiving workers' compensation	74 months (97.15)	MPI-sev. 4.07 (1.13)	Sixty-six participants had chronic low back pain (37.5%), 26 reported upper limb pain (15%), 24 had lower limb pain (n = 24,14%) and 6% had cervical pain (n ¼ 11)	1)Fear of Pain Questionnaire – III (FPQ-III) 2)Anxiety Sensitivity Index (ASI) 3)Depression, Anxiety, and Stress Scale (DASS) 4) Tampa Scale of Kinesiophobia (TSK) 5) pain severity subscale of West Haven–Yale Multidimensional Pain Inventory 6) Roland and Morris Disability Questionnaire (RDQ) 7)The Pain Responses Self Statements (PRSS) 8) Pain self-efficacy Questionnaire (PSEQ)

Dehghani et al. (2004)	M=42 (SD=9.9)	NA	22 (52.4%) females	not mentioned	Only seven (16.7%) were educated to University level, with 13 (31%) completing high school, and the remainder (52.3%) having less than 12 years of education	Twenty-seven (64.3%) patients were married//Most (64.3%) patients were unemployed, with 23.8% working full time, 9.5% part time and 2.4% retired. Thirty three (78.6%) were receiving workers compensation	at least two years (mean=5 yrs)//59 months (SD=63.8).	MPI-severity 4.25(1)	one (main)	1)Fear of pain questionnaire-III (FPQ-III) (McNeil and Rainwater, 1998) 2)Anxiety sensitivity index (ASI)(Peterson and Reiss, 1992) 3)Depression, anxiety and stress scale (DASS) (Lovibond and Lovibond, 1995) 4)Tampa Scale of Kinesiophobia (TSK) (Korri et al., 1990) 5)West Haven-Yale Multi-dimensional Pain Inventory (WHYMPI) (Kerns et al., 1985) 6) Roland and

										Morris Disability Questionnaire (RDQ) (Roland and Morris, 1983) 7)The pain responses self-statements (PRSS) (Flor et al., 1993) 8)Pain self-efficacy questionnaire (PSEQ) (Nicholas,1989)

Duschek et al. (2014)	M=52.7 years (SD = 9.2 years)	M=53.9 years (SD = 8.4 years),	Females 100%	not mentioned	13.7 years (SD = 3.1 years)	Not mentioned	6.0 years (SD = 5.6yrs	MPQ: total pain 26.7 6.7 14–38 1.1 4.9 0–28 MPQ: current pain intensity 53.8 16.5 18–77	15.3 active tender points (SD = 2.8)	1) Structured Clinical Interview for Axis I Disorders of the Diagnostic and Statistical Manual for Mental Disorders (SCID) 2) Short form of the McGill Pain Questionnaire (MPQ).
Fashler, & Katz (2014)	Total sample (M)= 21.32, (SD) =4.35 Range 18–44 years	(-)	Females 84 (74.3%) of the total sample	Caucasian (32.54%), South Asian (28.57%), African (10.32%), East Asian (9.53%), Middle Eastern (8.73%), Hispanic/Latino (4.76%), Caribbean (3.97%),	all participants were undergraduate students	Not mentioned	seven (13.70%) participants reported experiencing pain for 3–6 months, five (9.80%) for 6–12 months, and 39 (76.50%)	mild (15.7%), moderate (74.5%), or severe (9.8%)	one to five body locations (M location =2.16, SD location =1.08)	1)Eye tracking and E-prime 2) The Pain Disability Index 3) The Pain Catastrophizing Scale 4) The Pain Vigilance and Awareness Questionnaire 5) The State-Trait Anxiety Inventory 6) The Anxiety

				aboriginal (0.79%), and undisclosed (0.79%).			for 12 months or longer			Sensitivity Index-3 7) The Illness Sensitivity Index-Short Version 8) The Sensitivity to Pain Traumatization Scale 9) The Chronic Pain Acceptance Questionnaire (CPAQ)
Fashler, & Katz (2016)	Total sample (M)= 21.32, (SD) =4.35 Range 18–44 years	(-)	Females 84 (74.3%) of the total sample	Caucasian (32.54%), South Asian (28.57%), African (10.32%), East Asian (9.53%), Middle Eastern (8.73%), Hispanic/Latino (4.76%), Caribbean (3.97%), aboriginal (0.79%), and	all participants were undergraduate students	Not mentioned	seven (13.70%) participants reported experiencing pain for 3–6 months, five (9.80%) for 6–12 months, and 39 (76.50%) for 12 months or longer.	mild (15.7%), moderate (74.5%), or severe (9.8%).	one to five body locations (M location =2.16, SD location =1.08)	1)Eye tracking and E-prime 2) The Pain Disability Index 3) The Pain Catastrophizing Scale 4) The Fear of Pain Questionnaire-III 5) The Pain Vigilance and Awareness Questionnaire 6) The State-Trait Anxiety Inventory 7) The Anxiety

				undisclosed (0.79%).						Sensitivity Index-3 8) The Health Anxiety Questionnaire 9) The Illness Sensitivity Index-Short Version 10) The Sensitivity to Pain Traumatizatio n Scale
Franklin et al. (2016)	M= 50.7 (± 12.9)	M =36.1 (± 10.5)	CP= 45 females 25 males, Control= 9 females 11 males	Not specified (Northwest English)	not mentioned	not mentioned	More Than Three Months	Not mentione d	Back pain	1)Marlowe-Crowne Social Desirability Scale (MC-SDS-short form)To assess defensiveness and discriminate defensive high-anxious from high-anxious individuals 2)The State Trait Anxiety Inventory (STAI)

Garland, & Howard (2013)	M = 49.93±12.57	M = 44.03±12 .13	Females CP 24 (69%), Control 20 (63%)	not mentioned	some college MORE 26 (74%) //support group 28 (88%)	Work status (full time) MORE 6 (17%)/ Support 4 (13%)	MORE Group 12.26±8. 16 yrs/ Support group 8.44±10. 07	MORE 5.82±1.27 Support 5.94±1.59	Low back (lumbago) 22 (63%) /17 (53%) Fibromyalgi a 8 (23%)/ 5 (16%) Extremity (arthritis) 3 (9%)/ 6 (19%) Upper back/neck (cervicalgia) 1 (3%)/ 1 (3%) Other 1 (3%)/ 3 (9%)	1)Pain severity (BPI) 5.82±1.27 5.94±1.59 2) Functional interference (BPI) 6.29±2.07 6.63±2.11 3)Fear of pain (FPQ) 70.71±23.18 73.47±30.87 4)Perceived control over pain (CSQ) 2.39±1.41 2.75±1.05
Gonzalez et al. (2010)	M=50.56 (SD =8.66) range 25 to 65	M= 48.04 (SD=7.55)	Females 100%	not mentioned	not mentioned	Not mentioned	107.28 (52.49)	Not mentione d	3 or more	1)STAI
Haggman et al. (2010)	(43.6, 14.5) range 18 to 75	18 and 73 years (40.52, 14.8)	CP Females 44%/Con t. 36%	not mentioned	CP 31% primary education level, 43% higher education. Control 34% primary education,	CP 62% married or de facto, 55%full-time work and 17% part-time work. Control 66% married or de facto 28%	>12 months (81%)	PT 2.61 (2.25) Tertiary 4.85 (2.81)	1 LBP	1)Orebro Musculoskelet al Pain Screening Questionnaire 2) Depression Anxiety Stress Scale 3)Roland-Morris

					56% higher education	single 6% divorced				Disability 4)Fear of Pain Questionnaire III 5)Tampa Scale for Kinesiophobia Questionnaire 6)VAS
Harvold et al. (2018)	CP no PTSD M= 43.8±11.5	NA	Females 30 (85.7%)	not mentioned	not mentioned	not mentioned	CP no PTSD 9.1±9.3 CP and PTSD 7.4±5.5	CP no PTSD 6.4±1.6 CP and PTSD 7.4±1.5	Not mentioned	1) Anxiety (GAD-7: 0-21) 2) Depression (PHQ-9: 0-28) 3) Disability (PDI: 0-50) 4)PTSD symptomatology (ICD-11 Trauma Questionnaire

Jackson et al. (2019)	M =26.70 yrs, SD = 10.07 yrs, range 18 to 55 yrs	N/A	68 women, 21 men	Chinese	post–high school education (85%).	not mentioned	M 37.67 months (SD 5 58.11 months, range: 3-462 months)	Pain intensity: Baseline M=12.66, SD=4.82	Neck or shoulder (46%), low back (28%), extremity (13%), head or face (10%), and other (3%). reported more than one pain site (64%) (M = 1.89, SD = 1.11). Pain every day (84%), current analgesic use for pain (42%).	1,The 25-item Fear of Pain Questionnaire –Chinese (FPQ-C) 2.The 13-item pain catastrophizing scale (PCS). 3. The 20-item Center for Epidemiologic Studies Depression (CESD)
Khatibi et al. (2008)	M= 33 (SD=5.3)	M=31.4 (SD=6.2)	Females CP 49.4% control 50%	Persian	CP 14.3 yrs (3.1), control 13.4 yrs (3.5)	86% Married	Between 4 and 10 months (mean = 6.7 months; SD = 1.4).	VAS-current week 54.6 (13.6)	Not mentioned	1) Depression, Anxiety and Stress Scale (DASS) 2) VAS 3) Pain Vigilance and Awareness Questionnaire (PVAQ) 4)Pain Anxiety Symptoms

										Scale 20 (PASS-20) 5)Tampa Scale of Kinesiophobia (TSK) 6) Roland and Morris Disability Questionnaire (RDQ)
Liossi et al. (2010)	M=35.1 (SD=6.5)	M=34.6 (SD=3.1)	Females 59 (74%) of the total sample.	not mentioned	high education level	Majority of the participants were married or in a relationship/in full-time employment or education, and had a high education level	11.66 years (5.6)	2.5 (1.1)	1 headache	1)The State-Trait Anger Expression Inventory (STAXI) 2) 2)The Beck Depression Inventory–Second Edition (BDI-II) 3) 3) The Beck Anxiety Inventory (BAI) 4)The McGill Pain Questionnaire short-form (MPQ-SF)

Mazidi et al. (2019)	M = 34.07 years, (SD 12.84); range 20–59 years;	M = 29.48 years, (SD 11.73); range 20–65 years;	67.9% female in the CP group, 65.5% female in the control group	Persian	CP M = 15.25 yrs (SD =2.49), Control M=15.86 years, (SD 2.49)	46.4% married (CP group), Control 24.1% married	M = 5.93 years (SD 6.81)	VAS current week= 5.34(2.24) / VAS currently= 2.7 (2.17)	17.85% upper limbs, 21.43% lower limbs and 10.71% back pain (28 patients with chronic musculoskeletal pain)	1.The visual analogue scale (VAS) 2.Depression, Anxiety and Stress Scale 42 (DASS-42 3.The Attentional Control Scale (ACS). 4.The Pain Catastrophizing Scale (PCS)
Mohammadi et al. (2012)	M = 41.77	M =32.63	77.8% females	Persian	CP M=12.78 (3.7) Control M=13.48 (3.52)	CP 80.7% married, caregivers 71.2% married	> 3 months	VAS – present CP 51.41 (30.71) caregivers estimation 53.71 (28.43)	20.7% upper limbs, 23.7% lower limbs, 43% back pain and 12.6% reported pain problems in more than one location	1)Pain Catastrophizing Scale 2)VAS 3)Roland and Morris Disability Questionnaire 4) Tampa Scale of Kinesiophobia 5)Depression, Anxiety and Stress Scale

Peters et al. (2000)	M=47.1 years (range 24±60 years)	M=46.9 years (range 23±58 years).	Females 100%	not mentioned	not mentioned	Not mentioned	>3months	Not mentioned	3 or more	1)Electrical stimuli were delivered (Monitor, response box and electrodes) 2)the Body Vigilance Scale 3)PASS 4)TSK 5) NEM subscale of MPQ 6)PCS 7)PVAQ 8)VAS
Pincus et al. (1998) (experiment 1 only)	Not mentioned	not mentioned	Both groups, 12 females out of 20 (60%)	can`t tell	not mentioned	Not mentioned	>6 months	M= 30 (SD 17) (out of 100)	Not mentioned	1)MPQ 2)PPI scale 3)state-trait anxiety scale 4)Beck depression scale
Roelofs et al. (2005)	M=51.1 (SD=9.8); range, 29 to 64 years	M=45.6 (SD=13.0); range, 18 to 65 years	Females CP 26/49 (53.1%), Control 26/44 (59.1%)	not mentioned	not mentioned	Not mentioned	144 months (SD, 121 months; range, 18 to 420 months)	CP 60.1 mm (26.3), Control 3.6 mm (8.6 mm)	1 LBP	1)100mm-VAS 2) Quebec Back Pain Disability Scale 3)Tampa Scale for Kinesiophobia (TSK) for FOP measurement

Schoth et al. (2014)	M=35.39, (SD = 16.35); range 19–65 years	M=33.17 (SD =15.00); range 20–65 years	female (30; 64%) ((chronic headache group: 17 (74%) female, control group: 13 (54%) female))	not mentioned	not mentioned	Not mentioned	11.4 years (SD = 10.7, range 5 months to 35 years	not mentioned	1 location ---Nineteen (83%) participants had tension-type headache and four (17%) had migraine	1)The MIDAS Questionnaire (Stewart et al., 2001) (Migraine Disability Assessment) 2)The McGill Pain Questionnaire -Short Form (MPQ-SF; Melzack, 1987) 3) The Anxiety Sensitivity Index (ASI; Peterson and Reiss,1992) 4) The Hospital Anxiety and Depression Scale (HADS) (Zigmond and Snaith, 1983) 5)The State-Trait Anxiety Inventory (STAI; Spielberger et al., 1970)

Schoth, & Liossi (2013)	M=43.53(SD=17.04); range 18 to 69 y	M=42.68 (SD=17.41); range 19 to 69 y	Females 53 (70.7%) of the total sample	not mentioned	not mentioned	Not mentioned	18.36 years (14.62), range 16mo to 50 y	3.11 (1.22)	18 (48.6%) participants had tension-type headache, 18 (48.6%) migraine, and 1 (2.7%) had received a diagnosis of concurrent chronic migraine and chronic tension-type headache	1)Migraine Disability Assessment (MIDAS) 2)The short-form McGill Pain Questionnaire (MPQSF) 3)The State-Trait Anxiety Inventory (STAI) 4)The Hospital Anxiety and Depression Scale (HADS) 5)Anxiety Sensitivity Index (ASI)
Sharpe et al. (2009)	M=56.2 (SD=13.0)	NA	Females 78% (78)	Not mentioned	28% less than ten years of education, 43% completed a university degree (78% completed high school)	55% married or living in de facto relationships (in the table, another ratio is mentioned which is 63% married or cohabiting), Nineteen percent were working	13.4 years (SD = 14.7)	5.6 (9.9)	RA in the Joints	1) Hospital Anxiety and Depression Scales (HADS) 2) Health Assessment Questionnaire (HAQ) (including level of disability and VAS) 3) Ritchie

						full-time, 24% in part-time employment.				Articular Index (RAI) 4) Disease measures: Both erythrocyte sedimentation rate (ESR) and C-reactive protein
Sharpe et al. (2012) (study 2 only)	Not mentioned	NA	Not mentioned	not mentioned	not mentioned	Not mentioned	> 3 months	ABM 4.45 ± 2.0 Control 3.3 ± 2.0	Not mentioned	1)Örebro musculoskeletal pain questionnaire 2)VAS 3) Roland–Morris disability questionnaire 4)Tampa scale for kinesiophobia 5)Depression, anxiety and stress scale (DASS)

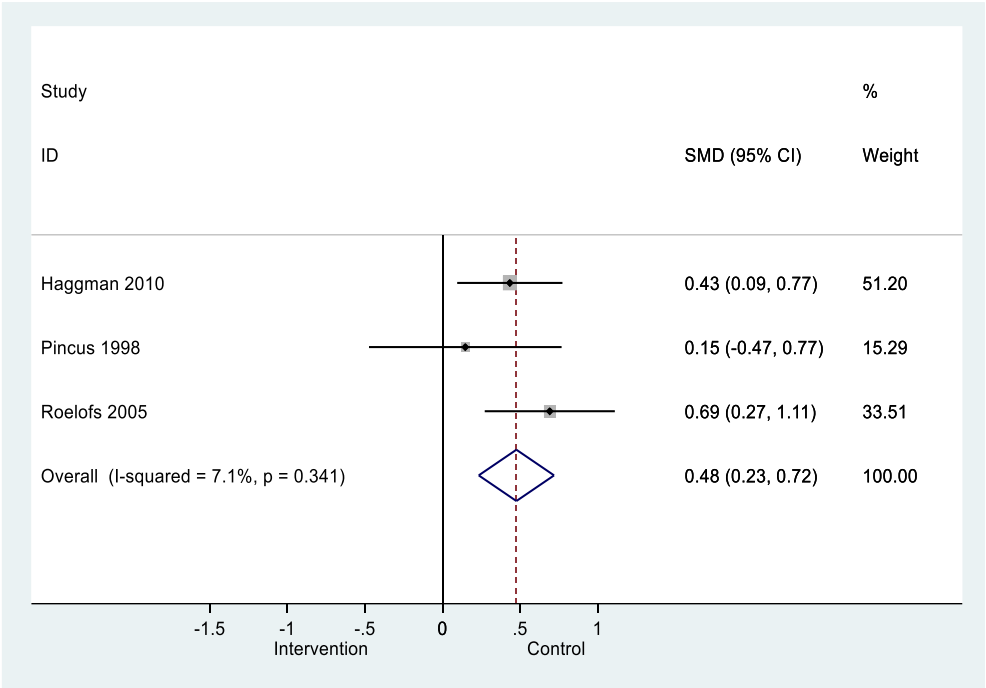
Snider et al. (2000)	M=35.5 (SD=10.3)	M=35.0 (SD=10.1)	60.6% female	not mentioned	Approximately 25% had some university or college education.	(87.9%) were not working at the time of testing, and all were receiving some level of compensation for disability related to their injury (63.6% from an automobile insurance agency; 36.4% from the Workers' Compensation Board). 51.1% were married or living with another person, and 6.1% were living alone. For the Control group, 56.3% were married or living with another	M = 32.8 months (median = 13.5 months; SD = 52.2 months)	Described using MPQ Short Form as discomforting to distressing (M = 2.4; SD = 0.9) and rated it as moderate in intensity (M = 5.6; SD = 2.1).	1 or 2 locations of chronic back and/or neck pain	1)BDI 2) BAI 3)ASI 4)PASS 5) The MPQ Short Form

						person, and 9.4% were living alone				
Van Ryckeghem et al. (2012)	(M=49.64, SD=9.82)	NA	46 out 69 females (67%)	Flemish	43.3% higher education 55.2% 2ndry school 1.5% primary school	married (62.3%) living together (10.1%).	(M= 170.74, SD =111.58)	M= 3.86 on the MPI (SD = 0.98)	M =3.86, SD =1.87; range 1-9	1-The Dutch version of the State-Trait Anxiety Inventory (STAI) 40 items 2-the Dutch version of the Pain Disability Index(PDI) 7 items 3-The depression subscale of the Hospital Anxiety and Depression Scale (HADS-

										D) 4-the Dutch version of the Pain Catastrophizing Scale (PCS), 13 items
Yang et al. (2013)	M= 20.75 (SD = 1.18)	matched +- 2yrs	40/48 female (20 in each group) 83.3%	Han majority (66.7%) or Tu (12.5%), Miao (12.5%), and Zhang (6.25%) minority ethnicity.	undergraduate students at Southwest University in Chongqing, China (2.31 years of higher education (SD = .88 years))	unmarried	38.63 months (SD = 30.00 months, range = 4–121 months	High FOP 16.85 (4.06) Low FOP 16.27 (1.90)	abdominal pain (n = 12), headache (n = 4), back pain (n = 3), orofacial pain (n = 2), shoulder pain (n = 1), neck pain (n = 1), and chest pain (n = 1).	1)Fear of Pain Questionnaire –III 2)The 21-item Depression, Anxiety, Stress Scale–Chinese Version (DASS-SF) 3)The 8-item CPG49 assesses duration, intensity, and disability from pain

Appendix 3.E: Meta-analysis plots

Meta-analysis forest plot to assess the effect size between CP and healthy controls groups for; A) the affective pain-related information; B) studies that used dot-probe task; C) studies that used Stroop task; D) studies that used word stimuli; E) studies that used pictorial stimuli; F) studies that recruited the chronic low back pain sample; G) Forest plot of the sensitivity analysis.; and H) Funnel plot of the sensitivity analysis.



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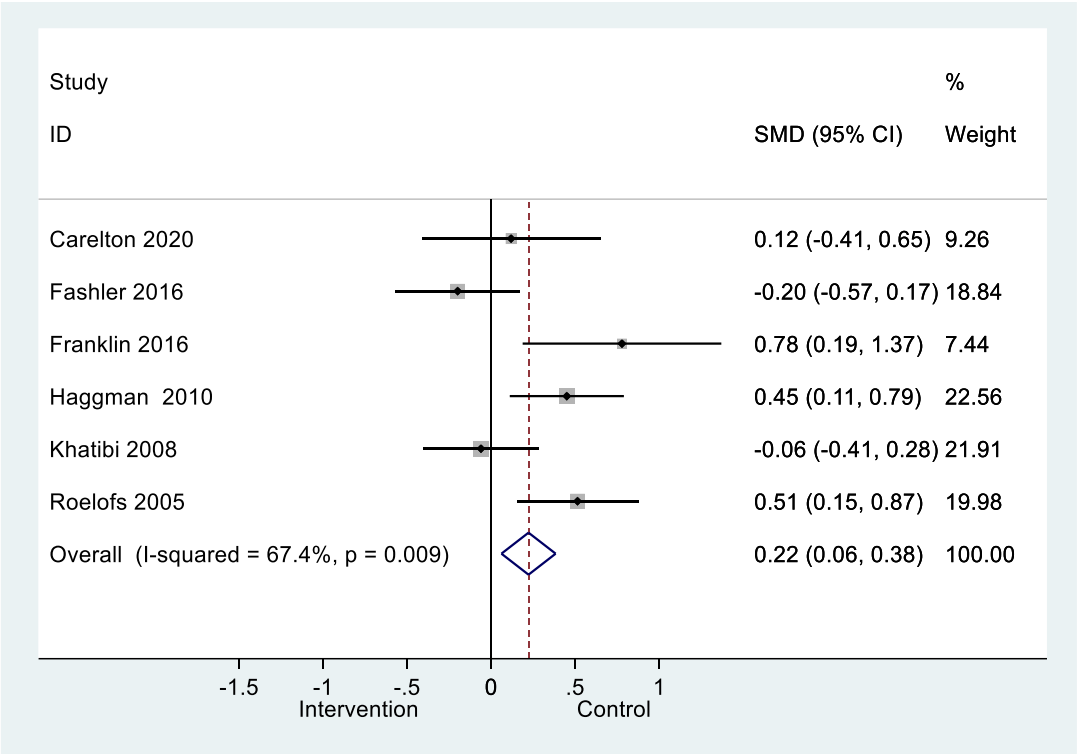
Study
ID
%
SMD (95% CI)
Weight
Carelton 2020
0.12 (-0.41, 0.65) 9.26
Fashler 2016
-0.20 (-0.57, 0.17) 18.84
Franklin 2016
0.78 (0.19, 1.37) 7.44
Haggman 2010
0.45 (0.11, 0.79) 22.56
Khatibi 2008
-0.06 (-0.41, 0.28) 21.91
Roelofs 2005
0.51 (0.15, 0.87) 19.98
Overall (I-squared = 67.4%, p = 0.009)
0.22 (0.06, 0.38) 100.00
-1.5
-1
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1
Intervention
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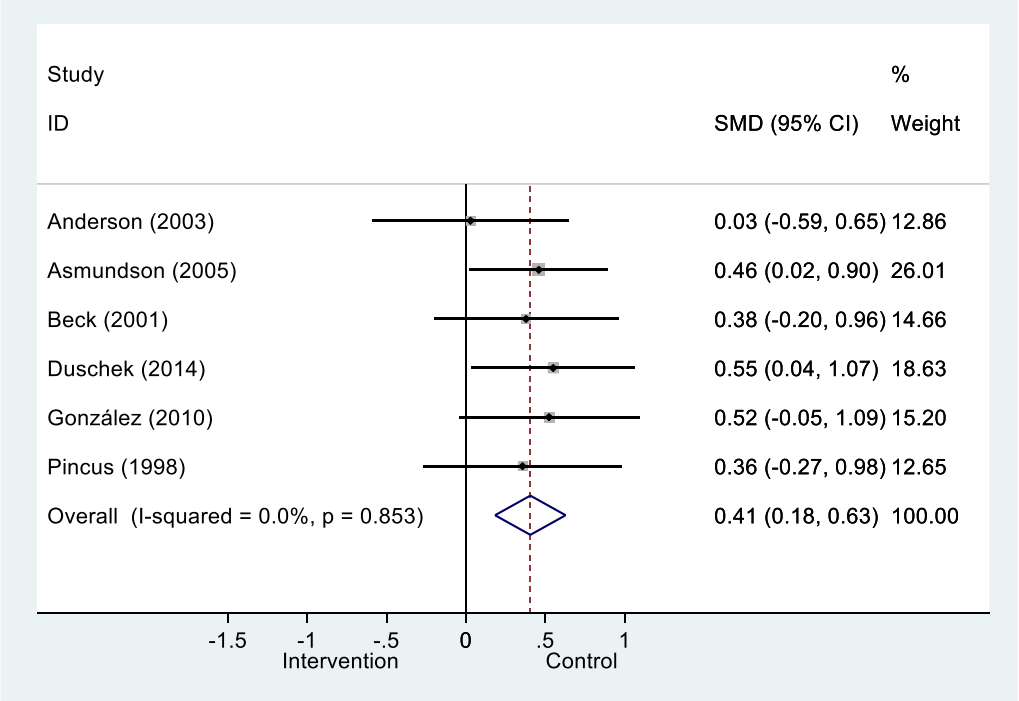
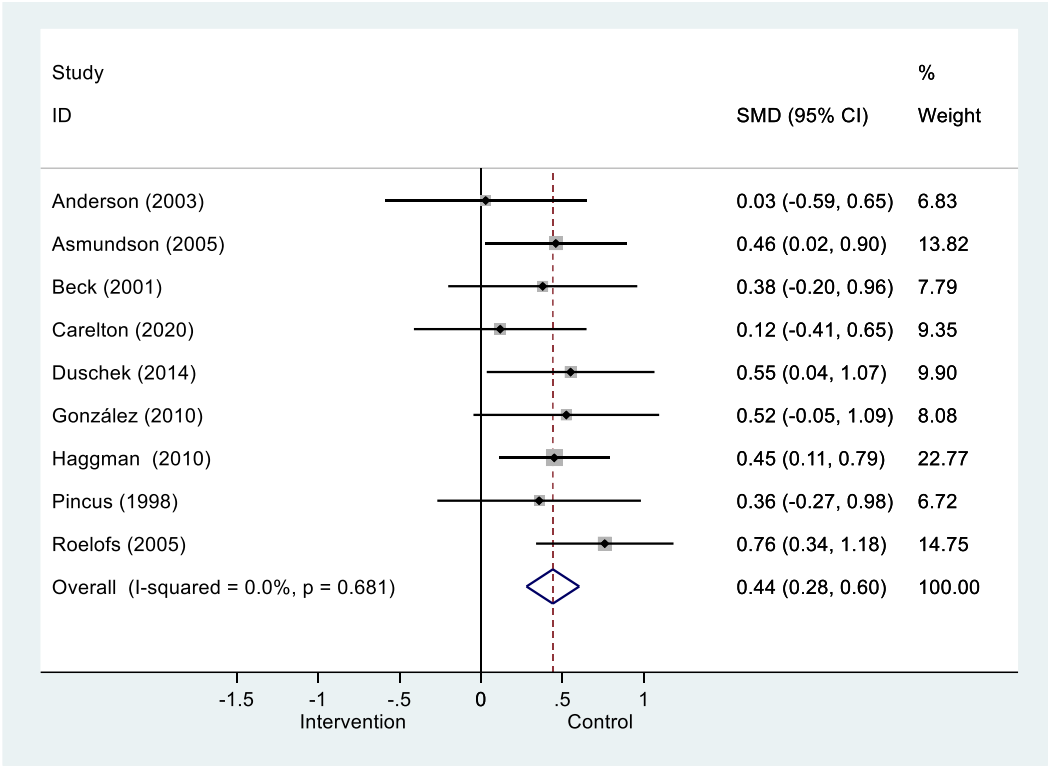
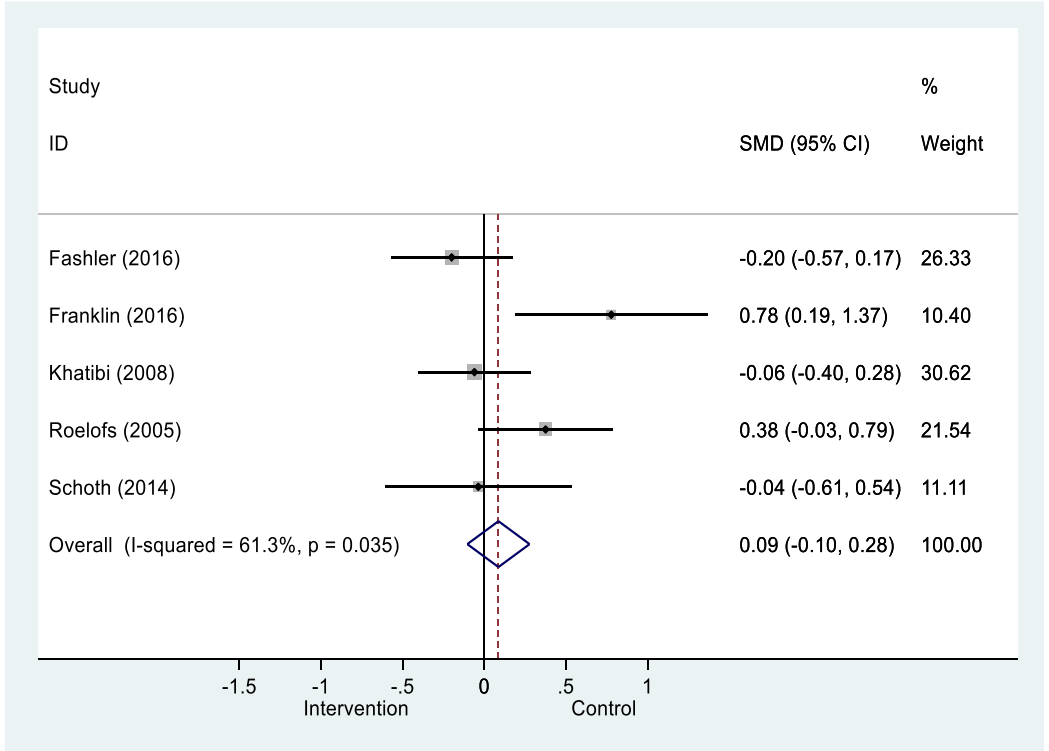
B


Study
ID
%
SMD (95% CI)
Weight
Anderson (2003)
0.03 (-0.59, 0.65) 12.86
Asmundson (2005)
0.46 (0.02, 0.90) 26.01
Beck (2001)
0.38 (-0.20, 0.96) 14.66
Duschek (2014)
0.55 (0.04, 1.07) 18.63
González (2010)
0.52 (-0.05, 1.09) 15.20
Pincus (1998)
0.36 (-0.27, 0.98) 12.65
Overall (I-squared = 0.0%, p = 0.853)
0.41 (0.18, 0.63) 100.00
-1.5
-1
-.5
0
.5
1
Intervention
Control

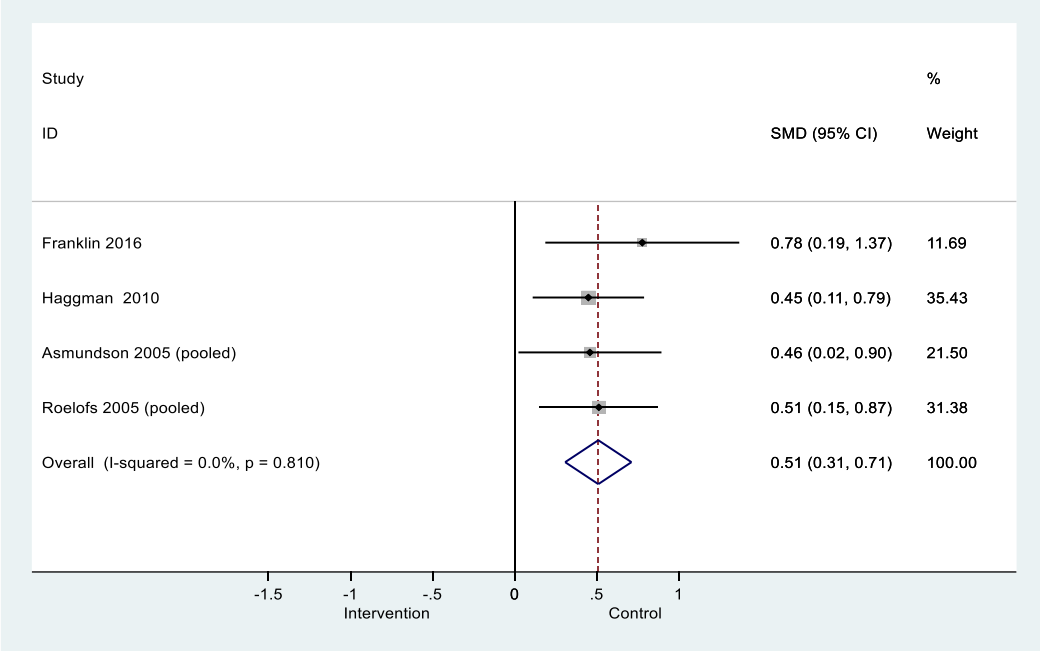
C


Study
ID
SMD (95% CI)
%
Weight
Anderson (2003) 0.03 (-0.59, 0.65) 6.83
Asmundson (2005) 0.46 (0.02, 0.90) 13.82
Beck (2001) 0.38 (-0.20, 0.96) 7.79
Carelton (2020) 0.12 (-0.41, 0.65) 9.35
Duschek (2014) 0.55 (0.04, 1.07) 9.90
González (2010) 0.52 (-0.05, 1.09) 8.08
Haggman (2010) 0.45 (0.11, 0.79) 22.77
Pincus (1998) 0.36 (-0.27, 0.98) 6.72
Roelofs (2005) 0.76 (0.34, 1.18) 14.75
Overall (I-squared = 0.0%, p = 0.681) 0.44 (0.28, 0.60) 100.00
-1.5
-1
-.5
0
.5
1
Intervention
Control

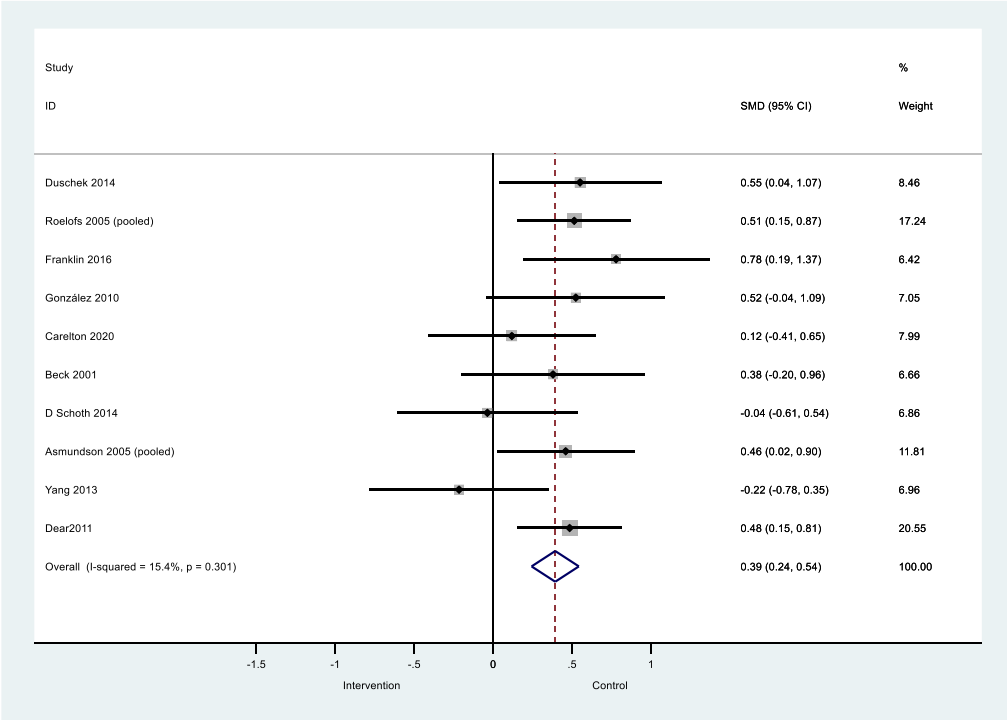
D


Study
ID
SMD (95% CI)
%
Weight
Fashler (2016) -0.20 (-0.57, 0.17) 26.33
Franklin (2016) 0.78 (0.19, 1.37) 10.40
Khatibi (2008) -0.06 (-0.40, 0.28) 30.62
Roelofs (2005) 0.38 (-0.03, 0.79) 21.54
Schoth (2014) -0.04 (-0.61, 0.54) 11.11
Overall (I-squared = 61.3%, p = 0.035) 0.09 (-0.10, 0.28) 100.00
-1.5
-1
-.5
0
.5
1
Intervention
Control

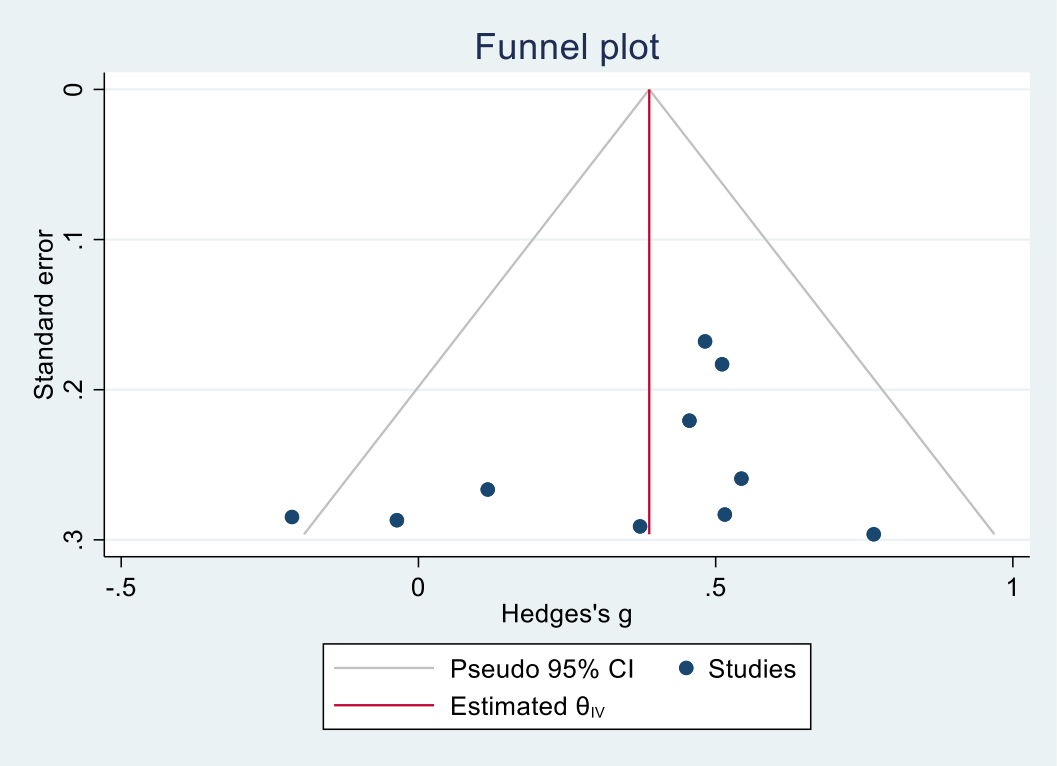
E


Study
ID
SMD (95% CI)
%
Weight
Franklin 2016
0.78 (0.19, 1.37)
11.69
Haggman 2010
0.45 (0.11, 0.79)
35.43
Asmundson 2005 (pooled)
0.46 (0.02, 0.90)
21.50
Roelofs 2005 (pooled)
0.51 (0.15, 0.87)
31.38
Overall (I-squared = 0.0%, p = 0.810)
0.51 (0.31, 0.71)
100.00
-1.5
-1
-.5
0
.5
1
Intervention
Control

F


Study
ID
SMD (95% CI)
%
Weight
Duschek 2014
0.55 (0.04, 1.07)
8.46
Roelofs 2005 (pooled)
0.51 (0.15, 0.87)
17.24
Franklin 2016
0.78 (0.19, 1.37)
6.42
González 2010
0.52 (-0.04, 1.09)
7.05
Carelton 2020
0.12 (-0.41, 0.65)
7.99
Beck 2001
0.38 (-0.20, 0.96)
6.66
D Schoth 2014
-0.04 (-0.61, 0.54)
6.86
Asmundson 2005 (pooled)
0.46 (0.02, 0.90)
11.81
Yang 2013
-0.22 (-0.78, 0.35)
6.96
Dear2011
0.48 (0.15, 0.81)
20.55
Overall (I-squared = 15.4%, p = 0.301)
0.39 (0.24, 0.54)
100.00
-1.5
-1
-.5
0
.5
1
Intervention
Control

G


Funnel plot
Standard error
0
.1
.2
.3
-.5
0
.5
1
Hedges's g
Pseudo 95% CI
Studies
Estimated θIV

H

Appendix 3.F: Studies included in the systematic review and meta-analysis.

ID/DOI	First Author	Year of Publication	Title
https://doi.org/10.1016/j.pain.2012.12.008*	Van Ryckeghem	2012	The predictive value of attentional bias towards pain-related information in chronic pain patients: A diary study
https://doi.org/10.1016/S1090-3801(03)00002-8	Gerhard Andersson	2003	Personalized pain words and Stroop interference in chronic pain patients
https://doi.org/10.1016/j.jpain.2006.05.008	Gordon J.G. Asmundson	2006	Is High Fear of Pain Associated With Attentional Biases for Pain-Related or General Threat? A Categorical Reanalysis
https://doi.org/10.1016/j.jpain.2011.07.003	Blake F. Dear	2011	The Psychometric Properties of the Dot-Probe Paradigm When Used in Pain-Related Attentional Bias Research
https://doi.org/10.1111/j.2044-8260.1998.tb01278.x	Tamar Pincus	1998	Do chronic pain patients 'Stroop' on pain stimuli? (experiment 1 only)
doi: 10.1037//0021-843X.110.4.536	J. Gayle Beck	2001	Specificity of Stroop Interference in Patients With Pain and PTSD
doi:10.1053/eujp.1999.0149	Geert Crombez	2000	The emotional stroop task and chronic pain: what is threatening for chronic pain sufferers?

doi:10.1016/j.jpain.2005.02.012*	Gordon J.G. Asmundson	2005	Hypervigilance and Attentional Fixedness in Chronic Musculoskeletal Pain: Consistency of Findings Across Modified Stroop and Dot-probe Tasks
doi:10.1016/j.jpain.2004.12.011*	Jeffrey Roelofs	2005	The Role of Fear of Movement and Injury in Selective Attentional Processing in Patients With Chronic Low Back Pain: A Dot-Probe Evaluation
https://doi.org/10.1016/S0304-3959(00)00259-1	Madelon L. Peters	2000	Do Fibromyalgia patients display hypervigilance for innocuous somatosensory stimuli? Application of a body scanningreaction time paradigm
doi:10.1016/j.jpain.2010.02.017	Sonia P. Haggman	2010	Attentional Biases Toward Sensory Pain Words in Acute and Chronic Pain Patients
doi:10.1016/j.jpsychores.2010.05.002*	José L. González	2010	Generalized hypervigilance in fibromyalgia patients: An experimental analysis with the emotional Stroop paradigm
DOI: 10.1159/000348868*	Eric L. Garland	2013	Mindfulness-Oriented Recovery Enhancement Reduces Pain Attentional Bias in Chronic Pain Patients
https://doi.org/10.1016/j.ejpain.2010.05.008	Christina Liossi	2011	Time-course of attentional bias for threat-related cues in patients with chronic daily headache–tension type: Evidence for the role of anger
doi: 10.1097/AJP.0b013e31826b4849	Daniel E. Schoth	2013	Specificity and Time-Course of Attentional Bias in Chronic

			Headache A Visual-Probe Investigation
https://doi.org/10.1016/j.pain.2011.12.014	Louise Sharpe	2012	Is there a potential role for attention bias modification in pain patients? Results of 2 randomised, controlled trials
DOI:10.1348/135910710X505887* oxford style	Sarah Chapman	2011	Attention to pain words in irritable bowel syndrome: Increased orienting and speeded engagement
doi:10.1016/j.jpain.2010.11.010* well detailed procedure	Blake F. Dear	2011	Pain-Related Attentional Biases: The Importance of the Personal Relevance and Ecological Validity of Stimuli
doi:10.1016/S0304-3959(03)00224-0	Mohsen Dehghani	2003	Selective attention to pain-related information in chronic musculoskeletal pain patients
doi:10.1016/j.ejpain.2004.02.003	Mohsen Dehghani	2004	Modification of attentional biases in chronic pain patients: a preliminary study
https://doi.org/10.1111/pme.12360	Stefan Duschek	2014	Attentional Bias Toward Negative Information in Patients with Fibromyalgia Syndrome
http://dx.doi.org/10.2147/JPR.S104268	Samantha R Fashler	2016	Keeping an eye on pain: investigating visual attention biases in individuals with chronic pain using eye-tracking methodology
http://dx.doi.org/10.2147/JPR.S67431	Samantha R Fashler (same sample)	2014	More than meets the eye: visual attention biases in individuals reporting chronic pain
DOI: https://doi.org/10.1097/AJP.0000000000000505	Mathea Harvold	2018	Attentional Avoidance is Associated With Increased Pain Sensitivity in Patients With Chronic Posttraumatic Pain and

			Comorbid Posttraumatic Stress
doi:10.1016/j.pain.2008.11.020.	Ali Khatibi	2008	Selective attention towards painful faces among chronic pain patients: Evidence from a modified version of the dot-probe
doi:10.1016/j.pain.2011.08.021	Somayeh Mohammadi	2012	Do main caregivers selectively attend to pain-related stimuli in the same way that patients do?
doi:10.1002/ejp.595	D Schoth	2014	Eye movements during visual search for emotional faces in individuals with chronic headache
doi:10.1016/j.jpain.2008.10.005	Sharpe	2009	Attentional Biases in Chronic Pain Associated With Rheumatoid Arthritis: Hypervigilance or Difficulties Disengaging?
DOI NOT FOUND	Snider Bonnie S	2000	Automatic and Strategic Processing of Threat Cues in Patients With Chronic Pain: A Modified Stroop Evaluation
https://doi.org/10.1016/j.jpain.2013.04.017**	Zhou Yang	2013	Effects of Chronic Pain and Pain-Related Fear on Orienting and Maintenance of Attention: An Eye Movement Study
doi: 10.1371/journal.pone.0147035	Franklin	2016	Personality Type Influences Attentional Bias in Individuals with Chronic Back Pain
http://dx.doi.org/10.1097/j.pain.0000000000001746	Nicholas Carleton	2020	Evaluating the efficacy of an attention modification program for patients with fibromyalgia:a randomized controlled trial

http://dx.doi.org/10.1097/j.pain.0000000000001614	Jackson	2019	Pain-related gaze biases and later functioning among adults with chronic pain: a longitudinal eye-tracking study
https://journals.sagepub.com/doi/10.1177/2049463719866877	Mahdi Mazidi	2019	Time course of attentional bias to painful facial expressions and the moderating role of attentional control: an eye-tracking study
https://doi.org/10.1371/journal.pone.0252398	J. Priebe et al.	2021	Attentional processing of pain faces and other emotional faces in chronic pain–an eyetracking study

Appendix 4.A: The ratio of data removed from through cleaning steps

Table 1: Trimming data for the Posner task

Cleaning step	Chronic pain group	Healthy control group
Removing wrong answers (>30%)	NA	N=1
Removing answers out of the pre-determined attention spectrum (<.25 or > 3.0 sec)	2.95%	1.52%
Trimming using interquartile equation	4.62% to 6.87%	3.56% to 4.70%
Removing data from tasks with 30% lost data on all conditions	NA	NA
Removing data from tasks with 50% lost data for each condition	2 conditions from 2 participants	5 conditions from 3 participants

Table 2: Trimming data for the emotional Stroop task

Cleaning step	Chronic pain group	Healthy control group
Removing wrong answers (>30%)	NA	N=1
Removing answers out of the pre-determined attention spectrum (<.25 or > 3.0 sec)	7.28%	4.34%
Trimming using interquartile equation	5.72% to 5.98%	4.90% to 5.33%
Removing data from tasks with 30% lost data on all conditions	N=5	N=4
Removing data from tasks with 50% lost data for each condition.	NA	NA

Appendix 4.B: Pain characteristics

Type of chronic pain	Lumbar low back pain	Cervical Neck pain	Thoracic Back pain	Headache (including migraine, tension headache, cluster headache, sinus headache)	Post-injury chronic pain (musculoskeletal, burn,	Ulcerative colitis	GERD (chronic acid reflux)	Limbs-pain Non- injury related (Osteoarthritis, overuse, ..)	**RA**	**FM**	IBS	Planter fasciitis-bone spur
Ratio Jordan	7 (21.21%)	4 (12.12%	-	5 (15.15%)	4 (12.12%)	1 (3.03%)	2 (6.06%)	5 (15.15%)	**1 (3.03 %)**	-	1 (3.03 %)	3 (9.09%)
Ratio UK	6 (24%)	2 (8%)	1 (4%)	5 (20%)	6 (24%)	-	-	3 (12%)	-	**1 (4%)**	**1 (4%)**	-
Total ratio	13 (22.41%	6 (10.34%)	1 (1.72%)	10 (17.24%)	10 (17.24%)	1 (1.72%)	2 (3.45%)	8 (13.79%)	1 (1.72 %)	**1 (1.72 %)**	**2 (3.45 %)**	3 (5.17%)

Appendix 4.C: Mean responses for words on the Short Form-McGill questionnaire subscales

Pain words from subscales dimensions (i.e. Sensory pain words, Affect pain words) of the Mild =1, Moderate 2, Severe =3

Sensory pain words	Mean	SD
Throbbing	1.24	1.26
Shooting	1.48	1.23
Stabbing	1.52	1.19
Sharp	1.93	1.07
Cramping	1.69	1.14
Gnawing	0.93	1.12
Hot-Burning	1.21	1.28
Aching	1.62	1.18
Heavy	1.93	1.12
Tender	1.72	1.15
Splitting	1.26	1.26
Affect pain words		
Tiring-Exhausting	2.22	0.94
Sickening	1.62	1.35
Fearful	1.50	1.25
Punishing-Cruel	2.10	1.04

Appendix 4.D: linear random mixed effect model results

Hypothesis one (Assessing between-groups differences on the Posner task)

Table1: ANOVA

Variable	df	F value	P-value
Group	1, 671	19.97	< .001 ***
Word	2, 671	0.20	0.819
Cue	1, 671	2.55	0.111
Group*Word*Cue	2, 671	0.52	0.593

Table2: Linear Mixed effect model

Variable	Estimate	Std. Error	df	t value	P-value
Intercept	-3.187e-01	1.020e-01	1.036e+02	-3.123	0.002**
Group:					
- HCG	-	-	-	-	Ref.
- CPG	3.015e-02	3.356e-02	1.409e+02	0.898	0.371
Words:					
- Neutral	-	-	-	-	Ref.
- Affect	-6.893e-03	1.430e-02	5.581e+02	-0.482	0.630
- Sensory	-2.539e-02	1.430e-02	5.581e+02	-1.776	0.076.
Cue:					
- cuedlog	-	-	-	-	Ref.
- uncuedlog	-4.635e-02	1.438e-02	5.583e+02	-3.224	0.001**
Age:	7.975e-03	1.330e-03	1.019e+02	5.994	3.12e-08***
Gender:					
- Female	-	-	-	-	Ref.
- Male	9.351e-02	3.120e-02	1.020e+02	2.997	0.003**
Interaction term:					
- HCG*cued*neutral	-	-	-	-	Ref.
- CPG*uncued*affect	-1.466e-02	2.839e-02	5.581e+02	-0.516	0.606
- CPG*uncued*sensory	-7.394e-02	2.835e-02	5.580e+02	-2.608	0.009**

Hypothesis two (Assessing between-groups differences on the Stroop task)

Table3: ANOVA

Variable	Df	F value	P-value
Group	1, 312	8.00	.005**
Word	2, 312	0.21	0.812
Group*Word	2, 312	0.05	0.954

Table4: Linear random mixed effect model

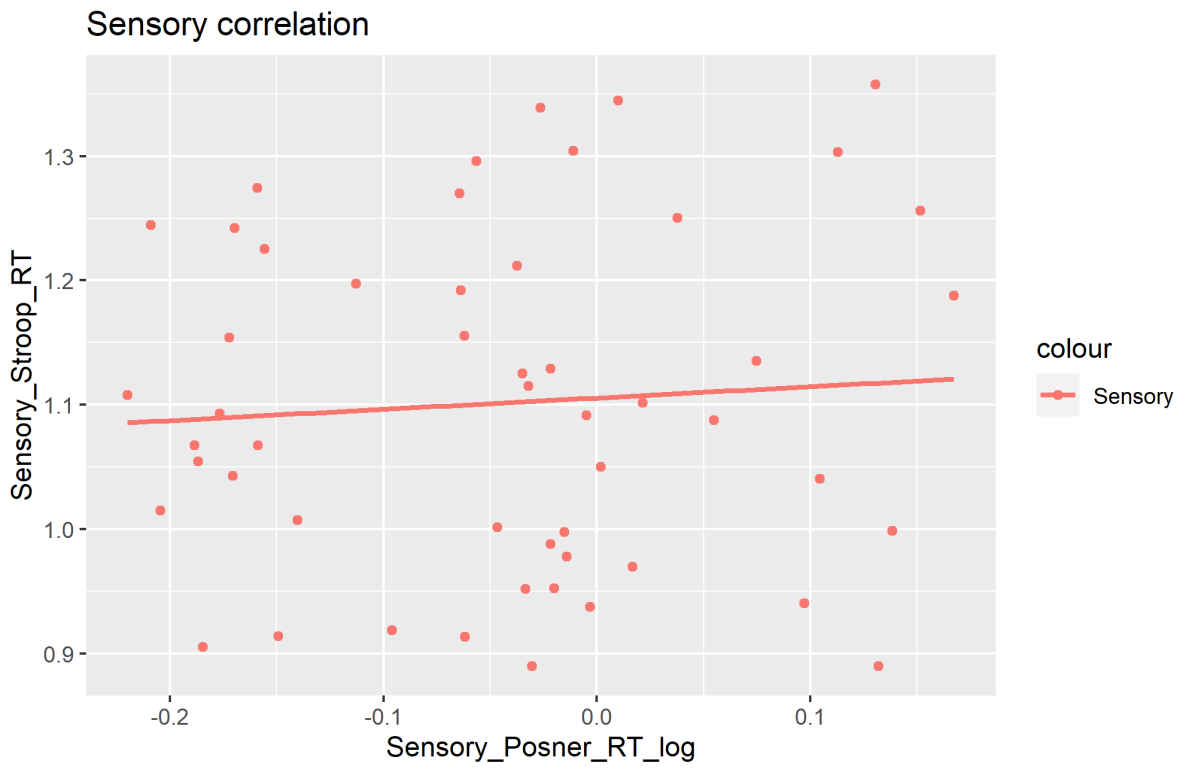
Variable	Estimate	Std. Error	df	t value	P-value
Intercept	1.058893	0.022345	127.533487	47.388	< 0.001***
Group:					
- HCG	-	-	-	-	Ref.
- CPG	0.046243	0.031601	127.533487	1.463	0.146
Words:					
- Neutral	-	-	-	-	Ref.
- Affect	0.004289	0.012222	208	-0.351	0.726
- Sensory	-0.015101	0.012222	208	-1.236	0.218
Interaction term:					
- HCG*cued*neutral	-	-	-	-	Ref.
- CPG*uncued*affect	0.002958	0.017284	208	0.171	0.864
- CPG*uncued*sensory	0.013087	0.017284	208	0.757	0.450

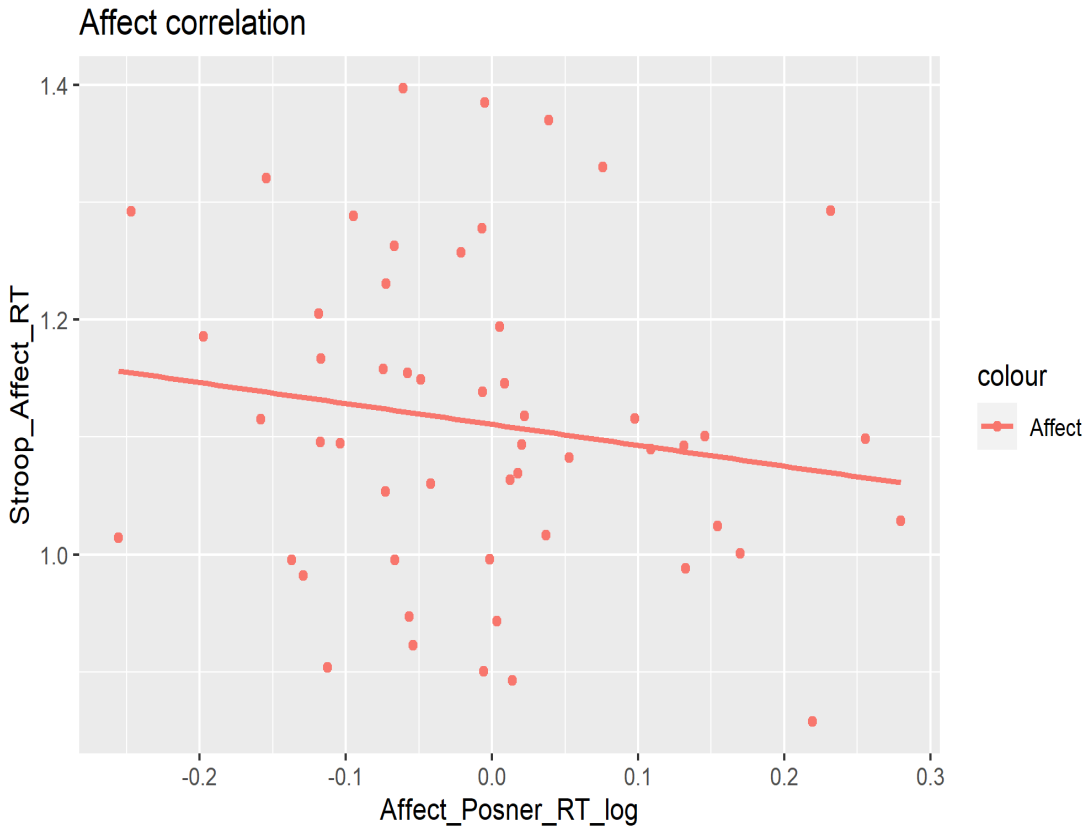
Appendix 4.E: Between groups and within groups means comparison

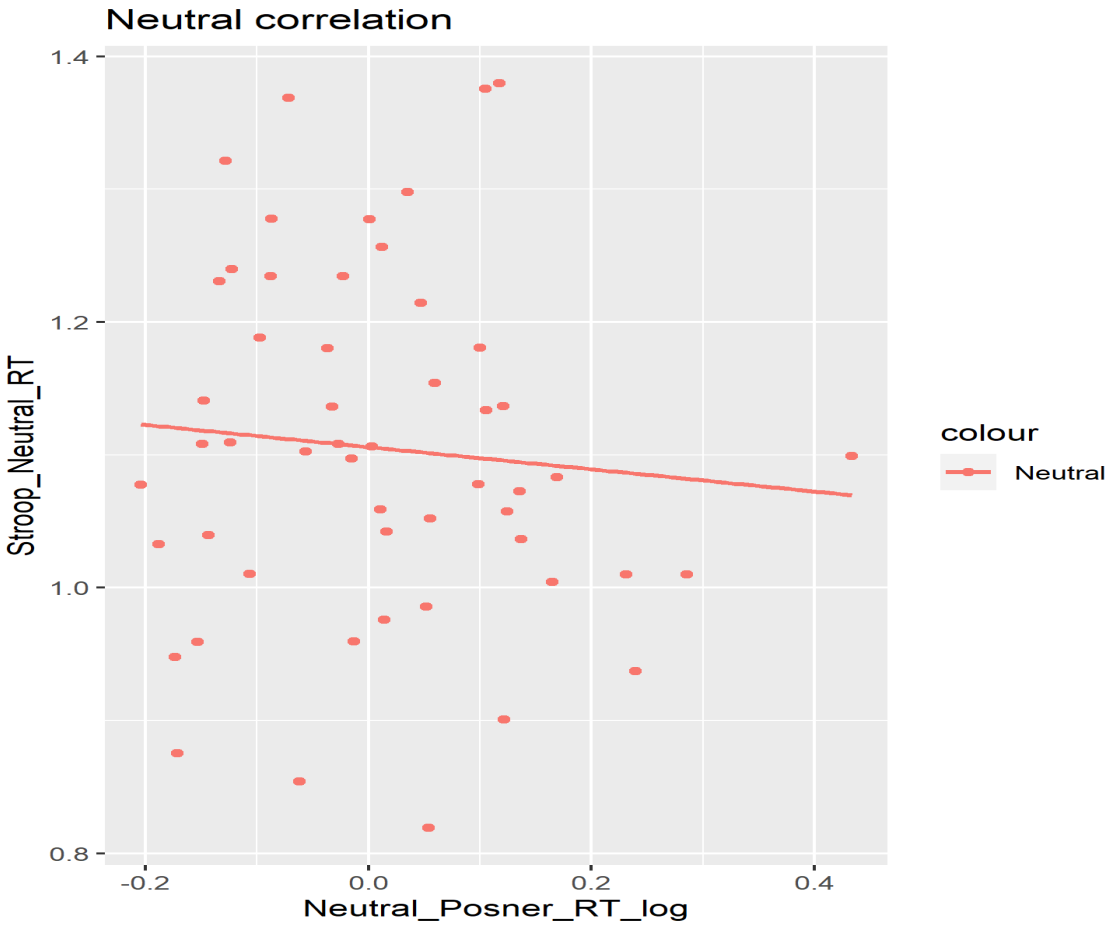
Between groups (CP-HC)	**t-value**	**DF**	**mean of difference**	**Standard error (se)**	**95% CI of the mean of the difference**	**P-value**
Sensory-Sensory	1.36	112	-0.028	0.021	[-0.07, 0.013]	0.178
Affect-Affect	1.79	111	0.036	0.02	[-0.004, 0.076]	0.076
Neutral-Neutral	2.9	109	0.052	0.022	[0.009, 0.096]	0.019*
Within-group (CP)	-	-	-	-	-	-
Sensory-Neutral	2.44	112	-0.054	0.022	[-0.098, -0.01]	0.016*
Affect-Neutral	0.69	113	-0.015	0.023	[-0.061, 0.03]	0.492
Affect-Sensory	1.86	113	-0.039	0.021	[-0.079, 0.003]	0.066
Within-group (HC)	-	-	-	-	-	-
Sensory-Neutral	1.29	109	0.017	0.021	[-0.014, 0.067]	0.199
Affect-Neutral	0.04	107	0	0.019	[-0.036, 0.037]	0.927
Affect-Sensory	1.28	110	0.02	0.02	[-0.01, 0.07]	0.205

Uncued minus cued reaction time; CP: chronic pain; HC: healthy control

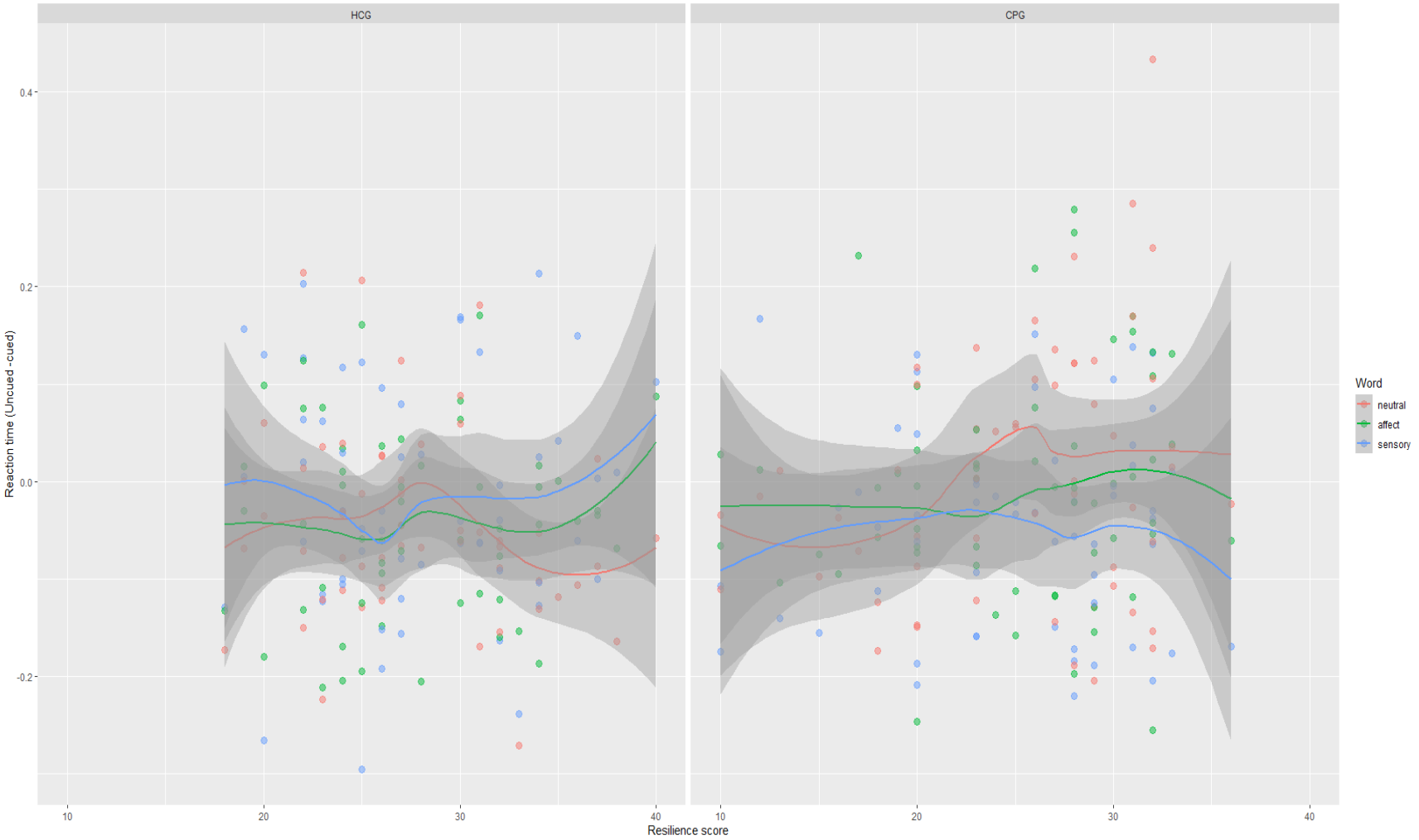
Appendix 4.F- Correlation scatter plot






Neutral correlation
1.4
1.2
1.0
0.8
Stroop_Neutral_RT
-0.2
0.0
0.2
0.4
Neutral_Posner_RT_log
colour
Neutral

Appendix 4.G: Moderation effect of resilience on reaction time in Posner tasks (Y axis shows the differences between the uncued minus cued effect, X axis shows the resilience score for each participant)



Appendix 4.H: Words Evaluation

Table 1: Words evaluation by the chronic pain group

Word English	Word Arabic	Cueing type	Mean	Median	SD	LQ	UQ	IQR
Pulsing	نابض	Sensory	3.672413793	4	1.443532838	3	5	2
Closet	خزانة	Neutral	4.189655172	5	1.468462575	4	5	1
Tiring	متعب	Affect	4.827586207	5	0.464075426	5	5	0
Throbbing	خافق	Sensory	3.534482759	4	1.569618539	2	5	3
Kitchen	مطبخ	Neutral	4.327586207	5	1.394071798	5	5	0
Exhausting	منهك	Affect	4.534482759	5	1.029657024	5	5	0
Beating	ضارب	Sensory	4	5	1.337712108	3	5	2
Table	طاولة	Neutral	4.344827586	5	1.408641552	5	5	0
Sickening	مقزز	Affect	4.224137931	5	1.351322983	4	5	1
Pounding	ساحق	Sensory	3.913793103	5	1.405309266	3	5	2
Blender	خلاط	Neutral	4.172413793	5	1.488410562	4	5	1
Suffocating	خانق	Affect	4.431034483	5	1.077880782	4	5	1
Drilling	لاذع	Sensory	3.948275862	5	1.419444094	3	5	2
Water	ماء	Neutral	4.534482759	5	1.231395119	5	5	0
Fearful	مخيف	Affect	4.517241379	5	1.188266898	5	5	0
Boring	ثاقب	Sensory	3.810344828	5	1.616330005	3	5	2
Vase	مزهرية	Neutral	4.362068966	5	1.397971913	5	5	0
Frightful	مرعب	Affect	4.431034483	5	1.229920393	5	5	0
Stabbing	طاعن	Sensory	3.982758621	5	1.468874486	3	5	2
Ladder	سلم	Neutral	4.224137931	5	1.351322983	4	5	1
Punishing	قاسي	Affect	4.603448276	5	0.954024811	5	5	0
Lancinating	يمزق	Sensory	4.655172414	5	0.909052411	5	5	0
Towels	مناشف	Neutral	4.431034483	5	1.258125436	5	5	0
Gruelling	مرهق	Affect	4.517241379	5	1.143116382	5	5	0
Pinching	قارص	Sensory	3.965517241	5	1.4505355	3	5	2
Dust	غبار	Neutral	4.396551724	5	1.269613219	5	5	0
Vicious	شديد	Affect	4.603448276	5	0.990120588	5	5	0
Pressing	ضاغط	Sensory	4.396551724	5	1.183803788	4.25	5	0.75
House	منزل	Neutral	4.517241379	5	1.202940539	5	5	0
Killing	قاتل	Affect	4.448275862	5	1.230780865	5	5	0

Table 2: Words evaluation by the healthy control group

Word English	Word Arabic	Cueing type	Mean	Median	SD	LQ	UQ	IQR
Pulsing	نابض	Sensory	3.614035	4	1.33302	3	5	2
Closet	خزانة	Neutral	4.263158	5	1.343321	4	5	1
Tiring	متعب	Affect	4.526316	5	1.053993	5	5	0
Throbbing	خافق	Sensory	3.736842	4	1.518062	3	5	2
Kitchen	مطبخ	Neutral	4.333333	5	1.327368	5	5	0
Exhausting	منهك	Affect	4.438596	5	1.195491	5	5	0
Beating	ضارب	Sensory	3.77193	4	1.427004	3	5	2
Table	طاولة	Neutral	4.385965	5	1.292207	5	5	0
Sickening	مقزز	Affect	4.017544	5	1.552547	3	5	2
Pounding	ساحق	Sensory	3.947368	5	1.481084	3	5	2
Blender	خلاط	Neutral	4.22807	5	1.464064	5	5	0
Suffocating	خانق	Affect	4.035088	5	1.349139	3	5	2
Drilling	لاذع	Sensory	3.842105	5	1.544454	3	5	2
Water	ماء	Neutral	4.649123	5	0.990873	5	5	0
Fearful	مخيف	Affect	4.631579	5	0.918687	5	5	0
Boring	ثاقب	Sensory	4.333333	5	1.074598	4	5	1
Vase	مزهرية	Neutral	4.298246	5	1.36231	5	5	0
Frightful	مرعب	Affect	4.45614	5	1.001252	4	5	1
Stabbing	طاعن	Sensory	3.982456	5	1.407775	3	5	2
Ladder	سلم	Neutral	3.877193	5	1.48889	3	5	2
Punishing	قاسي	Affect	4.473684	5	1.019546	4	5	1
Lancinating	يمزق	Sensory	4.140351	5	1.342154	3	5	2
Towels	مناشف	Neutral	4.105263	5	1.577568	3	5	2
Gruelling	مرهق	Affect	4.561404	5	1.000313	5	5	0
Pinching	قارص	Sensory	4.298246	5	1.179663	4	5	1
Dust	غبار	Neutral	4.491228	5	1.197062	5	5	0
Vicious	شديد	Affect	4.77193	5	0.567499	5	5	0
Pressing	ضاغط	Sensory	4.508772	5	0.947229	5	5	0
House	منزل	Neutral	4.596491	5	1.049824	5	5	0
Killing	قاتل	Affect	4.438596	5	1.295839	5	5	0