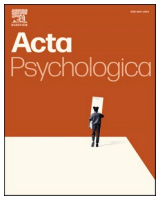
Acta Psychologica 250 (2024) 104555

Contents lists available at ScienceDirect

Acta Psychologica

journal homepage: www.elsevier.com/locate/actpsy



Attentional biases towards emotional information in chronic pain: A multilevel meta-analysis of eye-tracking studies

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ARTICLE INFO

Keywords:
Chronic pain
Attentional biases
Eye-tracking
Emotional stimuli

ABSTRACT

Objective: This meta-analysis reviewed the existing literature on attentional biases towards emotional stimuli measured with eye-tracking methodologies in individuals with chronic pain.
Method: Eighteen relevant studies (n = 1331 participants) were identified through three electronic databases: PubMed, PsycInfo, and Scopus. A multilevel random-effects meta-analysis was conducted by using the standardized mean difference between gaze variables for emotional and neutral stimuli with Hedge's correction as the effect size (ES).
Results: Between-group analyses revealed that healthy individuals make longer first fixation towards neutral stimuli compared to chronic pain patients. Within-group analyses showed that, compared to the healthy control group, the chronic pain group had more first fixations towards pain-related stimuli than to neutral ones and had shorter fixation duration towards anger-related stimuli than to neutral stimuli. A moderation effect of paradigm and type of stimuli was also found.
Conclusions: This is the first meta-analysis exploring attentional biases not only towards pain-related stimuli, but also towards other emotional information. Our findings revealed that chronic pain individuals tend to focus their attention firstly on pain-related information in comparison to healthy individuals. Furthermore, chronic pain individuals maintain their attention on anger-related stimuli less than on neutral ones.

1. Introduction

Chronic pain is a highly prevalent condition worldwide (Borchgrevink et al., 2022; Breivik et al., 2006) 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., 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

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https://doi.org/10.1016/j.actpsy.2024.104555
Received 12 July 2024; Received in revised form 15 October 2024; Accepted 22 October 2024
Available online 29 October 2024

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 towards pain-related stimuli, finding in general an attentional bias towards 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 & Vazquez, 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 & 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 (Martinez-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 and meta-analyses 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 towards pain-related stimuli in individuals with and without chronic pain. For instance, Jones et al. (2021) found attentional biases in early (e.g. probability of first fixation) and late (e.g. dwell time) stages of attention across both groups, indicating that this type of bias is not dependent on the pain status. Similarly, Chan et al. (2022) found more first fixations and total fixations on pain-related information compared to neutral ones in individuals with and without chronic pain. 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.

2. Methods

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 >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 senior 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 are depicted in the PRISMA flow diagram (Fig. 1).

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). Disagreements were resolved in the same way as with the literature search.

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

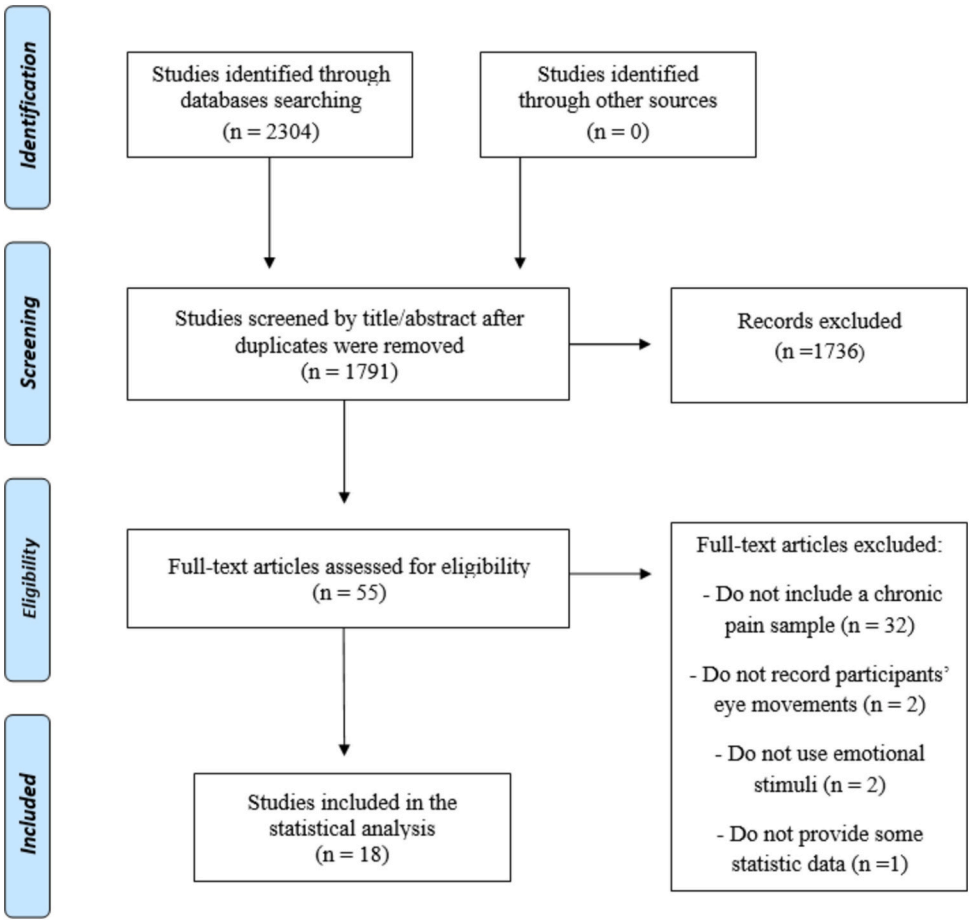

Fig. 1. PRISMA figure of searching and selection process of primary studies.

catastrophizing, pain vigilance and anxiety sensitivity were coded as psychological measures. As gaze measures, the following variables were coded as early attentional indices: latency, probability of first fixation and duration of first fixation. For attentional maintenance, we coded the total number of fixation and total fixation duration. Finally, we coded the paradigm, type and valence of stimuli, number of trials and duration of the task as experimental task characteristics.

2.3. Meta-analytic procedure

2.3.1. 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, 2021), 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). The validity and reliability of Web Plot Digitizer have been examined in previous studies, showing high levels of intercoder reliability and validity (Burda et al., 2017; Drevon et al., 2017). Moreover, it is a commonly used tool in meta-analyses published in peer-reviewed journals (e.g., Morton et al., 2018; Zangri et al., 2022).

Based on the type of primary studies, which in some cases included only samples with pain, we decided to conduct between- and within-group comparisons to add further value to the results. Supporting this decision, previous meta-analyses, such as the one by Jones et al. (2021), also made this distinction based on data from both sources of variance in the original studies. First, we conducted between-group analyses with 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 stimulus 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.

2.3.2. 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.

2.3.3. 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.

2.3.4. 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). However, we excluded three items from the checklist that were not applicable to our primary studies, as these items pertained to aspects specific to intervention studies (i.e., random allocation to treatment groups, blinding of investigators to the intervention, and blinding of participants). In addition, we added five questions to explore other specific aspects related to the research quality of eye-tracking studies and to open science issues: 1) reliability indexes of the experimental task; 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. Each item was scored by each reviewer by using a 3-point scale (0 = did not meet criteria; 1 = met criteria partially; 2 = met criteria). A total score (from 0 to 32) was obtained by summing all the scores.

The average total score for all studies was high (X = 24.0). Although most of the quality criteria analyzed were completely fulfilled by the majority of the primary studies (see Table 1), there were some exceptions where the criteria were only partially or completely fulfilled by a relatively small percentage of studies: pre-registration (5.5 %), reliability of attentional indices (16.6 %), open access to materials (11.1 %), method of subject selection (33 %), and power analyses (38.8 %).

3. Results

3.1. Descriptive information

Table 2 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; 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. All studies used emotional and neutral pairs of stimuli, while in the study by Schoth et al. (2015) every trial displayed eight different faces presented in a circular array. 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) 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. Regarding stimuli 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 <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). Finally, regarding stimuli databases, three were primarily used in the primary studies: IAPS (International Affective Picture System), KUFEC (Korea University Facial Expression Collection), and MPAFC (Montreal Pain and Affective Face Clips). The first database was created by Lang and Bradley (2007) and has been widely used in emotional and neurofunctional research. The second was created by Kim et al. (2017) and includes emotional facial expressions representative of the Korean population. The MPAFC consists of 1-second clips displaying emotional facial expressions of different emotions (e.g., pain, happiness, sadness) (Simon et al., 2008). Three studies conducted by Jieun Lee and their group used the KUFEC (Lee et al., 2018; Lee et al., 2019; Lee et al., 2020), three studies used stimuli from the IASP (Fashler & Katz, 2016; Franklin et al., 2018; Mahmoodi-Aghdam et al., 2017) and other three studies used the MPAFC (Liossi et al., 2014; Schoth et al., 2015 and Priebe et al., 2021).

In relation to pain-related stimuli, all studies were included in between-group analyses except for Jackson et al. (2019), Giel et al. (2018), Lee et al. (2018), and Lee et al. (2019). For within-group analyses, all studies were included except those by Giel et al. (2018), Mazidi et al. (2021), Soltani et al. (2020), and Soltani et al. (2022). Regarding anger-related stimuli, only three studies were included in between-group analyses (Liossi et al., 2014; Schoth et al.; Priebe et al., 2021), and five in within-group analyses (Liossi et al., 2014; Schoth et al., 2015; Lee et al., 2018; Lee et al., 2019; Priebe et al., 2021). Finally, for happy-related stimuli, five studies were included in between-group analyses (Liossi et al., 2014; Schoth et al., 2015; Giel et al., 2018; Mazidi et al., 2021; Priebe et al., 2021). The same studies were included for within-group analyses except for Mazidi et al. (2021).

3.2. Comparison analyses

Table 3 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., 2021; 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.

Table 1
Quality of primary studies.

	Objective	Design	Subject selection	Subjects' information	Measures	Sample size	Analysis	Variance	Confounding	Results	Conclusion	Reliability	Stimulus validation	Power	Register	Open access	Total score
Fashler and Katz (2014)	2	2	1	2	2	2	2	2	2	2	2	0	0	0	0	0	21
Liossi et al. (2014)	2	2	1	2	2	1	2	2	2	2	2	0	2	0	0	0	22
Schoth et al. (2015)	2	2	1	2	2	1	2	2	2	2	2	0	2	0	0	0	22
Jackson et al. (2019)	2	2	2	2	2	2	2	2	2	2	2	0	0	0	0	0	22
Lee et al. (2020)	2	2	1	2	2	1	2	2	2	2	2	0	2	0	0	0	22
Fashler and Katz (2016)	2	2	1	2	2	2	2	2	2	2	2	0	2	0	0	0	23
Mahmoodi-Aghdam et al. (2017)	2	2	0	2	2	1	2	2	2	2	2	0	2	2	0	0	23
Giel et al. (2018)	2	2	1	2	2	2	2	2	2	2	2	0	2	0	0	0	23
Mazidi et al. (2021)	2	2	1	2	2	1	2	2	2	2	2	2	2	0	0	0	24
Franklin et al. (2018)	2	2	1	2	2	1	2	2	2	2	2	2	2	0	0	0	24
Lee et al. (2018)	2	2	1	2	2	2	2	2	2	2	2	0	2	2	0	0	25
Lee et al. (2019)	2	2	1	2	2	2	2	2	2	2	2	0	2	2	0	0	25
Jones et al. (2021)	2	2	2	2	2	2	2	2	2	2	2	0	1	2	0	0	25
Priebe et al. (2021)	2	2	2	2	2	1	2	2	2	2	2	0	2	0	0	2	25
Chan et al. (2022)	2	2	2	2	2	2	2	2	2	1	2	2	2	0	0	0	25
Soltani et al. (2020)	2	2	2	2	2	2	2	2	2	2	2	0	2	2	0	0	26
Soltani et al. (2022)	2	2	2	2	2	2	2	2	2	2	2	0	2	2	0	0	26
Ten Brink et al. (2021)	2	2	1	2	2	2	2	2	2	2	2	0	2	2	2	2	29

Note. 0 = did not meet criteria; 1 = met criteria partially; 2 = met criteria. The total score was calculated summing the scores of all items.

Table 2
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., (2014)	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. (2015)	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 and Katz (2014)	Canadá	113	Chronic pain = 51 Control = 62	84 (74.30 %)	21.32 (4.35)	Dot-probe	Words	Pain/Neutral	2000	120
Fashler and 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. (2021)	UK	57	Chronic pain = 28 Control = 29	38 (66.66 %)	n.a.	Dot-probe	Faces	Pain/Neutral/ Happy	1500	80
Jackson et al. (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.

3.2.1. 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 = 0.1, 95 % CI [−0.06; 0.27], p = .23) or neutral stimuli (k = 13, g = − 0.01, 95 % CI [−0.17, 0.13], p = .82). Within-group analyses were significant for the chronic pain group (k = 11, g = 0.65, 95 % CI [0.16, 1.13], p = .008) but not for the control group (k = 8, g = 0.50, 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

Table 3
Effect sizes for between-group differences (pain, happy or angry vs neutral stimuli) of chronic pain and free-pain samples.

Authors, (year)		Effect Size (Hedges'g) (SE)				
	Stimuli	Probability of First Fixation	First Fixation Duration	Total Fixation	Total Fixation Duration	First Fixation Latency
Liossi et al. (2014)	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. (2015)	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 and Katz (2014)	Pain	——	——	0.477 (0.19)	−0.273 (0.19)	——
	Neutral	——	——	0.284 (0.19)	−0.372 (0.19)	——
Fashler and 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)

Authors, (year)		Effect Size (Hedges'g) (Standard Error)				
	Stimuli	Probability of First Fixation	First Fixation Duration	Total Fixation	Total Fixation Duration	First Fixation Latency
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. (2021)	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)
Soltani et al. (2020)	Low pain expression	0.39 (0.01)	——	——	0.04 (0.01)	——
	Moderate pain	0.22 (0.01)	——	——	−0.22 (0.01)	——
	expression	−0.55 (0.01)	——	——	0.21 (0.01)	——
	High pain expression					
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)	Pain	−0.27 (0.04)	–	−0.31 (0.04)	0.08 (0.04)	0.24 (0.04)
Comparison Group 1	Neutral	−0.28 (0.04)	–	−0.48 (0.04)	−0.47 (0.04)	0.26 (0.04)
Ten Brink et al. (2021)	Pain	−0.30 (0.04)	–	−0.14 (0.04)	0.12 (0.04)	0.12 (0.04)
Comparison Group 2	Neutral	0.09 (0.04)	–	−0.01 (0.04)	0.21 (0.04)	0.30 (0.04)
Ten Brink et al. (2021)	Pain	−0.38 (0.04)	——	−0.02 (0.04)	−0.03 (0.04)	−0.09 (0.04)
Comparison Group 3	Neutral	0.21 (0.04)	——	0.26 (0.04)	0.48 (0.04)	0.01 (0.04)

Authors, (year)		Effect Size (Hedges' g) (Standard Error)				
	Stimuli	Probability of First Fixation	First Fixation Duration	Total Fixation	Total Fixation Duration	First Fixation Latency
Ten Brink et al. (2021)	Pain	−0.73 (0.04)	——	−0.59 (0.04)	−0.54 (0.04)	0.22 (0.04)
Comparison Group 4	Neutral	−0.58 (0.04)	——	−0.57 (0.04)	−0.51 (0.04)	−0.09 (0.04)
Jones et al. (2021)	Pain	0.09 (0.015)	−0.32 (0.015)	0.15 (0.015)	——	−0.21 (0.015)
Comparison Group 1	Neutral	−0.08 (0.015)	−0.39 (0.015)	0.27 (0.015)	——	−0.28 (0.015)
Jones et al. (2021)	Pain	0.29 (0.015)	−0.39 (0.015)	0.18 (0.015)	——	−0.38 (0.015)
Comparison Group 2	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	0.2 (0.01)	—— —— -0.31 (0.01) ———			
	expression	0.1 (0.01)	—— —— 0.11 (0.01) ———			
	High pain expression					
Chan et al. (2022)	Pain	0 (0.02)	–	0.25 (0.02)	0.36 (0.02)	–

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 = 0.49, 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., 2015) 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 = −0.14, 95 % CI [−0.37, 0.08], $p = .21$), but it was significant for neutral stimuli (k = 5, g = −0.27, 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 = 0.004, 95 % CI [−0.20, 0.21], $p = .96$) or control group (k = 5, g = 0.06, 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 = − 0.14, 95 % CI [−0.44; 0.14], p = .31) or neutral stimuli (k = 11, g = − 0.11, 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 = − 0.10, 95 % CI [−0.40; 0.19], p = .49) or the control group (k = 8, g = 0.06, 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 = .38]. Within-group analyses revealed moderate heterogeneity in the chronic pain [I^2 = 58.70 %; Q(df = 8) = 17.9296, p = .02] and the control group [I^2 = 62.43 %; Q(df = 7) = 16.8153, p = .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 = 0.11, 95 % CI [−0.11; 0.34], p = .32) or neutral stimuli (k = 13, g = − 0.005, 95 % CI [−0.17; 0.16], p = .95). Within-group analyses revealed no evidence of attentional bias for the chronic pain (k = 9, g = 0.28, 95 % CI [−0.15; 0.72], p = .20) or the control group (k = 11, g = 0.35, 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 = 0.02, 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 = −0.005, 95 % CI [−0.12; 0.11], p = .93). Within-group analyses revealed no evidence of attentional bias for chronic pain (k = 17, g = − 0.80, 95 % CI [−1.88; 0.26], p = .14) or control group (k = 9, g = − 0.13, 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 = .26] or neutral stimuli [I^2 = 0.00 %, Q(df = 12) = 9.7242, p = .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 = .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).

3.2.2. 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 = −0.08, 95 % CI [−0.34; 0.18], p = .55). Within-group analyses did not show a significant effect in the chronic pain (k = 4, g = 0.56, 95 % CI [−0.06; 1.18], p = .07) or the control group (k = 4, g = 0.57, 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 = 0.07, 95 % CI [−0.27; 0.42], p = .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 = 0.46, 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.

3.2.3. 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 = − 0.08, 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 = 0.28, 95 % CI [−0.16; 0.73], p = .21) or the control group (k = 3, g = 0.03, 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 = .18] or the control group [I^2 = 37.24 %; Q(df = 2) = 3.1476, p = .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 exhibited 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.

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. 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 = .48; z = 1.80, p = .07, respectively). Given that asymmetry

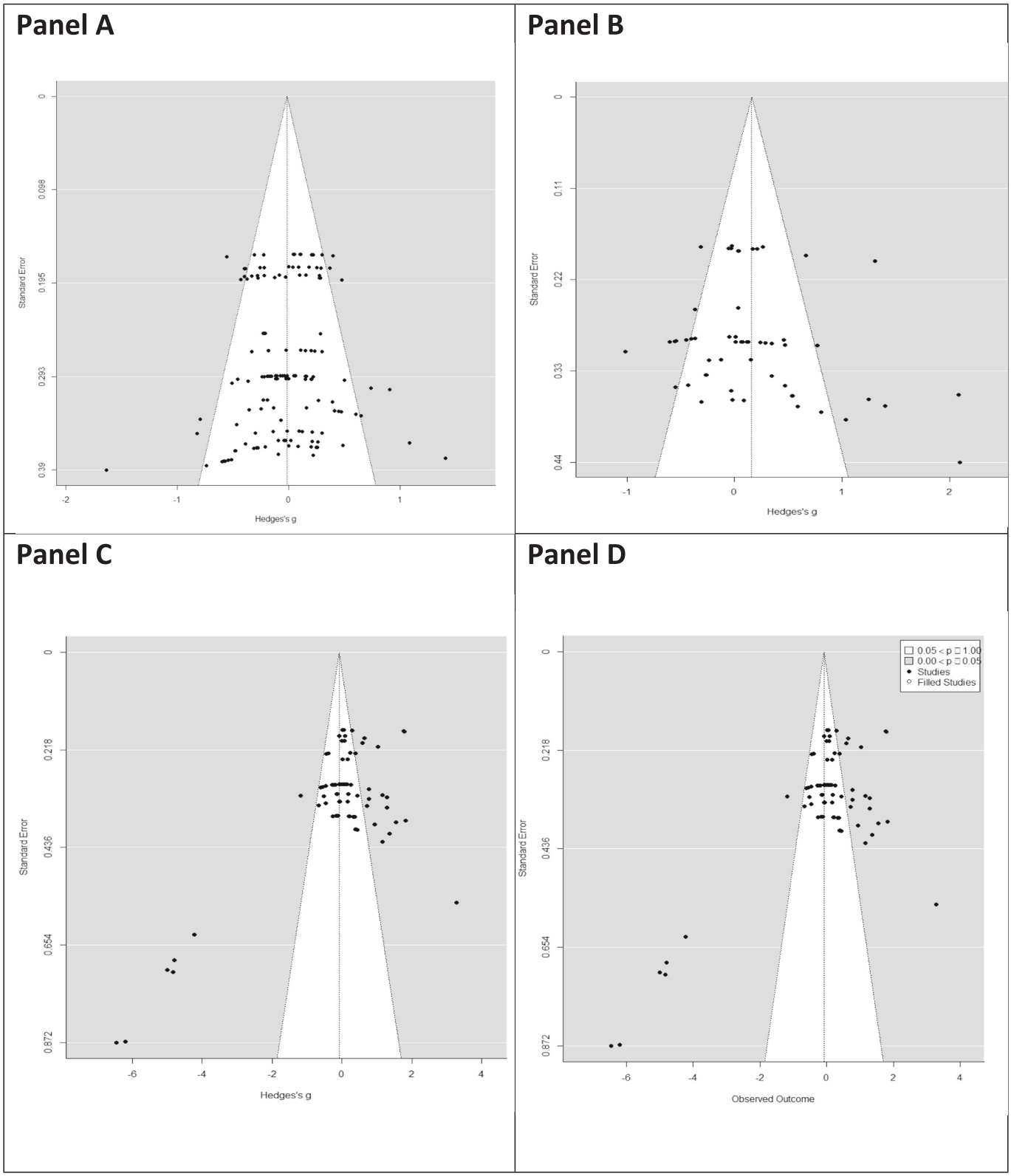

Fig. 2. Funnel plots for between-subjects meta-analysis (Panel A), within-subjects meta-analysis with control group (Panel B), within-subjects meta-analysis with experimental group (Panel C), and within-subjects meta-analysis with experimental group corrected with the trim-and-fill procedure (Panel D).

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. 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. 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.

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, utilizing 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 on neutral stimuli compared to healthy individuals. This finding may suggest a preference for attending to pain-related information, but it is also possible that chronic pain patients prefer attending to negative information in general, rather than to neutral information. Unfortunately, we cannot test this hypothesis with our data, as we did not have enough studies including healthy control participants with angry-neutral trials. Therefore, more experimental studies are needed to draw firmer conclusions. 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 towards emotional information that is reflected in the number of times that they fix their first attention on pain-related materials. Regarding the control group, we did not find differences in attentional patterns between pain and neutral stimuli, which contrasts with findings from previous studies. For instance, Schoth et al. (2019) found that healthy individuals took longer to first fixate on pain-related stimuli compared to neutral stimuli, indicating a bias away from pain information.

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 methodological differences between the studies included in the previous meta-analysis and those in the present study, as the new studies are primarily based on free-viewing paradigms, which tend to yield smaller effect sizes.

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. In fact, 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 & Vazquez, 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 the attention away from pain information has not been explored yet in chronic pain samples through the analysis of the 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 larger 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 towards sad faces, but also towards happy faces, in individuals with depression (Duque & Vazquez, 2015), which have been linked to the onset and maintenance of depressive disorders (Disner et al., 2011; Farb et al., 2015). Given that emotional disorders, including depression, are commonly comorbid conditions associated with chronic pain (Dhanju et al., 2019; Hooten, 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. Also, due to the small number of studies reporting reliability of eye-tracking measures in chronic pain samples (Franklin et al., 2018; Mazidi et al., 2021; Chan et al., 2022), we encourage researchers to do it for future studies. This information may be of great relevance to confirm the utility and quality of eye-tracking methods to explore attentional biases to visual information. 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. Finally, based on our analysis of the quality of the primary studies, some improvements appear necessary for future research in the field. In particular, in addition to complying with Open Science requirements (e.g., pre-registration), it is desirable to increase the statistical power of studies by using larger, more representative samples that encompass different types of pain, and the systematic inclusion of data on the reliability of the attentional indexes. 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.

CRediT authorship contribution statement

Elena Robles: Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis. **Inés Nieto:** Writing – review & editing, Methodology, Formal analysis. **Juan Francisco Navas:** Writing – review & editing, Methodology, Formal analysis. **Carmelo Vázquez:** Writing – review & editing, Supervision, Investigation, Funding acquisition, Conceptualization.

Research funding

This work was supported by the Ministry of Science PID2019-108711GB-I00 to Carmelo Vazquez and a Complutense University predoctoral grant (CT82/20-CT83/20) to Elena Robles.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

The authors would like to thank the authors of the primary studies who responded to our request for providing the necessary data to conduct our meta-analysis.

Data availability

Data will be made available on request.

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