UNIVERSIDAD COMPLUTENSE DE MADRID
FACULTAD DE PSICOLOGÍA

TESIS DOCTORAL

Sesgos Atencionales en Dolor Crónico

Attentional Biases in Chronic Pain

MEMORIA PARA OPTAR AL GRADO DE DOCTOR

PRESENTADA POR

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SCIENTIFIC ARTICLES INCLUDED IN THE DISSERTATION.

The present doctoral Thesis includes the following published articles, as well as a fourth study that has not been published yet:

- **Study 1:** Robles, E., Nieto, I., Navas, J. F., & Vázquez, C. (2024). Attentional biases towards emotional information in chronic pain: A multilevel meta-analysis of eye-tracking studies. *Acta Psychologica, 250*, 104555. https://doi.org/10.1016/j.actpsy.2024.104555
- **Study 2:** Robles, E., Blanco, I., Díez, G., & Vázquez, C. (2024). Mindfulness-based stress reduction for chronic pain: Enhancing psychological well-being without altering attentional biases towards pain faces. *European Journal of Pain, 00*:1–14. https://doi.org/10.1002/ejp.4714.
- **Study 3:** Robles, E., & Vázquez, C. (2024). Validation of the Montreal Pain and Affective Face Clips (MPAFC): The role of sex and participants' pain status. *Ansiedad y Estrés, 30*(1), 17-26. https://doi.org/10.5093/anyes2024a3

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1. Abstract

Chronic pain stands as one of the most disabling health problems, characterized by complex underlying mechanisms. In recent years, the interest of the attentional pattern towards pain-related stimuli has increased both in healthy and chronic pain population. Although the literature has yield mixed results, attention seems to have an important role in the pain perception and maintenance. In this respect, the main objectives of this dissertation are to explore attentional biases to pain-related information in individuals with and without chronic pain and the efficacy of non-pharmacological interventions to modify the attentional pattern and improve pain-related symptoms.

Firstly, the meta-analysis performed in the Study 1 showed a tendency in the general population to firstly look at pain-related information in comparison to neutral one, meaning that individuals with and without chronic pain show attentional biases in early stages of attention. However, a bias towards neutral stimuli in comparison to anger-related stimuli was found in chronic pain individuals, which suggest a tendency to avoid paying attention to anger-related stimuli in these persons. As attentional biases towards pain-related information seem to be present in individuals with chronic pain as well as healthy people, there might be other factors involved in the experience of pain such as biological or psychological variables.

Therapies focused on the attentional control such as Mindfulness Based Stress Reduction (MBSR) programs have shown to be useful to improve the symptomatology associated with pain. The Study 2 confirmed this through a reduction on depression, anxiety and stress and an increase in well-being and satisfaction with life. However, MBSR was not effective in modifying attentional biases to pain-related information.

The methodological aspects of the experimental tasks such as the stimuli used, may interfere with the detection of attentional biases. For this reason, a third study was conducted to explore the utility of the pain faces of the Montreal Pain and Affective Face Clips (MPAFC), one of the most widely facial expressions used in the field of pain. We found low representativeness for three of the eight faces. Also, we found that female pain facial expressions seem to be more representative of the pain emotion than the male ones. These results suggest the necessity of creating more reliable and accurate stimuli for the experimental research in the field of pain.

Finally, the last study (Study 4) analyses attentional biases in healthy individuals before and after an acute pain condition, and the effectiveness of acceptance and distraction to modify the attentional pattern to pain-related information. This is a novel study in which attention to stimuli was assessed while participants suffered from pain at the same time, instead of after a pain induction. We found attentional biases in early stages of attention in pain-free conditions. However, the induction of pain reduced attention to both pain and normal stimuli. Most importantly, we found that the combination of pain acceptance followed by distraction was effective to reduce first fixation duration and average fixation towards pain faces, showing that the beneficial effects of using cognitive strategies such as acceptance and distraction may depend on the order in which these strategies are applied.

The above-mentioned results confirm the presence of attentional biases regardless of the pain status and that meditation-based programs and the use of pain acceptance and distraction are effective to reduce the physical or psychological consequences associated with pain. However, in the case of meditation, further research is needed to explore the effectiveness of these programs to modify the attentional pattern.

2. Resumen

El dolor crónico es uno de los problemas de salud más incapacitantes, caracterizado por mecanismos subyacentes complejos. En los últimos años, ha aumentado el interés por el patrón atencional hacia los estímulos relacionados con el dolor, tanto en población sana como en con dolor crónico. Aunque la literatura ha mostrado resultados dispares, la atención parece tener un papel importante en la percepción y el mantenimiento del dolor. En este sentido, los principales objetivos de esta tesis son explorar los sesgos atencionales hacia la información relacionada con el dolor en individuos con y sin dolor crónico y la eficacia de intervenciones no farmacológicas para modificar el patrón atencional y mejorar los síntomas relacionados con el dolor.

En primer lugar, el metaanálisis realizado en el Estudio 1 mostró una tendencia en la población general a fijarse en primer lugar en la información relacionada con el dolor en comparación con la neutra, lo que significa que los individuos con y sin dolor crónico muestran sesgos atencionales en fases tempranas de la atención. Sin embargo, en las personas con dolor crónico se observó un sesgo hacia los estímulos neutros en comparación con los relacionados con la ira, lo que sugiere una tendencia a evitar atender a los estímulos relacionados con la ira en estas personas. Dado que los sesgos atencionales hacia la información relacionada con el dolor parecen estar presentes tanto en individuos con dolor crónico como en personas sanas, podría haber otros factores implicados en la experiencia del dolor, como variables biológicas o psicológicas.

Las terapias centradas en el control atencional, como los programas de Reducción de Estrés Basado en Mindfulness (MBSR), han demostrado ser útiles para mejorar la sintomatología asociada al dolor. El Estudio 2 lo confirmó mediante una reducción de la depresión, la ansiedad y el estrés y un aumento del bienestar y la satisfacción vital. Sin

embargo, el MBSR no fue eficaz para modificar los sesgos atencionales hacia la información relacionada con el dolor.

Los aspectos metodológicos de las tareas experimentales, como los estímulos utilizados, pueden interferir en la detección de los sesgos atencionales. Por este motivo, se realizó un tercer estudio para explorar la utilidad de las caras de dolor del Montreal Pain and Affective Face Clips (MPAFC), una de las expresiones faciales más utilizadas en el campo del dolor. Encontramos una baja representatividad para tres de las ocho caras. Además, observamos que las expresiones faciales de dolor femeninas parecen ser más representativas de la emoción dolorosa que las masculinas. Estos resultados sugieren la necesidad de crear estímulos más fiables y precisos para la investigación experimental en el campo del dolor.

Finalmente, el último estudio (Estudio 4) analiza los sesgos atencionales en individuos sanos antes y después de una condición de dolor agudo, y la eficacia de la aceptación y la distracción para modificar el patrón atencional hacia la información relacionada con el dolor. Se trata de un estudio novedoso en el que se evaluó la atención a los estímulos mientras los participantes sufrían dolor al mismo tiempo, en lugar de después de una inducción del dolor. Encontramos sesgos atencionales en fases tempranas de la atención en condiciones sin dolor. Sin embargo, la inducción del dolor redujo la atención tanto al dolor como a los estímulos normales. Y lo que es más importante, descubrimos que la combinación de aceptación del dolor seguida de distracción era eficaz para reducir la duración de la primera fijación y la fijación media hacia las caras de dolor, lo que demuestra que los efectos beneficiosos del uso de estrategias cognitivas como la aceptación y la distracción pueden depender del orden en que se apliquen estas estrategias.

Los resultados mencionados confirman la presencia de sesgos atencionales independientemente del estado del dolor y que los programas basados en la meditación y el

uso de la aceptación y la distracción del dolor son eficaces para reducir las consecuencias físicas o psicológicas asociadas al dolor. Sin embargo, en el caso de la meditación, se necesitan más investigaciones para explorar la eficacia de estos programas para modificar el patrón atencional.

3. Introduction and main objectives

According to the revised definition of the International Association for the Study of Pain (IASP), pain refers to “an unpleasant sensory and emotional experience associated with, or resembling that associated with, actual or potential tissue damage” (Raja et al., 2020). Pain is one of the most frequent reasons for consultation in primary care (López-Silva et al., 2007; Calsina-Berna et al., 2011) and it acts as a signal that something is wrong in the body and mobilises the person to seek treatment for the cause of that pain. In this regard, pain is essential for human survival. However, when the pain does not cease despite the treatment of the cause, it is considered chronified. Unlike acute pain, chronic pain lacks utility for human survival and contributes to the individual's maladaptation and worsening quality of life (Hunfeld, et al., 2001; Hadi et al., 2019; Agnus Tom et al., 2022).

Throughout history, different authors have tried to give meaning to the experience of pain, with a predominance of theories based on the medical model. In Ancient Greece, Hippocrates considered pain an alteration in the balance of the organism (Pérez-Cajaraville et al., 2005). Later, Galen proposed that pain was a specific characteristic of the tactile sensation and considered pain as a component of inflammatory processes (Rey, 1995; Chen, 2011). Subsequently, and based on the work of these and other authors such as Descartes and his ‘Cartesian dualism’ (Cabral et al., 1993; Duncan, 2000), new theories seeking to explain the biological mechanisms underlying pain perception have emerged. The Specificity Theory of pain, proposed by Schiff in 1858, considered that tactile and painful stimuli were encoded and transmitted through different pathways, while the Intensity Theory of pain, formulated by Erb in 1874, defended that both pathways did not exist and that the amount of nerve impulses determined the intensity of the stimulus (Moayedi & Davis, 2013). In contrast to both approaches, a group of theories grouped under the name of “Pattern

Theories" emerged, which argued that there are no specific receptors for pain, instead, sensory organs had different response levels to pain, which is caused by the stimulation of nonspecific receptors (Sinclair, 1955; Weddell, 1955).

However, these theories had limitations and were not sufficient to explain the perception of pain as well as its chronification. Within this context, a new theory that made it possible to establish the neurobiological bases involved in the perception of pain emerged: the Control Gate Theory (Melzack & Wall, 1965). This theory defends that skin stimulation produces signals that are transmitted to the different regions of the spinal cord. According to this theory, the substantia gelatinosa acts as a control gate that modulates the transmission of sensory information to specific cells in the spinal cord (transmission cells). This gating mechanism is facilitated or opened by small-fiber activity and inhibited or closed by larger-fiber activity. In addition, descending fibers from the supraspinal cord and projected to the dorsal horn can also modulate this gate. When nociceptive stimulation reaches a threshold, the gate is opened and, in consequence, pain-related pathways are activated (Moayedi & Davis, 2013). Although this theory has increased our knowledge about the biological bases of pain, other psychological and emotional factors are involved in the perception of pain.

Pain has traditionally been explained by the medical model of disease that considers pain as a sensory experience arising only from noxious stimulation. However, today some alternative models increase our understanding of pain by the incorporation of social, psychological, and behavioural factors to explain the pain experience such as the Biopsychosocial Model (Engel et al., 1977), which considers pain as a multidimensional experience, in which different biological, psychological and social aspects are intertwined. In relation to this, the participant's sex also seems to influence the perception of pain, and the symptomatology associated with it, as some studies have shown that women tend to show

more pain intensity (Rosseland & Stubhaug, 2004; Solheim et al., 2017) and pain anxiety (Ramírez-Maestre & Esteve, 2014).

From a psychological view, there are numerous contributions from different psychological approaches that have studied the experience of pain, beginning with the first psychodynamic considerations of physical pain as a subjective experience that acts as a symptom of an underlying psychological dysfunction (Merskey, 2000). From the behaviourism perspective, it has been emphasized the importance of pain behaviours (Fordyce, 1984) and conditioning processes (Vlaeyen, 2015; Harvie et al., 2017), and their relationship with fear-avoidance behaviours. Cognitive perspectives have highlighted the influence of motivational and thinking components involved in pain coping. It has been focused on examining the relationship between pain and cognitive variables such as beliefs, expectations, interpretations, or problem-solving (Turk, 1978; Turk, Meichenbaum, and Genest, 1983) and how they influence the symptomatology of chronic pain patients. For instance, self-efficacy beliefs have been associated with better functioning in individuals suffering from chronic pain (Martinez-Calderon et al., 2018).

A diversity of psychological models have aimed to elucidate pain onset and maintenance. One of the most widely accepted is the Fear-Avoidance of Pain Model, which emphasizes the pivotal role of fear in pain development and maintenance and has been supported by numerous studies (Turk & Wilson, 2010; Crombez et al., 2012; Markfelder & Pauli, 2020). The idea of a relationship between pain and fear has been observed in healthy individuals. For instance, Karos et al., (2017) found in a pain-free sample that movements associated with painful stimulation were also associated with increased self-reported fear of pain. This model considers that fear is associated with avoidance, escape, and hypervigilance behaviours (Lethem et al., 1983; Vlaeyen & Linton, 2012), which are hypothesized to be

rooted in attentional mechanisms. This tendency to hypervigilance is partly related to the attentional pattern of individuals and has been strongly associated with fear of pain (McCraken, 1997; Zale et al., 2013) and anxiety sensitivity (Wong et al., 2014). For instance, in a study with healthy and chronic back pain participants, it was found that those chronic pain individuals with higher levels of fear of pain showed attentional interference during different attentional tasks (Peters et al., 2002). This finding reflects a possible effect of hypervigilance to bodily and pain-related sensations in the attentional pattern of people suffering from chronic pain. Similarly to the Fear-Avoidance Model of Pain, Todd et al. (2015) proposed their Threat Interpretation Model, which suggests a relationship between pain, threat, and interpretation biases that interacts with attentional processing. Different authors have considered threat learning as a central mechanism in the chronification of pain, as well as in the relationship between pain and stress (Timmers et al., 2019). Threat has been also linked to shorter pain tolerance, higher pain intensity and distress in healthy individuals (Todd et al., 2016).

Attentional functioning is a complex process in which the frontal lobe and other brain structures such as the hippocampus and the amygdala are involved (Mirsky et al., 1991). It depends on three different attentional components (orienting, detecting, and alerting) that interact with each other helping to economize mental resources and to respond to the environment information in the most efficient way (Posner and Petersen, 1990). A well-studied attentional mechanism in both emotional and pain-related problems is attentional biases, which are deeply intertwined with other cognitive biases (Everaert et al., 2012; Sanchez et al., 2017) and might also contribute to the chronicity of pain. These biases towards emotional stimuli can appear at different stages of attentional processing revealing different mechanisms (Cisler & Koster, 2010). On the one hand, there may be facilitated

attention to pain stimuli, or hypervigilance (i.e., the relative speed with which attention is initially and involuntarily directed to such stimuli); this tendency would reveal the existence of altered mechanisms in the early stages of processing and is captured as specific attentional indices (e.g. first fixation latency). In this regard, it is also possible to assess the ability to disengage attention from emotional information (i.e. the time taken to change the attentional focus from a stimulus to a new one), another attentional measure that has not been widely studied in the field of pain and has been strongly associated to hypervigilance (Crombez et al., 2005; Van Damme et al., 2006). On the other hand, there may also be difficulties in avoiding attention from emotional stimuli (i.e., the degree to which such stimuli capture attention and hinder the possibility of shifting attention to other stimuli); this tendency would reveal problems in later stages of processing and is studied as attentional maintenance indices.

In this respect, numerous studies have explored the attentional pattern in individuals with acute or chronic pain, but also in free-pain individuals (Crombez et al., 2013; Todd et al., 2018), finding mixed results. However, the investigation has predominantly used experimental paradigms based on reaction times, such as the dot-probe or visual search tasks. This type of research has inherent limitations as response latencies do not directly capture attentional bias and may be influenced by factors unrelated to attention (e.g., slow motor response) (Duque and Vázquez, 2018). Furthermore, these approaches fail to provide comprehensive insights into the distinct temporal components of attention (e.g., early, intermediate, and late components), as described in attention theories (Posner and Petersen, 1990). Lastly, the reliability of tasks like the standard visual dot-probe is subject to limitations (Rodebaugh et al., 2016).

An alternative and promising means of investigating attention mechanisms towards emotional stimuli is the study of eye movement analysis (Martínez-Conde et al., 2004). Eye-tracking paradigms enable the examination of multiple stages in the attentional process, encompassing early components (e.g., proportion of first fixations or first fixation latencies) and late or maintenance components (e.g., total fixation time, first fixation duration). By using this methodology, it has been observed that individuals with chronic pain show increased attention to pain-related information in comparison to neutral (Mahmoodi-Aghdam et al., 2017; Franklin et al., 2018), although this effect has also been found in pain-free individuals (Jones et al., 2021).

In addition to attentional biases, emerging evidence from the literature has highlighted the influential role of cognitive and emotional processes in the context of pain. For instance, pain catastrophizing is implicated in heightened pain intensity among individuals with chronic low back pain (Meints et al., 2020), and it serves as a mediating factor in the association between depressed mood and pain intensity among individuals with chronic pain (Wood et al., 2013). Pain catastrophizing has also been strongly associated with chronic pain. Systematic reviews have found that catastrophizing of pain is a risk factor for pain chronification (Burns et al., 2015). Studies about selective attention have observed a link between pain catastrophizing and attentional biases towards pain-related information in individuals with (Ranjbar et al., 2020) and without chronic pain (Heathcote et al., 2015; Lee et al., 2018). Regarding fear of pain, similar results have been found. For instance, Jackson et al., (2018) found, in a mixed chronic pain sample, that participants showed longer overall gaze durations toward pain images in the higher threat context compared to the lower threat one, thus supporting the Threat Interpretation Model.

To date, a wide variety of pharmacological treatments (e.g., muscle relaxants, benzodiazepines, opioids, or antidepressants) have been used for the treatment of chronic pain. However, they have been considered of limited effectiveness (Deyo et al., 2009; Liebschutz et al., 2014). Thus, treating chronic pain has become a challenge for most countries, and in recent years, an interdisciplinary approach has been taken to treat chronic pain (Turk et al., 2010; Gatchel et al., 2014; Penney & Haro, 2019; Connell et al., 2022).

Although the treatment of chronic pain has been mostly focused on the use of analgesics, the interest in the effectiveness of psychological interventions to reduce the pain-related symptomatology and improve the quality of life of these patients has increased in the last years (Williams et al., 2020). For instance, systematic reviews and meta-analyses have highlighted the efficacy of Cognitive Behaviour Therapy (CBT) for chronic pain (Hoffman et al., 2007; Eccleston et al., 2009; Henschke et al., 2010). These interventions seem to be beneficial to improve pain outcomes, affect and social functioning, as well as cognitive coping and appraisal related to the pain experience (Morley et al., 2013). Selvanathan et al., (2021) also found that CBT was effective to improve sleep and depressive symptoms in patients with chronic pain, but not anxiety symptoms. Another systematic review of Randomized Clinical Trials (RCT) showed no differential effect between CBT and usual treatment to improve pain intensity or pain catastrophizing (Sanabria-Mazo et al., 2023). However, the reliability of RCT studies in this field has been questioned (O'Connel et al., 2023; Flowers et al., 2024), making it necessary to take the results with caution.

Acceptance and Commitment Therapy (ACT) has also shown to improve pain-related outcomes such as pain interference, and disability, as well as quality of life in chronic pain patients (McCracken et al., 2022). Acceptance of pain is associated with better functioning in chronic pain patients (McCraken & Eccleston, 2005; Esteve et al., 2007;

Thompson et al., 2011). Regarding attention, Viane et al., (2004) found that chronic pain patients who reported greater acceptance of chronic pain showed less self-reported attention to pain. In addition to acceptance, distraction is also an effective strategy to reduce pain (Kenney & Milling, 2016) and improve quality of life (Gupta et al., 2018).

Multicomponent interventions are another widely used treatment for chronic pain. Serrat et al., (2021) found a beneficial effect of a multi-component intervention (based on pain neuroscience education, therapeutic exercise, cognitive behavioral therapy, and mindfulness) to reduce pain, kinesophobia, anxiety, and depressive symptoms in patients with fibromyalgia. Arazi et al., (2023) also found that a multi-component intervention based on pain education and physical exercises reduced pain intensity and improved quality of life in elderly men with chronic musculoskeletal pain. Furthermore, a meta-analysis of RCT showed that multi-component interventions reduce pain and depressive symptoms in patients with fibromyalgia (Häuser et al., 2009).

Therapies focused on attentional control and breathing have been also used to treat chronic pain finding promising results. One of these new evidence-based practices is Mindfulness-Based Stress Reduction programs (MBSR). Standard MBSR programs incorporate a variety of formal mindfulness practices, such as training attentional control and self-compassion components, intending to reduce stress levels (Crane et al., 2017). In the field of chronic pain, Wong et., (2011) compared the effectiveness of an MBSR program with a Multidisciplinary Pain Intervention (MPI), which tackles pain management through clinical experts including a variety of physical and psychological aspects. The authors found that both MBSR and MPI programs were effective in reducing chronic pain symptoms, such as pain intensity and pain-related distress. In another research, chronic pain patients were randomly assigned to an 8-week mindfulness-based intervention or a waiting list control

group. The authors found that, compared to the control group, participants in the intervention group showed a significant reduction in pain severity and pain interference (Reiner et al., 2019). Furthermore, it has been observed that mindfulness practice reduces pain perception (Watson et al., 2020) and pain catastrophizing (Kearson et al., 2019). Pérez-Aranda et al., (2019) found, in a sample of individuals with fibromyalgia, that the combination of MBSR and usual treatment was superior to reducing symptoms associated with pain in comparison to usual treatment alone. Compared to other psychological interventions, a systematic review found that MBSR is more effective in reducing pain-related symptomatology than usual treatment, but it is not clear that it is more effective than CBT (Pardos-Gascón et al., 2021). Furthermore, MBSR has been shown to be better in terms of cost-utility than only usual treatment in individuals diagnosed with fibromyalgia (Pérez-Aranda et al., 2019). However, although most studies find evidence of the beneficial effect on the physical and mental functioning of chronic pain samples (Cramer et al., 2012; McClintock et al., 2019), studies that assess attentional mechanisms and how mindfulness-based programs may change them are needed to have a better knowledge of the effectiveness of mindfulness programs and the mechanisms operating in the reduction of pain.

Due to all the mentioned above, this doctoral dissertation presents two general objectives: (1) to explore the presence of attentional biases towards pain-related information in individuals with and without chronic pain and (2) to analyse the effect of non-pharmacological alternatives to modify the attentional pattern. More specifically, this thesis is composed of four studies that aims to:

a) Review the literature about attentional biases toward emotional stimuli in individuals with chronic pain measured through the analysis of eye movements (Study 1).

b) Explore attentional biases in individuals with chronic pain and the effect of a Mindfulness-Based Stress Reduction (MBSR) program to modify the attentional pattern and improve the symptomatology associated with chronic pain (Study 2).

c) Validate the pain-related faces of the Montreal Pain and Affective Face Clips (MPAFC) in the Spanish population (Study 3).

d) Explore attentional biases in pain-free individuals under an induced acute pain condition and the differential effect of an acceptance or distraction instruction to modify the pain response and the associated attentional pattern (Study 4).

4. Chapter I. Study 1: Attentional biases towards emotional information in chronic pain: A multilevel meta-analysis of eye-tracking studies.

Psychological research in the field of pain has focused on the study of how different psychological and cognitive factors affect the perception, origin and maintenance of pain. A recent area of study in this field has focused on the role of attention in the experience of pain. The literature has yielded mixed results on the attentional pattern of people with and without pain, and the variables that modulate the relationship between attention and pain. The following study published as *"Robles, E., Nieto, I., Navas, J. F., & Vázquez, C. (2024). Attentional biases towards emotional information in chronic pain: A multilevel meta-analysis of eye-tracking studies. Acta Psychologica, 250, 104555",* presents a meta-analysis of attentional biases in people with and without chronic pain measured by using eye-tracking methodology to emotional stimuli. The main finding of this study is that, as in previous meta-analyses, both chronic pain and healthy people show a tendency to pay attention first to pain stimuli compared to neutral stimuli. In addition, this study adds new information regarding the attentional pattern to angry stimuli. This study adds new information about the attentional pattern of individuals with chronic pain in comparison to healthy individuals.

4.1. Introduction

Chronic pain is a highly prevalent condition worldwide (Breivik et al., 2006; Borchgrevink et al., 2022) and represents a major global cause of disability (Rice et al., 2016; Scholz et al., 2019). Emerging evidence from the literature has highlighted the influential role of cognitive and emotional processes in the context of chronic pain experiences. For instance, pain catastrophizing has been implicated in heightened pain intensity among individuals with chronic low back pain (Meints et al., 2019), and it serves as a mediating factor in the association between depressed mood and pain intensity among individuals with chronic pain (Wood et al.,

Robles, E., Nieto, I., Navas, J. F., & Vázquez, C. (2024). Attentional biases towards emotional information in chronic pain: A multilevel meta-analysis of eye-tracking studies. *Acta Psychologica, 250, 104555.* https://doi.org/10.1016/j.actpsy.2024.104555

2013). Moreover, meta-analytic findings underscore links between chronic pain and emotional variables such as fear of pain (Zale et al., 2013) depression (Ishak et al., 2018; Rogers & Farris, 2022), and anxiety (Rogers & Farris, 2022).

While an all-encompassing understanding of the mechanisms underpinning the pain experience remains elusive, the contribution of cognitive and affective components is undeniably crucial (Vardeh et al., 2016). Attention has been considered a central component of cognitive and behavioral processes. Attention has been considered a central component of cognitive and behavioral processes. For instance, Posner's model argues that attention is composed of three components: alerting, orienting, and executive control (Posner & Petersen, 1990), all of which can be influenced by cognitive and emotional factors. In relation to this, the Fear-Avoidance of Pain Model has been widely accepted to explain the relationship between fear of pain and avoidance behaviors, as well as how this relationship is influenced by attention and vigilance (Lethem et al., 1983; Vlaeyen & Linton, 2012). Furthermore, various authors have advocated for a model of hypervigilance in pain-related contexts (Crombez et al., 2005). Similarly, Todd et al. (2015) proposed their Threat Interpretation Model, which suggests a relationship between pain, threat, and interpretation biases that interact with attentional processing.

A contemporary research focus in the study of chronic pain lies in analyzing attentional patterns in individuals with chronic pain during pain-related information processing (Legrain et al., 2009; Van Damme et al., 2010). Given that attentional focus can modulate pain experiences (Melzack & Wall, 1965), identifying consistent and significant attentional biases holds the potential for illuminating pathways related to the origin and maintenance of chronic pain experiences. In this respect, numerous studies have explored the attentional pattern of individuals with chronic pain toward pain-related stimuli, finding in general an attentional bias

toward this type of information (Haggman et al., 2010; Schoth et al., 2012). However, the investigation has predominantly used experimental paradigms based on reaction times, such as the dot-probe or visual search tasks (Crombez et al., 2013; Todd, et al., 2018), However, this type of research has inherent limitations as response latencies do not directly capture attentional bias and may be influenced by factors unrelated to attention (e.g., slow motor response) (Duque and Vázquez, 2018). Furthermore, these approaches fail to provide comprehensive insights into the distinct temporal components of attention (e.g., early, intermediate, and late components), as described in attention theories (Posner and Petersen, 1990). Lastly, the reliability of tasks like the standard visual dot-probe is subject to limitations (Rodebaugh et al., 2016).

An alternative and promising means of investigating attention mechanisms towards emotional stimuli is the study of visual behavior through eye movement analysis (Martínez-Conde et al., 2004). Eye-tracking paradigms enable the examination of multiple stages in the attentional process, encompassing early components (e.g., proportion of first fixations or first fixation latencies) and late or maintenance components (e.g., total fixation time, first fixation duration).

Despite extensive investigations, controversies persist regarding the existence of attentional biases associated with pain-related conditions. Previous systematic reviews (Chan et al., 2020) and meta-analyses (Jones et al., 2021) exploring attentional biases through eye-tracking methodologies have not revealed significant differences in gaze variables between individuals with chronic pain and controls. Rather, these reviews have found a general bias toward pain-related stimuli in individuals with and without chronic pain, indicating that this type of bias is not dependent on the pain status. This contrasts with meta-analyses based on reaction time studies, which have documented a bias towards pain-related stimuli among individuals with chronic pain compared to healthy participants (Todd et al., 2018).

These discrepancies may, in part, be attributable to the heterogeneity of participants included in these meta-analyses (i.e., studies involving chronic pain, non-chronic pain, and experimentally induced pain in healthy individuals). For instance, Jones et al., (2021) included 24 studies with a total sample of 1425 participants, of whom only 326 were chronic pain participants. Among these studies, ten were conducted with a chronic pain population, while the remaining 14 involved healthy samples. Although this meta-analysis analyzed data from chronic pain patients, the limited sample of this kind of patients poses challenges in adequately exploring both the presence of attentional biases in this population and the potential moderator role of other cognitive, emotional, and experimental task variables. Accordingly, updating and expanding the existing knowledge of attentional biases in the chronic pain population necessitates the inclusion of new eye-tracking studies with increased sample sizes to facilitate more robust statistical analyses.

Apart from this updating of studies with respect to previous meta-analyses, the present study presents several novel features. First, this study explores attentional biases not only towards pain-related information but also towards stimuli evoking happy and angry emotions as it is plausible that attentional biases in chronic pain may be also present regarding other types of emotional stimuli (e.g., happiness-related stimuli). For instance, in a dot-probe study conducted in a chronic pain sample (Khatibi et al., 2009), they found that participants with lower fear levels shifted attention away from painful faces whereas those with higher fear levels shifted attention towards painful faces. However, the authors observed that all participants tended to shift attention away from happy faces regardless of their fear levels, showing a bias away from happiness-related information. Other studies (Priebe et al., 2021) have also explored attentional differences towards angry, happy, and pain-related faces in comparison to neutral ones between participants with chronic pain and healthy individuals, finding longer fixations

for happy and angry faces compared to neutral ones in both groups. However, this effect was not found for pain-related faces. Unfortunately, these attentional differences regarding the valence of the emotional stimuli have not been explored in previous eye-tracking reviews and meta-analysis. Exploring this issue may provide relevant information to better understand the attentional pattern of individuals with chronic pain and allow researchers and clinicians to adapt clinical studies and interventions for chronic pain patients. Second, given the heterogeneity of studies and types of chronic pain samples in the primary studies, we will investigate the potential moderating role of some variables that have not been analyzed before, such as participants' characteristics (e.g., sex), experimental task variables (e.g., number of trials), or the total sample size of the studies on the presence of attentional biases. Third, this is the first meta-analysis to focus solely on eye-tracking attentional biases in samples of individuals with chronic pain and to explore attentional biases towards non-pain-related information. Finally, this study employs a multilevel meta-analysis, which allows for the inclusion of additional levels of data, such as participants' characteristics or differences in study design, which can be a source of heterogeneity across studies not identified in previous meta-analyses.

4.2. Methodology

4.2.1. Literature search

Relevant published articles were identified through three electronic databases: PubMed, PsycInfo, and Scopus using the following search strategy: ((attention* OR bias* OR "visual orientation" OR gaze OR hypervigilance OR engage*) AND (pain AND eye*)). In addition, a secondary search of ProQuest dissertations was carried out. Eligibility criteria were: 1) empirical studies; 2) analyzing attentional patterns by using emotional stimuli (faces, words, or scenes); 3) recording the eye movements; 4) including a chronic pain

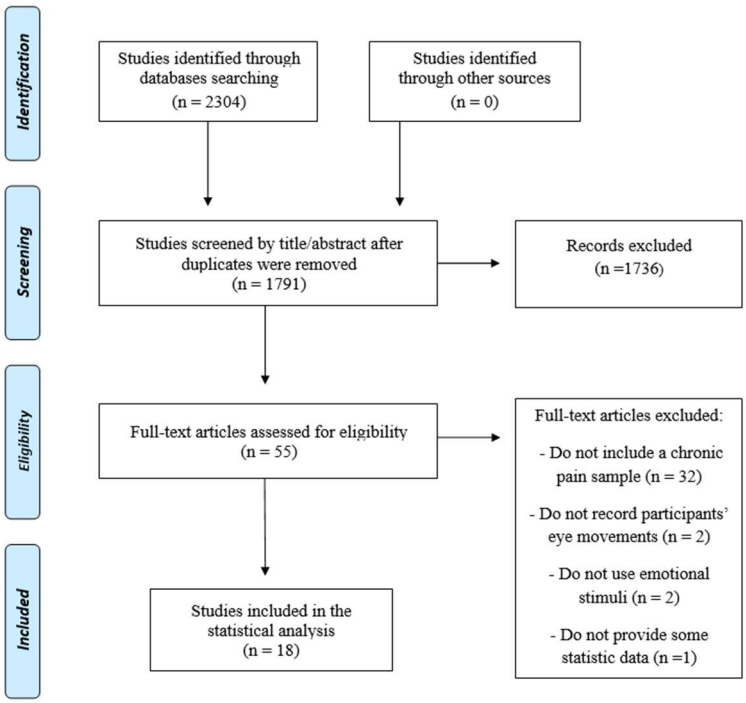
sample, suffering from pain for more than 3 months according to the International Classification of Diseases-11 definition (WHO, 2019) and 5) published in English or Spanish.

This meta-analysis was registered in PROSPERO (CRD42021247982). The final search was conducted in January 2024, resulting in 2304 references. Two of the authors (E. R. & J.F.N.) independently screened all titles and abstracts, identifying 19 possible primary studies that met the eligibility criteria to be included in the meta-analysis. One of them (Yang et al., 2013) was excluded for not providing the necessary statistical data and not answering our requests to provide that information. Disagreements were discussed between the reviewers and, if necessary, a third author was consulted (C.V.) to reach a consensus.

The inter-rater reliability for the selection of studies was high (kappa = 0.97). The search and study selection process is depicted in the PRISMA flow diagram (Fig. 1.1.).

Figure 1.1.

PRISMA figure of searching and selection process of primary studies.



Robles, E., Nieto, I., Navas, J. F., & Vázquez, C. (2024). Attentional biases towards emotional information in chronic pain: A multilevel meta-analysis of eye-tracking studies. *Acta Psychologica, 250, 104555*. https://doi.org/10.1016/j.actpsy.2024.104555

4.2.2. Coding system

The same two authors coded all the relevant variables to the analyses independently, having a high kappa inter-rater reliability (kappa = 0.95). As in the literature search, disagreements between the reviewers were solved by a third author (C.V.) to reach a consensus.

The year of publication and geographical location were coded as study characteristics. For sample characteristics, the sample size, percentage of women, and participants' mean age were coded. Regarding pain-related characteristics, we coded diagnosis, mean duration of pain, and intensity of pain, while depression, anxiety, fear of pain, pain catastrophizing, pain vigilance, and anxiety sensitivity were coded as psychological measures. As gaze measures, the following variables were coded as early attentional indices: latency of first fixation, probability of first fixation, and duration of first fixation. For attentional maintenance, we coded the total number of fixations and total fixation duration. Finally, regarding the experimental tasks, we coded the paradigm used in each study, the type and valence of stimuli, the number of trials, and the duration of the task.

4.2.3. Meta-analytic procedure

Main analyses

Assuming heterogeneity of the included data, random-effects multilevel meta-analyses were conducted in SPSS 28.0 and R 3.5.0 by using the standardized mean difference ($d = \bar{X}_1\text{-}X_2/S_{pooled}$) between gaze variables for emotional and neutral stimuli with Hedge's correction as the effect size (ES). According to Cohen (1998), Hedge's *g* values were categorized as small (0.2–0.5), medium (0.5–0.8), or large (>0.8). *T* values from t-tests and *F* values from univariate ANOVAs were used as alternative parameters when means and standard deviations were not provided by the authors in their publications or after requests

via e-mail. In other cases, the Web Plot Digitizer (Rohatgi, 2022), a software that helps extract numerical data from images, was used to obtain data (mean, SD, or SE) from the figures of two primary studies (Giel et al., 2018; Priebe et al., 2021). This program has shown high reliability and validity (Drevon et al., 2017).

Two different analyses were conducted. First, between-group analyses across studies that included a chronic pain group and a control group, comparing the means and standard deviation towards emotional stimuli (i.e., pain, happiness, and anger) and neutral stimuli of every group. Positive values reflect the presence of bias towards the emotional stimuli in the chronic pain group compared to the control group. Second, within-group analyses were performed individually for the chronic pain groups and control groups, comparing the means and standard deviation of attentional measures for emotional stimuli vs. neutral stimuli. Positive values reflect the presence of bias towards emotional stimuli in comparison to neutral stimuli. For all analyses, a minimum requirement of three studies in each comparison group was established.

Five attentional indices were analyzed, three related to the initial orientation of attention (proportion of first fixations, first fixation duration, and first fixation latency) and two related to attentional maintenance (total number of fixations and total fixation duration). Each index was analyzed separately for each type of emotional stimulus (i.e., pain, happiness, anger, and neutral).

A multilevel approach was used to consider the dependency between effect sizes. Specifically, we introduced a third level to model effect sizes based on the different attentional indices used in the literature. This model allows effect sizes to vary between participants (level 1), attentional indices (level 2), and studies (level 3). Multilevel meta-analyses were performed using the metafor package in R 3.5.0 (Viechtbauer, 2010), with restricted maximum likelihood (REML) as the method of estimation.

Heterogeneity and Moderation analyses

Heterogeneity was assessed using two indicators: the Q-value and the I^2index. Q values lower than 0.05 indicate that included studies are estimating a different parameter. Thus, the null hypothesis of homogeneity is rejected. Regarding the I^2 index, values can be categorized as no heterogeneity (0 %); low heterogeneity (≥ 25%); moderate heterogeneity (≥ 50%), and high heterogeneity (≥ 75%) (Borenstein et al., 2009).

To explain possible heterogeneity levels, moderation analyses were conducted with a multivariate linear model fitted via the restricted maximum-likelihood method. Participants' characteristics (sample size, percentage of women, and pain diagnosis) and task parameters (type of stimuli, stimuli duration, valence, paradigm, and the number of trials) were coded as moderators.

Risk of biases

The funnel plot was inspected to explore the precision of each primary study (standard error, SE) against its individual effect size. Without publication bias, the shape and density should be symmetric. Egger's regression test (Sterne et al., 2006) was used to test the symmetry of the funnel plot (H0: perfect symmetry). Finally, the trim-and-fill procedure (Duval & Tweedie, 2000) was used as a sensitive analysis to calculate the ESs and confidence intervals of the individual studies accounting for the missing values reflected in the asymmetry of the funnel plot.

Analyses were repeated after removing outliers. These were defined as those primary studies with both sides of their 95% confidence interval outside the 95% confidence interval of the pooled studies. Only those results that changed after removing outliers will be commented on.

Quality of studies

The quality of primary studies was analyzed using the Standard Quality Assessment Criteria (Kmet et al., 2004). This tool uses 14 criteria to assess key parameters related to the quality of a study (e.g., well-established objectives, hypotheses, sample selection, or appropriate analytic methods). In addition to these criteria, we added 5 questions to explore other specific aspects related to the research quality of eye-tracking studies and to open science issues: 1) reliability degree; 2) use of validated datasets of experimental stimuli; 3) information on pre-experiment power analysis; 4) pre-registration of study and 5) open access to the materials**.**

Most of the quality criteria analyzed were completely fulfilled by all primary studies, except pre-registration (5.5%), reliability of attentional indices (11.10%), open access to materials (11.10%), method of subject selection (33%), power analyses (38.80%), appropriate sample size (61%), use of validated stimuli (83.30%), and results reported in sufficient detail (94.5%).

4.3. Results

4.3.1. Descriptive information

Table 1.1. provides a summary of the included studies. A total of 18 studies were included, comprising a total sample of 1331 (832 chronic pain participants and 499 free-pain participants). Two articles were based on the same sample (Fashler & Katz, 2014 and Fashler & Katz, 2016) but were considered independent studies as they used diverse types of stimuli for the experimental task. Fifteen studies included both pain and pain-free groups while 3 studies included just a pain group. Regarding the experimental paradigm, 11 studies used a free-viewing task, 6 used a dot-probe task, and 1 used a visual search task. Concerning the type of stimuli, 9 studies used faces, 6 used pain-related or injury scenes, 1 used words, and

2 used both faces and words. Pain-related stimuli were used in all primary studies except Giel et al., (2018) while happy and angry stimuli were analyzed by 5 studies. Just one study included sad-related stimuli (Giel et al., 2018), which is why sad valence was not included in the analyses. Finally, regarding stimulus duration, which has been explored as a moderator in previous meta-analyses (Jones et al., 2021) and usually lasts between 1000 and 5000 ms, we divided the included studies into two separate groups depending on the stimuli duration. One group was composed of 8 studies that presented visual stimuli for less than 3000 ms, and another included 8 studies that used a stimuli duration equal to or longer than 3000 ms (two articles didn't report data about trial duration).

All studies were included in within-group analyses, except that of Mazidi et al., (2019) as it did not provide information on means and standard deviation for the neutral stimuli, and 15 were included in between-group analyses.

4.3.2 Comparison analyses

Table 1.2. shows between-group effect sizes (Hedges'*g* and SE) of attentional indices towards emotional versus neutral stimuli. Two articles had more than one group comparison (Jones et al., 2020; Ten Brink, et al., 2021).

The results of the three-level meta-analysis model showed no between-group variance ($sigma^2 = 0.0001$). Therefore, the inclusion of a third level did not significantly explain the total variance. Furthermore, model fit indices showed a better fit for the two-level model given that AIC and BIC values were lower (two-level model: AIC = 105.6879, BIC = 111.5995; three-level model AIC = 107.6879, BIC = 116.5554. Moreover, the likelihood-ratio test (LRT) showed that there was not a significant improvement of the fit when including the third level ($\chi^2 = 0.00$, p-value = 1). Thus, only two levels were used in the

between and within-group analyses to study the presence of attentional biases in chronic pain people.

Robles, E., Nieto, I., Navas, J. F., & Vázquez, C. (2024). Attentional biases towards emotional information in chronic pain: A multilevel meta-analysis of eye-tracking studies. *Acta Psychologica, 250, 104555*. https://doi.org/10.1016/j.actpsy.2024.104555

Table 1.1.

Descriptive data of primary studies

Study			Sample			Attentional Task				
Authors, year	**Geographic location**	**N**	**Size**	**Women**	**Mean age**	**Paradigm**	**Stimuli**	**Valence**	**Duration**	**Trials**
Liossi et al., (2013)	UK	46	Chronic pain = 23 Control = 23	26 (57%)	45.61 (14.93)	Free-viewing	Faces	Pain/Neutral Happy/Angry	4000	144
Schoth et al., (2014)	UK	47	Chronic pain = 24 Control = 23	30 (63.82%)	34.26 (15.54)	Visual Search	Faces	Pain/Neutral /Happy/Angry	n.a.	240
Fashler & Katz (2014)	Canadá	113	Chronic pain = 51 Control = 62	84 (74.30%)	21.32 (4.35)	Dot-probe	Words	Pain/Neutral	2000	120
Fashler & Katz (2016)	Canadá	113	Chronic pain = 51 Control = 62	84 (74.30%)	21.32 (4.35)	Dot-probe	Pictures/Scenes	Pain/Neutral	2000	120
Mahmoodi-Aghdam et al., (2017)	Turkey	38	Chronic pain = 20 Control = 18	24 (64%) n.a.	n.a.	Free-viewing	Pictures/Scenes	Pain/Neutral	1000	80
Giel et al., (2018)	Alemania	34	Chronic pain = 17 Control = 17	13 (38.25%)	n.a.	Free-viewing	Faces	Neutral/Happy/Sad	3000	n.a.
Franklin et al., (2018)	UK	35	Chronic pain = 18 Control = 17	23 (65.7%)	n.a.	Dot-probe	Pictures/Scenes	Pain/Neutral	500	150
Lee et al., (2018)	South Korea	50	Chronic pain = 50	33 (66%)	21.8 (2.06)	Free-viewing	Faces	Pain/Neutral/Angry	3000	n.a.
Lee et al., (2019)	South Korea	40	Chronic pain = 40	25 (62.5%)	46.58 (16.26)	Free-viewing	Faces and words	Pain/Neutral/Angry	3000	n.a.
Mazidi et al., (2019)	UK	57	Chronic pain = 28 Control = 29	38 (66.66%)	n.a.	Dot-probe	Faces	Pain/Neutral/Happy	1500	80

Note: n.a. = Not available

Study			Sample			Attentional Task				
Authors, year	**Geographic location**	**N**	**Size**	**Women**	**Mean age**	**Paradigm**	**Stimuli**	**Valence**	**Duration**	**Trials**
Jackson, Yang & Su (2019)	China	89	Chronic pain = 89	68 (76.4%)	26.70 (10.7)	Dot-probe	Pictures/Scenes	Pain/Neutral	2000	128
Lee et al., (2020)	South Korea	66	Chronic pain = 35 Control = 31	46 (69.70%)	n.a.	Free-viewing	Faces	Pain/Neutral	3000	n.a.
Soltani et al., (2020)	Canadá	155	Chronic pain = 102 Control = 53	98 (63.5%)	13.8	Free-viewing	Faces	Pain/Neutral	3000	120
Ten Brink et al., (2021)	UK	92	Chronic pain = 61 Control = 31	93 (77.5%)	n.a.	Dot-probe	Pictures/Scenes	Pain/Neutral	2000	192
Blaisdale Jones et al., (2021)	Australia	126	Chronic pain = 66 Control = 60	73 (52.5%)	49.53 (16.39)	Free-viewing	Faces and words	Pain/Neutral	4000	40
Priebe et al., (2021)	Alemania	40	Chronic pain = 20 Control = 20	21 (52.5%)	n.a.	Free-viewing	Faces	Pain/Neutral Happy/Angry	2000	64
Soltani et al., (2022)	Canadá	177	Chronic pain = 125 Control = 52	114 (64.5%)	13.7	Free-viewing	Faces	Pain/Neutral	3000	n.a.
Chan et al., (2022)	Hong Kong	126	Chronic pain = 63 Control = 63	84 (66%)	n.a.	Free-viewing	Pictures/Scenes	Pain/Neutral	5000	24

Note: n.a. = Not available

Table 1.2.

Effect sizes for between-group differences (pain, happy or angry vs neutral stimuli) of chronic pain and free-pain samples.

Authors, (year)	Stimuli	Effect Size (Hedges'g) (SE)				
		Probability of First Fixation	First Fixation Duration	Total Fixation	Total Fixation Duration	First Fixation Latency
Liossi et al., (2013)	Pain	0.738 (0.04)	-0.103 (0.04)	----	-0.023 (0.04)	----
	Neutral	-0.363 (0.04)	0.203 (0.04)	----	0.201 (0.04)	----
	Happy	0 (0.04)	-0.11 (0.04)	----	-0.02 (0.04)	----
	Angry	-0.5 (0.04)	0.2 (0.04)	----	0.14 (0.04)	----
Schoth et al., (2014)	Pain	0.907 (0.04)	----	-0.155 (0.04)	-0.015 (0.04)	-0.176 (0.04)
	Neutral	0.061 (0.04)	----	-0.190 (0.04)	0.158 (0.04)	-0.108 (0.04)
	Happy	-0.07 (0.04)	----	-0.11 (0.04)	0.21 (0.04)	-0.05 (0.04)
	Angry	-0.11 (0.04)	----	-0.15 (0.04)	0.14 (0.04)	-0.03 (0.04)
Fashler & Katz (2014)	Pain	----	----	0.477 (0.19)	-0.273 (0.19)	----
	Neutral	----	----	0.284 (0.19)	-0.372 (0.19)	----
Fashler & Katz (2016)	Pain	----	----	-0.430 (0.19)	0.278 (0.19)	----
	Neutral	----	----	-0.124 (0.19)	-0.028 (0.19)	----
Mahmoodi-Aghdam et al., (2017)	Pain	0.448 (0.33)	-0.246 (0.33)	0.410 (0.33)	-0.133 (0.33)	0.160 (0.33)
	Neutral	0.603 (0.33)	-0.793 (0.33)	0.473 (0.33)	-0.352 (0.33)	0.651 (0.33)
Franklin et al., (2018)	Pain	----	----	1.41 (0.06)	1.08 (0.06)	-1.63 (0.06)
	Neutral	----	----	-0.819 (0.06)	-0.07 (0.06)	-0.467 (0.06)
Giel et al., (2018)	Neutral	0.20 (0.06)	----	----	0 (0.06)	----
	Sad	0.21 (0.06)	----	----	0 (0.06)	----
Mazidi et al., (2019)	Pain	0.15 (0.03)	0.10 (0.03)	0.23 (0.03)	----	0.20 (0.03)
	Sad	-0.32 (0.03)	-0.02 (0.03)	0.29 (0.03)	----	-0.18 (0.03)

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Authors, (year)	Stimuli	Effect Size (Hedges'g) (Standard Error)				
		Probability of First Fixation	First Fixation Duration	Total Fixation	Total Fixation Duration	First Fixation Latency
Soltani et al., (2020)	Low pain expression	0.39 (0.01)	----	----	0.04 (0.01)	----
	Moderate pain expression	0.22 (0.01)	----	----	-0.22 (0.01)	----
	High pain expression	-0.55 (0.01)	----	----	0.21 (0.01)	----
Lee et al., (2020)	Pain	----	0.28 (0.03)	----	-0.22 (0.03)	----
	Neutral	----	-0.22 (0.03)	----	-0.20 (0.03)	----
Ten Brink et al., (2021) Comparison Group 1	Pain	-0.27 (0.04)	----	-0.31 (0.04)	0.08 (0.04)	0.24 (0.04)
	Neutral	-0.28 (0.04)	----	-0.48 (0.04)	-0.47 (0.04)	0.26 (0.04)
Ten Brink et al., (2021) Comparison Group 2	Pain	-0.30 (0.04)	----	-0.14 (0.04)	0.12 (0.04)	0.12 (0.04)
	Neutral	0.09 (0.04)	----	-0.01 (0.04)	0.21 (0.04)	0.30 (0.04)
Ten Brink et al., (2021) Comparison Group 3	Pain	-0.38 (0.04)	----	-0.02 (0.04)	-0.03 (0.04)	-0.09 (0.04)
	Neutral	0.21 (0.04)	----	0.26 (0.04)	0.48 (0.04)	0.01 (0.04)
Ten Brink et al., (2021) Comparison Group 4	Pain	-0.73 (0.04)	----	-0.59 (0.04)	-0.54 (0.04)	0.22 (0.04)
	Neutral	-0.58 (0.04)	----	-0.57 (0.04)	-0.51 (0.04)	-0.09 (0.04)
Jones et al., (2021) Comparison Group 1	Pain	0.09 (0.015)	-0.32 (0.015)	0.15 (0.015)	----	-0.21 (0.015)
	Neutral	-0.08 (0.015)	-0.39 (0.015)	0.27 (0.015)	----	-0.28 (0.015)
Jones et al., (2021) Comparison Group 2	Pain	0.29 (0.015)	-0.39 (0.015)	0.18 (0.015)	----	-0.38 (0.015)
	Neutral	0.03 (0.015)	-0.21 (0.015)	0.09 (0.015)	----	-0.25 (0.015)
Priebe et al., (2021)	Pain	-0.22 (0.05)	----	----	----	----
	Neutral	-0.19 (0.05)	----	----	----	----
	Happy	0.26 (0.05)	----	----	----	----
	Angry	0.39 (0.05)	----	----	----	----
Soltani et al., (2022)	Low pain expression	0.29 (0.01)	----	----	0.05 (0.01)	----
	Moderate pain expression	0.2 (0.01)	----	----	-0.31 (0.01)	----
	High pain expression	0.1 (0.01)	----	----	0.11 (0.01)	----
Chan et al., (2021)	Pain	0 (0.02)	----	0.25 (0.02)	0.36 (0.02)	----

Note: n.a. = Not available

Attentional biases towards pain-related stimuli

a) Indexes of initial orientation

Proportion of first fixations. Between-group analyses showed no significant differences between individuals with chronic pain and pain-free controls on pain (k = 18, g = .1, 95% CI [-0.06; 0.27], p = .23) or neutral stimuli (k = 13, g = - .01, 95% CI [-0.17, 0.13], p = .82). Within-group analyses were significant for the chronic pain group (k = 11, g = .65, 95% CI [0.16, 1.13], p = .008) but not for the control group (k = 8, g = .50, 95% CI [-0.03, 1.03], p = .06), indicating that the chronic pain group made more first fixation towards pain-related stimuli in comparison to neutral ones.

Between-group analyses revealed moderate heterogeneity related to pain stimuli [I^2 = 62.70%; Q(df = 17) = 44.5271, p = .0007], but no significant heterogeneity for neutral stimuli [I^2 = 0.00%, Q(df = 12) = 14.32, p = .28]. Within-group analyses revealed high heterogeneity in the chronic pain [I^2 = 88.60%; Q(df = 10) = 87.8235, p<.0001] and control group [I^2 = 86.53%; Q(df = 7) = 38.2591 , p<.0001].

Regarding moderation analyses, there was only a significant effect of paradigm for between-group analyses (k = 18, g = .49, 95%, CI [0.15, 0.82], p = .004) indicating that dot-probe paradigms (*M* = - 0.31, *SD* = 0.31) detected higher effect sizes than free-viewing paradigms (*M* = 0.16, *SD* = 0.33). The only study using a visual search paradigm (Schoth et al., 2014) could not be included in the analyses.

First fixation duration. Between-group analyses showed no significant differences between chronic pain and pain-free individuals on pain stimuli (k = 6, g = -.14, 95% CI [-0.37, 0.08], p = .21), but it was significant for neutral stimuli (k = 5, g = -.27, 95% [-0.47, -0.07], p = .007). Overall, healthy individuals made longer first fixations towards neutral stimuli compared to chronic pain individuals. Within-group analyses were not significant for

the chronic pain (k = 5, g = .004, 95% CI [-0.20, 0.21], p = .96) or control group (k = 5, g = .06, 95% CI [-0.13, 0.25], p = .52).

For between-group analyses, there was no heterogeneity related to pain [I^2 = 19.52%; Q(df = 5) = 6.8746, p = .23] or neutral stimuli [I^2 = 0.00%; Q(df = 4) = 5.5305, p = .23]. For within-groups analyses, there was no significant heterogeneity in the chronic pain group [I^2 = 0.00%; Q(df = 4) = 1.0036, p = .90] or control group[I^2 = 6.99%; Q(df = 4) = 4.2238, p = .37].

There was no significant moderation effect for between or within-group analyses.

First fixation latency. Between-group analyses showed no significant differences between individuals with and without chronic pain on pain (k = 10, g = - .14, 95% CI [-0.44; 0.14], p = .31) or neutral stimuli (k = 11, g = - .11, 95% CI [-0.28; 0.04], p = .15). Within-group analyses revealed no evidence of attentional bias for the chronic pain group (k = 9, g = - .10, 95% CI [-0.40; 0.19], p = .49) or the control group (k = 8, g = .06, 95% CI [-0.25; 0.39], p = .68).

Between-group analyses revealed moderate significant heterogeneity related to emotional stimuli [I^2 = 61.62%; Q(df = 9) = 21.6358, p = .01], while there was no heterogeneity for neutral stimuli [I^2 = 0.01%, Q(df = 10) = 10.6323, p = 0.38]. Within-group analyses revealed moderate heterogeneity in the chronic pain [I^2 = 58.70%; Q(df = 8) = 17.9296, p = 0.02] and the control group [I^2 = 62.43%; Q(df = 7) = 16.8153, p = 0.01].

There was no significant moderation effect for between or within-group analyses.

b) Indexes of attentional maintenance

Number of fixations. Between-group analyses showed no significant differences between chronic pain individuals and pain-free controls on pain (k = 13, g = .11, 95% CI [-0.11; 0.34], p = .32) or neutral stimuli (k = 13, g = - .005, 95% CI [-0.17; 0.16], p = .95).

Within-group analyses revealed no evidence of attentional bias for the chronic pain (k = 9, g = .28, 95% CI [-0.15; 0.72], p = .20) or the control group (k = 11, g = .35, 95% CI [-0.14; 0.86], p = .16).

Between-groups analysis showed moderate heterogeneity for pain-related stimuli (I^2 = 63.66%; Q(df = 12) = 31.5960, p = .001) and no heterogeneity for neutral stimuli (I^2 = 26.91%, Q(df = 12) = 17.7336, p = .12). Within-groups analyses revealed high heterogeneity in the chronic pain [I^2 = 86.30%; Q(df = 8) = 53.7305, p < .0001] and the control group[I^2 = 86.30%; Q(df = 8) = 53.7305, p < .0001].

There was no significant moderation effect for between or within-group analyses.

Total fixation duration. Between-group analyses showed no significant differences between chronic pain individuals and pain-free controls on pain (k = 18, g = .02, 95% CI [-0.10; 0.15], p = .72) or neutral stimuli (k = 13, g = -0.11, 95% CI [-0.27; 0.03], p = .12). After an outlier was detected (Franklin et al., 2018) and removed from the analysis, the effect size remained no significant (k = 17, g = -.005, 95% CI [-0.12; 0.11], p = .93). Within-group analyses revealed no evidence of attentional bias for chronic pain (k = 17, g = - .80, 95% CI [-1.88; 0.26], p = .14) or control group (k = 9, g = - .13, 95% CI [-0.30, 0.03], p = .12).

Between-group analyses revealed no significant heterogeneity related to either emotional stimuli [I^2 = 26.21%; Q(df = 16) = 19.1514, p = 0.26] or neutral stimuli [I^2 = 0.00%, Q(df = 12) = 9.7242, p = 0.64]. Within-group analyses revealed high heterogeneity in the chronic pain group [I^2 = 98.37%; Q(df = 16) = 270.5908, p < .0001] and no heterogeneity in the control group [I^2 = 0.00%; Q(df = 8) = 8.4180, p = 0.39].

Moderation analyses showed a significant effect of type of stimuli (k = 17, g = 1.43, 95% CI [0.45; 2.41], p = .004) in the chronic pain group. Further analyses revealed that facial expressions (M = - 2.67, SD = 2-99) detected higher effect sizes than scenes (M = 0.44, SD = 0.68).

Attentional biases towards happiness-related stimuli

Due to the small number of studies that included happiness-related stimuli, it was possible to analyze attentional biases towards this type of stimuli only for the proportion of initial fixations (an index of initial orientation) and the total fixation duration (and an index of attentional maintenance), the only two parameters with at least three effect sizes (k = 3) available.

Proportion of initial fixations. Between-group analyses showed no significant effect on the proportion of initial fixations on happiness-related stimuli (k = 5, g = -.08, 95% CI [-0.34; 0.18], p = 0.55). Within-group analyses did not show a significant effect in the chronic pain (k = 4, g = .56, 95% CI [-0.06; 1.18], p = .07) or the control group (k = 4, g = .57, 95% CI [-0.10; 1.26], p = .09).

For between-group analyses, there was no significant heterogeneity related to happy stimuli [I^2 = 0.00%; Q(df = 4) = 2.2802, p = .68]. For within-group analyses, there was high heterogeneity in the chronic pain [I^2 = 89.23%; Q(df = 2) = 15.9150, *p* = .0004] and moderate in the control group [I^2 = 78.07%; Q(df = 3) = 11.5647, p = .009].

There was no significant moderation effect for between or within-group analyses.

Total fixation duration. Regarding this index of maintenance of attention, between-group analyses showed no significant effect for happiness-related stimuli (k = 3, g = .07, 95% CI [-0.27; 0.42], p = 0.67). Within-group analyses showed no significant effects in the chronic pain (k = 3, g = 1.04, 95% CI [-1.04; 3.13], p = .32) or the control group (k = 3, g = .46, 95% CI [-0.66; 1.60], p = .41).

Between-group analyses revealed no significant heterogeneity related to happy stimuli [I^2 = 0.00%; Q(df = 2) = 0.3926, p = .82]. Within-group analyses revealed high heterogeneity in the chronic pain [I^2 = 96.22%; Q(df = 2) = 29.6060, p < .0001] and the control group [I^2 = 89.23%; Q(df = 2) = 15.9150, p = .0004].

There was no significant moderation effect for between or within-group analyses.

Attentional biases towards anger-related stimuli

The small number of studies that included these types of stimuli, allowed us to conduct analyses only for the proportion of initial fixations (a measure of initial orientation) and the total fixation duration (a measure of maintenance of attention), as there were at least three effect sizes obtained from primary studies.

Proportion of initial fixations. Between-group analyses showed no significant effect for the proportion of initial fixations (k = 3, g = - .08, 95% CI [-0.58; 0.41], p = .73). Within-group analyses did not show a significant effect in the chronic pain group (k = 3, g = .28, 95% CI [-0.16; 0.73], p = .21) or the control group (k = 3, g = .03, 95% CI [-0.39; 0.46], p = .86).

For between-group analyses, there was no significant heterogeneity related to happiness-related stimuli [I^2 = 52.78%; Q(df = 2) = 4.2251, p = .12]. For within-group analyses, there was no significant heterogeneity in the chronic pain [I^2 = 40.56%; Q(df = 2) = 3.4100, p = 0.18] or the control group [I^2 = 37.24%; Q(df = 2) = 3.1476, p = 0.20].

There was no significant moderation effect for between or within-group analyses.

Total fixation duration. For the total fixation duration towards anger-related stimuli, it was possible to analyze only within-group differences in the chronic pain group, finding a significant effect (k = 7, g = -1.95, 95% CI [-3.79; -0.11], p = .03). Individuals with chronic pain did longer fixations towards neutral stimuli in comparison to anger-related stimuli. There was a significant high heterogeneity [I^2 = 98.15%; Q(df = 6) = 129.4273, p < .0001].

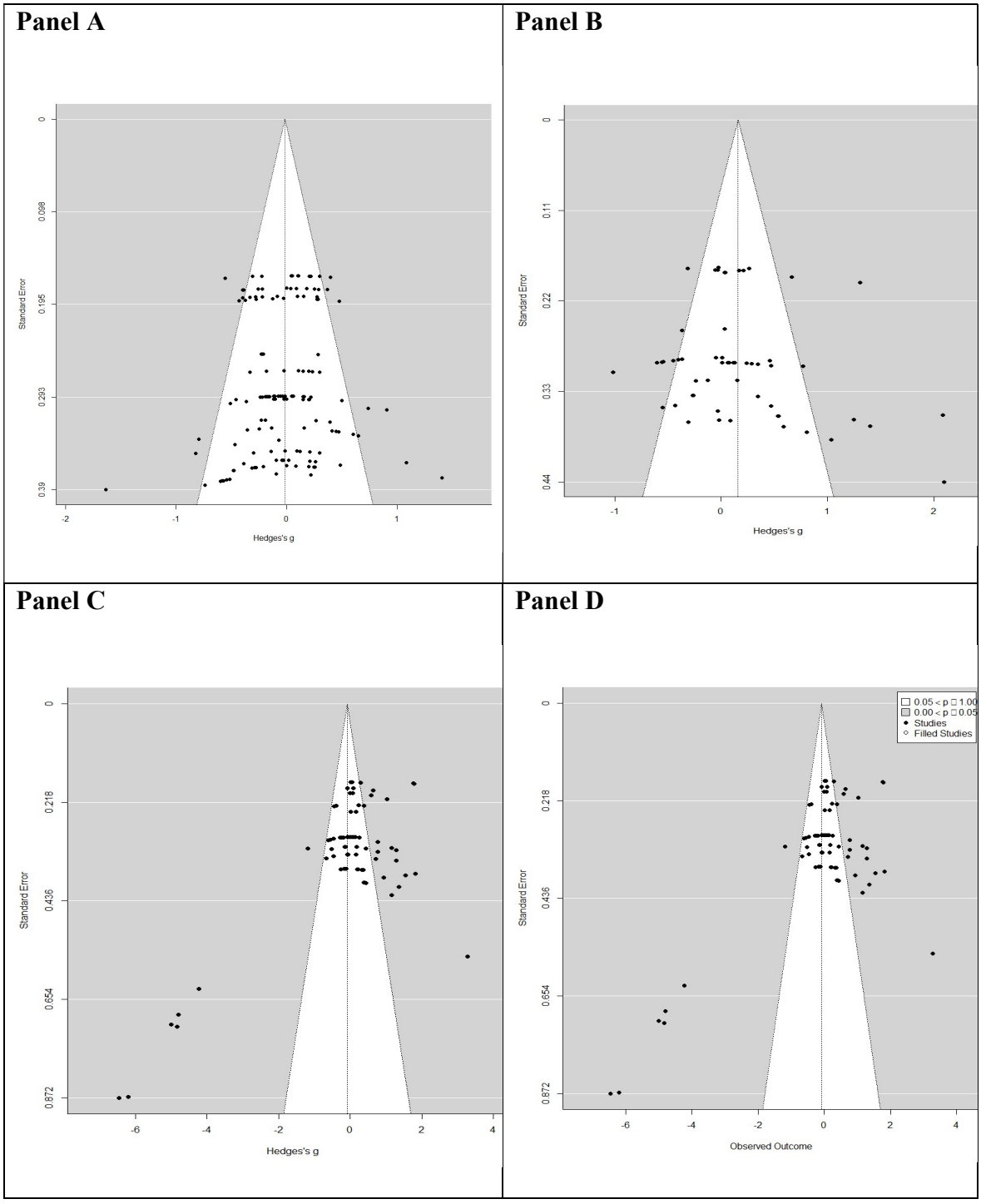
There was no significant moderation effect for between or within-group analyses.

4.3.3. Risk of bias

An inspection of the funnel plot for between-subjects studies and within-subject studies with a control group (see Fig. 1.2. Panels A and B) showed that the shape and density of the funnel plot seemed to be symmetric, which was confirmed by the Egger's regression test ($z = -0.71$, $p = 0.48$; $z = 1.80$, $p = 0.07$, respectively). Given that asymmetry was not found, the trim-and-fill procedure was not conducted in these cases. The Egger's regression test for within-subject studies with the chronic pain group showed that there was no perfect symmetry in the funnel plot ($z = -7.94$, $p<.0001$) [Fig. 1.2. Panel C]. Therefore, the trim-and-fill procedure was conducted but the result estimated no missing studies on the right side ($SE = 2.8023$) [Fig. 1.2. D]. This suggests that the symmetry is not perfect but the ESs and confidence intervals of the individual studies do not change due to missing values from publication bias.

Figure 1.2.

Funnel plots for between-subjects meta-analysis (Panel A), within-subjects meta-analysis with control group (Panel B), within-subjects meta-analysis with experimental group (Panel C), and within-subjects meta-analysis with experimental group corrected with the trim-and-fill procedure (Panel D).



Robles, E., Nieto, I., Navas, J. F., & Vázquez, C. (2024). Attentional biases towards emotional information in chronic pain: A multilevel meta-analysis of eye-tracking studies. *Acta Psychologica, 250, 104555*. https://doi.org/10.1016/j.actpsy.2024.104555

4.4. Discussion

This meta-analysis aimed to investigate the presence of attentional biases towards information related to pain but also other relevant emotions (i.e., happiness and anger) in individuals suffering from chronic pain, utilising eye-tracking methodology in primary studies. Regarding pain-related stimuli, we did not find significant between-group differences. Thus, our findings align with previous meta-analyses (Jones et al. 2021), which similarly did not find differences in attentional biases towards pain information in individuals with chronic pain compared to control. However, we found that chronic pain patients made shorter first fixations towards neutral stimuli compared to healthy individuals. This finding may suggest a preference for attending to pain information. However, more experimental studies are needed to establish a firmer conclusion. Within-group analyses showed no significant differences for any index except for the proportion of initial fixations. The chronic pain group made more first fixations towards pain-related stimuli in comparison to neutral ones. This result, in line with the previous literature, reflects that individuals with chronic pain have an initial orientation toward emotional information that is reflected in the number of times that they fix their first attention on pain-related materials.

Moderation analyses revealed that, for the proportion of initial fixations, dot-probe paradigms detect higher effect sizes than free-viewing paradigms. However, previous meta-analyses (Jones et al. 2021), found the opposite: free-viewing tasks were better at detecting attentional biases than dot-probe tasks. This result could be explained by the methodological differences between the studies included in that previous meta-analysis and the new ones included in this study.

In addition, for the total fixation duration, which is a reliable index of maintenance of attention, pain facial expressions had higher effect sizes than pain-related scenes in the chronic pain group. This finding could be explained in two ways. Firstly, some studies have

found that pain facial expressions activate the perception of pain. For instance, Botvinick et al. (2005) found, using fMRI (functional magnetic resonance imaging), that pain facial expressions produced an activation of cortical areas associated with the experience of pain. These authors also found that these brain regions were more activated when individuals viewed pain facial expressions in comparison to neutral ones. Simon et al. (2006) also found an activation of specific cortical regions, such as the ventromedial prefrontal cortex, when healthy individuals observed pain-related facial expressions than neutral or angry ones. Secondly, the effectiveness of scenes in generating a perception of pain may depend on the type of pain and harm depicted in the scene and their similarity with the pain suffered by participants. Previous studies have shown that the personal relevance of pain-related stimuli plays a key role in the detection of attentional biases towards pain-related information (Dear et al., 2011)

Regarding anger-related stimuli, we did not find significant between-group differences. The number of primary studies that included these types of stimuli was small, making it not possible to explore some of the attentional indices we aimed to study. However, we found initial evidence that individuals with chronic pain had longer fixations towards neutral stimuli in comparison to anger-related stimuli, which may suggest a tendency to avoid paying attention to anger-related stimuli in these persons. This bias could be in part explained by the fact that the experience of pain and anger are often interconnected and people with chronic pain have been shown to feel more anger than healthy individuals (Adachi et al., 2022; Carson et al., 2007; Greenwood et al., 2003), which may magnify the intensity of pain and associated disability in their daily life. Furthermore, it has been observed that pain and angry-related facial expressions showed similarly sustained activation in the superior temporal sulcus (Simon et al., 2006). Finally, concerning

happiness-related stimuli, we did not find any significant result, although the number of primary studies is still very low.

This study represents the first multilevel meta-analysis investigating attentional biases towards emotional stimuli, other than the classical pain-related stimuli, in individuals with chronic pain. Although we did analyze emotions relevant to the clinical condition of pain (i.e., stimuli reflecting pain, happiness, or anger), other important emotions, like sadness, could not be analyzed because there were no sufficient primary studies.

From our results, it can be hypothesized that the lack of consensus regarding the relationship between attentional patterns and pain may be partially attributed to methodological variations, the restricted number of studies, and their inherent heterogeneity, precluding definitive conclusions. For instance, several studies relied on the same set of faces, highlighting the need to create more databases incorporating ecologically valid pain-related stimuli (Fernandes-Magalhaes et al., 2022). The limited variety of reliable and validated stimuli depicting pain facial expressions may constrain the exploration of attentional biases in individuals with chronic pain. For instance, sets of available emotional faces often lack representation of diverse racial groups and primarily focus on the young and middle-aged population, and, in most cases, the primary studies did not investigate or report the reliability or adequacy of their stimulus sets (Robles et al., 2024).

Furthermore, the studies included in this meta-analysis are focused on the traditional gaze indices such as the number and duration of fixations. However, little is known about the ability to disengage attention from emotional stimuli in chronic pain contexts. Sharpe et al., (2009) found, in a dot-probe study with a chronic pain sample due to rheumatoid arthritis, that these patients showed difficulties disengaging their attention from pain-related words. However, this ability to divert attention away from pain information has not been explored yet in chronic pain samples through the analysis of eye movements, which

could yield new information about the attentional pattern of people with chronic pain as well as offer a new possible focus for pain intervention.

We are aware of several limitations in our study. Although the inclusion of a larger number of primary studies including chronic pain participants and a higher chronic pain sample size has improved relative to previous meta-analyses (Jones et al., 2021), a significant proportion of studies focused solely on pain-related information, excluding other emotional stimuli of potential interest (e.g., sadness or happy). This limitation, stemming from the research strategy adopted in primary studies, may have implications for advancements in the field. The case of sadness-related stimuli could be relevant to discuss this general limitation. Existing eye-tracking research has consistently identified attentional biases toward sad faces, but also toward happy faces, in individuals with depression (Duque et al., 2015), which have been linked to the onset and maintenance of depressive disorders (Farb et al., 2015; Disner et al., 2011). Given that emotional disorders, including depression, are commonly comorbid conditions associated with chronic pain (Dhanju et al., 2019; Hooten et al., 2016), the inclusion of diverse emotional stimuli is pertinent to assess the specificity of findings and whether stimuli unrelated to pain are sufficiently sensitive to detect attentional biases in individuals with chronic pain. Moreover, substantial heterogeneity among primary studies, particularly in the exploration of cognitive and emotional variables, poses challenges for robust moderator analyses.

Based on the results of our comprehensive review, we offer several recommendations for future investigations on attentional biases in the chronic pain domain. A paramount priority is the augmentation of eye-tracking studies exploring attentional mechanisms in individuals with chronic pain while establishing greater homogeneity in experimental task parameters to facilitate definitive conclusions. Concerning the tasks designed to explore attentional bias, many primary studies employed free-viewing paradigms, wherein

participants passively observed stimuli without specific engagement requirements. Establishing a parallel with studies on attentional biases in psychopathology, studies investigating attentional biases in depression (Sanchez et al., 2013) or anxiety (Günther et al., 2021) have demonstrated that paradigms designed to capture engagement/disengagement attentional processes, rather than passive attentional patterns, are invaluable for detecting participants' difficulties in disengaging attention from threatening or negative stimuli. Consequently, we need to foster a new generation of innovative studies that enable a more nuanced understanding of potential attentional mechanisms related to conditions such as chronic pain.

Robles, E., Nieto, I., Navas, J. F., & Vázquez, C. (2024). Attentional biases towards emotional information in chronic pain: A multilevel meta-analysis of eye-tracking studies. *Acta Psychologica, 250, 104555*. https://doi.org/10.1016/j.actpsy.2024.104555

5. Chapter II. Study 2: Mindfulness-based stress reduction for chronic pain: Enhancing psychological well-being without altering attentional biases towards pain faces.

The first study aimed to explore attentional biases in chronic pain patients as well as in healthy individuals, showing that both individuals with and without chronic pain have a biased attention to pain-related information. Regarding attentional modification, therapies focused on the control attention and breath have shown to be effective to modify attentional mechanisms and have been proposed as an alternative to the use of medication to treat chronic pain, showing promising results in reducing the pain-related symptomatology in this population. However, the effectiveness of these therapies in modifying the attentional pattern of people with chronic pain has not been explored. For that reason, the following study published as *"Robles, E., Blanco, I., Díez, G., & Vázquez, C. (2024). Mindfulness-based stress reduction for chronic pain: Enhancing psychological well-being without altering attentional biases towards pain faces. European Journal of Pain, 00:1–14",* aimed to analyse the effectiveness of a Mindfulness-Based Stress Reduction (MBSR) program to improve the symptomatology of people with chronic back pain, as well as to modify their attentional pattern to stimuli expressing pain. For that reason, individuals with a discopathy for at least two years were recruited thought announcements in Nirakara, a research institute, and invited to take part in the program without any cost. The main results of this study show the beneficial effect of this type of programs to reduce anxious and depressive symptoms, as well as to improve the quality of life and well-being of people with chronic pain. However, the programme did not produce any significant change in the attentional pattern. These results show the benefits of mindfulness to treat chronic pain symptomatology and suggest the potential effect of meditation to modify attention to pain-related information, which may allow to implement better non-pharmacological interventions for chronic pain patients.

Robles, E., Blanco, I., Díez, G., & Vázquez, C. (2024). Mindfulness-based stress reduction for chronic pain: Enhancing psychological well-being without altering attentional biases towards pain faces. *European Journal of Pain*, *00*:1–14. https://doi.org/10.1002/ejp.4714

5.1. Introduction

Chronic pain is one of the most frequent health problems worldwide, which undermines people from doing a normal daily life (Van Hecke et al., 2014; Rice et al., 2016).This medical condition has not only an economic impact on the health systems due to the high demand for sanitary resources (Torralba et al., 2014) but also on the quality of life (Hadi et al., 2019) and life satisfaction (McNamee & Mendolia, 2014) of these patients. This scenario makes it imperative to investigate the underlying psychobiological mechanisms of pain as well as to develop new treatments capable of targeting them.

There are several psychological models that have tried to explain the onset and maintenance of pain. From a cognitive perspective, one of the most relevant models is the Fear-Avoidance of Pain Model, whose basic tenet is that fear of pain has a key role in the development and maintenance of pain and it is associated with avoidance, escape, and hypervigilance behaviors (Lethem et al., 1983; Vlaeyen & Linton, 2012). There is evidence enough to consider that fear of pain has a key contributing role to the maintenance of chronic pain as it may be associated with cognitive biases towards pain-related information (De Peuter et al., 2011).

Cognitive biases have been widely studied not only in disorders such as depression (Nieto et al., 2020) or anxiety (Leung et al., 2022) but also in people suffering from chronic pain (Schoth et al., 2019). One of the most studied cognitive biases in this field is the interpretation bias toward ambiguous stimuli. In a meta-analysis carried out by Schoth and Liossi (2016), the authors found that chronic pain patients made significantly more pain-related interpretations of ambiguous information than did healthy controls. A catastrophic interpretation of pain is another cognitive bias that has been widely studied in the chronic pain population, which may also be involved in the development and maintenance of chronic

pain (Dong et al., 2020). In a recent study, it was found that greater catastrophizing was associated with greater clinical pain sensitivity in chronic low back pain (CLBP) patients (Meints et al., 2019).

Another well-studied cognitive mechanism in both emotional and pain-related problems is attentional bias. Attentional biases are deeply intertwined with other cognitive biases (Everaert & Koster, 2012; Sanchez et al., 2017) and might also contribute to the chronicity of pain. These biases towards emotional stimuli can appear at different stages of attentional processing revealing different mechanisms (Cisler & Koster, 2010). On the one hand, there may be facilitated attention to pain stimuli, or hypervigilance (i.e., the relative speed with which attention is initially and involuntarily directed to such stimuli); this tendency would reveal the existence of altered mechanisms in early stages of processing. On the other hand, there may also be difficulties in avoiding attention from emotional stimuli (i.e., the degree to which such stimuli capture attention and hinder the possibility of shifting attention to other stimuli); this tendency would reveal problems in later stages of processing.

In the case of chronic pain, some studies have found attentional biases in the early stages of the attentional process. For instance, Franklin et al., (2018) compared the attentional performance (using eye-tracking technologies and a dot-probe task) towards pain-related images in comparison to neutral ones in a sample of chronic back pain and healthy participants. The authors found that chronic pain participants made first fixations to pain-related stimuli significantly faster than the healthy group. In another study, Mahmoodi-Aghdam et al., (2017) compared the attentional pattern of people with and without chronic pain towards pictures of pain-provoking activities in comparison to neutral ones, finding no significant differences between groups. However, the authors found that people without chronic pain fixated more quickly on neutral than pain stimuli while people with chronic

pain fixated relatively quickly on pain-related stimuli in comparison to neutral ones. In contrast to this, other studies comparing attentional biases in early attentional stages between chronic pain and healthy individuals have not found significant differences between both groups (Priebe et al., 2021).

Regarding attentional processing toward pain stimuli at late stages of attentional performance, most of the research has not found differences between people suffering from chronic pain and healthy controls. For instance, in a study using pain, angry, happy and neutral stimuli, Liossi et al. (2013) found that participants with and without chronic headaches tended to spend more time viewing happy images in comparison to pain, angry and neutral ones. This is in line with other studies that have also failed to find attentional differences in the maintenance of visual attention between individuals with and without chronic pain (Lee et al., 2020; Priebe et al., 2021).In fact, systematic reviews (Chan et al., 2020) and meta-analyses (Jones et al., 2021) have not found significant differences in the attentional pattern between people with and without chronic pain. However, the authors observed a general bias to first fixate on pain-related stimuli in comparison to neutral ones in both individuals with and without chronic pain. However, the study of attentional biases in chronic pain through the analysis of eye movements is very recent, and in consequence, systematic reviews and meta-analyses are based on few studies. Additionally, these studies feature a limited sample size of individuals experiencing chronic pain, potentially impeding the thorough investigation of attentional biases within this population and the potential moderating role of other cognitive, emotional, and experimental task variables.

Back pain is highly prevalent in the general population, with low back pain being recognized as the leading cause of chronic pain (Bassols & Baños, 2006) and the primary contributor to disability (Ehrlich, 2003). Studies suggest that 84% of adults will experience

an episode of low back pain episode at some point in their lives (Selkirk & Ruff, 2016). Moreover, a significant proportion of these patients progress to a diagnosis of chronic back pain diagnosis, which stands out as one of the most prevalent conditions associated with chronic pain (Murray et al., 2022). Indeed, chronic back pain contributes to rise in prevalence within the general population and remains a primary motive for seeking medical attention **(**Meucci et al., 2015). This condition has been associated with the presence of high levels of depression, anxiety, and stress (Azfar et al., 2019). Relevant cognitive biases have been also found in chronic back pain patients, such as pain catastrophizing (Owens et al., 2016), which has been considered a main predictor of pain chronification in this condition (Severeijnset al., 2001; Picavet et al., 2002). Regarding attentional biases, dot-probe studies have found attentional biases towards pain information. For instance, Haggman et al., (2010) compared attentional biases towards pain-related words (sensory, affective, disability and threat) in comparison to neutral in individuals with acute and chronic back pain and healthy individuals. The authors found that both pain groups showed attentional biases towards sensory pain words compared to controls. Although meta-analyses have not shown differences in the attentional patterns between people with and without chronic pain, some eye-tracking studies focusing on chronic back pain patients have identified biases during early attentional stages in these individuals. (Mahmoodi-Aghdam et al., 2017; Franklin et al., 2018) that may be amplifying the back pain experience and contribute to its progression into chronic conditions.

To date, a wide variety of pharmacological treatments (e.g., muscle relaxants, benzodiazepines, opioids, or antidepressants) have been used for the treatment of chronic pain. However, they have been considered of limited effectiveness (Deyo et al., 2009; Liebschutz et al., 2014). In recent years, the interest in the effects of psychological therapies

in chronic pain conditions has increased (Williams et al., 2020). Different therapies focused on attentional control and breathing have been used to treat chronic pain. One of these new evidence-based practices is Mindfulness-Based Stress Reduction programs (MBSR). Standard MBSR programs incorporate a variety of formal mindfulness practices, such as training attentional control and self-compassion components, intending to reduce stress levels (Crane et al., 2017).In the field of chronic pain, Wong et., (2011) compared the effectiveness of a MBSR program with a Multidisciplinary Pain Intervention (MPI), which tackles the pain management through clinical experts of different approaches which deal with a variety of physical and psychological aspects. The authors found that both MBSR and MPI programs were effective in reducing chronic pain symptoms, such as pain intensity and pain-related distress. In another research, chronic pain patients were randomly assigned to an 8-week mindfulness-based intervention or a waiting list control group. The authors found that, compared to the control group, participants in the intervention group showed a significant reduction in pain severity and pain interference (Reiner et al., 2019). Furthermore, it has been observed that mindfulness practice reduces pain perception (Watson et al., 2018) and pain catastrophizing (Kearson et al., 2019). However, although most studies find evidence of the beneficial effect on the physical and mental functioning of chronic pain samples (Cramer et al., 2012; McClintock et al., 2019), studies which assess attentional mechanisms and how mindfulness-based programs may change them are needed to have a better knowledge of the effectiveness of mindfulness programs and the mechanisms operating in the reduction of pain.

A meta-analysis conducted by Sumantry & Stewart (2021) with healthy individuals found that meditation was effective to improve attentional processes such as executive control and inhibition. More specifically, eye-tracking studies using emotional faces as

experimental stimuli, have shown attentional changes at both early (Roca & Vazquez, 2020) and at late stages of attentional processing (e.g., Pavlov et al., 2015; Blanco et al., 2020). Meditation-based interventions have also been shown to be effective to modify attentional mechanisms in individuals suffering from chronic pain. For example, Vago & Nakamura (2011) found, using reaction times in a dot-probe task, that an8-week mindfulness-based meditation training (MMT) was effective to reduce avoidance and facilitate disengagement from pain-related information in patients with fibromyalgia. In another dot-probe study carried out by Garland & Howard., (2013) it was found that taking part in a mindfulness program can reduce attentional biases towards pain-related images in people suffering chronic pain. Eye-tracking studies exploring the effect of mindfulness-based programs on attentional biases in experimental pain conditions have also found promising results. For example, Shires et al., (2018) compared the effects of a mindfulness-based intervention versus distraction or no instructions in the ability to disengage from pain-related stimuli after a pain induction, finding that the mindfulness-based program was more effective to reduce the time to disengage from pain-related stimuli. Thus, the study of the effects of mindfulness-based programs is very recent, but it has yielded promising results not only in terms of its ability to reduce the impact of certain variables related to pain but also to reduce attention bias towards information that involves pain.

Given the aforementioned factors, the aim of the present study was to investigate the effect of an MBSR program, tailored for individuals with chronic back pain, on both their psychological well-being and attentional patterns to pain-related stimuli. To achieve this goal, we assessed various cognitive and emotional parameters in participants suffering from chronic back pain and analyzed their eye movements before and after completing the MBSR program. Our first hypothesis posited that, compared to the control group, the experimental group would exhibit improvement in symptoms associated with chronic pain following the

MBSR program. Additionally, we anticipated that the program would not only modify the initial orientation or maintenance of attention towards pain faces in the experimental group relative to the control group, but also enhance their capacity to disengage attention from such stimuli.

5.2. Methodology

5.2.1. Participants

Thirty-nine chronic back pain individuals took part in the study and were randomly allocated to the MBSR or control group. However, four of them could not have their attentional indices measured due to technical problems or visual alterations, two participants dropped out of the study, and another participant was diagnosed with cancer during the study, thus fulfilling an exclusion criterion. Therefore, the final sample was composed of 32 participants. They were recruited through the website of (hidden for review), a training and research centre specializing in meditation and neuroscience. The inclusion criteria for all participants were: 1) being older than 18 years old, 2) having been diagnosed with a recent discopathy (less than 2 years since the diagnosis), 3) suffering from chronic pain (i.e., more than 3 months), 4) being able to have a minimum mobility to perform gentle muscle exercises included in the MBSR program, and 5) not having previous experience in mindfulness. The exclusion criteria were: 1) having suicidal thoughts, severe depression or psychosis, and 2) having drug addiction problems.

5.2.2. Pain and psychological measures

Visual Analogue Scale (VAS) for Pain Intensity. A 10-point visual scale was used to assess the intensity of pain, ranging from 0 (absence of pain) to 10 (the maximum pain).

Depression, Anxiety, and Stress Scale (DASS-21), (Lovibond & Lovibond, 1995). It consists of 21 items scored on a 4-point Likert-type scale ranging from 0 (did not apply to me at all) to 3 (applied to me very much, or most of the time), assessing levels of depression, anxiety, and stress. In this study, the total score showed good internal consistency (α = .90) and the three subscales showed acceptable internal consistency (depression, α = .77; anxiety, α = .62; stress, α = .84).

Pain Catastrophizing Scale (PCS) (Sullivan, Bishop, & Pivik, 1995). It consists of 13 items scored on a 5-point Likert scale ranging from 0 (not at all) to 4 (all the time)to assess the tendency to magnify the threat of painful stimuli and the feeling of helplessness in the presence of pain, as well as the inability to prevent or inhibit pain-related thoughts. This instrument is divided into three subscales related to pain: rumination, magnification, and helplessness. For this study, internal consistency was good for the total score (α = .94) and the subscales: rumination (α = .93), magnification (α=.81), and helplessness (α=.89).

Chronic Pain Acceptance Questionnaire-Revised (CPAQ-R), (McCracken, Vowles, & Eccleston, (2004). It consists of 20 items rated on a 7-point Likert scale from 0 (never true) to 6 (always true). This questionnaire was designed to assess the acceptance through two factors: activity engagement and pain willingness. In this study, the internal consistency was acceptable for both dimensions: activity engagement (α = .79) and pain willingness (α =.71).

Five Facet Mindfulness Questionnaire Short Form (FFMQ-SF), (Bohlmeijer, ten Klooster, Fledderus, Veehof, & Baer, 2011). It is a 20-ítems questionnaire that provides a total score of a person's mindfulness level. Each item is rated on a 5-point Likert scale ranging from 1 (never or rarely true) to 5 (very often or always true). It is divided into 5 subscales: Observing; Describing; Acting with Awareness; Non-judgement; and Non-

reactivity (Baer et al., 2006). In this study, internal consistency was acceptable for the total score (α = .70).

Satisfaction With Life Questionnaire (SWLS) (Diener, Emmons, Larsen, & Griffin, 1985). It consists of 5 items rated on a 7-point Likert scale from 1 (strongly disagree) to 7 (strongly agree). This instrument was designed to measure individuals' global cognitive judgments about their satisfaction with life. In this study, the internal consistency was good (α = .83).

Five Well-Being Index (WHO-5), (World Health Organization, 1998). This is a 5-item scale designed to assess global mental well-being (WHO, 1998) and has been widely used in health research (Topp et al., 2015). Each item is scored on a 6-point Likert scale from 0 (none of the time) to 5 (all of the time). In this study, the internal consistency was good (α = .82).

The Tampa Scale of Kinesiophobia (TSK-11-SV), (Miller, Kori, & Todd, 1991). This is a shortened version of the original 17-item questionnaire. It consists of 11 items assessing the subjective rating of kinesiophobia (i.e., fear of movement) on a 4-point Likert scale ranging from 1 (strongly disagree) to 4 (strongly agree). The total score varies between 11 and 44. The internal consistency in this study was good (α = .81).

Scale for Mood Assessment or Mood Evaluation Scale (EVEA), (Sanz, 2001). The EVEA was used to assess participants' mood states before performing the eye-tracking task to control the influence of participants' mood on their attentional patterns. It consists of 16 items and each one has an 11-point Likert scale with scoring alternatives ranging from 0 (nothing) to 10 (a lot). The EVEA assesses four mood states: anxiety, anger-hostility, sadness-depression, and joy. For this intervention study, we added four ad hoc items to assess boredom, fatigue, curiosity, and entertainment. Reliability analysis showed high internal

consistency for all the subscales: depression (α = .89); anxiety (α = .93); anger (α = .91) and joy (α = .94).

5.2.3. Stimuli

The pain and neutral faces pictures used in the current study were taken from the Montreal Pain and Affective Face Clips (MPAFC), a database of 64 facial expressions created by Simon et al., (2008). These faces have been validated in a large sample of healthy individuals and people with chronic pain (Robles & Vazquez, 2024) showing that both men and women rated female facial expressions of pain as more representative and emotionally intense than male faces. Following Blanco et al.'s procedures (2019), surrounding parts of the images, including the hair and neck, were cropped to remove their non-informative aspects. Eight pain expressions (4 males, 4 females) were selected as stimuli for the current study. Every pain facial expression was matched with its corresponding neutral facial expression, resulting in eight pairs of pain-neutral facial expressions.

5.2.4. Apparatus

A Tobbi Tx-120 eye tracker was used to record participants' eye movements at a frequency of 120 Hz. The distance between the participant's eyes and the eye-tracker device was 60 cm. The stimuli presentation was controlled by Tobbi Studio software (2.0.6) and all the stimuli were presented on a 24" LCD monitor (frame rate 60 Hz).

5.2.5. Eye-tracking task

The task used in the present study was a modification of a previously used task to evaluate attentional patterns in both early and later stages of attentional processing (see Sanchez et al., 2013; Duque & Vazquez, 2015; Blanco et al., 2019). The task was comprised

of two different subtasks (i.e., free-viewing task and disengagement task) embedded in each trial (see Figure 2.1.).

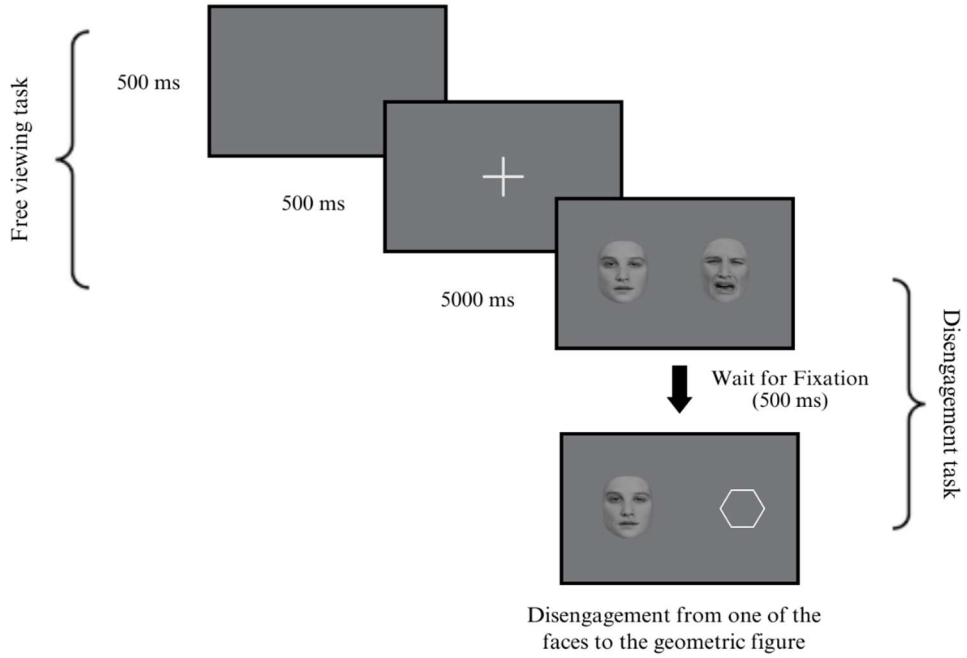
- Free-viewing task: each trial begins with a grey background on the screen for 500 ms, followed by a white fixing cross in the middle of the screen until the participant fixates the gaze on it for 500 ms. After this fixation cross, a pair of faces (neutral and pain) are presented for 5000 msec. During this phase, participants are asked to freely view the screen without any constraints.

- Disengagement task: This task was designed to assess the participants' ability to disengage from a given face (i.e., the pain or the neutral face) and the ability to re-direct their attentional focus when requested. After the presentation of both faces in the free viewing task in each trial, a waiting period for fixation begins. Once the individual has fixed his/her gaze on a given face for 500 ms, the program replaces the opposite face with a geometric figure (a square or a hexagon). Then, participants are required to press on the keyboard one of the two available buttons to indicate which type of figure has appeared. A precise response to this request demands individuals to disengage their gaze from the face to which they were engaged. After the response, the following trial begins.

The entire attention task consisted of 64 randomized trials. Both neutral and painful faces were presented equally on the left and right sides of the screen. Before starting the first block of the task, a block of 8 practice trials (with other facial expressions than the one used in the task) was carried out. The entire task lasted an average of 10 minutes.

Figure 2.1.

The two-part eye-tracking attentional task (i.e., the Free Viewing Task and the Disengagement Task).



5.2.6. Selective attention and disengagement indexes

During the completion of the experimental task, five attentional measures were computed to analyze the attentional pattern towards emotional information at different temporal stages during the free-viewing phase of the task.

- Time to First Fixation (TFF): The time elapsed between the appearance of the stimuli and the first fixation made on each type of face in each trial.
- First Fixation Duration (FFD): The duration of the first fixation made on each type of face in each trial.
- Total Fixation Duration (TFD): The total time participants spent looking and making fixations at each type of face in each trial (based on the duration of every fixation).

- Fixation Count (FC): The total number of fixations made on each type of facial expression during the entire trial.
- Total Visits Duration (TVD): The mean time spent looking at the pain or neutral face AOI during all visits. A visit was defined as one or more contiguous eye movements within an AOI, while an AOI refers to the area of interest in every facial expression during its visualization.

The ability to disengage from a given face was assessed by using the first fixation latency towards the geometric figure in the disengagement subtask.

Internal consistency of the eye-tracking measures was analyzed by calculating Cronbach's alpha for both the pain and neutral stimuli and for pre- and post-intervention measures (see Table 2.1.).

Table 2.1.

Reliability scores (Cronbach's alpha) for every type of stimuli at two separate assessments (Time 1 and Time 2) for the entire sample of participants

	Time 1		**Time 2**	
	Pain	**Neutral**	**Pain**	**Neutral**
TFF Index	α=.79	α=.81	α=.81	α=.81
FFD Index	α=.84	α=.86	α=.76	α=.79
TFD Index	α=.82	α=.81	α=.79	α=.80
FC Index	α=.95	α=.94	α=.93	α=.92
TVD Index	α=.74	α=.73	α=.68	α=.72
Disengagement Index	α=.83	α=.81	α=.82	α=.50

Note: TFF = Time to First Fixation; FFD = First Fixation Duration; TFD = Total Fixation Duration; FC = Fixation Count; TVD = Total Visits Duration.

5.2.7. Mindfulness-Based Stress Reduction program

The MBSR program was originally developed (by the Mindfulness Center of the University of Massachusetts) to reduce stress and has been one of the most researched interventions based on mindfulness practice (Kabat-Zinn, 2013). For the present study, the exercises of the program were adapted to chronic back pain individuals (see Diez et al., (2022) for an extensive explanation of the program components). The program consisted of an 8-week course with 2.5 hours per session and an intensive session of 7.5 hours performed between the sixth and seventh week. All sessions were taught by qualified professionals who are certified instructors by the University of Massachusetts Medical Center.

5.2.8. Procedure

First, all participants completed the informed consent and filled out a series of questionnaires before starting the study. After that, they were scheduled to carry out the experimental tasks in the laboratory, where they completed the EVEA before initiating the eye-tracking tasks. Then, the experimental group started the 8-week MBSR program while the control group was part of a waiting list. After finishing the program, both groups completed the questionnaire and the attentional task again.

The protocol was approved by the University Ethics Committee (blinded for review) and was registered in clinicaltrials.gov (blinded for review) previously for recruiting patients.

5.2.9. Analyses

A series of 2 (Group: experimental, control) x 2 (Time: time 1, time 2) repeated-measures ANOVAs were conducted to analyze the effect of the MBSR program on self-reported measures of symptoms and well-being. Also, a series of 2 (Group: Experimental,

Control) x 2 (Time of assessment: Time 1, Time 2) x 2 (Valence of faces: Neutral, Pain) repeated-measures ANOVAs were conducted to analyze attentional indices. Bonferroni post-hoc comparisons were conducted to analyze mean differences.

In addition, correlational analyses were conducted between baseline attentional biases and pain and psychological changes after the program in the experimental group.

5. 3. Results

5.3.1. Demographic data

The final sample was composed of 32 participants (21 women and 11 men), with a mean age of 55.09 years (*SD* = 10.16; range = 33-73 years). The experimental group was composed of 19 participants (10 women) with a mean age of 52.42 years (*SD* = 9.63) and the control group was composed of 13 participants (11 women) with a mean age of 59.00 (*SD* = 10.06). There were no significant differences between the participating groups concerning sex (χ^2 = 3.5, p = .06), age [*t (32)* = -1.82, p = .07], pain intensity [*t* (32) = .27, p = .79] or psychological measures. Regarding EVEA subscales, there were no significant differences between both groups in sadness-depression [*t* (32) = .21, p = .83], anxiety [*t* (32) = .65, p = .52], anger [*t* (32) = .87, p = .39] or joy [*t* (32) = .59, p = .55].

5.3.2. Initial attentional indices

Means and standard deviations of attentional indices are presented in Table 2.2. Independent t-tests were performed for both painful and neutral faces for the entire sample (N = 32). There were no significant differences between stimuli for total fixation duration [*t (32)* = -.49, *p* = .62], fixation count [*t(32)* = -.45, *p* = .65], and total visit duration [*t (32)* = -.45, *p* = .65]. However, there were significant differences in time to first fixation [*t (32)* = -

3.60, $p < .001$] and first fixation duration [$t\ (32) = 2.90$, $p = .007$] between pain and neutral stimuli. Participants's first gaze was faster for pain faces ($M = .81$, $SD = .13$) than for neutral faces ($M = .92$, $SD = .18$) and they did longer first fixations on pain faces ($M = .36$, $SD = .08$) than on neutral faces ($M = .33$, $SD = .08$). For the disengagement index, no significant differences were found between pain and neutral stimuli [$t\ (32) = -1.01$, $p = .31$].

Table 2.2.

Means and standard deviations for pain and neutral stimuli at Time 1 for all participants.

	Pain Faces	**Neutral Faces**			
	Mean (SD)	**Mean (SD)**	**t-test**	***p***	**Cohen's d**
Time to the first fixation (sec)	.81 (.13)	.92 (.18)	-3.60	.001	.17
First fixation duration (sec)	.36 (.08)	.33 (.08)	2.90	.007	.05
Fixation count	6.21 (1.49)	6.35 (1.70)	-.45	.65	1.64
Total fixation duration (sec)	2.03 (.42)	2.09 (.40)	-.49	.62	.63
Total visit duration (sec)	2.12 (.42)	2.18 (.39)	-.45	.65	.67
Disengagement (sec)	.42 (.07)	.43 (.11)	-1.01	.31	.08

5.3.3. Efficacy of the MBSR

Psychological symptoms and well-being

Means and standard deviations of pain intensity and measures of psychological symptoms and well-being are presented in Table 2.3. A series of 2 (Group: Experimental, Control) x 2 (Time: Time 1, Time 2) ANOVAs was conducted. There were significant interaction effects on the DASS Depression [$F(1, 24) = 8.80$, $p = .007$, $\eta^2 = .28$], DASS Anxiety ($F = 17.77$, $p < .001$, $\eta^2 = .44$), DASS Stress [$F(1, 24) = 12.38$, $p = .002$, $\eta^2 = .36$], and DASS Total [$F(1, 24) = 16.29$, $p < .001$, $\eta^2 = .42$]. At Time 2, participants from the

experimental group showed lower levels of depression, anxiety, stress, and total score than the control group. There were also significant interaction effects for the CPAQ [$F(1, 24) = 6.58$, $p = .01$, $\eta^2 = .23$], SWLS [$F(1, 24) = 14.32$, $p = .001$, $\eta^2 = .39$] and the WHO-5 [$F(1, 24) = 11.47$, $p = .003$, $\eta^2 = .34$]. At Time 2, the experimental group showed higher levels of both chronic pain acceptance and higher satisfaction with life than the control group. A full explanation of the analysis can be found in the Supplementary Material ("resultsS1").

Table 2.3.

Means and standard deviations for pain and psychological measures for every group

	Experimental group		**Control group**	
	Time 1	**Time 2**	**Time 1**	**Time 2**
Pain Intensity (VAS)	4.29 (.74)	3.08 (.63)	4.37 (.96)	4.64 (.82)
DASS Depression	5.53 (.99)	3.60 (1.25)	5.44 (1.27)	9.11 (1.61)
DASS Anxiety	3.86 (.67)	3.06 (.92)	3.55 (.86)	8.66 (1.19)
DASS Stress	8.93 (.95)	6.20 (1.02)	6.55 (1.22)	10.88 (1.31)
DASS Total	18.33 (2.27)	12.86 (2.73)	15.55 (2.94)	28.66 (3.52)
TSK	29.33 (1.97)	26.06 (1.81)	31.11 (2.55)	29.44 (2.33)
FFMQ-SF	60.00 (2.08)	60.60 (1.91)	62.44 (2.69)	65.55 (2.47)
PCS Rumination	7.46 (1.62)	5.53 (1.13)	9.11 (2.09)	8.00 (1.46)
PCS Magnification	5.26 (1.00)	3.33 (.68)	4.66 (1.29)	4.55 (.88)
PCS Helplessness	9.00 (1.98)	5.13 (1.44)	11.00 (2.56)	10.22 (1.86)
PCS Total	21.73 (4.28)	14.00 (2.99)	24.77 (5.53)	22.77 (3.86)
CPAQ Total	60.80 (2.56)	64.60 (2.49)	65.44 (3.31)	56.00 (3.22)
SWLS	19.73 (1.75)	22.73 (1.65)	20.44 (2.27)	18.44 (2.14)
WHO-5	10.40 (1.20)	14.20 (1.37)	8.55 (1.56)	7.11 (1.77)

Note: DASS = Depression, Anxiety and Stress Scale; TSK = Tampa Scale for Kinesiophobia; FFMQ-SF = Five Facets Mindfulness Questionnaire Short Form; PCS = Pain Catastrophizing Scale; CPAQ = Chronic Pain Acceptance Questionnaire; SWLS = Satisfaction With Life Scale; WHO-5 = The World Health Organization-Five Well-Being Index.

Attentional measures

Table 2.4. shows the means and standard deviations of pain-neutral indices at the two assessment time points. A series of 2 (Group: Experimental, Control) x 2 (Time: Time 1, Time 2) x 2 (Valence: Pain, Neutral) was conducted for every index.

Time to first fixation. There were no significant main effects of Group [F (1, 30) = .89; p = .35, η^2=.029], Time [F (1, 30) = 2.13; p = .15, η^2 = .066], Time x Group [F(1, 30) = 1.93; p = .17, η^2 = .061], Valence x Group [F (1, 30) = .43; p = .51, η^2 =.014], Time x Valence [F (1, 30) = .43; p = .51, η^2 =.014] or Time x Valence x Group [F (1, 30) = 3.84; p = .059, η^2 =.114]. However, there was a significant effect of Valence [F (1, 30) = 19.79; p < .001, η^2 =.039]. Post-hoc analyses revealed that all participants took less to fixate on pain faces (M = .82, SD = .02) than on neutral ones (M = .94, SD = .03).

First fixation duration. There were no significant main effects of Group [F (1, 30) = .48; p = .49, η^2 =.016], Time [F (1, 30) = .04; p = .83, η^2= .001], Time x Group [F(1, 30) = 1.31; p = .26, η^2 = .042], Time x Valence [F (1, 30) = .18; p = .66, η^2 =.006] or Time x Valence x Group [F (1, 30) = 1.32; p = .25, η^2 =.042]. However, there was a significant effect of Valence [F (1, 30) = 6.68; p = .015, η^2 =.182] and Valence x Group [F (1, 30) = 4.20; p = .049, η^2 =.123]. Post-hoc analyses revealed that all participants did longer first fixations on pain faces (M = .36, SD = .012) than on neutral ones (M = .34, SD = .014) and that controls did longer first fixations on pain faces (M = .38, SD = .01) than on neutral ones (M = .33, SD = .02).

Total fixation duration. There were no significant main effects of Group [F (1, 30) = 3.33; p = .07, η^2 =.100], Time [F (1, 30) = .17; p = .68, η^2 = .006], Valence [F (1, 30) = .56; p = .45, η^2 =.018], Valence x Group [F (1, 30) = .07; p = .78, η^2 = .003], Time x Valence [F(1, 30) = .002; p = .96, η^2 = .000] or Time x Valence x Group [F (1, 30) = .06; p = .80, η^2

=.002]. However, there was a significant effect of Time x Group [F (1, 30) = 10.84; p = .003, η^2 = .266]. Post-hoc analyses revealed that, at Time 1, participants from the experimental group displayed overall shorter fixations (M = 1.96, SD = .048) than the control group (M = 2.20, SD = .058). Furthermore, the experimental group showed shorter fixations at Time 1 (M = 1.96, SD = .048) than at Time 2 (M = 2.07, SD = .045) while the opposite was found in the control group.

Fixation count. There were no significant main effects of Group [F (1, 30) = .41; p = .52, η^2 =.014], Time [F (1, 30) = .71; p = .40, η^2 = .023], Valence [F (1, 30) = .94; p = .33, η^2 = .031], Time x Group [F(1, 30) = .029; p = .86, η^2 = .001], Time x Valence [F (1, 30) = .23; p = .63, η^2 =.008], Valence x Group [F (1, 30) = 1.37; p = .25, η^2 = .044] or Time x Valence x Group [F (1, 30) = .21; p = .64, η^2 =.007].

Total visit duration. There were no significant main effects of Group [F (1, 30) = 2.64; p = .11, η^2 =.081], Time [F (1, 30) = .01; p = .92, η^2 = .000], Valence [F (1, 30) = .60; p = .44, η^2 = .020], Time x Valence [F (1, 30) = .03; p = .86, η^2 =.001], Valence x Group [F (1, 30) = .13; p = .71, η^2 = .004] or Time x Valence x Group [F (1, 30) = .03; p = .84, η^2 =.001]. However, there was a significant effect of Time x Group [F (1, 30) = 7.64; p = .01, η^2 = .0203]. Post-hoc analyses revealed that the experimental group displayed shorter visits at Time 1 (M =2.07, SD = .04) than at Time 2 (M =2.17, SD = .03), and also displayed shorter visits compared to the control group (M = 2.26, SD = .05) at Time 1.

Disengagement. There were no significant main effects of Group [F (1, 30) = .31; p = .57, η^2 =.010], Time [F (1, 30) = .72; p = .40, η^2 = .023], Valence [F (1, 30) = 3.81; p = .06, η^2 = .113], Time x Group [F(1, 30) = 3.004; p = .09, η^2 = .091], Time x Valence [F (1, 30) = 2.11; p = .15, η^2 =.066], Valence x Group [F (1, 30) = 1.05; p = .31, η^2 = .034] or Time x Valence x Group [F (1, 30) = .57; p = .45, η^2 =.019].

Table 2.4.

Means and standard deviations for pain and neutral faces for the two participating groups.

	Experimental Group				Control Group			
	Time 1		Time 2		Time 1		Time 2	
	Pain Faces Mean (SD)	Neutral Faces Mean (SD)	Pain Faces Mean (SD)	Neutral Faces Mean (SD)	Pain Faces Mean (SD)	Neutral Faces Mean (SD)	Pain Faces Mean (SD)	Neutral Faces Mean (SD)
Time to first fixation (sec)	.83 (.03)	.98 (.04)	.85 (.03)	.96 (.04)	.80 (.03)	.85 (.04)	.83 (.04)	.97 (.05)
First fixation duration (sec)	.34 (.01)	.33 (.01)	.35 (.01)	.35 (.02)	.39 (.02)	.34 (.02)	.38 (.02)	.33 (.02)
Total fixation duration (sec)	1.96 (.09)	1.98 (.08)	2.05 (.08)	2.11 (.07)	2.15 (.11)	2.26 (.10)	2.02 (.09)	2.10 (.08)
Fixation count	6.21 (.35)	6.16 (.39)	6.01 (.27)	5.97 (.35)	6.21 (.42)	6.63 (.47)	5.96 (.33)	6.62 (.42)
Total visits duration (sec)	2.07 (.09)	2.08 (.08)	2.14 (.07)	2.21 (.08)	2.21 (.11)	2.32 (.10)	2.10 (.09)	2.22 (.10)
Disengagement (sec)	.44 (.01)	.45 (.02)	.42 (.02)	.45 (.04)	.39 (.02)	.41 (.03)	.40 (.02)	.49 (.04)

Note. Sec = Second; SD = Standard Deviation

Robles, E., Blanco, I., Díez, G., & Vázquez, C. (2024). Mindfulness-based stress reduction for chronic pain: Enhancing psychological well-being without altering attentional biases towards pain faces. *European Journal of Pain*, *00*:1–14. https://doi.org/10.1002/ejp.4714

5.3.4. Correlational analyses

To explore the relation between pain and psychological changes and baseline levels of attentional biases, bivariate correlations were conducted between attentional indices pre-program (Time 1) and pain and psychological outcomes post-program (Time 2) in the experimental group. There were significant negative correlations between disengagement speed from pain faces and PCS Helplessness ($r = -.57$, $p = .02$), and disengagement speed from neutral faces and DASS Depression ($r = -.58$, $p = .017$) and DASS Anxiety ($r = -.52$, $p = .036$).

There was also a significant correlation between time to first fixation towards pain faces and PCS Rumination ($r = .53$, $p = .033$), PCS Magnification ($r = .51$, $p = .039$), and PCS Total ($r = .51$, $p = .044$).

5.4. Discussion

The present study aimed to analyze the potential efficacy of an MBSR program to modify psychological symptoms and well-being associated as well as attentional biases towards pain-related stimuli in participants with chronic back pain. Regarding the presence of attentional biases in the entire sample before starting the program, our results revealed significant differences between pain and neutral faces for the time to display a first fixation, indicating that chronic pain individuals tended to initially direct their gaze on pain stimuli. Also, regarding the duration of this first fixation, participants with chronic pain displayed longer first fixation toward pain faces than to neutral ones. These results are in line with findings obtained in previous studies which found that individuals with chronic pain show attentional biases during the early stages of attention in comparison to pain-free individuals

(Liossi et al., 2014; Franklin et al., 2018). It should also be noted that the indices obtained presented an overall good reliability.

Following our hypotheses related to the randomized intervention, we initially hypothesized that the MBSR program would reduce symptoms associated with chronic pain, which indeed proved to be the case. Notably, participants in the control group exhibited heightened levels of depression, anxiety, and stress, alongside decreased acceptance of pain programs in comparison to the experimental group, while this one reduced the stress levels and increased satisfaction with life and well-being.

The program effectively ameliorated psychological symptoms in the experimental group, aligning with findings from prior research. For instance, Sheybani et al., (2022) demonstrated in a randomized clinical trial that a MBSR intervention improved depression, anxiety, and quality of life among chronic pain patients. Additionally, systematic reviews have highlighted the efficacy of mindfulness-based interventions in enhancing depression and quality of life within the chronic pain population (Hilton et al., 2017). Furthermore, even shorter MBSR programs, such as 4-week courses, have been shown to enhance psychological variables such as well-being, perceived stress, and acceptance of chronic pain (Brintz et al., 2020). However, other psychological measures like pain catastrophizing, did not exhibit improvement following our program, contrary to findings from previous studies. For instance, Marske et al., (2020) reported a reduction in pain catastrophizing levels among chronic pain participants following participation in a MBSR. Similarly, Brintz et al., (2020) found improvements in pain catastrophizing levels among chronic noncancer participants after a MBSR program.

Although we did not find a reduction in the pain intensity, the improvement in the psychological symptomatology associated with chronic pain revealed that MBSR programs are beneficial for individuals with chronic back pain and could be a useful therapeutic

complement for these patients. Considering that for most of the patients diagnosed with chronic pain the use of analgesics is not effective in reducing pain, the application of programs that contribute to reducing the associated symptomatology (such as MBSR programs) may be an effective alternative to improve the mental health of these patients as well as their physical functioning. Furthermore, as previous meta-analyses and systematic reviews have found, mind-body therapies can reduce the use (and abuse) of opioids (Garland et al., 2020). This would have a positive impact on the daily lives of people with chronic pain, as well as a reduction of medical interventions and their subsequent economic costs. However, it is important to follow the guidelines and recommendations established in these programs to achieve this beneficial effect.

Secondly, we hypothesized that the MBSR program would modify the attentional patterns of individuals within the experimental group. We found a significant effect on total fixation duration (i.e. total time that participants spent looking at every type of face), wherein participants in the experimental group displayed shorter fixations at Time 1 (i.e., pre-program) compared to Time 2 (i.e., post-program) while the control group exhibited shorter fixations at Time 2 relative to Time 1. A similar result was found for visit duration (i.e. the mean time spent looking at every AOI during all visits) in the experimental group, where participants displayed shorter visit durations at Time 1 compared to Time 2. These results show that the MBSR program increased the duration of the fixations and visits made on pain and neutral stimuli, that is, it increased attentional maintenance towards both stimuli. However, no significant effects were found on other gaze indices. This outcome diverges from findings of previous studies involving pain-free participants (Garland & Howard, 2013) or those based on reaction times (Shires et al., 2018), which reported that mindfulness interventions reduced attentional biases towards pain-related stimuli.

Regarding correlational analyses, we identified associations between baseline levels of attentional biases and psychological outcomes post-program within the experimental group. Specifically, higher baseline disengagement bias from pain faces correlated with lower feelings of helplessness post-program, while greater disengagement bias from neutral faces correlated with reduced levels of depression and anxiety post-program. Additionally, a longer time to first fixation towards pain faces pre-program correlated with higher scores on the Pain Catastrophizing Scale (PCS) and greater rumination and magnification subscale scores post-program. Furthermore, a longer first fixation duration for pain faces at Time 1 correlated with higher pain intensity at Time 2, indicating that a tendency to sustain attention to pain stimuli could impede the program's efficacy in reducing pain.

This study has several strengths. Firstly, to our knowledge, it is the first to investigate the effects of a mindfulness-based intervention on the attentional patterns of chronic pain patients by analyzing participants' eye movements, rather than relying solely on reaction time outcomes. In addition, the selection of participants was very careful as only individuals with no previous experience in mindfulness were included. Also, the instructors were highly qualified in mindfulness and experienced in dealing with pain. Participants had no previous experience in mindfulness and the MBSR program was given by highly experienced and qualified teachers. Furthermore, an innovative attentional disengagement task was specifically designed for this study, which allows us to explore not only traditional indices of the gaze pattern (i.e., fixation duration and fixation count) but also the ability to shift the attentional focus from one stimulus to another. Of note, we analyzed and reported reliability analyses of the attentional indexes, which is not often done in eye-tracking studies (Fashler and Katz, 2016; Giel et al., 2018; Lee et al., 2020).

However, we also recognize some limitations in our study. First, the sample size, although a usual size in eye-tracking studies, is relatively small. Also, participants had

normal or moderate mobility (i.e., they were able to come to the laboratory), which makes it difficult to generalize the results to individuals with more serious disabilities. Second, we did not control for the influence of medication on participants, as individuals with chronic pain usually take analgesics to mitigate symptoms associated with their condition. Third, we used static stimuli instead of dynamic stimuli, which have been suggested to better represent the emotion of pain and are known to facilitate facial recognition (Biele & Grabowska, 2006); therefore, it is conceivable that dynamic stimuli could enhance emotion and offers a more precise means of examining the attentional processing of emotional stimuli.

Some variables not considered in our study might have affected the results. For instance, it is known that the speed of stimulus presentation may affect the recognition of facial stimuli. For instance, Sato & Yoshikawa (2004) found that some expressions are better recognized depending on whether they are presented quickly or slowly. It might be also possible that attentional biases are dependent on the type of stimuli. Previous studies have yielded varying results regarding attentional bias when using words or faces as emotional stimuli across different contexts. For instance, Lee et al. (2019) noted in their eye-tracking study that chronic pain patients exhibiting higher levels of pain catastrophizing fixated significantly longer on pain and anger words compared to neutral words, in contrast to those with lower levels of pain catastrophizing. However, the authors did not replicate this visual pattern for facial stimuli. Additionally, regarding participants' characteristics, attentional biases may be contingent upon the specific pain diagnosis (e.g. headache, musculoskeletal pain), a facet that remains unexplored. Future research endeavours aimed at elucidating attentional mechanisms should consider in their designs the variety of pain-related diagnoses to yield more generalizable results.

In summary, the current study did not find evidence supporting the notion that MBSR can modify the attentional patterns of individuals with chronic back pain. Nonetheless, it

effectively improved the psychological symptoms associated with chronic pain. Consequently, participation in an adapted MBSR program is strongly advocated for enhancing the psychological well-being of individuals with chronic back pain and may serve as a viable alternative to pharmacotherapy. However, further research in this domain is imperative to gain a deeper understanding of the attentional mechanisms involved in the experience and chronification of pain, as well as to ascertain the efficacy of mindfulness-based interventions in modifying the attentional patterns of individuals coping with chronic pain.

Robles, E., Blanco, I., Díez, G., & Vázquez, C. (2024). Mindfulness-based stress reduction for chronic pain: Enhancing psychological well-being without altering attentional biases towards pain faces. *European Journal of Pain*, *00*:1–14. https://doi.org/10.1002/ejp.4714

6. Chapter III. Study 3. Validation of the Montreal Pain and Affective Face Clips (MPAFC): The role of sex and participants' pain status.

The previous study did not yield significant data about the effect of a MBSR program to modify the attentional pattern to pain facial expressions, which may be partly due to the stimuli used. Experimental research in the field of pain has used a variety of emotional stimuli (words, scenes or facial expressions) to analyse the attentional pattern. One of the most widely used emotional stimuli sets to study attentional responses in pain conditions is the Montreal Pain and Affective Faces Clip (MPAFC), which have been used in the Study 2 and includes facial expressions that express 8 different emotions (including pain). To analyze the reliability of these stimuli, the following study published as *"Robles, E., & Vazquez, C. (2024). Validation of the Montreal Pain and Affective Face Clips (MPAFC): The role of sex and participants' pain status. Ansiedad y Estrés, 30(1), 17-26"* presents the results of a validation of the pain-related stimuli of this set in a Spanish population, both individuals with acute and chronic pain, as well as without pain, that were recruited through announcements at the university and by using snowball sampling. The main findings of this study show that three of the eight stimuli analysed were not evaluated by the participants as sufficiently representative of the emotion of pain, which implies the necessity to create more reliable pain-related stimuli that better capture the pain emotion. In addition, female faces were rated by both sexes as more representative of pain and emotionally intense than male faces. These results may help to create more appropriate stimuli to the experimental study of attention in pain-related contexts.

Robles, E., & Vazquez, C. (2024). Validation of the Montreal Pain and Affective Face Clips (MPAFC): The role of sex and participants' pain status. *Ansiedad y Estrés, 30*(1), 17-26. https://doi.org/10.5093/anyes2024a3

6.1. Introduction

The study of visual attention has become a standard strategy to assess cognitive biases toward specific stimuli. A variety of experimental tasks (e.g., dot-probe, Stroop test, visual search, or free viewing tasks) have been developed to assess visual attentional biases in pain and healthy individuals. For instance, the dot-probe task, which has been one of the most applied methods to study attentional biases in emotional problems like depression (Winer & Salem, 2016) or social anxiety (Bantin et al., 2016), has also been used to analyze biases in chronic and acute pain (Todd et al., 2018).

Most of these traditional experimental approaches to studying attentional biases have been rooted in the analyses of reaction times, which has some limitations as the speed of response is not necessarily a direct measure of bias (Waechter & Stolz, 2015; Rodebaugh et al., 2016; Duque & Vazquez, 2018). Alternatively, attentional biases can be better explored with eye-tracking technology, which allows for analyzing eye movements in the presence of visual stimuli (Martínez-Conde et al., 2004). Using this approach, attentional biases have been widely studied in different disorders such as depression (Duque & Vazquez, 2015), anxiety (Günther et al., 2021), and eating disorders (Ralph-Nearman et al., 2019), among others.

Besides attentional biases towards pain-related visual stimuli, the experimental literature has found that other cognitive variables are also associated with pain conditions. For example, pain catastrophizing (i.e., the tendency to increase the threat value of the pain stimulus and to experience helplessness in the context of pain) has been associated not only with higher pain intensity levels (Severeijns et al., 2001) but also with attentional biases towards pain-related stimuli (Lee et al., 2018; Ranjbar et al., 2020). Anxiety sensitivity (i.e., the belief that anxiety symptoms or arousal can have harmful consequences) has also been

associated with pain intensity and interference (Rogers et al., 2022), and with fearful appraisals of pain (Ocañez et al., 2010). In a study by Keogh & Cochrane (2002), it was found that participants with higher levels of anxiety sensitivity exhibited a greater interpretative bias and reported more negative pain experiences than participants with lower levels of anxiety sensitivity. Thus, these two cognitive aspects seem to have a key role in the perception of pain-related information and, consequently, were also assessed in the present validation study.

A variety of images, words, and face sets have been validated and used as experimental stimuli to analyze the attentional biases toward emotional information. In the field of the study of pain, pain-related faces have been used to explore attentional biases. One of the most widely used sets of faces is the Montréal Pain and Affective Face Clips (MPAFC). It consists of a set of 64 standardized dynamic stimuli created by Simon et al., (2008), showing the facial change of eight models (4 male, 4 female) from a neutral state to a full expression of eight different emotions (including pain). The MPAFC has been used in different types of psychological problems and conditions, such as depression (Trapp et al., 2018), anxiety sensitivity (Schoth et al., 2016) or optimism (Peters et al., 2016), but has been also used in a variety of eye-tracking studies with chronic pain population (Liossi et al., 2014; Schoth et al., 2015; Priebe et al., 2021; Jones et al., 2021) as it also includes the emotion of pain.

Regarding differences in emotional recognition between men and women, previous studies (Proverbio, 2017; Plouffe-Demers et al., 2022) and meta-analyses (Thompson & Voyer, 2014) have observed that men and women show differences in the recognition and perception of emotional expressions. It has been found that women are faster and more accurate at recognizing facial expressions than male (Saylik et al., 2018; Wingenbach et al.,

2018). However, although this superiority of women in terms of emotion recognition has been observed independently of the actor's sex (Thayer & Johnsen, 2000) other studies have found that women are better at recognizing female emotional expressions in comparison to male ones (Lewin & Herlitz, 2002). Given this controversy, we decided to incorporate an analysis of the effect of the sex of the model and participants in our study.

In summary, the present study aims to validate the pain faces of the Montréal Pain and Affective Face Clips (MPAFC) in the Spanish population. To carry out the study, individuals with and without chronic pain assessed all the pain-related images included in the database. Following previous studies (e.g., Sánchez & Vázquez, 2013), we assessed the prototypicality (or typicality, that is, the extent to which a specific face represents the category of pain) (Rosch, 1988) and the emotional intensity of every pain expression. To facilitate the assessment of each face in terms of prototypicality and intensity, we selected the anchor-point procedure (Sánchez & Vázquez, 2013). In this procedure, participants compare the pain face to a neutral face from the same actor or actress representing that emotion. Furthermore, as attentional biases toward pain information have been found not only in patients with chronic pain but also in patients suffering from acute pain (Haggman et al., 2010; Skinner et al., 2021), we decided to analyze possible differences in the assessment of faces in both samples of participants and healthy control individuals. The last objective of this study was to explore sex differences in the assessment of pain facial expressions but also the effect of the sex of the individual representing the emotion. We hypothesized that all eight pain faces of the MPAFC would reach values of prototypicality and intensity that make them adequate to be used in further experimental studies. We also hypothesized that participants suffering chronic or acute pain would perceive the pain faces as more prototypical of the pain emotion than healthy participants, as it has been considered

that chronic and acute pain experiences are explained by different mechanisms and have different physical and emotional consequences (Cohen et al., 2021), which may affect the perception of emotional stimuli such as pain facial expressions. Finally, we explored whether the sex of participants was related to their respective assessments of prototypicality and intensity of male and female faces expressing pain. We hypothesized that women would perceive female faces as more representative and/or emotionally intense than male ones.

6.2. Method

6.2.1. Participants

A total of 291 participants took part voluntarily in the study. The sample was drawn from two main sources: 1) undergraduates who were recruited through messages at the Psychology School and 2) individuals from the general population, who were recruited through (hidden for review), an institute for research and training on mindfulness and cognitive sciences. Announcements in social networks were also used to recruit students and the general population. The only inclusion criteria to participate in the study were being older than 18 and being fluent in Spanish. The sample was composed of 221 women and 69 men (one participant preferred not to answer), with a mean age of 30.29 (*SD*=14.23).

Based on the *International Association for the Study of Pain* (IASP), which considers chronic pain to last longer than 3 months (Treede et al., 2015), the entire sample (including students and the general population from the research institute) was divided into three groups according to their pain status and duration: an acute pain group (with pain duration under 3 months), a chronic pain group (with pain duration over 3 months), and a current pain-free group. The demographic characteristics of the three groups are shown in Table 1. The pain-free group was composed of 188 participants (51 men and 137 women), with a mean age of

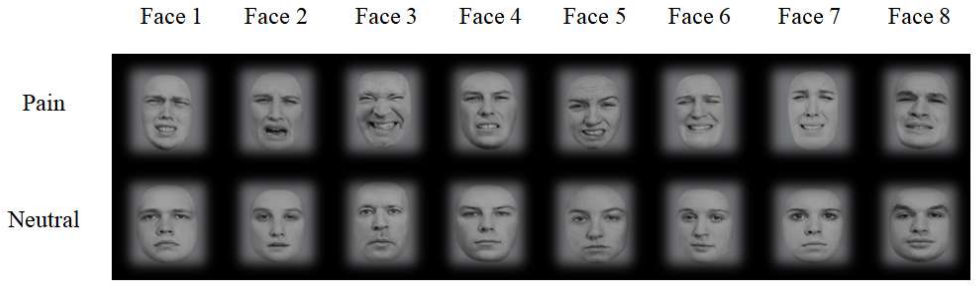
26.88 (*SD*=10.95; range=18-70 years). The acute pain group was composed of 35 participants (6 men, 28 women, and 1 person who preferred not to answer), with a mean age of 26.71 (*SD*=12.10, range=18-66 years). The chronic pain group was composed of 68 participants (12 men and 56 women), with a mean age of 41.53 (*SD*=17.31, range=18-75 years).

6.2.2. Stimuli

The Montréal Pain and Affective Face Clips (MPAFC) is a set of emotional face clips created by Simon et al., (2008). It consists of 64 one-second film clips of 4men and 4 women who imitate prototypical facial expressions of pain, happiness, sadness, anger, disgust, fear, surprise, and neutral emotions. Figure 3.1. shows the eight individuals' neutral and pain faces included in the dataset which were included in our study. Due to the purpose of this study, only pain and neutral faces were included in the validation task.

Figure 3.1.

Neutral and pain-related facial expressions from the eight clips of the Montréal Pain and Affective Faces Clips (MPAFC).



As most experimental studies in the field of pain until now have employed static stimuli, all clips were converted to pictures of every face by selecting the final part of every clip, to explore between-groups differences (e.g., pain status, sex) in the perception of these

types of stimuli. Furthermore, as in previous studies (Calvo & Lundqvist, 2008, Sanchez et al., 2013; Sanchez & Vazquez, 2013), the surrounding areas of the faces (including hair and neck) were darkened to remove irrelevant aspects of the faces that may affect the perception and assessment of each image.

6.2.3. Instruments

Before starting the validation task, participants were asked to answer the following psychological measures:

Pain-related questions. For participants suffering from pain, specific questions related to pain intensity, interference, and duration were included.

Mood Evaluation Scale (EVEA). It consists of 16 items assessing four current mood states (anxiety, anger-hostility, sadness-depression, and joy) with four items for each mood. Each item is scored by using an 11-point Likert scale from 0 (nothing) to 10 (a lot). For this study, the Spanish version of this scale was used (Sanz, 2001). We added four items to assess other processes that may occur when performing demanding experimental tasks (bored, tired, entertained, and curious). In our study, the EVEA showed high internal consistencies for the sadness-depression (α=0.86), anxiety (α=0.89), anger-hostility (α=0.92), and joy subscale (α=0.88).

Patient Health Questionnaire (PHQ-9). The PHQ-9 measures the severity of depression through the rating of the nine items included in the diagnosis of major depression (APA, 2013), from 0 (“not at all”) to 3 (“nearly every day”). The PHQ-9 had good internal consistency in this study (α=.86).

Pain Catastrophizing Scale (PCS). This is a 13-item scale measuring three aspects of pain catastrophizing (rumination, magnification, and helplessness) and a total score (Sullivan et al., 1995). Participants are asked to rate their responses on a five-point Likert scale ranging from 0 (not at all) to 4 (always). The PCS showed good internal consistency for total PCS (α=.93), rumination (α=.91), magnification (α=.68), and helplessness (α=.88) in this study.

Anxiety Sensitivity Index (ASI-3). It is an 18-item scale assessing the consequences of symptoms associated with anxiety. Participants are asked to indicate their agreement with each item from 0 ("very little") to 4 ("very much"). Total scores range from 0 to 72. The ASI-3 contains three subscales related to social, physical, and psychological concerns, and it showed high internal consistency in this study (α=.91).

6.2.4. Procedure

As in other similar validation studies (e.g., Duque et al., 2023), the study was conducted online through Qualtrics (Provo, UT, 2017). Before starting the task, the participants received a link with an invitation to take part in the study. Then, they filled in the informed consent and the set of self-report questionnaires. After that, the validation task started. Each trial started with a pair of pain-neutral faces that appeared on the screen. Participants were asked to rate two dimensions of every pain face (prototypicality and emotional intensity) by using two different Likert scales, with a range from 0 ("not at all") to 10 ("extremely"). Higher scores reflect that the pain face is highly prototypical and emotionally intense, while lower scores reflect that the pain face is not very prototypical and emotionally intense. Figure 3.2. shows an example of how the stimuli were presented in each trial. To minimize spatial location effects (Blanco, et al., 2021), each pair of pain-neutral faces was randomly presented twice (one with the emotional face on the left side and the

other on the right side). The completion of the self-reported measures and the validation task lasted 15 minutes.

Figure 3.2.

Example of a simultaneous presentation of neutral versus pain faces used in the validation task (i.e., anchor-point method).

6.2.5. Data analyses

Firstly, means and standard deviations were calculated for the prototypicality and emotional intensity of every face for the entire sample (*N*=291). After that, means and standard deviations were calculated for the three subgroups of participants. Cronbach's alpha coefficient was calculated for prototypicality and emotional intensity to explore the reliability of the ratings.

Secondly, a series of one-way ANOVAs were carried out to explore differences between the three groups of participants on prototypicality and emotional intensity, followed by post-hoc analyses using Bonferroni tests.

Thirdly, the effect of sex in the assessment of pain faces was analyzed following two strategies. On one hand, we analyzed the sex differences of participants on the mean scores in prototypicality and emotional intensity by using a series of t-tests. On the other hand, we also analyzed the interaction between the sex of the models and the participants using a 2x2 ANOVA on the prototypicality and intensity scores.

Finally, to explore the influence of psychological variables (e.g. pain catastrophizing) in the perception of the pain-related faces, correlational analyses were conducted. Furthermore, subgroups were created according to the levels of PCS, ASI-3, and PHQ-9 to explore differences in the stimuli ratings.

6.3. Results

6.3.1. Demographics and clinical status

Table 3.1. shows the demographics and self-reported clinical information of the sample. Groups were statistically different in age [$F(2, 291)=33.62$; $p<.001$]. Individuals in the chronic pain group were older than those in the pain-free and acute pain groups. Participants with chronic pain in general reported more severe levels of pain intensity, interference, and longer-lasting conditions than those in the acute pain group.

Table 3.1.

Demographic and clinical data of the groups.

	Pain-free (N= 188)	Acute pain (N=34)	Chronic pain (N=69)		
	Mean (SD)	Mean (SD)	Mean (SD)	F	p
Age	27.40 (11.67)	25.88 (11.22)	42.02 (17.30)	33.62	< .001
	N (%)	N (%)	N (%)	χ^2	*p*
Women (%)	137 (72.9)	27 (81.8)	57 (82.6)	3.28	.19
Education				2.72	0.84
Primary school	9	1	6		
High school	67	14	22		
University degree	82	13	29		
Post-university	30	6	12		
Race or ethnic group				16.17	0.18
White	172	31	67		
Black/African	1	1	0		
Asian	2	0	1		
North African	2	0	0		
Hispanic	8	0	0		
Romani	1	0	1		
Prefer not to answer	2	2	0		
Pain diagnosis				7.81	0.16
Musculoskeletal pain	-	13	43		
Headache	-	5	10		
Orofacial pain	-	4	2		
Stomachache	-	5	5		
Other pain	-	7	9		
Pain intensity				6.82	0.07
Mild	-	16	17		
Moderate	-	15	36		
Strong	-	3	13		
Unbearable	-	0	3		
Pain duration				103.00	<.001
Less than 1 month	-	26	-		
1-3 months	-	8	-		
3-12 months	-	-	3		
More than 1 year	-	-	66		
Interference				18.75	<.001
At all	-	13	5		
A bit	-	17	38		
Quite	-	4	18		
Too much	-	0	8		

6.3.2. Psychological measures

Means and standard deviations for psychological measures are shown in Table 3.2. The three groups were similar in the level of rumination, magnification, and the three subscales of the ASI-3 (physical, psychological, and social concerns). However, they were statistically different in EVEA subscales: sadness-depression [$F(2, 291)=21.16$; $p<.001$], anxiety [$F(2, 291)=6.06$; $p=0.003$], anger-hostility [$F(2, 291)=14.95$; $p<.001$] and joy [$F(2, 291)=10.32$; $p<.001$]. The groups were also different in the helplessness subscale of PCS [$F(2, 291)=4.69$; $p=0.01$] and PHQ-9 score [$F(2, 291)=7.83$; $p<.001$]. Bonferroni's post-hoc analyses revealed that individuals with either acute pain or chronic pain showed higher levels of sadness-depression than the pain-free group. Furthermore, individuals with acute pain presented higher levels of sadness-depression than the chronic pain group. Regarding anxiety, the chronic pain group showed higher levels of anxiety than the pain-free group. Both the acute and chronic pain groups showed higher levels of anger-hostility and lower levels of joy than people without pain. Finally, the chronic pain group presented higher levels of helplessness than the other two groups and higher levels of depression symptoms, as assessed by the PHQ-9, than the pain-free group.

6.3.3. Validation of the pain-related faces

Firstly, the means and standard deviations for prototypicality and emotional intensity of all faces, for the entire sample ($N=291$), are shown in Figure 3.2. For the prototypicality dimension, only face 1 ($M=6.00$; $SD=1.98$), face 2 ($M=6.71$; $SD=1.99$), face 6 ($M=5.54$; $SD=2.28$), and face 7 ($M=5.82$; $SD=2.25$) were rated over 5 points out of 10. For emotional intensity, only face 1 ($M=5.33$; $SD=2.14$), face 2 ($M=6.12$; $SD=2.32$), face 3 ($M=5.59$; $SD=2.75$), face 6 ($M=5.19$; $SD=2.19$) and face 7 ($M=5.45$; $SD=2.36$) were rated over 5 points out of 10.

Secondly, means and standard deviations for prototypicality and emotional intensity were calculated for the three groups (Table 3.3.). To explore between-group differences, a series of one-way ANOVAs were conducted. Regarding the prototypicality of stimuli, there were no significant differences between groups for any face: face 1 [$F(2, 291)=0.54$; $p=0.57$], face 2 [$F(2, 291)=0.69$; $p=0.50$], face 3 [$F(2, 291)=0.48$; $p=0.61$]; face 4 [$F(2, 291)=1.52$; $p=0.22$], face 5 [$F(2, 291)=0.12$; $p=0.88$], face 6 [$F(2, 291)=0.82$; $p=0.43$], face 7 [$F(2, 291)=0.07$; $p=0.92$], and face 8 [$F(2, 291)=1.18$; $p=0.30$]. Concerning the emotional intensity, there were no significant differences between groups for any face: face 1 [$F(2, 291)=1.29$; $p=0.27$], face 2 [$F(2, 291)=0.10$; $p=0.90$], face 3 [$F(2, 291)=1.41$;$p=0.24$], face 4[$F(2, 291)=1.00$; $p=0.36$], face 5 [$F(2, 291)=0.28$; $p=0.75$], face 6 [$F(2, 291)=1.58$; $p=0.20$], face 7 [$F(2, 291)=0.45$; $p=0.63$], and face 8 [$F(2, 291)=0.85$; $p=0.42$].

Table 3.2.

Means and standard deviations for psychological measures of all participant groups.

	Pain-free (N= 188)	Acute pain (N=35)	Chronic pain (N=68)		
	Mean (SD)	Mean (SD)	Mean (SD)	F	*p*
EVEA Sadness-Depression	2.57 (2.01)	5.02 (2.09)	3.65 (2.56)	21.16	<.001
EVEA Anxiety	3.31 (2.51)	4.19 (2.77)	4.50 (2.60)	6.06	0.003
EVEA Anger-hostility	1.54 (1.96)	2.92 (2.63)	3.09 (2.64)	14.95	<.001
EVEA Joy	5.43 (2.14)	3.97 (2.19)	4.36 (2.32)	10.32	<.001
PCS Rumination	10.73 (4.01)	9.82 (4.35)	10.53 (4.34)	0.70	0.49
PCS Magnification	6.97 (2.44)	7.05 (3.00)	6.92 (2.51)	0.03	0.97
PCS Helplessness	12.56 (4.84)	11.32 (5.03)	14.30 (5.62)	4.69	0.01
PCS Total	30.27 (10.17)	28.20 (11.08)	31.76 (11.40)	1.31	0.26
ASI Physical	7.51 (5.69)	7.50 (4.93)	8.50 (6.14)	0.79	0.45
ASI Cognitive	5.17 (5.18)	4.91 (5.54)	6.79 (6.45)	2.40	0.09
ASI Social	9.44 (6.04)	10.32 (4.99)	9.89 (6.29)	0.38	0.67
PHQ-9	8.82 (5.7)	10.61 (5.89)	12.08 (6.71)	7.83	<.001

Note: EVEA = Scale for Mood Assessment; PCS = Pain Catastrophizing Scale; ASI = Anxiety Sensitivity Index; PHQ-9 = Patient Health Questionnaire

Figure 3.3.

Means and standard deviations for all pain faces from the MPAFC in the entire sample of participants.

Prototypicality	6.00 (1.98)	6.71 (1.99)	4.13 (3.14)	3.57 (2.05)	4.69 (2.12)	5.54 (2.28)	5.82 (2.25)	4.30 (2.21)
Intensity	5.33 (2.14)	6.12 (2.32)	5.59 (2.75)	3.16 (2.05)	4.33 (2.19)	5.19 (2.19)	5.45 (2.36)	3.80 (2.23)

Analyses were controlled for age and psychological measures, finding a significant effect of PHQ-9 on the prototypicality of pain faces [F(2, 291) = 5.76; p = .017], which indicates that individuals with higher PHQ-9 scores rated the pain faces as more prototypical of the pain emotion. For the rest of the variables, there were no significant effects.

To test the reliability of the anchor-point method used in our study, Cronbach's alpha values were calculated for prototypicality and emotional intensity. Excellent internal consistencies were found for prototypicality (α=0.90) and emotional intensity (α=0.91).

6.3.4. Sex differences

Table 3.4. shows the means and standard deviations for prototypicality and emotional intensity according to the participants' sex. A series of t-tests were used to analyze differences in prototypicality and emotional intensity ratings between male and female participants. For prototypicality, there were significant differences between groups in face 3 (t=3.58; p<.001) and face 5 (t=2.15; p=0.03). Men rated those two faces as being more prototypical of pain (Face 3: M=5.26, SD=2.99; Face 5: M=5.18, SD=2.11) than women (Face 3: M=3.78, SD=3.11; Face 5: M=4.55, SD=2.11).

Table 3.3.

Means and standard deviations for prototypicality and emotional intensity ratings of the three participant groups.

	Pain-free		Acute Pain		Chronic Pain	
	Prototypicality Mean (SD)	Intensity Mean (SD)	Prototypicality Mean (SD)	Intensity Mean (SD)	Prototypicality Mean (SD)	Intensity Mean (SD)
FACE 1	5.92 (2.05)	5.22 (2.13)	6.29 (1.52)	5.20 (2.03)	6.06 (2.01)	5.69 (2.20)
FACE 2	6.62 (2.05)	6.11 (2.36)	7.02 (1.75)	5.97 (2.17)	6.81 (1.95)	6.19 (2.32)
FACE 3	4.22 (3.15)	5.76 (2.72)	3.64 (3.15)	4.94 (2.79)	4.11 (3.12)	5.46 (2.81)
FACE 4	3.43 (1.9)	3.11 (1.86)	3.63 (1.89)	2.86 (1.96)	3.93 (2.47)	3.43 (2.53)
FACE 5	4.73 (2.02)	4.3 (2.13)	4.54 (2.25)	4.16 (2.06)	4.65 (2.35)	4.58 (2.42)
FACE 6	5.61 (2.14)	5.3 (2.05)	5.07 (2.47)	4.57 (1.92)	5.59 (2.53)	5.20 (2.64)
FACE 7	5.84 (2.16)	5.52 (2.25)	5.89 (2.07)	5.10 (2.27)	5.73 (2.59)	5.43 (2.69)
FACE 8	4.22 (2.1)	3.74 (2.14)	4.05 (2.15)	3.55 (1.77)	4.65 (2.50)	4.09 (2.63)
TOTAL	5.07 (1.67)	4.88 (1.73)	5.02 (1.67)	4.54 (1.56)	5.19 (2.03)	5.00 (2.14)

Table 3.4.

Means and standard deviations for prototypicality and emotional intensity ratings according to the participant's sex.

	Male participants		Female participants	
	Prototypicality Mean (SD)	Intensity Mean (SD)	Prototypicality Mean (SD)	Intensity Mean (SD)
FACE 1	5.85 (1.94)	4.75 (2.05)	6.06 (1.99)	5.52 (2.14)
FACE 2	6.60 (2.03)	5.62 (2.35)	6.76 (1.98)	6.27 (2.30)
FACE 3	5.26 (2.99)	5.10 (2.55)	3.78 (3.11)	5.75 (2.81)
FACE 4	3.76 (2.03)	3.38 (1.97)	3.52 (2.06)	3.09 (2.08)
FACE 5	5.18 (2.11)	4.18 (2.09)	4.55 (2.11)	4.37 (2.23)
FACE 6	5.71 (2.22)	5.18 (2.27)	5.50 (2.29)	5.19 (2.18)
FACE 7	5.54 (2.11)	4.89 (2.28)	5.92 (2.29)	5.62 (2.37)
FACE 8	4.47 (2.17)	3.59 (1.80)	4.26 (2.23)	3.87 (2.35)
TOTAL	5.29 (0.86)	4.58 (0.79)	5.04 (1.17)	4.96 (1.08)

Regarding emotional intensity, there were significant differences between groups in face 1 (t=-2.62; p=0.009), face 2 (t=-2.04; p=0.04) and face 7 (t=-2.23; p=0.02). Women rated those faces as expressing more intense pain (Face 1: M=5.52, SD=2.14; Face 2: M=6.27, SD=2.30; Face 7: M=5.62, SD=2.37) than men (Face 1: M=4.75, SD=2.05; Face 2: M=5.62, SD=2.35; Face 7: M=4.89; SD=2.28).

To explore the interaction between the sex of the participants and the sex of the individuals expressing the emotion, a 2 (participants' sex) x 2 (model) ANOVA was conducted for both prototypicality and emotional intensity. For prototypicality, there were no main effects for participants' sex [F(1, 290)= 1.06; p=0.30], but there was a significant effect for model [F(1, 290)= 172.97; p<0.001], indicating that female faces (M=5.72; SD=0.13) were rated significantly judged as more prototypical of pain than male faces (M=4.62; SD=0.12). This significant main factor was qualified by a significant interaction effect [F(1, 290)= 4.53; p=0.03]. Bonferroni's post-hoc tests showed that both men and women rated the prototypicality of female faces higher than male ones. For emotional intensity, there were no main effects for the participant's sex [F(1, 290)=2.22; p=0.13) or the interaction effect [F(1, 290)=0.07; p=0.78]. However, a significant effect for the model [F(1, 290)=95.55; p<0.001], revealed that female faces (M=5.17; SD=0.13) were judged to reflect more pain intensity than male ones (M=4.38; SD=0.12).

6.3.5. Correlational Analysis

Correlational analyses were conducted to explore the association between both dimensions (prototypicality and emotional intensity) and psychological measures. There was a small but significant correlation between prototypicality and PCS Rumination (r = .12; p = .037) and ASI-3 total score (r = .11, p = .046). This result shows that irrespective of the pain

status, individuals with higher levels of anxiety sensitivity and rumination rated the pain faces as more prototypical of the pain emotion than those with lower levels.

Regarding emotional intensity, it was significantly correlated with PCS Helplessness (r =.13; p =.018), which indicates that individuals with higher levels of helplessness rated the pain faces as more emotionally intense in comparison to those with lower levels of helplessness.

6.3.6. Influence of ASI-3, PCS, and PHQ-9 on facial perception

To explore the influence of some psychological variables in the perception of the pain faces, the entire sample was divided into two groups depending on their levels of pain catastrophizing, anxiety sensitivity, and depression, not finding significant between-groups differences in the prototypicality and emotional intensity scores. However, when comparing individuals with higher versus lower levels of pain catastrophizing, anxiety sensitivity, or depression in every group, it was found a significant effect of anxiety sensitivity in the pain-free group (t = -2.002; p = .04), which shows that healthy individuals with higher levels of anxiety sensitivity (*M* = 5.62; *SD* = 1.79) rated the pain faces as more prototypical than those with lower levels of anxiety sensitivity (*M* = 4.97; *SD* = 1.63). There was also a significant effect of pain catastrophizing in the chronic pain group (*t* = -2.17; *p* = .03), indicating that chronic pain individuals with higher levels of pain catastrophizing (*M* = 5.67; *SD* = 2.20) rated the pain faces as more prototypical than those with lower levels of pain catastrophizing (*M* = 4.78; *SD* = 1.79). There were no significant between-group differences for depression.

6.4. Discussion

The main goal of this study was to validate the pain-related stimuli from the Montréal Pain and Affective Faces Clips (MPAFC) in Spanish samples with different conditions of pain. To that end, individuals from the general population were recruited and divided into three

groups depending on the presence and characteristics of pain. All participants rated each face according to two dimensions (i.e., prototypicality and emotional intensity).

Regarding our first hypothesis on the overall adequacy of the pain faces from the MPAFC, not all the faces reached adequate values in the domains measured in our study. Although there is no golden criterion to quantitatively define the optimal values of prototypicality and intensity of the selected emotional faces, a conservative criterion could be that they should at least obtain a score of 5 (on a scale of 0 to 10) in both parameters (see Figure 3). Considering the mean scores of the faces in the total sample of participants, only four faces met this criterion. This low representativeness could be explained by the fact that although some facial actions accompany pain, such as raising the cheeks or wrinkling the nose (Craig, et al., 2011), the pain facial expression shares some similarities with other emotional facial expressions, such as disgust (Kunz et al., 2013), what may lead to less clear classifications compared to other emotional facial expressions. Our second hypothesis was not confirmed either, as there were no significant differences between groups (i.e., pain-free, acute pain, or chronic pain) in assessing the prototypicality and intensity of the faces.

Reliability analyses showed a high internal consistency for the two dimensions analyzed (prototypicality and emotional intensity). Previous studies using arousal, intensity, and valence ratings to validate the MPAFC found similar reliability levels (Simon et al., 2008).

Our third aim was to explore sex differences associated with the ratings of pain-related faces, which have not been sufficiently analyzed in the previous literature. Firstly, there were no significant differences in the overall ratings between male and female participants. However, previous studies which have used neutral faces taken from a web dataset to compare the ability to recognize facial expressions between men and women, found that female participants were more efficient in recognizing female neutral faces (Cellerino et al., 2004).

Concerning the MPAFC, previous studies did not find sex differences in ratings (Simon et al., 2008). Secondly, although the three subgroups of participants rated female faces as more prototypical of the pain emotion than male faces, a significant interaction showed that female participants rated the expression of pain in men's faces particularly low. This result may be explained by the fact that women have been considered to be more emotionally expressive than men (Fischer & LaFrance, 2015; Wang et al., 2022). Furthermore, sociocultural beliefs about the expression of pain in men and women could be affecting the perception of pain facial expression, as women tend to publicly show painful experiences more than men. Furthermore, pain has been more socially associated with women in comparison to men (Robinson et al., 2001). Due to this, it could be the case that female expressions of pain may be more credible and representative than male ones as they are more frequently exposed in public. However, regarding the generalizability of these results, it is important to take into account that the sample size was mostly composed of female participants, making it difficult to generalize the results to the male population. The subgroup size differences should be also taken into consideration, as the pain-free group size was larger than the acute and chronic pain group size.

Regarding the relationship between pain and other psychological problems, it has been shown that patients in primary care centers who endorse symptoms of muscle pain, headache, or stomach pain are approximately 2.5-10 times more likely to have a panic disorder, generalized anxiety disorder, or major depressive disorder (Means-Christensen et al., 2008). The experience of pain is directly connected with psychological suffering and factors traditionally associated with anxiety like catastrophizing, or negative anticipation (Todd et al., 2015). The use of facial expressions of pain has been used as stimuli to explore the connections between emotional and cognitive components. For instance, Ranjbar et al. (2020) showed that individuals with high pain catastrophizing had a poor capacity to disengage their attention towards painful faces. In our study, we found that stimuli scores are associated with anxiety

sensitivity and pain catastrophizing. The more anxiety sensitivity or pain catastrophizing, the more representative of pain the faces are perceived. Furthermore, anxiety sensitivity seems to influence the perception of the pain faces in individuals without pain, as those with higher levels of anxiety sensitivity rated the faces as more prototypical. In addition, chronic pain individuals with high pain catastrophizing perceived the faces as more representative of the pain emotion compared to those with lower levels of pain catastrophizing. These findings are in line with the previous literature which has found a relation between anxiety and self-perception of pain. For example, Keogh and Mansoor (2001) found, in a healthy female sample, that those with high anxiety sensitivity reported higher levels of pain during the cold pressor task, a widely used pain induction method. Metzger et al., (2022) found, in a healthy sample, that anxiety increased pain perception only in those individuals with clinical levels of anxiety sensitivity. Thus, sensitivity to anxiety may be acting as a vulnerability factor in the origin, maintenance and perception of pain. On the other hand, pain catastrophizing has also been frequently linked to an increase in the pain perception in individuals with (Terry et al., 2016) and without chronic pain (Weissman-Fogel, et al., 2008; Campbell, et al., 2010). For instance, Kristiansen et al., (2014) found a positive correlation between pain catastrophizing and self-perception of pain on the cold pressor test. Furthermore, pain catastrophizing has been considered an explanatory mechanism of the relationship between positive traits and pain perception (Pulvers & Hoods, 2013).

In general, our results show that it is important to consider the sex factor (both of participants and models) in the validation of faces expressing pain. Similarly, other factors, like the race and age of the individuals expressing the emotion, may also affect the processing of facial expressions and rating decisions (Hirsh et al., 2008). It has been observed that young people are better at perceiving emotions compared to older adults (Isaacowitz et al., 2007). Although, in our study, sex differences in the assessment of prototypicality and intensity do

not inform on the precision of these judgments, other studies have found a relationship between age and sex in the recognition of emotional faces, showing an advantage for women across the lifespan (Olderbak et al., 2019). In terms of race, it has been demonstrated that people tend to better recognize neutral and emotional expressions in individuals of their race (Elfenbein& Ambady, 2002; Hunter et al., 2009; Kang et al., 2019). However, aspects such as age and race are not usually included in the validation of face stimuli, as most of the facial stimuli are based on young or middle-aged Caucasian individuals thus contributing to a lack of more precise validation of the stimuli used in the literature and to general cultural and socioeconomic biases in psychological research (Henrich et al., 2010).

The main strength of this study is that stimuli have been validated not only by healthy individuals but also by individuals with different pain statuses (chronic or pain), with a variety of pain diagnoses, which has not been done before. Interestingly, our study did not find significant differences in perceiving pain-related stimuli between individuals with and without pain. One explanation for this finding is that the perception of pain facial expressions is not dependent on the pain status, but on other variables such as the sex, age, or race of the face (Wandner et al., 2012). Psychological aspects (e.g. anxiety sensitivity and pain catastrophizing) seem to be involved in the perception of pain as well. Besides, other cognitive variables (e.g., attentional and interpretational biases) as well as experimental task characteristics have shown to be linked to pain perception. It has been observed in previous studies that the personal relevance of stimuli is crucial to detecting attentional or interpretational biases towards pain-related stimuli in both healthy and chronic pain individuals (Dear et al., 2011; Traxler et al., 2019).These findings might be also applied to the perception of pain in others, being another possible reason why differences between healthy, acute, and chronic pain individuals are not found in this study.

Moreover, we analyzed not only the role of the participants' sex in rating the stimuli, which has only been explored in a few studies (Simon et al., 2008) but also the interaction of that factor with the sex of the actor/actress portraying the emotion which, as far as we know, has not been explored before. However, this study has some limitations. Firstly, as in the majority of published studies of emotional expressions, we used static images instead of dynamic ones (Liossi et al., 2014; Schoth et al., 2015; Jones et al., 2021). In our case, we selected the last image of the eight MPAFC clips which admittedly shows the highest level of intensity of pain, to focus on the pain facial expression from the first moment. Nevertheless, it has been found that dynamic emotional faces expressing happiness or disgust seem to be more representative of the emotion than static facial expressions (Trautmann et al., 2009). Recent evidence (Dildine et al., 2023) from computer-generated faces of pain, shows that the movement intensity of the faces was positively associated with higher rates of pain by the participants observing these images. Thus, it could be possible that, although we selected the highest peak of the expression of pain in each face from the MPAFC database, eliminating the sequence of movements might have reduced the perceived intensity of the pain and provided a more accurate approach to examining the attentional processing of emotional facial expressions (Biele & Grabowska, 2006; Fernandes-Magalhaes et al., 2022). Nevertheless, static images are still the most frequently used stimuli in experimental studies. Secondly, the sample of participants was mainly composed of Caucasian individuals, as well as the facial stimuli used in the study. Due to cultural differences, it may affect the generalizability of the results and their clinical applications to the general population.

In any case, our study indicates the need for validation of the stimuli to be used in experimental studies on pain. Likewise, it illuminates the convenience of considering different validation parameters (e.g., prototypicality and intensity) and analyzing the effect that central variables such as sex (both of participants and the models) have on the results. According to

our results, female faces might be more representative of the pain emotion and, possibly, of other emotional facial expressions. Thus, female faces could be more useful and reliable for experimental investigation. Our findings suggest that other variables, such as age or race, should be more systematically explored and not taken for granted in similar validation studies. As we did not find differences between healthy and acute or chronic pain individuals, it is highly likely that other cognitive aspects are involved in the perception of pain (in oneself or others). Thus, future experimental studies should explore the role of other psychological processes in pain perception and consider including facial expressions of different ages as well as different races and ethnic groups. It is also highly recommended for future studies to use dynamic and personally relevant stimuli for participants, as they would be more reliable and representative of every participant.

There is a vast literature using faces in the field of depression (e.g.), anxiety, and pain (e.g., Kunz et al., 2019) and our study contributes to this growing field of research. Analyses of the perception of emotional states (as those related to pain) are still of the utmost importance. Detecting when individuals have pain is socially and clinically important and facial expressions are one of the most commonly used indicators for casual observers and professionals. As a new avenue of research, the current interest in AI models to 'detect' faces of pain shows that this is still an interesting issue in psychological research. Interestingly, these models must 'learn' from real human faces and their ability to detect precise expressions of pain must be based on robust databases. In the case of the MPAFC, we have shown that even faces preselected as indicators of pain, are not perceived as such by the majority of our participants. Thus, our results also call for a note of caution regarding the validity of faces in databases, which should not be taken for granted (De Sario et al., 2023). Teaching to detect genuine expressions of pain is important and is often included in clinical assessments of specific populations (e.g., infants, nonverbal patients, or cognitively impaired individuals). Another potential implication for the

field is that future studies using models (like the MPAFC database) or computer-generated images, should pay attention to the specific groups of muscles more directly involved in the expression of pain (i.e., contraction of the eyebrows, contraction of the muscles surrounding the eyes, nose wrinkle/lip raise, and opening of the mouth) (Kunz et al., 2019) and are not involved in the expression of emotions like fear (Dildine et al., 2023). Thus, future studies using actors or computer-generated images might improve the validity of the stimuli paying attention to these unique muscle features of facial expressions of pain.

Finally, it is possible that the low replicability of findings in some areas of pain research, such as the existence of attentional biases toward emotional stimuli (Chan et al., 2020), could be partly due to limitations in the validity of the stimuli used. The selection and validation of stimuli is a relatively neglected aspect of research, and we are convinced, based on our results, that more attention should be paid to these issues to make more substantial advances in the psychological literature on pain**.**

7. Chapter IV: Study 4: Does accepting painful sensations change our attention towards pain-related stimuli? An eye-tracking study with the Cold Pressor Test.

Research on attentional mechanisms involved in the experience of pain is very recent and has not yet yielded solid results. Although it seems that the general population, both with or without pain, shows biases in early stages of attention towards pain-expressing stimuli, it has been found that other variables may be involved in the relationship between attention and pain. Among some of the psychological interventions that are being applied in recent years to reduce pain-associated symptomatology, such as mindfulness-based therapies (explored in the Study 2), is the use of cognitive strategies such as acceptance or distraction, which have been shown to be effective in reducing some pain-related measures. However, the mechanisms by which these strategies are effective are unclear. As one of the main objectives of this dissertation is to study the potential benefits of psychological interventions to modify attention to pain-related information, the following study aimed to explore the effectiveness of pain acceptance and distraction in healthy individuals while experiencing induced acute pain. To do that, healthy undergraduates, master's and doctoral students were recruited through announcements at the Complutense University of Madrid. The main findings of this study, that has not been published yet, show that an acute pain induction does not increase attention to pain stimuli compared to a pain-free state. On the other hand, the combination of pain acceptance followed by distraction was effective in reducing attentional biases towards pain stimuli during an acute pain state. These findings are of great relevance to improve the psychological interventions for chronic pain patients as well as to better use cognitive strategies such as acceptance and distraction to improve their sympatomatology.

7.1. Introduction

According to the revised definition of the International Association for the Study of Pain (IASP), pain is defined as "an unpleasant sensory and emotional experience associated with, or resembling that associated with, actual or potential tissue damage" (Raja et al., 2020, p. 14). Different cognitive processes can modify this experience, amplifying or attenuating it. Among these processes, the mechanisms of attention to pain-related information are particularly important.

Selective attention to pain-related information has been widely explored in individuals with (Haggman et al., 2010; Van Ryckeghem et al., 2013; Todd et al., 2018) and without chronic pain (Keogh et al., 2001; Schoth et al., 2016) by using different experimental paradigms related to time-reaction measures (e.g., dot-probe). Recently, eye-tracking methodologies have been implemented as they provide a more direct assessment of the attentional processing. Evidence of attentional bias towards pain-related stimuli using this methodology has been mixed. While some studies have found differences in attentional orientation and maintenance between people with and without chronic pain (e.g., Franklin et al., 2018), others have not (Mazidi et al., 2019; Priebe et al., 2021). The meta-analytic evidence on this type of studies has revealed that, in general, individuals with and without chronic pain do not show a different attentional pattern to pain-related information, and that both individuals with chronic pain and healthy individuals show an attentional bias towards pain stimuli in early and late stages of attention (Jones et al., 2021).

However, most of the studies conducted on selective attention using eye-tracking methodologies, have focused on traditional indices such as number of fixations or duration of fixations. Recently, new attentional paradigms have been used to explore the ability to disengage attention from emotional stimuli, an important aspect related to attentional flexibility

that could be of importance in the analysis of biases toward pain-related stimuli. Difficulties in disengagement from emotional stimuli have been observed not only in chronic pain patients (Vago & Nakamura, 2011), but also in individuals with depression (Sanchez et al., 2013) or anxiety (Clarke et al., 2013).

A variety of interpretation mechanisms have been found to be involved in the processes of attention to painful stimuli. For instance, Lee et al. (2018) found, in a chronic pain sample, that higher levels of pain catastrophizing (i.e., the tendency to magnify the negative impact of pain due to a maladaptive cognitive style) were associated with spending more time attending to pain stimuli. Another variable of potential relevance in the pain experience is fear of pain. Also, Yang et al., (2013) found that higher levels of fear of pain (i.e., anticipated fear of movement or activity) were associated with attentional biases towards health-related catastrophic words among participants with chronic pain. In another study carried out by Keogh et al., (2001), with a pain-free sample, an association between levels of fear of pain and attentional bias towards pain information was also found. Thus, it seems that there is a complex interaction between attentional and other psychological variables that still needs further research.

Within the relatively large body of psychological interventions in the field of pain (Hoffman et al., 2007; Roditi et al., 2011; Niknejad et al., 2018; Driscoll et al., 2021; Ho et al., 2022), the use of affect regulation strategies, such as pain acceptance, has shown to be effective to reduce pain and psychological symptomatology. In addition, there is a vast literature showing a robust association between interpretation biases and attentional biases toward pain-related stimuli. For instance, Viane et al., (2004) found that chronic pain patients who reported greater acceptance of chronic pain showed less self-reported attention to pain. Pain acceptance has also been shown to improve the quality of life (Semeru & Halim, 2019) and well-being (Viane et al., 2003) of individuals with chronic pain. Furthermore, experimental studies

analyzing the effects of emotion regulation on pain have found that acceptance significantly increases pain tolerance in healthy individuals (Blacker et al., 2012; Liu et al., 2013; Wang et al., 2019). Distraction is another affect regulation strategy that has also been shown to have beneficial effects on pain. Studies using virtual reality distraction-based interventions have found a reduction in pain-related outcomes (e.g., pain intensity, pain tolerance) in chronic pain samples (Matheve et al., 2020; Brown et al., 2022). Distraction is also effective in reducing the perception of pain in healthy individuals. For instance, Rischer et al., (2020) found that participants engaging in a working memory task with a high cognitive load reduced the intensity and unpleasantness of pain in comparison to those participants who performed the task with a low cognitive load. The same finding was found in healthy children (Gaultney et al., 2021).

However, although acceptance and distraction seem to reduce pain-related measures, their differential efficacy is not yet clear. In some of the few studies directly comparing these strategies, McMullen et al., (2008) found that pain acceptance is more effective at increasing pain tolerance than distraction, whereas Kohl et al., (2013) found that distraction was more effective in reducing pain intensity than acceptance. Thus, it remains unclear which strategy could benefit or help in dealing with pain experiences as well as the mechanisms involved in the process. It might be possible that other psychological variables mediate the effect of these strategies on the pain experience. For instance, acceptance has been negatively associated with pain catastrophizing (de Boer et al., 2014; Mun et al., 2019). Regarding distraction, previous studies have found that this strategy is only effective in individuals with low levels of pain catastrophizing (Verhoeven et al., 2012; Prins et al., 2014).

The present study had a threefold objective. First, we aimed to analyze selective attentional patterns towards pain information in healthy individuals during the experience of

experimentally induced pain sensations by the Cold Pressor Test, which has been extensively used in experimental research of pain (Fanninger et al., 2023). Second, we aimed to analyze the differential effects of acceptance versus distraction guided strategies on both pain sensations and selective attention. Our first hypothesis, related to the first goal, was that the pain induction procedure would increase attentional biases towards pain-related stimuli and reduce the ability to disengage attention from pain-related information in comparison to neutral information. Our second hypothesis, related to the second goal, was that acceptance would be more effective in reducing attention to pain-related information compared with distraction-based instructions. One novelty of this study is that we investigate the effect of the order in which both strategies (i.e. acceptance and distraction) are used while individuals are feeling pain.

7.2. Methodology

7.2.1. Participants

Sixty-two healthy students voluntarily participated in the study. Inclusion criteria were: 1) being older than 18 years; 2) having a normal or corrected-to-normal vision and 3) being able to use both hands. The exclusion criteria were: 1) having a current diagnosed psychological disorder; 2) having cardiovascular diseases (e.g., high blood pressure, dysrhythmia), Raynaud syndrome, diabetes, epilepsy, or neurological diseases; 3) having a recent injury; 4) having a history of fainting or seizure; and 5) being pregnant. All information collected on the participants' health status was self-reported.

Sample size calculation was performed with G*Power 3.1 software, revealing that 54 participants were needed to detect a medium effect size (d = 0.25). Therefore, considering the possibility of a 10-15% drop-out rate, we included 62 participants.

7.2.2. Procedure

The whole study was composed of three different stages (see Figure 4.1.):

Stage 1. Baseline Task

First, all participants signed the informed consent and filled out a series of questionnaires (see below). Then, before the attentional task, a nine-point calibration was performed with eye-tracking apparatus. After this individualized calibration procedure, the participants performed the attentional task as a baseline measure. Once they had finished, they carried out the first Cold Pressor Test, which served as a baseline measure of pain intensity, pain threshold, and pain tolerance. To do that, all participants submerged their non-dominant hand into a room-temperature water bucket for 1 minute and, after that, they transferred their hand into a cold-water bucket (4ºC/39.2ºF), being asked to maintain the hand in the cold water until they could not tolerate the pain. To guarantee the safety of participants, a time limit of 4 minutes was established.

Stage 2. Water Task

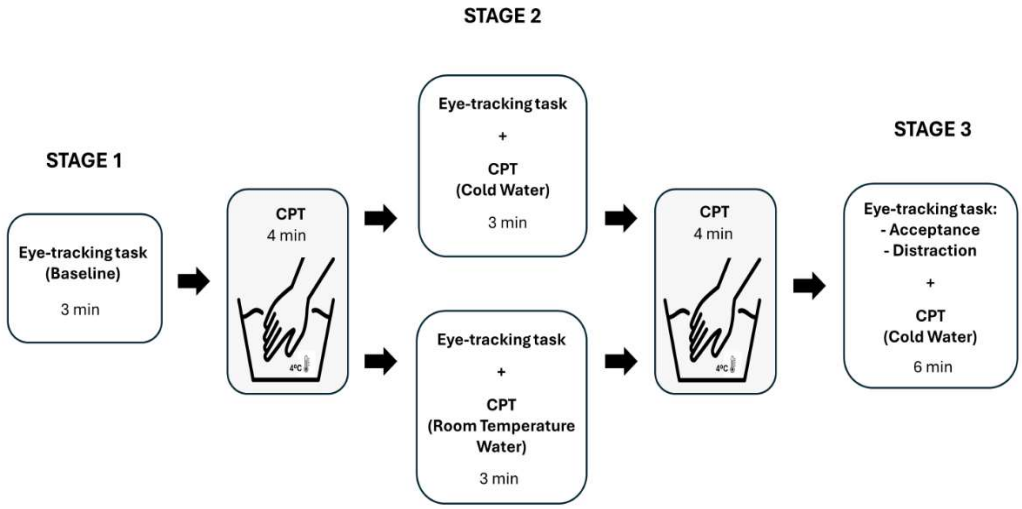
Immediately afterwards, a rest period of 2 minutes was performed. Then, participants were randomly assigned to a cold or room temperature water condition. After this, the second attentional task started after another individualized calibration. Participants in the cold-water group were asked to perform the attentional task while maintaining their hand submerged in the cold-water bucket (4ºC/39.2ºF); participants in the room-temperature water group were asked to do the same but with a room-temperature water bucket (20ºC/68ºF). To maintain the sensation of pain as constant as possible during the cognitive task, the cold-water group was instructed to get their hand out of the bucket when they could not tolerate the pain and submerge it again at all times they needed, thereby avoiding any risk to their health.

Stage 3. Pain regulation task

After completing the Second stage, all participants took another 2-minute rest and, to balance the temperature of the participants' hands in both groups, the participants from the cold-water group were allowed to submerge their hands in a room-temperature water bucket. In Stage 3, all participants performed a second CPT and took another 2- 2-minute rest. Then, all participants completed, again, the attentional tasks. As in the previous stage, participants were asked to maintain one hand in the cold-water bucket (with the possibility to get out and submerge the hand in the bucket every time they needed it). Additionally, during this attentional task, participants were asked to use acceptance or distraction-based instructions that were briefly presented, as is common in studies of emotion regulation following mood induction procedures (Zangri et al., 2022). The order of the two instructions was counterbalanced across subjects.

Figure 4.1.

Stages of the procedure.



Note. CPT = Cold Pressor Task.

7.2.3. Materials

Stimuli

Pain and neutral facial expressions were taken from the Montréal Pain and Affective Face Clips (MPAFC). This is a set of emotional faces clips created by Simon et al., (2008), including 64 faces of 4 men and 4 women who imitate prototypical facial expressions of pain, happiness, sadness, anger, disgust, fear, surprise, and neutral emotions. Sixteen pictures (the eight pictures of pain and the eight pictures of neutral faces) were extracted from the clips. However, as a previous validation study (Robles & Vazquez, 2024) showed that faces 4, 5, and 8 reached very low mean scores of either intensity or prototypicality of pain (both in samples of individuals with pain or not), these stimuli were not selected in the current study. Therefore, the final set of pictures used in the present study was composed of 5 painful faces with their corresponding neutral face.

Following previous eye-tracking studies (Blanco et al., 2019), each picture was converted to grayscale, and the surrounding areas of the faces (including hair and neck) were cropped to remove non-emotional features.

Apparatus

The whole task (including the attentional and the instruction tasks) was presented through e-Prime 3.0 (Psychology Software Tools, Pittsburgh, PA). A Tobii Pro Fusion eye-tracker at a sampling of 250 Hz (binocular) was used. Participants were asked to sit at a distance between 60-65 cm from the screen. Before starting every attentional task, a 9-point calibration was done.

Attentional paradigm

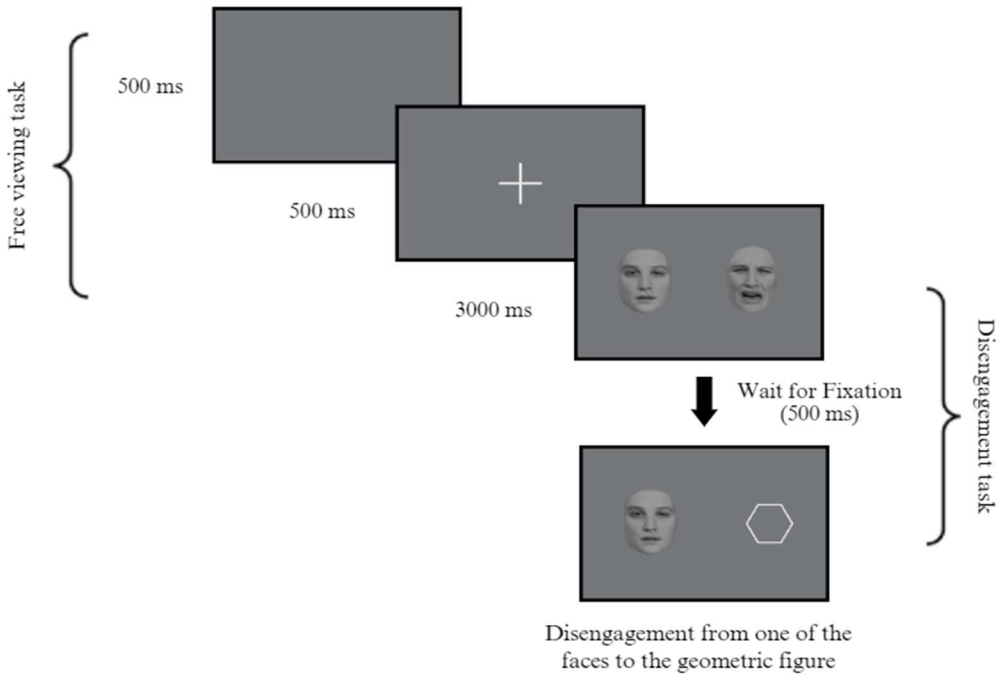
The attention task (see Figure 4.2.) consisted of 40 randomized trials. Both neutral and painful faces were presented counterbalanced on the left and right sides of the screen. Before starting the task, a 6-trial block of practice was carried out. The task consisted of two different subtasks embedded in the same trial:

a) *Free-viewing task*: each trial begins with a grey background on the screen for 500 ms, followed by a white fixation cross in the middle of the screen for another 500 ms. Afterwards, a pair of pain and neutral faces were presented for 3000 ms and participants were asked to freely look at them.

b) Disengagement task: this task was designed to assess participants' ability to disengage from a given face (either a pain or a neutral face). After the presentation of both faces in the free-viewing task (3000 ms), a waiting-for-fixing procedure begins. Once the participant has fixed his gaze on a given face for 500 ms, the program replaces the opposite face with a figure (a square or a hexagon). Participants then are asked to press on the keyboard one of two buttons to indicate whether the figure is a square or a hexagon. A precise response to this request demands individuals to disengage their gaze from the face to which they are currently engaged. After the response, the following trial begins.

Figure 4.2.

Attentional task



7.2.4. Selective attention and disengagement indexes

During the completion of the experimental task, five attentional measures related to early and late components of attention were computed to analyze the attentional pattern towards emotional information at different temporal stages during the free-viewing phase of the task.

1. First Fixation Latency (FFL): The time elapsed between the appearance of the stimuli and the first fixation made on each type of face in each trial.

2. First Fixation Duration (FFD): The duration of the first fixation made on each type of face in each trial.

3. Number of Fixations (NF): The total number of fixations made on each type of facial expression during the entire trial.

4. Average Fixation Duration (AFD): The average time that participants spent looking and making fixations at each type of face in all trials.

5. Total Fixation Duration (TFD): The total time participants spent looking and making fixations at each type of face in each trial.

6. Disengagement: The ability to disengage from a given face toward a geometric shape was assessed by the first fixation latency towards the geometric figure in the disengagement task.

Internal consistency of the eye-tracking measures was analyzed by calculating Cronbach's alpha for both the pain and neutral stimuli in every task (see Table 4.1.).

Table 4.1.

Cronbach's alpha for pain and neutral stimuli.

	FFL		FFD		NF		AFD		TFD		D	
	Pain	Neutral	Pain	Neutral	Pain	Neutral	Pain	Neutral	Pain	Neutral	Pain	Neutral
Baseline Task	.67	.79	.71	.81	.89	.88	.82	.91	.84	.83	.41	.61
Cold Water Task	.67	.64	.85	.90	.91	.85	.92	.94	.79	.75	.81	.80
RT Water Task	.52	.62	.87	.83	.87	.82	.89	.89	.62	.75	.40	.56
Acceptance Task	.70	.60	.84	.88	.90	.87	.87	.86	.80	.74	.82	.89
Distraction Task	.57	.59	.84	.88	.89	.87	.86	.86	.74	.77	.64	.47

Note: RT Water Task = Room Temperature Water Task; FFL = First Fixation Latency; FFD = First Fixation Duration; NF = Number of Fixations; AFD = Average Fixation Duration; TFD = Total Fixation Duration; D = Disengagement

7.2.5. Pain and psychological measures

Pain assessment. The Brief Pain Inventory *(BPI; Cleeland, 2001)*, a self-reported questionnaire, was used to measure both the intensity and the interference of current and past chronic pain in a patient's life. Participants manifesting current pain in the questionnaire were excluded from the study. Reliability studies show high internal consistency for intensity (α = 0.85) and interference (α = 0.88) (Tan, Jensen, Thornby, & Shanti, 2004).

Patient Health Questionnaire (PHQ-9; Kroenke, Spitzer, & Williams, 2001). This is a 9-item self-reported measure to assess the severity of depressive symptoms in the last 2 weeks. Every item can be rated on a 4-point Likert scale ranging from 0 *(not at all)* to 3 *(nearly every day*). In this study, this scale showed good internal consistency (*α = .84).*

General Anxiety Disorder (GAD-7; Spitzer, Kroenke, Williams, & Löwe, 2006). This is a 7-item self-reported measure to assess anxiety symptomatology during the previous 2 weeks. Every item is rated on a 4-point Likert scale ranging from 0 *(not at all)* to 3 *(nearly every day*). The total score of the GAD-7 ranges from 0 to 21 and it showed good internal consistency in our study (*α = .86).*

Pain Catastrophizing Scale (PCS; Sullivan, Bishop, & Pivik, 1995). It assesses the tendency to magnify the threat of a painful stimulus and the feeling of helplessness in the presence of pain, as well as the inability to prevent or inhibit pain-related thoughts. This instrument is divided into three subscales: rumination, magnification, and helplessness. The scale consists of 13 items rated on a Likert-type scale from 0 *(not at all)* to 4 *(all the time).* In this study, it showed good internal consistency for the total score (α = .89), and all subscales except for magnification (rumination: α = .84; magnification: α = .60; helplessness: α = .82).

Fear of Pain (FPQ-III; McNeil & Rainwater, 1998). This 30-item questionnaire assesses fear of different stimuli related to severe pain (e.g. 'Breaking your leg'), minor pain (e.g. 'Getting a paper cut on your finger'), and medical pain (e.g. 'Receiving an injection in your hip/buttocks'). Every item is scored on a 5-point Likert scale ranging from 1 *(not at all)* to 5 *(extreme).* In this study, this instrument showed excellent internal consistency (α = .90).

Attentional Control Scale (ACS; Derryberry & Reed, 2002). It measures individual differences in attentional control capacity. This instrument contains 20 items that are rated on a 4-point Likert scale ranging from 1 *(almost never)* to 4 *(always).* The total score ranges from 20 to 80. Higher scores indicate a greater self-reported ability to focus and attentional shifting. In this study, the ACS showed low internal consistency (α = .45).

Pain Vigilance and Awareness Questionnaire (PVAQ; McCracken, 1997). This instrument was originally built to investigate pain care in people with chronic pain. It includes 16 items rated on a 6-point scale, from 0 *(almost never)* to 5 *(always),* that assess pain awareness, awareness, alertness, and observation. PVAQ scores range from 0 to 90 (McCracken, 1997; Roelofs et al., 2002). In this study, it showed good internal consistency (α = .82).

Cognitive Emotion Regulation Questionnaire (CERQ; Garnefski, Kraaij, & Spinhoven, 2001). This is a 36-item questionnaire composed of nine subscales measuring cognitive strategies used when facing negative events. Items are measured on a 5-point Likert scale ranging from 1 *(almost never)* to 5 *(almost always).* Due to the purpose of this study, only items from the acceptance and catastrophizing subscales were used. In this study, internal consistency was low for acceptance (α = .57) and acceptable for catastrophizing (α = .73).

7.2.6. Cold Pressor Task (CPT)

Acute pain can be induced in healthy individuals by using different experimental methods (Olesen et al., 2012). One of the most used induction procedures is the Cold Pressor Task (CPT), which has been used to investigate participant's responses to pain under controlled and safe conditions (Feldner & Hekmat, 2001; Liu et al., 2013; Paccione et al., 2022).

The CPT requires participants to submerge their non-dominant hand or forearm in cold water for as long as it can be tolerated. According to Carrillo et al. (2005), at 0ºC (32ºF) some physiological changes typically occur, like the stimulation of the sympathetic nervous system, the elevation of blood pressure, and decreased blood flow. Most of the CPT studies have used water temperatures between 1ºC (33.8ºF) – 4ºC (39.2ºF) (Fanninger et al., 2023). However, as participants will perform this procedure several times in this study, it was decided to establish a temperature of 4ºC (30.2ºF). Regarding the duration of immersion, a maximum time of 3 or 4 minutes is generally established due to safety reasons (von Baeyer et al., 2005; Santarcangelo et al., 2013; Birnie et al., 2013; Koenig et al., 2014).

Two main measures can be obtained from the CPT. First, the cold pain threshold is a latency measure that registers the first time that participants report feeling pain from the introduction of the hand in the cold water. Second, cold pain tolerance refers to the total duration of the immersion (McIntyre et al., 2020). From these two measures, an index of pain maintenance can be derived (i.e., the duration of the immersion from the appearance of the pain threshold, (Carrillo et al., 2005).

7.2.7. Data analysis plan

First, means and standard deviations for pain and neutral faces during the baseline task were calculated in the entire sample by conducting a series of t-tests. Secondly, to explore the

effect of the pain induction in the attentional indices, a series of 2 (Group: Cold water, Room temperature water) x 2 (Time: Baseline task, Water task) x 2 (Valence of the faces: Pain, Neutral) repeated measures ANOVAs were conducted. To explore the differential effect of the strategies to modify the attentional pattern, a series of 2 (Order of the instructions: Acceptance-Distraction, Distraction-Acceptance) x 2 (Instruction type: Acceptance, Distraction) x 2 (Valence of the faces: Pain, Neutral) repeated measures ANOVAs were conducted.

7.3. Results

7.3.1. Demographic and psychological information

Table 4.2. shows means and standard deviations for age and psychological measures in the cold and room temperature water groups. There were no significant differences between both groups in any of these variables except for the catastrophizing subscale of the CERQ (the group assigned to the cold temperature water condition showed significantly lower scores in this subscale than the group assigned to the room temperature group). Regarding sex, there were no significant differences between both groups (χ^2 = .577, p = .44). The cold-water group was composed of 5 men and 25 women, with a mean age of 23.70 (SD = 3.65), while the control group was composed of 3 men and 27 women, with a mean age of 22.10 (SD = 2.56).

Table 4.2.

Means and standard deviations for age and psychological measures for every group

	Cold water group (N = 30)	**Room Temperature water group (N = 30)**		
	Mean (SD)	Mean (SD)	*t*	*p*
Age	23.70 (3.65)	22.10 (2.56)	1.96	.055
PHQ-9	7.50 (4.14)	8.10 (5.97)	-.41	.67
GAD-7	5.70 (4.68)	6.40 (4.86)	-.52	.60
PCS Rumination	10.16 (3.49)	11.40 (3.36)	-1.39	.16
PCS Magnification	6.56 (2.34)	6.40 (2.01)	.29	.76
PCS Helplessness	11.83 (4.06)	11.86 (4.15)	-.31	.97
PCS Total	28.56 (8.82)	29.66 (7.90)	-.51	.61
FPQ-III	52.13 (19.40)	46.86 (14.57)	1.18	.23
ACS	28.66 (4.81)	28.86 (5.49)	-.14	.88
PVAQ-9	19.50 (7.99)	21.93 (7.10)	-1.24	.21
CERQ-Acceptance	10.86 (6.07)	12.46 (2.17)	-1.35	.18
CERQ-Catastrophizing	5.76 (3.77)	7.76 (3.01)	-2.26	**.02***

Note: PCS = Pain Catastrophizing Scale; PHQ-9 = Patient Health Questionnaire-9; GAD-7 = General Anxiety Disorder-7; Pain Catastrophizing Scale; FPQ-III = Fear of Pain Questionnaire-III; ACS = Attentional Control Scale; PVAQ-9 = Pain Vigilance and Awareness Questionnaire-9; CERQ = Cognitive Emotion Regulation Questionnaire. (Significant differences are marked in bold).

*p<0.05; **p<0.001

Stages 1 and 2: Does a pain induction produce attentional biases towards pain stimuli?

Table 4.3. shows the means and standard deviation for pain and neutral faces in both groups. A series of 2 (Group: Cold Water, Room Temperature) x 2 [Time: Baseline Task (Stage 1), Water Task (Stage 2)] x 2 (Valence: Pain, Neutral) repeated measures ANOVAs was conducted.

First Fixation Latency. There was no significant effect of Time [F (57, 2) = .081, p = .37, η^2 = .000] or Group [F (57, 2) = 1.19, p = .27, η^2 = .021]. However, there was a significant effect of Valence [F (57, 2) = 5.26, p = .02, η^2 = .085]. A significant Time x Valence interaction [F (57, 2) = 6.57, p = .01, η^2 = .103] was found. Post-hoc analyses revealed that all participants fixated faster on pain faces at Stage 1 (Baseline Task) than at Stage 2 (Water Task) (p = .032) (see Figure 3a). However, the results did not reveal any difference between Stage 1 and Stage 2 in the latency to fixate on neutral faces (p = .37). Also, post-hoc analyses showed that all participants fixated their attention faster on the pain faces compared to the neutral ones at Stage 1 (p = .001). However, no differences between pain and neutral faces were found at Stage 2 (p = .784).

First Fixation Duration. There was no significant effect of Time [F (57, 2) = 1.86, p = .17, η^2 = .032], Group [F (57, 2) = .78, p = .38, η^2 = .014] or Valence [F (57, 2) = .79, p = .37, η^2 = .014]. Analyses revealed a significant Time x Valence interaction [F (57, 2) = 13.10, p < .001, η^2 = .187], showing that compared to the first fixation duration to neutral faces, all participants did longer first fixation on pain faces at Stage 1 (p = .001). However, no differences between pain and neutral faces were found at Stage 2 (p = .055). The analysis also revealed that there were no differences in the first fixation duration on pain faces between Stage 1 and Stage 2 (p = .428), but there were differences for neutral faces (p < .001) (see Figure 3b).

Number of Fixations. There was no significant effect of Group [F (57, 2) = .028, p = .86, η^2 = .000] or Valence [F (57, 2) = .56, p = .45, η^2 = .010]. However, there was a significant effect of Time [F (57, 2) = 24.47, p < .001, η^2 = .300]. Also, a significant Time x Group interaction [F (57, 2) = 4.65, p = .035, η^2 = .075] was found. post-hoc analyses revealed that there were no significant differences between groups at Stage 1 (p = .538) or Stage 2 (p = .357) in the total number of fixations. However, the cold water group significantly reduced the

number of fixations from Stage 1 to Stage 2 ($p < .001$) whereas the room temperature water group did not ($p = .055$).

Average Fixation Duration. There was no significant effect of Time [F (57, 2) = 3.50, $p = .06$, $\eta^2 = .058$], Group [F (57, 2) = 1.29, $p = .25$, $\eta^2 = .022$] or Valence [F (57, 2) = .35, $p = .55$, $\eta^2 = .006$]. There was a significant Time x Valence interaction [F (57, 2) = 6.70, $p = .012$, $\eta^2 = .100$]. Post-hoc analyses revealed that, for pain faces, there were no differences in participants' average fixation duration between Stage 1 and Stage 2 ($p = .862$) whereas, for neutral faces, they showed higher average fixation duration at Stage 2 than at Stage 1 ($p = .002$) (see Figure 3c). Additionally, at Stage 1 all participants showed higher average fixation duration to pain faces than to neutral ones ($p = .011$) but there were no differences between both types of faces at Stage 2 ($p = .135$).

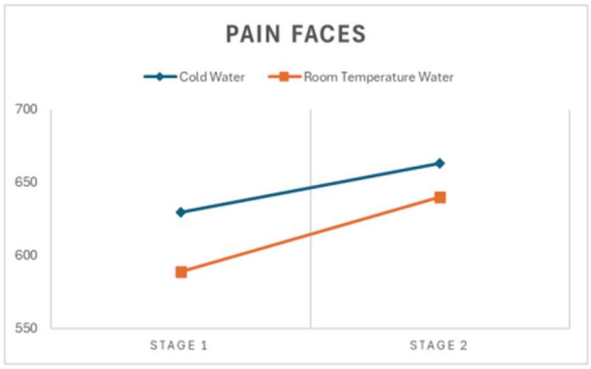
Total Fixations Duration. There was no significant effect of Time [F (57, 2) = 3.30, p = .07, $n^2 = .055$], Group [F (57, 2) = .74, p = .39, $n^2 = .013$], Valence [F (57, 2) = .07, p = .78, $n^2 = .001$], Time x Group [F (57, 2) = 3.59, p = .06, $n^2 = .059$], Time x Valence [F (57, 2) = 1.01, p = .31, $n^2 = .017$], Valence x Group [F (57, 2) = .038, p = .84, $n^2 = .001$] or Time x Valence x Group [F (57, 2) = 2.29, p = .13, $n^2 = .039$].

Disengagement. There was no significant effect of Group [F (57, 2) = .07, p = .79, $n^2 = .001$], Valence [F (57, 2) = .59, p = .44, $n^2 = .010$], Time x Group [F (57, 2) = 3.43, p = .069, $n^2 = .057$], Time x Valence [F (57, 2) = 2.34, p = .13, $n^2 = .039$], Valence x Group [F (57, 2) = .01, p = .89, $n^2 = .000$] or Time x Valence x Group [F (57, 2) = 2.22, p = .14, $n^2 = .038$]. However, there was a significant effect of Time [F (57, 2) = 29.38, p < .001, $n^2 = .034$], which indicates that all participants took longer to disengage their attention from pain or neutral faces during Stage 1 (Baseline Task) ($M = 263.42$; $SD = 10.58$) compared to Stage 2 (Water Task) ($M = 222.81$, $SD = 7.65$).

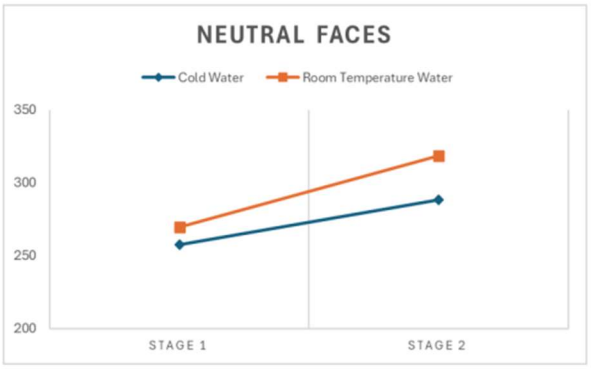
Figure 4.3.

Time x Valence interactions for FFL, FFD, and AFD during Stage 1 and 2.

a) First Fixation Latency (FFL)



b) First Fixation Duration (FFD)



c) Average Fixation Duration (AFD)

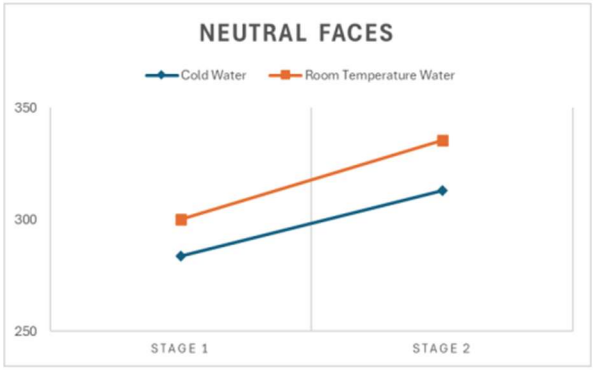


Table 4.3.

Means and standard deviations for pain and neutral faces in the cold and room temperature water groups.

	Cold Water				Room Temperature											
	Time 1		Time 2		Time 1		Time 2		Time x Group		Time x Valence		Valence x Group		Time x Valence x Group	
	Pain	Neutral	Pain	Neutral	Pain	Neutral	Pain	Neutral								
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	*F*	*p*	*F*	*p*	*F*	*p*	*F*	*p*
FFL (ms)	629.45 (22.37)	685.80 (27.75)	663.20 (27.95)	675.32 (29.67)	588.82 (22.76)	655.25 (28.22)	639.93 (28.42)	637.73 (30.18)	.02	.87	6.57	.01	.00	.94	.30	.58
FFD (ms)	293.40 (20.79)	257.52 (13.64)	268.15 (17.82)	287.98 (20.06)	296.66 (21.15)	269.81 (13.88)	299.38 (18.13)	318.62 (20.41)	1.24	.27	13.10	**< .001****	.10	.75	.11	.73
NF	3.85 (.14)	3.81 (.14)	3.37 (.15)	3.31 (.13)	3.72 (.14)	3.71 (.14)	3.56 (.16)	3.47 (.13)	4.65	**.03***	.38	.53	.00	.98	.09	.76
AFD (ms)	298.13 (20.15)	283.53 (14.32)	291.93 (16.80)	313.01 (19.46)	321.53 (20.50)	300.12 (14.56)	331.88 (17.09)	335.59 (10.79)	.37	.54	6.70	**.01***	1.64	.20	.20	.65
TFD (ms)	1083.71 (36.25)	1051.78 (35.28)	971.11 (32.78)	1021.62 (37.67)	1060.15 (36.87)	1069.98 (35.88)	1069.94 (33.34)	1063.19 (38.32)	3.59	.06	1.01	.31	.03	.84	2.29	.13
D (ms)	265.30 (14.24)	270.94 (17.27)	210.60 (11.07)	216.65 (13.72)	264.96 (14.48)	252.47 (17.56)	221.65 (11.26)	242.32 (13.96)	3.43	.06	2.34	.13	.01	.89	2.22	.14

Note: FFL = First Fixation Latency; FFD = First Fixation Duration; NF = Number of fixations; AFD = Average Fixation Duration; TFD = Total Fixation Duration; D = Disengagement, Ms = Milliseconds.

Stage 3: Do acceptance or distraction strategies while experiencing pain affect the attentional pattern towards pain-related information?

Table 4.4. shows the means and standard deviations for pain and neutral faces under every strategy. A series of 2 [Order: Acceptance - Distraction (AD), Distraction - Acceptance (DA)] x 2 (Instruction: Acceptance, Distraction) x 2 (Valence: Pain, Neutral) repeated measures ANOVAs was conducted (see Table 2).

First Fixation Latency. There was no significant effect of Strategy [F (55, 2) = 1.74, p = .19, η^2 = .031] or Order [F (55, 2) = .40, p = .52, η^2 = .007]. However, there was a significant effect of Valence [F (55, 2) = 5.88, p = .019, η^2 = .097]. A significant interaction of Order x Instruction [F (2, 55) = 4.92, p = .031, η^2 = .082] was found. Post-hoc analyses revealed that the AD group was faster in their first fixation to both types of faces when using distraction than when using acceptance (p = .016).

First Fixation Duration. There was no significant effect of Strategy [F (55, 2) = .31, p = .57, η^2 = .006], Order [F (55, 2) = 1.56, p = .21, η^2 = .028] or Valence [F (55, 2) = 1.54, p = .22, η^2 = .027], Analyses showed a significant effect of Order x Instruction [F (2, 55) = 10.78, p = .002, η^2 = .164] interaction. More importantly, a Order x Instruction x Valence interaction [F (55, 2) = 40.16, p < .001, η^2 = .422] was also significant (see Figure 4.3.a). To decompose this three-way interaction, two independent 2 (Order) x 2 (Instruction) ANOVAs were carried out for pain and neutral faces separately.

Concerning pain stimuli, analyses showed a significant Order x Instruction interaction [F (1, 55) = 30.26; p < .001; η^2 = .355]. Post-hoc analyses revealed that, for Acceptance, the order of the instructions did not affect its effectiveness (p = .551). However, for Distraction, the AD group showed a lower first fixation than the DA group (p < .001). Additionally, within the AD order, participants showed larger first fixations on pain stimuli when using Acceptance

than when using Distraction ($p < .001$) whereas no differential effect was observed within the DA order ($p < .001$).

Concerning neutral stimuli, analyses did not show significant main effects for Order ($p = .345$), Instruction ($p = .674$), or their interaction ($p = .175$).

Number of Fixations. There was no significant effect of Strategy [F (55, 2) = 2.94, p = .09, $\eta^2 = .051$], Order [F (55, 2) = 1.41, p = .23, $\eta^2 = .025$], Valence [F (55, 2) = .50, p = .48, $\eta^2 = .009$], Strategy x Group [F (55, 2) = .46, p = .50, $\eta^2 = .008$], Strategy x Valence [F (55, 2) = .14, p = .70, $\eta^2 = .003$], Valence x Group [F (55, 2) = .04, p = .83, $\eta^2 = .001$] or Strategy x Valence x Group [F (55, 2) = .03, p = .84, $\eta^2 = .001$].

Total Fixation Duration. There was no significant effect of Strategy [F (55, 2) = .32, p = .57, $\eta^2 = .006$], Order [F (55, 2) = .37, p = .54, $\eta^2 = .007$] or Valence [F (55, 2) = .32, p = .56, $\eta^2 = .006$]. A significant Order x Instruction [F (55, 2) = 10.29, $p = .002$, $\eta^2 = .158$] emerged. The post-hoc comparison showed that, within the AD group, participants spent more time attending to both stimuli when using distraction than when using acceptance ($p = .011$).

Average Fixation Duration. There was no significant effect of Strategy [F (55, 2) = 2.90, p = .09, $\eta^2 = .050$], Order [F (55, 2) = .43, p = .51, $\eta^2 = .008$]. However, there was a significant effect of Valence [F (55, 2) = 218.47, p < .001, $\eta^2 = .799$]. Results also revealed a significant Order x Instruction [F (55, 2) = 63.81, $p < .001$, $\eta^2 = .537$] interaction, which was qualified by a significant Order x Instruction x Valence [F (55, 2) = 69.78, $p < .001$, $\eta^2 = .559$] interaction (see Figure 4.4.b). As in previous analyses two independent 2 (Order) x 2 (Instruction) ANOVAs were carried out for pain and neutral faces separately.

Concerning pain stimuli, analyses showed a significant Order x Instruction interaction [F (1, 55) = 76.52; $p < .001$; $\eta^2 = .355$]. Post-hoc analyses revealed that acceptance was

associated with a larger average fixation duration in the AD order than in the DA order (p = .001).

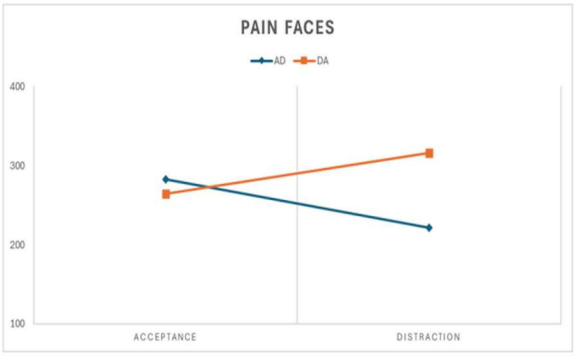
With regard to neutral stimuli, analyses did not show significant effects for Order (p = .497), Instruction (p = .573), or their interaction (p = .116).

Attentional disengagement. There was no significant effect of Strategy [F (55, 2) = .01, p = .91, η^2 = .000], Order [F (55, 2) = .04, p = .01, η^2 = .032] or Valence [F (55, 2) = 1.55, p = .21, η^2 = .029]. A significant Order x Instruction interaction [F (55, 2) = 337.26, p < .001, η^2 = .086] was found. Post-hoc analyses revealed that in the AD order participants disengaged their attention faster than in the DA order independently of the stimuli (p = <.001).

Figure 4.4.

Order x Instruction x Valence interactions for FFD and AFD during Stage 3.

a) First Fixation Duration (FFD)



b) Average Fixation Duration (AFD)

Table 4.4.

Means and standard deviations for pain and neutral faces in the acceptance and distraction strategies.

	Order: Acceptance → Distraction				Order: Distraction → Acceptance											
	Acceptance		Distraction		Distraction		Acceptance		Instruction x Order		Instruction x Valence		Valence x Order		Instruction x Valence x Order	
	Pain	Neutral	Pain	Neutral	Pain	Neutral	Pain	Neutral								
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	*F*	*p*	*F*	*p*	*F*	*p*	*F*	*p*
FFL (ms)	683.96 (25.65)	736.10 (28.56)	656.41 (25.59)	658.30 (28.32)	644.75 (25.15)	700.19 (27.83)	635.45 (25.21)	682.73 (28.06)	4.92	**.03***	.67	41	.56	.45	1.29	.26
FFD (ms)	282.67 (21.43)	263.13 (19.71)	221.45 (18.08)	269.85 (18.65)	315.93 (17.76)	284.88 (18.32)	264.64 (21.05)	297.59 (19.37)	10.78	**.002***	.03	.85	1.18	.28	40.16	**<.001****
NF	3.46 (.17)	3.56 (.15)	3.63 (.17)	3.67 (.16)	3.35 (.17)	3.38 (.16)	3.28 (.17)	3.33 (.15)	.46	.50	.14	.70	.04	.83	.03	.84
AFD (ms)	506.62 (28.02)	298.32 (19.66)	325.30 (23.79)	305.27 (20.40)	499.12 (23.37)	313.13 (20.04)	371.41 (27.54)	327.74 (19.31)	63.81	**<.001****	1.34	.25	.002	.96	69.78	**<.001****
TFD (ms)	982.45 (37.53)	1008.64 (34.82)	1051.83 (38.00)	1026.81 (41.24)	1032.34 (37.34)	1023.35 (40.52)	1082.36 (36.88)	1034.38 (34.21)	10.29	**.002***	.02	.87	.35	.55	1.38	.24
D (ms)	112.69 (10.50)	121.00 (12.56)	230.82 (10.88)	231.53 (11.44)	109.42 (10.48)	119.98 (11.03)	225.49 (10.12)	229.88 (12.10)	337.26	**<.001****	.008	.92	.09	.76	.75	.39

Note: FFL = First Fixation Latency; FFD = First Fixation Duration; NF = Number of fixations; AFD = Average Fixation Duration; TFD = Total Fixation Duration; D = Disengagement

7.4. Discussion

The present study aimed to assess attentional biases towards pain-related stimuli in healthy individuals before and during a pain induction, and the differential effectiveness of an acceptance vs distraction instruction on the attentional pattern.

Initially, we found that all participants fixated their attention faster on pain faces and did longer first fixations and longer average fixations on the pain faces compared to the neutral ones at Stage 1 (Baseline Task), which is in line with previous findings that confirm the existence of a bias toward pain-related information in free-pain individuals (Chan et al., 2020; Jones et al., 2021). Regarding our first hypothesis (i.e. a pain induction increases attentional biases towards pain-related stimuli in comparison to a non-painful condition) we did not find such an effect. However, we found that at Stage 1 (Baseline Task), compared with Stage 2 (Water Task), all participants fixated faster on pain faces and did shorter average fixations and first fixations towards neutral faces. This reflects that regardless of the temperature of the water, the attention to pain information does not increase, instead it increases for neutral information. This effect may be explained by the competition of attention with other cognitive demands such as doing a CPT at the same time as the attentional task, as it has been demonstrated that increasing the workload affects attentional performance (Tanaka et al., 2013; Mun et al., 2017).

These results show that healthy individuals have attentional biases towards pain stimuli and that these biases are not increased by a pain induction. However, these findings differ from previous studies which have found an increase in attentional biases under acute pain conditions. For instance, Sun et al., (2016) found, in a healthy sample, that participants experiencing experimental heat pain increased their attention towards pain-related pictures in comparison to those from the control group. One explanation for our different results could be the use of cold as a painful stimulation, but also, other

psychological factors (e.g. pain catastrophizing, attentional control, fear of pain) may be involved in the relationship between attentional bias and acute pain (Heathcote et al., 2015; Sharpe et al., 2017; Mazidi et al., 2019; Ranjbar et al., 2020). Our second hypothesis was that acceptance-based instruction would be more effective in reducing attention to pain-related information than distraction. Concerning this, we did not find significant differences in the effect of both strategies on attentional indices. However, the most interesting effect regarding our hypothesis is related to different attentional patterns depending on the order in which the instructions were presented. Firstly, we found that the group that started accepting the pain took less time to first fixate on pain or neutral stimuli and more time to disengage from them, showing a positive effect of acceptance to pay attention to stimuli in general. These findings suggest that acceptance contributes to reducing avoidance of stimuli expressing pain and to paying attention to the information, whether it expresses pain or not.

Regarding attentional maintenance, we found that those participants who started using acceptance made shorter first fixations and average fixations towards pain faces when they were asked to use a distraction strategy. These results could be an explanation for previous studies that have found different effects of acceptance and distraction on pain (Jackson et al., 2012; Kohl et al., 2012; Kohl et al., 2013; Moore et al., 2015; Hernández-Gómez & Hervas, 2022). In this regard, our findings help to understand the role of both strategies in painful contexts, as we found that accepting the pain contributes to getting distracted from it subsequently. Thus, it seems that neither of the strategies has an intrinsic effect on its own. In support of that idea, we found a beneficial effect of both strategies that depend on the order in which they are used. Previous studies have found that acceptance reduces negative emotion, respiration, and heart rate, and it also produces greater brain responses in areas involved in cognitive control and attention (Goldin et al.,

2019). In chronic pain samples, a positive relationship was also found between pain acceptance and cognitive control of pain (Viane et al., 2003). This effect may facilitate the use and effectiveness of pain distraction later.

To our knowledge, this is the first study that explores attentional biases towards pain-related information in healthy individuals when experiencing cold pain at the same time. This allows us to explore the impact of acute pain in the attentional processing of pain stimuli in free-pain individuals. To analyze the attention to pain-related and neutral information, an eye-tracker was used, which is an accurate methodology to evaluate attentional patterns. We also included a disengagement measure that has been little studied previously and provides information about the ability to divert attention away from emotional information. Furthermore, we explore the effect of acceptance and distraction on gaze measures, as well as the effect of the order of these strategies. However, this study also has some limitations. We used static stimuli instead of dynamic stimuli, which could be more representative of the emotion (Trautmann et al., 2009). Also, participants increased cold pain tolerance in every stage due to the practice, and we did not control psychophysiological variables involved in pain perception such as heart rate or skin conductance.

To sum up, this study shows that experimental acute pain reduces attention in general, rather than increasing attention to pain-related information. Regarding cognitive strategies, we found that accepting pain helps to ignore it, which may reduce the physical and psychological impact of pain on daily life. These findings are of great clinical relevance as they show the efficacy of combining both emotional regulation strategies to work in acute pain contexts. For future studies, it would be interesting to assess this question in chronic pain samples and the clinical usefulness of combining acceptance and distraction to reduce the symptomatology associated with chronic pain. This would

contribute to establishing effective non-pharmacological interventions to treat chronic pain, thus reducing the frequency of medical interventions as well as the negative effects of opioid medication and its overuse.

8. General conclusions and main findings

Pain is a complex phenomenon in which different biological, psychological and social factors are involved. The main objective of this dissertation was to study the attentional pattern to emotional stimuli, but specially to pain-related stimuli in individuals with different pain status (e.g. chronic pain, acute pain and healthy individuals). In addition, this thesis explores the effectiveness of psychological interventions to modify the attentional pattern as well as to improve pain-related outcomes.

Firstly, as Studies 1, 2 and 4 showed, individuals with and without chronic pain show attentional biases towards pain-related information in the early stages of attention. Furthermore, chronic pain individuals showed attention biases towards anger-related stimuli compared to neutral ones (Study 1). In addition, it was found that a pain induction, contrary to expectations, did not increase the attention to pain information, instead, it increased the attention to neutral stimuli probably due to the attentional demands of the task (Study 4). This finding shows that attentional biases to pain-related information are not exclusive of chronic pain patients, and that, according to Study 4, paying attention to other task may be allowing participants to distract from the pain sensation, highlighting the potential of distraction as a cognitive strategy to reduce the effect of pain on the attentional pattern.

Regarding non-pharmacological alternatives to treat chronic pain, mindfulness-based programs such as MBSR are effective in improving the symptomatology associated

with chronic back pain (e.g. depression, anxiety, well-being), although it does not affect attentional patterns to pain-related information (Study 2). However, although the effect of the program on attention was not significant, it was observed a reduction in the initial attention (e.g. latency and first fixation duration) to pain-related stimuli in the experimental group. These results encourage to further explore the effectiveness of mindfulness-based programs in modifying attentional patterns, both in people with and without chronic pain.

On the other hand, the acceptance of pain followed by distraction seems to be useful to reduce attention to pain-related stimuli in healthy individuals under a cold pain induction (Study 4). Until now, the differential effect of acceptance and distraction on pain-related outcomes has been widely studied finding mixed results. However, our finding is of great relevance as it shows the effectiveness of combining two cognitive strategies (acceptance of pain and distraction) to reduce attention to pain-related information, which may be useful to improve pain coping in healthy individuals and, possibly, in patients with chronic or acute pain.

In addition to all this, we found that some of the pain-related faces from the Montreal Pain and Affective Face Clips (MPAFC), one of the most used in the field of pain, are not sufficiently representative of the pain emotion (Study 3). This finding reveals the necessity of creating a new database of pain-related stimuli. Furthermore, we found that both men and women perceive female facial expressions as more representative of the pain emotion and emotionally intense than male ones (Study 3). This is important as it would help to better select the most appropriate stimuli to capture visual attention in experimental tasks and in different emotional contexts (e.g. pain, happiness). Also, it is important to take into consideration the pain diagnosis (e.g. location of pain) when selecting stimuli, as it would help to increase the reliability of the pain-related stimuli

Finally, it is important to mention that the small number of eye-tracking studies with chronic or acute pain samples and their methodological differences make further research necessary. The type of chronic pain diagnosis (e.g. headache, musculoskeletal pain) and the influence of other cognitive and emotional factors (e.g. interpretation biases) and their interaction with attention may also provide relevant information about the perception and management of pain, opening new ways of intervention for chronic pain patients. Thus, the study of attentional patterns to emotional stimuli in pain-related contexts is recent but yields promising information on the influence of attentional mechanisms on the experience of pain, which should be further explored in future studies. However, pain is a complex phenomenon in which different psychological, physiological and social components interact, entailing a major research challenge. For this reason, focusing on the pain treatment is a major concern that requires extensive investigation of the different factors, both general and specific of the pain diagnosis and patient's characteristics. This would allow to personalize the treatment of individuals with different chronic pain diagnoses and grades of pain interference and disability.

9. Final conclusions

The literature has shown the presence of attentional biases to pain-related information both in individuals with and without chronic pain. This thesis confirms that, regardless of the pain status, people tend to firstly look at pain-related stimuli in comparison to neutral ones, indicating a general bias to pain-related information in early stages of attention. Furthermore, it was found that individuals suffering from chronic pain also show attention biases towards stimuli depicting anger compared to neutral ones. Although attention to angry-related information has not been deeply explored in the field

of pain, previous studies have not found attentional differences between individuals with and without chronic pain (Liossi et al., 2011; Liossi et al., 2013; Schoth et al., 2015). However, although there is little information about the attention to other type of emotional information, anger has been linked to the pain experience. In fact, increases in state anger have been related to increases in pain intensity and pain interference in individuals with chronic low back pain (Burns et al., 2015).

According to Trost et al., (2012), there is three cognitive dimensions of anger: goal frustration due to external obstructions to personally significant goals, external attribution of the cause of events in their day-to-day lives, and perceived injustice. In relation to pain, perceived injustice has been associated to pain-related outcomes. For instance, a systematic review of individuals with musculoskeletal pain resulting mainly from injuries found an association between perceived injustice and pain intensity and disability, depression, anxiety, post-traumatic stress disorder as well as quality of life and well-being (Carriere et al., 2020). Tenti et al., (2023) observed in a sample with fibromyalgia, a mediational role of anger rumination and anger-state in the relationship between cognition (e.g. negative beliefs, cognitive self-consciousness) and pain intensity. Other studies have also found an association between pain and anger-related outcomes (e.g. trait anger) (Adachi et al., 2022). Exploring the relationship between pain and anger (state or trait) may help to understand the pain experience and personalize the treatment for chronic pain patients, including anger management.

Interventions based on meditation seem to be effective to reduce state anger through the reduction of rumination and improvement of emotional regulation processes (Borders et al., 2010, Robins et al., 2012; Fennell et al., 2016). In this thesis, anger-state was not explored, however, it was found that a MBSR intervention reduced depression, anxiety and stress and increased quality of life and wellbeing in individuals with chronic

back pain. Considering that mindfulness interventions reduce rumination (Jain et al., 2007; Wolkin, 2015; Owens & Bunce, 2022), this may be helpful to improve other cognitive and psychological variables such as anger, depression or anxiety that are strongly associated with rumination in a pain context.

Attention to pain-related information can be also modified using cognitive strategies such as acceptance or distraction. Numerous meta-analyses and systematic reviews have highlighted the beneficial effect of acceptance (Trindade et al., 2021 Ma et al., 2023 White et al., 2024) and distraction (Malloy & Milling, 2010; Birnie et al., 2014; Cho & Choi, 2021), to treat pain-related symptoms, although the mechanisms while they works remained unclear and depends on the study and the characteristics of the sample (e.g. pain status, chronic pain diagnosis). One of the most relevant findings of this thesis is the beneficial effect of the combination of both strategies to modify pain-related variable, which has not been observed before. Thus, the acceptance of pain followed by distraction is useful to modify the initial attention to pain-related information. This finding may help to increase the effectiveness of psychological treatments for chronic pain.

The results of this dissertation yield promising information about the beneficial effect of mindfulness, acceptance and distraction in a pain context. These types of interventions may be a useful and more efficient alternative to the pharmacological treatment that chronic, but also acute pain patients, usually take. We did not find a significant effect of mindfulness on attention, although a tendency to reduce the initial attention to pain-related information was observed in the experimental group after the program. As mindfulness practice involves attentional processes such as attentional control, it could be beneficial to modify the attentional pattern of chronic pain patients, and consequently, to reduce rumination and other cognitive-emotional disorders (e.g.

anxious and depressive symptoms) that are usually present in this population. In this respect, mindfulness and acceptance-based interventions have shown to be effective to reduce anxiety, depression (Vøllestad et al., 2012; Hofmann & Gómez, 2017; Johannsen et al., 2022) and rumination (Hawley et al., 2014; Perestelo-Perez et al., 2017), psychological variables widely observed not only in chronic pain patients, but also in the general population. In fact, pain has been linked to higher levels of anxiety or depression in both acute (Pinto et al., 2013; Michaelides & Zis, 2019; Wong et al., 2022) and chronic pain samples (Lerman et al., 2015; Wong et al., 2022; Mullins et al., 2023), and they have been considered as predictors of pain intensity (Mok & Lee, 2008; Lerman et al., 2015; Dadgostar et al., 2017). For instance, Carr et al., (2005) found, in a sample of women undergoing major abdominal gynaecological surgery, that post-operative pain at fourth day was associated to higher levels of anxiety and depression.

All above mentioned reflects the necessity of still exploring the psychological mechanisms involved in the pain experience and how they can be modified to reduce the chronic pain symptomatology, thus reducing the use of medication in this population.

Finally, it is important to consider the influence of other factors such as the characteristics and specificity of the stimuli (e.g. sex, pain location) or the paradigms (e.g. dot-probe, free-viewing) used in experimental studies as well as the participant's characteristics (e.g. pain diagnosis). For instance, although in this dissertation it was not found a significant effect of pain catastrophizing on attentional biases or the pain symptomatology, the literature has highlighted its influence not only on the attentional pattern (Lee et al., 2018; Ranjbar et al., 2020) but also in pain-related measures (Anagnostopoulos et al., 2023; Chan et al., 2024). Furthermore, it has been considered a risk factor (Pavlin et al., 2005; Burns et al., 2015) as well as a predictor of pain chronification (Severeijnset al., 2001). Therefore, exploring the role that other cognitive

variables exert in the relationship between attentional bias and pain-related outcomes is of great relevance to better understand the pain experience, prevent its chronification and create more appropriate and effective treatments for chronic pain.

10. Strengths and limitations

Table 5 shows the main strengths and limitations of this dissertation. Firstly, a multilevel meta-analysis was carried out, which has not been done before in the field of attentional biases and chronic pain measures with eye-tracking methodology. Furthermore, it was the first meta-analysis to analyse attention biases towards happy and anger-related stimuli (Study 1). Secondly, two novel experimental studies in the field of pain research were conducted (Studies 2 and 4). Both studies include a gaze index measuring attentional disengagement that has been little studied previously. Thirdly, the emotional facial expressions employed have been validated in the Spanish population (with and without acute or chronic pain) by using a well-established and previously used method (Study 3). In addition, the findings of this work are based on eye-tracking studies, which are more reliable when talking about visual attention (Studies 1, 2 and 4).

Regarding limitations, the number of primary studies included in the meta-analysis (Study 1) was small and only three emotional stimuli could be included in the analysis. Furthermore, moderation analyses were also limited due to the small number of studies and the consequent number of effect sizes included in the analyses. Similarly, the sample size included in the Study 2 was small, making it not possible to find an effect of mindfulness to modify the attentional pattern.

On the other hand, taking into account that attention is a complex cognitive process that can be interfered by numerous internal and external factors, the Study 4 could be

considered highly demanding for participants due to the necessity of doing different tasks at the same time.

Another limitation was that the number of female participants was larger than the male ones and chronic pain participants (Studies 1, 2 and 4) were mostly diagnosed with musculoskeletal chronic pain, making it difficult to generalize the results to the general population having other pain-related conditions.

Also, it is important to mention the limitations of experimental studies based on eye-tracking studies. These studies are carried out in experimental contexts and in a specific moment, being possible that other variables not controlled during the experiments interference with the results (e.g. physiological variables). In addition, these studies have methodological differences (e.g. paradigm and stimuli used) that increase the heterogeneity of the findings. Regarding the study of pain, the necessity of creating new emotional stimuli for eye-tracking studies that better capture the pain emotion is evident, as there are not a great variety of data bases that include pain-relate stimuli and some of the existent may not be sufficiently representative of the pain emotion.

The study of the attentional pattern in pain contexts (e.g. chronic pain, acute pain, induced pain) thought the analysis of the eye movements is very recent, leaving some unclear questions about its usefulness and clinical application. In addition, although numerous studies have found evidence of the effectiveness of Attentional Biases Modification (ABM) interventions to modify the attentional pattern in different populations (e.g. depressed and anxious individuals), it is not clear the utility of these interventions in the case of pain-related disorders. For that reason, it is of special interest to further investigate the influence of attentional biases on the perception and

maintenance of pain, and their modification as a possible non-pharmacological intervention for patients with pain-associated pathologies.

To finish, it is important to mention the complexity of studying pain due to the involvement of numerous physiological (e.g. heart rate variability, the effect of medication) and psychological variables (e.g. pain catastrophizing, coping strategies) that are difficult to control and could have interfered with the results (Studies 2 and 4).

Table 5

Main strengths and limitations of every study.

	Strengths	Limitations
Study 1	Multilevel analysis	Small number of primary studies
	Larger chronic pain sample size	Absence of primary studies including other emotional stimuli (e.g. sadness)
	Inclusion of primary studies using anger and happy-related stimuli	
Study 2	Innovative attentional paradigm	Small sample size
	Reliability analyses of the attentional indexes reported	Not control of medication and psychophysiological variables (e.g. heart rate)
	Standardized MBSR program and adapted to chronic back pain population	Use of non-dynamic stimuli
	First study analyzing the effect of mindfulness in the attentional pattern of chronic pain patients	Sample predominantly feminine
	Disengagement index	
Study 3	Well-established validation method	Validation focused solely on pain-related faces.
	Inclusion of individuals with acute and chronic pain	Small number of acute pain participants
		Sample predominantly feminine
Study 4	Innovative attentional paradigm	Use of non-dynamic stimuli
	First study analyzing attentional biases concurrently to acute cold pain	Not control of psychophysiological variables (e.g. rate)
	Disengagement index	Complexity of studying the pain experience
		Sample predominantly feminine

11. Future directions

Attentional biases to pain information seem to play a relevant role in the perception of pain. However, the study of this issue is recent and still requires further research. To establish a firmer conclusion of the relationship between attention and pain, future studies must focus on the study of the attentional pattern towards not only pain-related information, but also other types of emotional information related to the experience of pain such as anger or sadness. For instance, the literature in the field has shown a relationship between pain and depression (Bair et al., 2003; Surah et al., 2014; Ishak et al., 2018). However, regarding attentional biases, there is only one eye-tracking study exploring attention to sad and happy faces in individuals with chronic pain (Giel et al., 2018). These authors found an early attentional bias for happy faces, but not for the sad ones, in the chronic pain group, while depressive participants did not show any preference for sad or happy faces in comparison to neutral ones. Studying the attention to sad or happy-related stimuli in individuals suffering from pain may yield further information about the attentional pattern in pain-related contexts, and the relationship between depression and pain (e.g. common mechanisms).

It is also of great interest to explore the utility of interventions based on attention modification in pain perception, but more importantly in pain management. In this respect, the efficacy of Attentional Bias Modification (ABM) programs to reduce attentional bias towards negative information has been widely studied in different contexts (Mogoaşe et al., 2014). Regarding anxiety, which is strongly linked to pain (Means-Christensen et al., 2008; Carleton et al., 2009; Lerman et al., 2015), meta-analyses have found that ABM is effective in reducing threat-related attention bias (Hakamata et al., 2010; Mogoaşe et al., 2014). In the context of pain, ABM has also

shown benefits (Dehghani et al., 2004; Sharpe et al., 2015). For instance, ABM seems to be useful to reduce pain intensity in acute back pain patients and to reduce anxiety sensitivity and disability in chronic pain patients (Sharpe et al., 2012). Thus, ABM may be a useful strategy to reduce the symptoms associated with pain and disability.

In addition, the application of psychological interventions that focus on attentional components such as mindfulness-based interventions are another topic of interest in the field of pain. These interventions are focused on attentional control and breathing and have been shown to exert important effects on pain-related and quality of life (Hilton et al., 2017; Majeed et al., 2018; Smith & Langen, 2020). Studying the mechanisms by which meditation exerts its beneficial effects on pain may yield information about the complex experience of pain and may help to establish new interventions to treat chronic pain beyond the use of medication, as meditation has been shown to produce analgesic effects in both acute and chronic pain patients, as well as healthy individuals (Zeidan et al., 2016; McClintock et al., 2019; Ploesser & Martin, 2024).

Regarding methodological aspects in the study of attention, it is important to increase the validity of the visual stimuli used to assess attentional biases, for example by creating stimuli that are more representative of the type of pain the participant is experiencing, as well as the area of the pain. Also, exploring attentional biases in different contexts may be useful to better know the implication of other factors in the attentional pattern toward pain-related information.

In addition, future studies should assess the role of emotional variables involved in attentional processing, such as pain catastrophizing or fear of pain, and the individual differences implied in the origin and maintenance of pain and its management. Also, although the literature has shown an effect of different cognitive strategies (e.g. acceptance, distraction) on pain-related measures, it is not clear in which cases they are

effective. For this reason, it is recommended to explore the utility of coping strategies in different pain contexts and the relationship between these strategies and other cognitive factors such as pain catastrophizing, fear of pain and hypervigilance. Furthermore, future research should also explore the effectiveness of combining different cognitive strategies to modify attentional patterns and improve pain-related symptomatology in individuals with chronic pain diagnoses. This would help to improve psychological interventions for chronic pain patients as well as create individualized interventions that contribute to reducing the disability and interference caused by chronic pain.

12. Appendices

Scale for Mood Assessment (EVEA)

Below you will find a series of statements that describe different feelings and moods and a 0-10 scale beside each statement. Read each statement and circle the number from 0 ("Not at all") to 10 ("Very much") that best indicates how you FEEL RIGHT NOW, at this moment. Do not spend too much time on each statement and choose a response for each of them.

	Not at all										Very much
I feel nervous	0	1	2	3	4	5	6	7	8	9	10
I feel irritated	0	1	2	3	4	5	6	7	8	9	10
I feel happy	0	1	2	3	4	5	6	7	8	9	10
I feel melancholy	0	1	2	3	4	5	6	7	8	9	10
I feel tense	0	1	2	3	4	5	6	7	8	9	10
I feel optimistic	0	1	2	3	4	5	6	7	8	9	10
I feel depressed	0	1	2	3	4	5	6	7	8	9	10
I feel angry	0	1	2	3	4	5	6	7	8	9	10
I feel anxious	0	1	2	3	4	5	6	7	8	9	10
I feel downcast	0	1	2	3	4	5	6	7	8	9	10
I feel annoyed	0	1	2	3	4	5	6	7	8	9	10
I feel joyful	0	1	2	3	4	5	6	7	8	9	10
I feel restless	0	1	2	3	4	5	6	7	8	9	10
I feel displeased	0	1	2	3	4	5	6	7	8	9	10
I feel cheerful	0	1	2	3	4	5	6	7	8	9	10
I feel sad	0	1	2	3	4	5	6	7	8	9	10

Depression, Anxiety and Stress Scale (DASS-21)

Please read each statement and circle a number 0, 1, 2 or 3 that indicates how much the statement applied to you over the past week. There are no right or wrong answers. Do not spend too much time on any statement. The rating scale is as follows:

0 Did not apply to me at all
1 Applied to me to some degree, or some of the time
2 Applied to me to a considerable degree, or a good part of time
3 Applied to me very much, or most of the time

1. I found it hard to wind down	0 1 2 3
2. I was aware of dryness of my mouth	0 1 2 3
3. I couldn't seem to experience any positive feeling at all	0 1 2 3
4. I experienced breathing difficulty (eg, excessively rapid breathing, breathlessness in the absence of physical exertion)	0 1 2 3
5. I found it difficult to work up the initiative to do things	0 1 2 3
6. I tended to over-react to situations	0 1 2 3
7. I experienced trembling (eg, in the hands)	0 1 2 3
8. I felt that I was using a lot of nervous energy	0 1 2 3
9. I was worried about situations in which I might panic and make a fool of myself	0 1 2 3
10. I felt that I had nothing to look forward to	0 1 2 3
11. I found myself getting agitated	0 1 2 3
12. I found it difficult to relax	0 1 2 3
13. I felt down-hearted and blue	0 1 2 3
14. I was intolerant of anything that kept me from getting on with what I was doing	0 1 2 3
15. I felt I was close to panic	0 1 2 3
16. I was unable to become enthusiastic about anything	0 1 2 3
17. I felt I wasn't worth much as a person	0 1 2 3
18. I felt that I was rather touchy	0 1 2 3
19. I was aware of the action of my heart in the absence of physical exertion (eg, sense of heart rate increase, heart missing a beat)	0 1 2 3
20. I felt scared without any good reason	0 1 2 3
21. I felt that life was meaningless	0 1 2 3

Pain Catastrophizing Scale (PCS)

Everyone experiences painful situations at some point in their lives. Such experiences may include headaches, tooth pain, joint or muscle pain. People are often exposed to situations that may cause pain such as illness, injury, dental procedures or surgery.

We are interested in the types of thoughts and feelings that you have when you are in pain. Listed below are thirteen statements describing different thoughts and feelings that may be associated with pain. Using the following scale, please indicate the degree to which you have these thoughts and feelings when you are experiencing pain.

0 – not at all 1 – to a slight degree 2 – to a moderate degree 3 – to a great degree 4 – all the time

When I'm in pain …

1☐ I worry all the time about whether the pain will end.

2☐ I feel I can't go on.

3☐ It's terrible and I think it's never going to get any better.

4☐ It's awful and I feel that it overwhelms me.

5☐ I feel I can't stand it anymore.

6☐ I become afraid that the pain will get worse.

7☐ I keep thinking of other painful events.

8☐ I anxiously want the pain to go away.

9☐ I can't seem to keep it out of my mind.

10☐ I keep thinking about how much it hurts.

11☐ I keep thinking about how badly I want the pain to stop.

12☐ There's nothing I can do to reduce the intensity of the pain.

13☐ I wonder whether something serious may happen.

Chronic Pain Acceptance Questionnaire – Revised (CPAQ-R)

Below you will find a list of statements. Please rate the truth of each statement as it applies to you. Use the following rating scale to make your choices. For instance, if you believe a statement is 'Always True,' you would write a 6 in the blank next to that statement.

0	1	2	3	4	5	6
Never True	Very rarery true	Seldom true	Sometimes true	Often true	Almost always true	Always true

__ 1. I am getting on with the business of living no matter what my level of pain is.

__ 2. My life is going well, even though I have chronic pain.

__ 3. It's OK to experience pain.

__ 4. I would gladly sacrifice important things in my life to control this pain better.

__ 5. It's not necessary for me to control my pain in order to handle my life well.

__ 6. Although things have changed, I am living a normal life despite my chronic pain.

__ 7. I need to concentrate on getting ride of my pain.

__ 8. There are many activities I do when I feel pain.

__ 9. I lead a full life even though I have chronic pain.

__ 10. Controlling my pain is less important than any other goals in my life.

__ 11. My thoughts and feelings about pain must change before I can take important steps in my life.

__ 12. Despite the pain, I am now sticking to a certain course in my life.

__ 13. Keeping my pain level under control takes first priority whenever I'm doing something.

__ 14. Before I can make any serious plans, I have to get some control over my pain.

__ 15. When my pain increases, I can still take care of my responsibilities.

__ 16. I will have better control over my life if I can control my negative thoughts about pain.

__ 17. I avoid putting myself in situations where my pain might increase.

__ 18. My worries and fears about what pain will do to me are true.

__ 19. It's a great relief to realize that I don't have to change my pain to get on with life.

__ 20. I have to struggle to do things when I have pain.

Five Facet Mindfulness Questionnaire – Short Form (FFMQ-SF)

Below is a collection of statements about your everyday experience. Using the scale of 1 to 5 below, please indicate, on the line to the left of each statement, how frequently or infrequently you've had each experience in the last month (or other agreed-upon time period). Please answer according to what really reflects your experience, rather than what you think your experience should be.

1 = never or very rarely true
2 = not often true
3 = sometimes true, sometimes not true
4 = often true
5 = very often or always true

___1. I'm good at finding the words to describe my feelings.

___2. I can easily put my beliefs, opinions, and expectations into words.

___3. I watch my feelings without getting carried away by them.

___4. I tell myself that I shouldn't be feeling the way I'm feeling.

___5. It's hard for me to find the words to describe what I'm thinking.

___6. I pay attention to physical experiences, such as the wind in my hair or the sun on my face.

___7. I make judgments about whether my thoughts are good or bad.

___8. I find it difficult to stay focused on what's happening in the present moment.

___9. When I have distressing thoughts or images, I don't let myself be carried away by them.

___10. Generally, I pay attention to sounds, such as clocks ticking, birds chirping, or cars passing.

___11. When I feel something in my body, it's hard for me to find the right words to describe it.

___12. It seems I am running on automatic without much awareness of what I'm doing.

___13. When I have distressing thoughts or images, I feel calm soon after.

___14. I tell myself I shouldn't be thinking the way I'm thinking.

___15. I notice the smells and aromas of things.

___16. Even when I'm feeling terribly upset, I can find a way to put it into words.

___17. I rush through activities without being really attentive to them

___18. When I have distressing thoughts or images, I can just notice them without reacting.

___19. I think some of my emotions are bad or inappropriate and I shouldn't feel them.

___20. I notice visual elements in art or nature, such as colors, shapes, textures, or patterns of light and shadow.

___21. When I have distressing thoughts or images, I just notice them and let them go.

___22. I do jobs or tasks automatically without being aware of what I'm doing.

___23. I find myself doing things without paying attention.

___24. I disapprove of myself when I have illogical ideas.

Satisfaction With Life Scale (SWLS)

Below are five statements that you may agree or disagree with. Using the 1 - 7 scale below, indicate your agreement with each item by placing the appropriate number on the line preceding that item. Please be open and honest in your responding.

7 - Strongly agree
6 - Agree
5 - Slightly agree
4 - Neither agree nor disagree
3 - Slightly disagree
2 - Disagree
1 - Strongly disagree

____ In most ways my life is close to my ideal.
____ The conditions of my life are excellent.
____ I am satisfied with my life.
____ So far I have gotten the important things I want in life.
____ If I could live my life over, I would change almost nothing.

Tampa Scale for Kinesiophobia (TSK-11)

Below is a collection of statements. Please, indicate to what extent this is the case in your case according to the following scale:

1 = strongly disagree
2 = disagree
3 = agree
4 = strongly agree

1. I'm afraid that I might injury myself if I exercise	1 2 3 4
2. If I were to try to overcome it, my pain would increase	1 2 3 4
3. My body is telling me I have something dangerously wrong	1 2 3 4
4. People aren't taking my medical condition seriously enough	1 2 3 4
5. My accident has put my body at risk for the rest of my life	1 2 3 4
6. Pain always means I have injured my body	
7. Simply being careful that I do not make any unnecessary movements is the safest thing I can do to prevent my pain from worsening	1 2 3 4
8. I wouldn't have this much pain if there weren't something potentially dangerous going on in my body	1 2 3 4
9. Pain lets me know when to stop exercising so that I don't injure myself	1 2 3 4
10. I can't do all the things normal people do because it's too easy for me to get injured	1 2 3 4
11. No one should have to exercise when he/she is in pain	1 2 3 4

Anxiety Sensitivity Index – 3 (ASI-3)

Enter the number from the scale below that best describes how typical or characteristic each of the 16 items is of you, putting the number next to the item. You should make your ratings in terms of how much you agree or disagree with the statement as a general description of yourself.

0	1	2	3	4
very little	a little	some	much	very much

___ 1. It is important for me not to appear nervous.

___ 2. When I cannot keep my mind on a task, I worry that I might be going crazy.

___ 3. It scares me when my heart beats rapidly.

___ 4. When my stomach is upset, I worry that I might be seriously ill.

___ 5. It scares me when I am unable to keep my mind on a task.

___ 6. When I tremble in the presence of others, I fear what people might think of me.

___ 7. When my chest feels tight, I get scared that I won't be able to breathe properly.

___ 8. When I feel pain in my chest, I worry that I'm going to have a heart attack.

___ 9. I worry that other people will notice my anxiety.

___ 10. When I feel "spacey" or spaced out I worry that I may be mentally ill.

___ 11. It scares me when I blush in front of people.

___ 12. When I notice my heart skipping a beat, I worry that there is something seriously wrong with me.

___ 13. When I begin to sweat in a social situation, I fear people will think negatively of me.

___ 14. When my thoughts seem to speed up, I worry that I might be going crazy.

___ 15. When my throat feels tight, I worry that I could choke to death.

___ 16. When I have trouble thinking clearly, I worry that there is something wrong with me.

___ 17. I think it would be horrible for me to faint in public.

___ 18. When my mind goes blank, I worry there is something terribly wrong with me.

The World Health Organization-Five Well-Being Index (WHO-5)

Please indicate for each of the five statements which is closest to how you have been feeling over the last two weeks. Notice that higher numbers mean better well-being. Example. If you have felt cheerful and in good spirits more than half of the time during the last two weeks, select number three.

0 = At no time
1 = Some of the time
2 = Less than half of the time
3 = More than half of the time
4 = Most of the time
5 = All of the time

____ I have felt cheerful and in good spirits

____ I have felt calm and relaxed

____ I have felt active and vigorous

____ I woke up feeling fresh and rested

____ My daily life has been filled with things that interest me

Patient Health Questionnaire - 9 (PHQ-9)

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

0 = Not at all

1 = Several days

2 = More than half the days

3 = Nearly every day

1. Little interest or pleasure in doing things	0 1 2 3
2. Feeling down, depressed, or hopeless	0 1 2 3
3. Trouble falling or staying asleep, or sleeping too much	0 1 2 3
4. Feeling tired or having little energy	0 1 2 3
5. Poor appetite or overeating	0 1 2 3
6. Feeling bad about yourself — or that you are a failure or have let yourself or your family down	0 1 2 3
7. Trouble concentrating on things, such as reading the newspaper or watching television	0 1 2 3
8. Moving or speaking so slowly that other people could have noticed? Or the opposite — being so fidgety or restless that you have been moving around a lot more than usual	0 1 2 3
9. Thoughts that you would be better off dead or of hurting yourself in some way	0 1 2 3

General Anxiety Disorder – 7 (GAD-7)

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

0 = Not at all

1 = Several days

2 = More than half the days

3 = Nearly every day

1. Feeling nervous, anxious, or on edge	0 1 2 3
2. Not being able to stop or control worrying	0 1 2 3
3. Worrying too much about different things	0 1 2 3
4. Trouble relaxing	0 1 2 3
5. Being so restless that it is hard to sit still	0 1 2 3
6. Becoming easily annoyed or irritable	0 1 2 3
7. Feeling afraid, as if something awful might happen	0 1 2 3

Attentional Control Scale (ACS)

Here are some different ways that people can feel about working and concentrating. Please indicate how strongly each statement applies to you.

1 = Almost never

2 = Sometimes

3 = Often

4 = Always

1. It's very hard for me to concentrate on a difficult task when there are noises around.	1 2 3 4
2. When I need to concentrate and solve a problem, I have trouble focusing my attention.	1 2 3 4
3. When I am working hard on something, I still get distracted by events around me.	1 2 3 4
4. My concentration is good even if there is music in the room around me.	1 2 3 4
5. When concentrating, I can focus my attention so that I become unaware of what's going on in the room around me.	1 2 3 4
6. When I am reading or studying, I am easily distracted if there are people talking in the same room.	1 2 3 4
7. When trying to focus my attention on something, I have difficulty blocking out distracting thoughts.	1 2 3 4
8. I have a hard time concentrating when I'm excited about something.	1 2 3 4
9. When concentrating I ignore feelings of hunger or thirst.	1 2 3 4
10. I can quickly switch from one task to another.	1 2 3 4
11. It takes me a while to get really involved in a new task.	1 2 3 4
12. It is difficult for me to coordinate my attention between the listening and writing required when taking notes during lectures.	1 2 3 4
13. I can become interested in a new topic very quickly when I need to.	1 2 3 4

14. It is easy for me to read or write while I'm also talking on the phone.	1	2	3	4
15. I have trouble carrying on two conversations at once.	1	2	3	4
16. I have a hard time coming up with new ideas quickly	1	2	3	4
17. After being interrupted or distracted, I can easily shift my attention back to what I was doing before.	1	2	3	4
18. When a distracting thought comes to mind, it is easy for me to shift my attention away from it.	1	2	3	4
19. It is easy for me to alternate between two different tasks.	1	2	3	4
20. It is hard for me to break from one way of thinking about something and look at it from another point of view.	1	2	3	4

Fear of Pain Questionnaire – III (FPQ-III)

INSTRUCTIONS: The items listed below describe painful experiences. Please look at each item and think about how FEARFUL you are of experiencing the PAIN associated with each item. If you have never experienced the PAIN of a particular item, please answer on the basis of how FEARFUL you expect you would be if you had such an experience. Circle one number for each item below to rate your FEAR OF PAIN in relation to each event.

1 = Not At All

2 = A Little

3 = A Fair Amount

4 = Very Much

5 = Extreme

1. Being in an automobile accident.	1 2 3 4 5
2. Biting your tongue while eating.	1 2 3 4 5
3. Breaking your arm.	1 2 3 4 5
4. Cutting your tongue licking an envelope.	1 2 3 4 5
5. Having a heavy object hit you in the head.	1 2 3 4 5
6. Breaking your leg.	1 2 3 4 5
7. Hitting a sensitive bone in your elbow – your “funny bone.”	1 2 3 4 5
8. Having a blood sample drawn with a hypodermic needle.	1 2 3 4 5
9. Having someone slam a heavy car door on your hand.	1 2 3 4 5
10. Falling down a flight of concrete stairs.	1 2 3 4 5
11. Receiving an injection in your arm.	1 2 3 4 5
12. Burning your fingers with a match.	1 2 3 4 5
13. Breaking your neck.	1 2 3 4 5
14. Receiving an injection in your hip/buttocks.	1 2 3 4 5
15. Having a deep splinter in the sole of your foot probed	

and removed with tweezers.	1 2 3 4 5
16. Having an eye doctor remove a foreign particle stuck in your eye.	1 2 3 4 5
17. Receiving an injection in your mouth.	1 2 3 4 5
18. Being burned on your face by a lit cigarette.	1 2 3 4 5
19. Getting a paper-cut on your finger.	1 2 3 4 5
20. Receiving stitches in your lip.	1 2 3 4 5
21. Having a foot doctor remove a wart from your foot with a sharp instrument.	1 2 3 4 5
22. Cutting yourself while shaving with a sharp razor.	1 2 3 4 5
23. Gulping a hot drink before it has cooled.	1 2 3 4 5
24. Getting strong soap in both your eyes while bathing or showering.	1 2 3 4 5
25. Having a terminal illness that causes you daily pain	1 2 3 4 5
26. Having a tooth pulled.	1 2 3 4 5
27. Vomiting repeatedly because of food poisoning.	1 2 3 4 5
28. Having sand or dust blow into your eyes.	1 2 3 4 5
29. Having one of your teeth drilled.	1 2 3 4 5
30. Having a muscle cramp.	1 2 3 4 5

Pain and Vigilance Awareness Questionnaire (PVAQ)

Please, indicate to what extent the following statements apply to you.

0 = Never
1 = Almost never
2 = Sometimes
3 = Often
4 = Almost always
5 = Always

1	I am very sensitive to pain	0 1 2 3 4 5
2	I am aware of sudden or temporary changes in pain	0 1 2 3 4 5
3	I am quickly to notice changes in pain intensity	0 1 2 3 4 5
4	I am quick to notice effects of medication on pain	0 1 2 3 4 5
5	I am quick to notice changes in location or extent of pain	0 1 2 3 4 5
6	I focus on sensations of pain	0 1 2 3 4 5
7	I notice pain even if I am busy with another activity	0 1 2 3 4 5
8	I find it easy to ignore pain	0 1 2 3 4 5
9	I know immediately when pain starts or increases	0 1 2 3 4 5
10	When I do something that increases the pain, the first thing I do is check to see how much pain was increased	0 1 2 3 4 5
11	I know immediately when pain decreases	0 1 2 3 4 5
12	I seem to be more conscious of pain than others	0 1 2 3 4 5
13	I pay close attention to my pain	0 1 2 3 4 5
14	I keep track of my pain level	0 1 2 3 4 5
15	I become preoccupied with pain	0 1 2 3 4 5
16	I do not dwell on pain	0 1 2 3 4 5

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Note: asterisks indicate studies included in the meta-analysis (Study 1).