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Meta-analysis on the neurophysiological modulation of attention to threat by anxiety: data on the P3 and LPP

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ATTENTION TO THREAT BY ANXIETY: DATA ON THE P3 AND LPP**

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Esta dissertação é apresentada em formato de artigo científico.

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Resumo

Apesar da extensa literatura sugerir o papel do viés atencional no aparecimento e manutenção das perturbações de ansiedade, o conhecimento acerca das características temporais do processamento atencional, a nível cerebral, é escasso, principalmente em etapas tardias, refletido através do P3 e LPP. Foi realizada uma pesquisa sistemática da literatura a fim de analisar a modulação do P3 e LPP pela ansiedade, em paradigmas do viés atencional relacionados com a ameaça. Formulou-se a seguinte hipótese: as amplitudes do P3 e LPP seriam distintas entre grupos de participantes ansiosos e de controlo.

Esta meta-análise foi registada na PROSPERO em 2020 (ID: CRD42021219741). Foram recolhidos 32 estudos ($n = 1372$) para a análise quantitativa. Os resultados demonstraram maiores amplitudes do P3 e LPP perante estímulos negativos relevantes, o que confirma parcialmente a hipótese em estudo. Assim, participantes ansiosos parecem apresentar dificuldades em desviar a atenção de estímulos negativos congruentes com a sua sintomatologia. A análise de moderação revelou um aumento das amplitudes do P3 e LPP em elétrodos parietais, para amostras comunitárias, não medicadas e sem comorbilidades, e para tarefas de processamento afetivo. Este efeito foi específico para a sintomatologia pertencente à dimensão Medo do Espectro Internalizante *Hierarchical Taxonomy of Psychopathology* (HiTOP).

Esta meta-análise sugere que o viés atencional é específico para estímulos ameaçadores congruentes com a patologia individual. Importa enfatizar que este fenómeno pode não ser um mecanismo transversal e transdiagnóstico do espectro ansiedade, mas sim específico para as perturbações relacionadas com o medo.

Palavras-chave: ansiedade; ameaça; viés atencional; P3; LPP.

Abstract

Despite extensive literature addressing the role of attentional bias in the onset and maintenance of anxiety-related disorders, less is known about its subjacent brain temporal dynamics, specifically at late processing stages reflected by the P3 and LPP. A systematic search of the literature was conducted to analyze the P3 and LPP modulation by anxiety in threat-related attentional bias paradigms. It was hypothesized that P3 and LPP amplitudes would differ between anxious and non-anxious participants.

This meta-analysis has been registered at PROSPERO in 2020 (ID: CRD42021219741). Thirty-two studies ($n = 1372$) were retrieved for the quantitative analysis. Increased P3 and LPP amplitudes were found for negative-relevant stimuli in anxious individuals, which partially confirms our hypothesis. Thus, anxious individuals seem to exhibit difficulties in disengaging attention away from disorder-congruent stimuli. Moderation analysis revealed increased P3 and LPP amplitudes at parietal electrode sites, for affective processing tasks, and for community-dwelling, non-medicated and comorbidity-free samples. Additionally, this effect was specific for disorders clustered within the Fear Dimension of HiTOP Internalizing Spectrum. Overall, our results suggest that attentional bias to threat may not be general to all threatful cues, but only to disorder-congruent ones. Importantly, this phenomenon may not be a cross-cutting, transdiagnostic mechanism of the anxiety spectrum since it is specific to fear-related anxiety disorders.

Key-words: anxiety; threat; attentional bias; P3; LPP.

Introduction

Anxiety is theorized as the brain's response to potentially dangerous situations, facilitating its avoidance. It can be considered adaptive in many scenarios if it does not interfere with normal functioning. However, when characterized by persisting or extensive degrees of anxiety symptoms and avoidance associated with subjective distress in response to environmental cues, it may become maladaptive (Beesdo et al., 2009). For instance, anxiety disorders are characterized by increased self-reported symptoms of fear, heightened behavioral and cognitive responses to threat-relevant stimuli, as well as elevated amygdalae and physiological responses to such stimuli (Craske et al., 2009; Lang et al., 2016; Stein, 2014).

Attentional biases are an example of altered cognitive processes in anxiety and reflect a preference to attend to concern-related stimuli, comparing to other stimuli (Dennis-Tiwary et al., 2019; Mansell et al., 2008; Mathews & MacLeod, 2005; Rogers et al., 2020). This phenomenon translates difficulties in allocating attention towards and away from salient stimuli, which in turn seems to contribute to the onset and maintenance of anxiety disorders in children, adolescents, and adults (e.g. Bar-Haim et al., 2007; Brotman et al., 2007; Dennis-Tiwary et al., 2019; Fox et al., 2001, 2002; Hakamata et al., 2010; Mathews & Mackintosh, 1998; Mathews & Macleod, 1985; Mathews & MacLeod, 2002). Indeed, there is evidence that increased biases toward emotionally negative stimuli can act as an intensifier of anxiety (Sallard et al., 2018), becoming a risk factor for such disorders (Dennis-Tiwary et al., 2019; Pérez-Edgar et al., 2013).

More specifically, threat-related attention is a specific type of affect-biased attention and has been observed across multiple anxiety-related disorders: Generalized Anxiety Disorder, Separation Anxiety Disorder, Social Anxiety Disorder, Specific Phobia, Selective Mutism, Panic Disorder, Agoraphobia, Posttraumatic Stress Disorder, and Obsessive-Compulsive Disorder (DSM-5; American Psychiatric Association, 2013); as well as in subclinical and trait anxiety (Dennis-Tiwary et al., 2019; Fu & Perez-Edgar, 2019; Rogers et al., 2020). In this sense, it can be considered a transdiagnostic process of anxiety (Garland & Howard, 2014; Rogers et al., 2020); that is, a process that cross-cuts the boundaries of anxiety disorders that were initially considered to be independent (Garland & Howard, 2014; Mansell et al., 2008; Rogers et al., 2020). Recent approaches to psychopathology, such as

the Research Domain Criteria (RDoC; Insel et al., 2010), and the Hierarchical Taxonomy of Psychopathology (HiTOP; Kotov et al., 2017) convey such a transdiagnostic perspective.

Attentional biases to threat encompass three components: (a) facilitation; (b) difficulty in disengagement; and (c) attentional avoidance (Amso & Scerif, 2015; Cisler et al., 2009; Cisler & Koster, 2010; Fox et al., 2001; Fu & Perez-Edgar, 2019; Zhang et al., 2017). The first designates the faster allocation of attention to threatening stimuli than to non-threatening ones (Cisler & Koster, 2010). The second refers to slower attentional shifts from threatening stimuli compared to non-threatening stimuli. The last component illustrates directing attention away from threatening stimuli to an alternative focus of attention (Rogers et al., 2020).

From this definition, there are four hypotheses addressing the timing of attentional bias to emotional stimuli in anxiety, three of these focusing on threat. The first hypothesis states that attention is rapidly and automatically allocated to threatening stimuli (Öhman et al., 2001; Öhman & Soares, 1998; Sass et al., 2010; Williams et al., 1996). The second one, related to the delayed disengagement theory, proposes that it is difficult for anxious individuals to inhibit and shift attention away from threatening stimuli (Fox et al., 2001). Inversely, the third one – the vigilance–avoidance hypothesis (Mogg et al., 1987) – suggests that anxious individuals are faster in directing their attention towards threatening stimuli, while in later stages they disengage attention from these stimuli to avoid the source of anxiety (Buodo et al., 2006). Despite mitigating distress in the short-term, re-directing attention away from threatening stimuli can also sustain distress over time, since it does not promote habituation in the presence of these stimuli (Felmingham et al., 2016; Hagemann et al., 2016; Harrewijn et al., 2017; Mogg et al., 1987, 1997, 2004; Mogg & Bradley, 1998). Lastly, the fourth hypothesis, the emotionality hypothesis, states that emotional stimuli in general (not only threatening stimuli) attract more attention relative to neutral stimuli in anxious individuals (Martin et al., 1991; Sass et al., 2010).

On this account, the literature further suggests that the impact of attentional allocation on cognitive resources varies with stages of processing (Shi et al., 2019). In line with the attention control theory (Eysenck et al., 2007), Cisler and Koster (2010) conceptualize attention in multiple processes, where the initial orientation to threatening information is driven by “bottom-up” processes, followed by either avoidance or difficulty in disengaging from the threatening stimulus, theorized to be controlled by “top-down” processing. This latter process translates the individual’s ability to control attention, which impacts the degree of attentional bias. Thus, higher levels of anxiety may lead to deficits in

attention control, which can be a risk factor for anxiety disorders and vice-versa (Shi et al., 2019).

Attentional bias has been the subject of systematic reviews and meta-analyses regarding behavioral data. This literature shows that anxiety vulnerable individuals demonstrate a heightened tendency to attentional vigilance for threat (Armstrong & Olatunji, 2012; Dudeney et al., 2015; Macleod et al., 2019), regardless of the experimental paradigm or conditions (Bar-Haim et al., 2007). Hence, these results support the implication of threat bias in the genesis and maintenance of anxiety (Macleod et al., 2019). Moreover, Pergamin-Hight et al. (2015) found an attentional bias in favor of disorder-congruent over disorder-incongruent threat stimuli, across anxiety disorders. This latter finding supports the association between anxiety and specific processing patterns of personally-relevant threat information (Mathews & Macleod, 1994), also confirming cognitive theories stressing the role of schema-driven processing threat-bias (e.g., Bar-Haim et al., 2007; Beck & Clark, 1997; Mogg & Bradley, 1998). Finally, a systematic review by Roy et al. (2020) also brings evidence in favor of delayed disengagement in anxiety, but not for avoidance since most studies that were reviewed did not report significant avoidance effects.

Despite these interesting results, most studies only collect behavioral measures, namely reaction times. As such, they are only able to capture the end-stage output of attention processes and do not offer a continuous measure of attention functioning. Therefore, these studies lack a continuous measure of attention functioning at the brain temporal dynamics levels (Fu & Perez-Edgar, 2019). Current research has taken a greater interest in Event-Related Potentials (ERPs) and functional Magnetic Resonance Imaging (fMRI). These techniques are of greater importance, since implementing multiple levels of analysis does not only enhance the reliability of attention measurements, as also increases the temporal and spatial sensitivity of attentional bias dynamics (Price et al., 2015; Rodebaugh et al., 2016). Consequently, these neurobiological measures can deepen our understanding of threat-related attention processes linked to anxiety (Fu & Perez-Edgar, 2019) and may unveil important transdiagnostic biomarkers of anxiety (Pérez-Edgar et al., 2010).

ERP and fMRI research provide support for the dual-processing perspective, which emphasizes the role of “bottom-up automatic and top-down controlled processes” in the genesis and preservation of anxiety symptoms (Bishop, 2008; Eysenck et al., 2007; Fu & Perez-Edgar, 2019; Henderson et al., 2015; Henderson & Wilson, 2017). Specifically, ERPs provide objective and detailed information about the very early and late stages of stimulus

processing. While early potentials reflect stimulus-driven or bottom-up effects on attention, later potentials translate top-down effects on attention (Harrewijn et al., 2017; Luck, 2014). Regarding these last ERPs, the P3 and the Late Positive Potential (LPP) have been frequently used to study attentional processes in clinical and subclinical anxious groups.

The P3 is defined by a positive deflection usually observed 300-500 ms after stimulus onset, distributed at centroparietal and frontocentral scalp sites. It is also sensitive to the amount of attention allocated to a stimulus and its emotional content (Harrewijn et al., 2017; Luck & Kappenman, 2011; Polich, 2007). Overall, this ERP is an index of voluntary attentional shifts towards target cues in the environment (Harrewijn et al., 2017). The LPP is a sustained positive deflection in the ERP that extends the time window of the P3. Some studies have found that the LPP is larger for pleasant and unpleasant stimuli compared to neutral (Harrewijn et al., 2017; Wauthia & Rossignol, 2016), reflecting “the encoding and storage of intrinsically motivating stimuli” (Harrewijn et al., 2017, p. 35).

Findings regarding the P3 and LPP modulation do not provide clear evidence in favor or against an attentional bias in anxiety. Even though behavioral studies suggest an association between anxiety disorders and attentional bias to threat, literature findings based on the ERPs are contradictory: some studies support the attentional bias to threat (Leutgeb et al., 2009; Sewell et al., 2008; Zhang et al., 2017), while others do not (e.g., Fan et al., 2014; Metzger et al., 1997; Michalowski et al., 2009).

Therefore, the present study aims to have a better understanding of attentional bias mechanisms reflected by the P3 and LPP modulation across the anxiety spectrum. For this purpose, this meta-analysis intends to: (a) explore if the P3 and LPP modulation by anxiety are consistent with behavioral findings previously described; (b) assess the P3 and LPP amplitude variations in the anxious groups relative to controls; and (c) test if specific variables (e.g., task, stimuli category, and electrode sites) may moderate the findings. For this purpose, a systematic search of the literature was conducted to find empirical studies analyzing the effect of anxiety on P3 and LPP amplitudes. It was expected to find differences in the LPP and P3 amplitudes (either reduced or increased) between anxiety and control groups.

Method

This meta-analysis followed the PRISMA guidelines (Moher et al., 2009).

1. Search and study selection strategy

Studies were selected via PUBMED and Web of Knowledge databases using the following search expressions: (anxi* OR phobi* OR “obsessive-compulsive” OR traum*) AND (“attention* bias*” OR threat* OR fear) AND (“event-related potentials” OR ERP OR “late positive potential” OR “LPP” OR P3* OR LPC OR “late positive complex”). These expressions (Appendix) were searched in abstracts and topics of the articles. Mesh terms were used in PUBMED to optimize the search.

Additionally, filters were applied for language (Portuguese, English, and Spanish), article type (journal article), and species (human). No filters for age or publication date were applied.

The initial screening of the articles was limited to the title, abstract, and keywords. The following inclusion criteria were used to assess the eligibility of studies: (1) empirical study – the study had to report empirical findings; (2) ERP – the study had to include analysis of ERP’s, specifically LPP and P3; (3) clinical and subclinical anxiety - the study had to include samples assessed either for anxiety disorders, posttraumatic stress disorder or obsessive-compulsive disorder; or for trait and state anxiety; (4) attentional bias – specifically for fearful stimuli: the study had to assess neuronal responses to attentional bias paradigms (e.g., The Dot Probe Task – DPT; The Exogenous Cueing Task – ECT; The Emotional Stroop Task – EST; The Negative Affective Priming Task - NAPT).

Included studies were analyzed for the following exclusion criteria: (5) repeated data: overlapping data across studies; (6) methodological issues: studies including tasks with an inadequate design for ERP analysis or reporting low signal-to-noise ratio; (7) missing data: studies not describing the sample size or the direction of the results.

2. Data extracted

2.1. Sample and subgroup characteristics

Anxiety groups' codification was made considering the following anxiety-related disorders: generalized anxiety disorder; separation anxiety disorder; social anxiety disorder; specific phobia; selective mutism; panic disorder; agoraphobia; posttraumatic stress disorder; and obsessive-compulsive disorder (DSM-5; American Psychiatric Association, 2013). These anxiety syndromes were also framed within the HiTOP Internalizing Spectrum, namely in the Fear and Distress subdimensions (Kotov et al., 2017). The experimental group included clinical and subclinical samples, depending on the existence of a clinical diagnosis (e.g., DSM) or the assessment of anxiety symptoms based on non-clinical instruments (e.g., self-report measures), respectively.

2.2. Task and study characteristics

Tasks were coded regarding the standardized nomenclature (Dot Probe Task, Emotional Stroop Task, Oddball Paradigm, Eriksen Flanker Task, Cue Reactivity Task, Affective processing tasks), and the stimulus type (Neutral, Positive, Negative).

Affective processing tasks involved the emotional processing of the stimulus, i.e., tasks where participants passively viewed pictures with emotional content (e.g., faces displaying emotions), passively read words (e.g., trauma-related words, neutral words), or had to identify the emotion portrayed in faces (e.g., angry faces, sad faces, neutral faces).

Negative stimuli were further categorized as Relevant, Fear/Threat, or Unpleasant stimuli. Relevant stimuli referred to stimuli related to the diagnosis/symptoms of the experimental group (e.g., OCD-related threat words, spider pictures, war-related words). Fear/Threat stimuli included life-threatening or feared pictures/words/faces that were not disorder-relevant (e.g., pictures of physical assault, mutilated bodies, predators, angry faces). Unpleasant stimuli designated disgusting/repulsive stimuli (e.g., poor hygiene, repulsive animals, faces displaying disgust), and sad stimuli (e.g., sad faces).

Positive stimuli included, for example, happy faces, cute animals, and babies. Neutral stimuli included neutral words (e.g., hydrant, carpet) or neutral pictures (e.g., household items, flowers, neutral human faces).

2.3. P3 and LPP amplitudes (time-domain analysis)

P3 and LPP amplitudes (mean and standard deviation) observed in control and experimental groups, as t and p -values of between-group effects, were coded regarding each sample and condition. The amplitudes referred to the electrode topographical region in which the amplitude difference between-groups was maximal (frontal, central, parietal, and occipital). Missing information was requested from corresponding authors. A total of 40 authors were contacted (response rate providing the requested data = 32.5%).

The functional significance of the P3 and the LPP was coded as higher amplitudes reflecting an increased allocation of attentional resources to the stimulus.

3. Data analysis

Since the purpose of the present study is to explore the attentional bias in P3 and LPP amplitudes modulation across the anxiety spectrum, three meta-analyses were conducted for different categories of stimuli (neutral, positive, and negative). All effect sizes were computed from random-effects models, using the Comprehensive Meta-Analysis software (CMA 3.0; Biostat, USA).

Hedges' g (Hedges, 1981) was used to estimate the effect sizes. Effect sizes were coded such that a positive g indicated that the anxiety group exhibited enhanced P3 and LPP amplitudes, while a negative g indicated reduced P3 and LPP amplitudes in this group compared to controls.

Recent meta-analytical normative guidelines for interpreting results in the individual differences research field (Funder & Ozer, 2019; Gignac & Szodorai, 2016) propose the following classification for correlational-based effect sizes: small ($r \geq .10$), medium ($r \geq .20$), and large ($r \geq .30$). Like previous meta-analytic studies from our laboratory, these cut-off values were converted to between-group effect sizes using the formulas provided by Rosenthal (1994) to allow for comparability across analyses. Thus, for group-based analyses, effect sizes were labelled as small ($g = 0.20$), medium ($g = 0.41$), and large ($g = 0.63$).

The variability between studies, i.e., the differences in effect sizes that are caused by other factors than chance (sampling error), was analyzed on overall effect sizes using the Q (Cochran, 1954) and the I^2 statistic (Higgins et al., 2003).

To examine which factors may be accounting for the main effect sizes, we conducted moderation analysis using the categorical variables of interest, namely: ERP (P3, LPP);

Sample (community-dwelling, clinical); Medication (yes, no); Comorbidity (yes, no); Task (Affective Processing, Dot Probe Task, Emotional Stroop Task, Oddball Paradigm, Cue Reactivity Task, Eriksen Flanker Task); Electrode Topographical Region (all, central, centroparietal, frontal, parietooccipital, frontocentral, parietal); ERP measure (mean, peak amplitude); HiTOP Internalizing Spectrum (Fear, Distress). In this sense, categorical variables were coded as level-statistical factors to examine the level-wise significance of these moderators. A meta-regression was conducted for age and percentage of females as continuous variables reflecting the differences between groups. These procedures were only conducted for negative stimuli as neutral and positive stimuli were not the focus of the current meta-analysis, only acting as a point of comparison to see if attentional bias would be specific or not to threatful stimuli.

Lastly, the Eggers's regression intercept (Egger et al., 1997) was used to calculate the publication bias.

Results

1. Search Results

A total of 684 non-duplicated studies were found (figure 1). After the screening by title and abstract, 251 out of topic records were removed, and the remaining studies ($n = 433$) were assessed for eligibility criteria (abstract + full text). Thirty-five articles did not comply with criteria 1 (experimental study), 67 with criteria 2 (ERP), 202 with criteria 3 (anxiety assessment), and 88 with criteria 4 (attentional bias paradigms). The remaining 41 studies were assessed for exclusion criteria (full text). One study was removed by criteria 5 (repeated data), and 11 were excluded by criteria 7 (missing data) because the authors did not provide the requested data (e.g., mean and standard deviations were not reported or the direction of the results was not clear).

Twenty-nine articles were retrieved for the quantitative analysis, representing a total of 32 studies (Table 1 and Figure 1). Articles' publication year ranged from 1996 to 2020.

Figure 1

PRISMA flow diagram

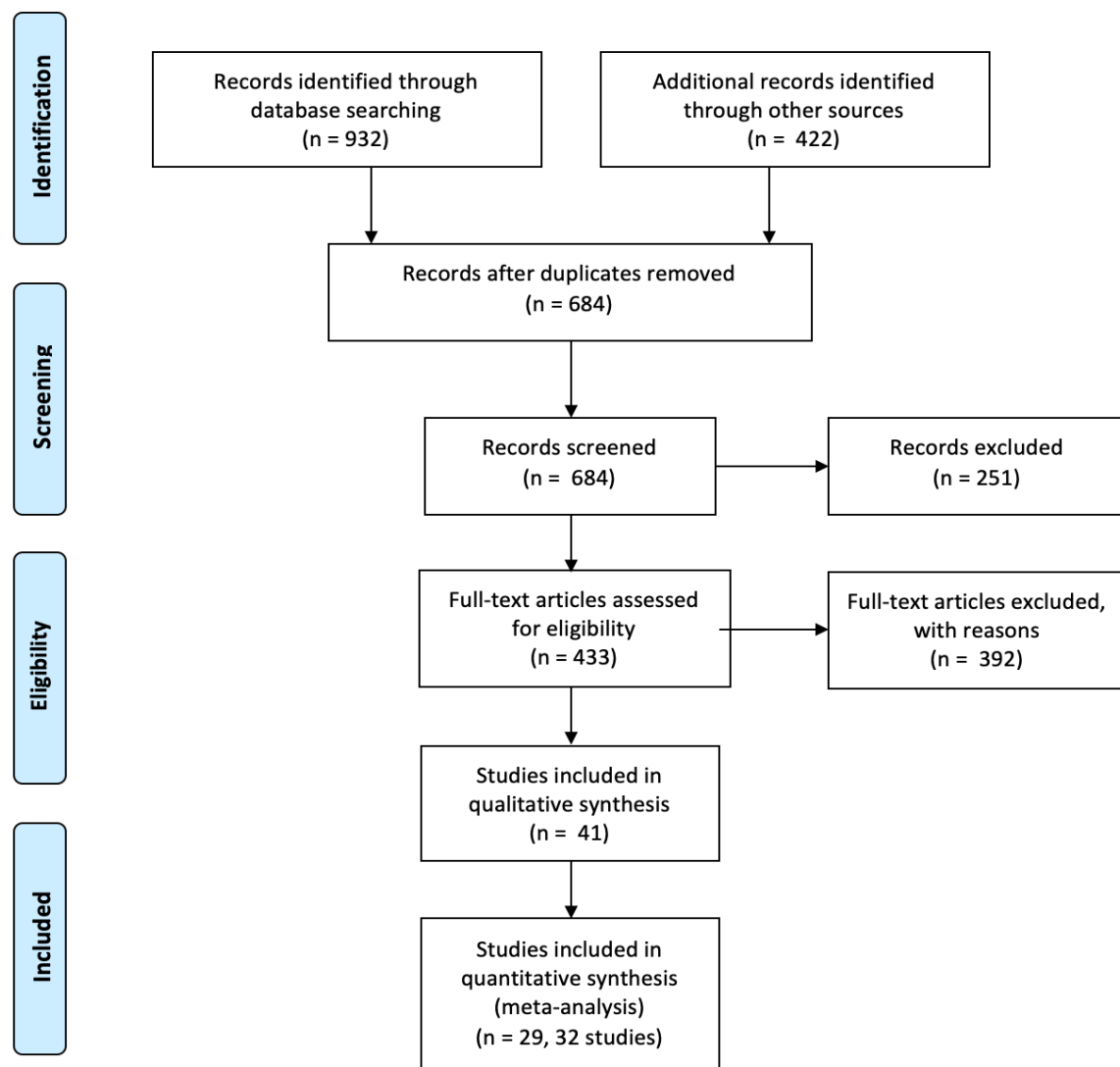


Table 1*Characteristics of the included studies*

	HiTOP Internalizing Subfactors	n	Females (%)	Mean sample age	Sample	Measure	Task	ERP	Medication	Comorbidity
Attias et al. (1996)	Distress	40	0	—	Clinical	DSM	Oddball Paradigm	P3	No	—
Metzger et al. (1997)	Distress	19	52.6	34.21	Clinical	DSM	Emotional Stroop Task	P3	No	Yes
Pauli et al. (1997)	Fear	30	73.(3)	35.4	Clinical	DSM	Affective processing	P3 LPP	Yes	—
Blomhoff et al. (1998)	Distress	20	70	44.01	Community- dwelling	DSM	Oddball Paradigm	P3	—	Yes
Kolassa et al. (2005) - Spider phobics	Fear	38	50	23.20	Community- dwelling	DSM	Emotional Stroop Task	P3 LPP	No	No
Kolassa et al. (2005) -Social phobics	Fear	37	48.65	23.20	Community- dwelling	DSM	Emotional Stroop Task	P3 LPP	No	No
Moser et al. (2008)	Fear	42	61.90	—	Community- dwelling	SPI	Eriksen Flanker task	P3/LPP	—	—
Schienze et al. (2008)	Fear	36	100	25.70	Clinical	DSM	Affective processing	P3 LPP	—	—
Michalowski et al. (2009)	Fear	43	69.77	—	Community- dwelling	SPQ	Affective processing	LPP	—	—
Leutgeb et al. (2009) – Training group	Fear	42	100	25.14	Clinical	DSM	Affective processing	P3 LPP	No	No
Leutgeb et al. (2009) – Waiting group	Fear	43	100	26.66	Clinical	DSM	Affective processing	P3 LPP	No	No

	HiTOP Internalizing Subfactors	n	Females (%)	Mean sample age	Sample	Measure	Task	ERP	Medication	Comorbidity
MacNamara and Hajcak (2010)	Distress	30	80	32.63	Community-dwelling	DSM	Affective processing	LPP	No	Yes
Leutgeb et al. (2010)	Fear	28	100	10.(6)	Community-dwelling	DSM	Affective processing	P3 LPP	No	—
Weinberg et al. (2011)	Distress	46	71.76	30.25	Community-dwelling	DSM	Affective processing	LPP	—	Yes
Leutgeb et al. (2011)	Fear	36	100	26.95	Community-dwelling	DSM	Affective processing	LPP	No	No
Scharmüller et al. (2011)	Fear	45	100	26.53	Clinical	DSM	Affective processing	P3 LPP	—	No
Grasso and Simons (2012)	Distress	38	63.20	13.49	Clinical	K-SADS-PL	Oddball Paradigm	LPP	—	Yes
Fan et al. (2014)	Fear	60	43.(3)	21.01	Clinical	DSM	Emotional Stroop Task	P3	No	—
Leutgeb et al. (2014)	Fear	40	100	22.30	Clinical	DSM	Dot Probe Task	P3	No	—
Weinberg et al. (2016)	—	83	63.20	44.04	Clinical	DSM	Affective processing	LPP	—	Yes
Zhang et al. (2017)	Fear	32	25	25.85	Clinical	DSM	Emotional Stroop Task	P3 LPP	—	—
Shah et al. (2018)	Distress	36	0	34.01	Clinical	PSDC-CV	Dot Probe Task	P3	Yes	Yes
Dayan-Riva et al. (2018)	Fear	76	73.68	23.82	Community-dwelling	OCI-R	Oddball Paradigm	P3	No	—
Zhang et al. (2018)	Distress	45	44.(4)	19.76	Community-dwelling	TAI	Dot Probe Task	LPP	—	—
Kim et al. (2018)	Fear	43	30.23	25.03	Clinical	CTQ-SF	Cue reactivity task	LPP	Yes	—
Sandre et al. (2018)	Distress	76	84.52	20.81	Community-dwelling	DSM	Affective Processing	LPP	—	—
Bechor et al. (2018)	—	42	40.48	11.48	Clinical	DSM	Dot Probe Task	P3	Yes	Yes

	HiTOP Internalizing Subfactors	n	Females (%)	Mean sample age	Sample	Measure	Task	ERP	Medication	Comorbidity
Keil et al. (2018) – Social anxious	Fear	65	42.55	11.76	Community- dwelling	K-DIPS	Affective Processing	LPP	–	Yes
Keil et al. (2018) – Mixed anxious	–	65	42.55	11.76	Community- dwelling	K-DIPS	Affective Processing	LPP	–	Yes
Klein et al. (2019)	Distress	78	73.06	17.31	Clinical	DSM	Affective Processing	P3 LPP	Yes	–
Yuan et al. (2019)	Fear	38	73.68	22.32	Community- dwelling	LSAS	Dot Probe Task	P3	–	–
Letkiewicz et al. (2020)	Distress	52	59.48	34.62	Community- dwelling	CTQ-SF	Emotional Stroop Task	LPP	–	Yes

Note. CTQ-SF: Childhood Trauma Questionnaire – Short Form; K-DIPS: Kinder – Diagnostisches Interview bei Psychischen Störungen; K-SADS-PL: Kiddie Schedule for Affective Disorders – Present and Lifetime Version; OCI-R: Obsessive Compulsive Inventory – Revised; PSDC-CV: Posttraumatic Stress Disorder Checklist - Civilian Version; SPQ: Spider Phobia Questionnaire; SPI: Social Phobia Inventory; TAI: Test Anxiety Inventory; LSAS: Leibowitz Social Anxiety Scale.

2. Sample characteristics

A total of 32 studies involving 1,372 participants (63.74% females, $M_{\text{age}} = 22.33$) were analyzed to test P3 and LPP amplitudes differences between anxious individuals ($n = 722$) and controls ($n = 650$). Of the included studies, 16 were recruited from clinical settings and 16 from the community. DSM-based interviews and questionnaires were the most frequently used to assess participants' anxiety symptoms ($n = 22$), followed by the Childhood Trauma Questionnaire – Short Form ($n = 2$), the Kinder – Diagnostisches Interview bei Psychischen Störungen ($n = 1$), the Leibowitz Social Anxiety Scale ($n = 1$), the Kiddie Schedule for Affective Disorders – Present and Lifetime Version ($n = 1$), the Obsessive Compulsive Inventory – Revised ($n = 1$), the Posttraumatic Stress Disorder Checklist - Civilian Version ($n = 1$), the Spider Phobia Questionnaire ($n = 1$), the Social Phobia Inventory ($n = 1$), and the Test Anxiety Inventory ($n = 1$).

Posttraumatic Stress Disorder ($n = 8$) and Spider Phobia ($n = 8$) were the most frequent anxious-related disorders, followed by Social Anxiety Disorder ($n = 4$), Obsessive-Compulsive Disorder ($n = 4$), Generalized Anxiety Disorder ($n = 2$), non-specified anxiety symptoms ($n = 3$), Test Anxiety ($n = 1$), Panic Disorder ($n = 1$), and Dental Phobia ($n = 1$). Regarding the HiTOP Internalizing Spectrum, 17 studies were included in the Fear factor, 12 in the Distress factor, and three did not fit the previous factors. Affective processing paradigms were the most frequently used tasks ($n = 15$) to assess attentional bias to threat, followed by the Emotional Stroop Task ($n = 6$), the Dot Probe Task ($n = 5$), the Oddball Paradigm ($n = 4$), the Eriksen Flanker Task ($n = 1$), and the Cue Reactivity Task ($n = 1$). Of the 32 studies included, 12 measured LPP amplitudes, nine measured P3 amplitudes, and 11 measured both ERPs.

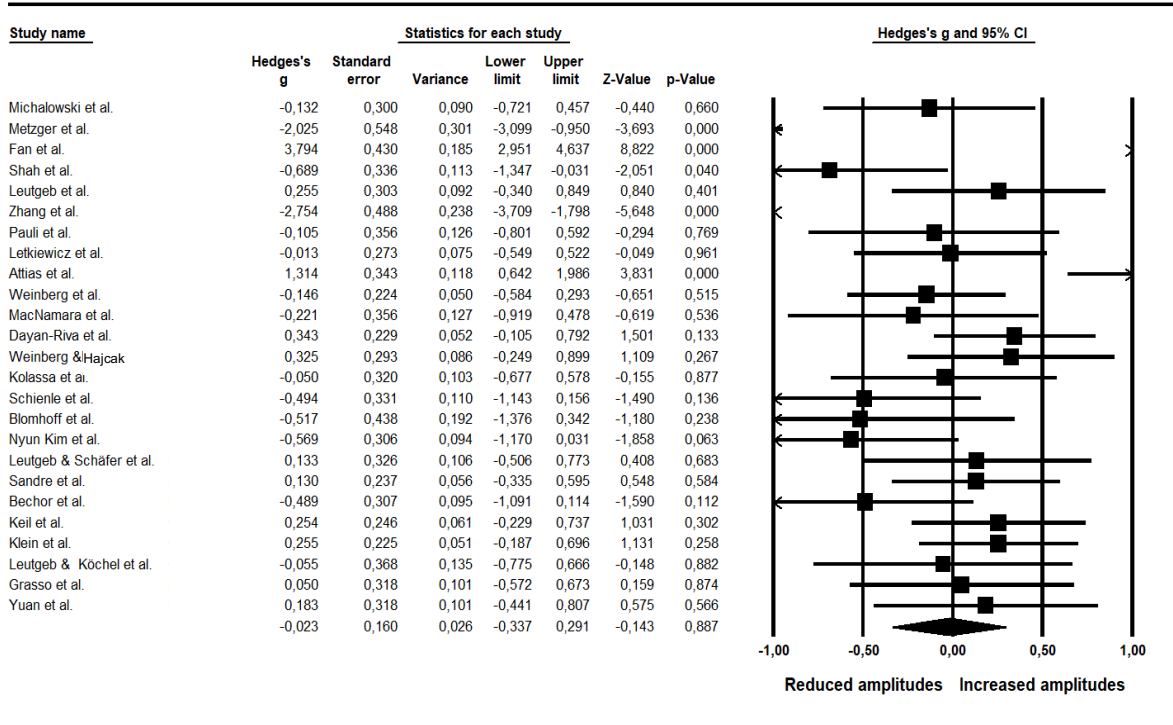
3. Overall Effect

3.1. Neutral Stimuli

A total of 42 effects were included in the estimation of the meta-analytical overall effect for the neutral stimuli (Figure 2). The overall effect was not statistically significant, $g = -0.023$, CI 95% $[-0.337, 0.291]$, $p = .887$. The overall effect was affected by significant heterogeneity, $Q(24) = 160.0$, $p < .001$, $I^2 = 85.0$. No evidence for publication bias was found on the overall effect, $b = -2.30$, $p = .354$.

Figure 2

Neutral Stimuli: Forest Plot

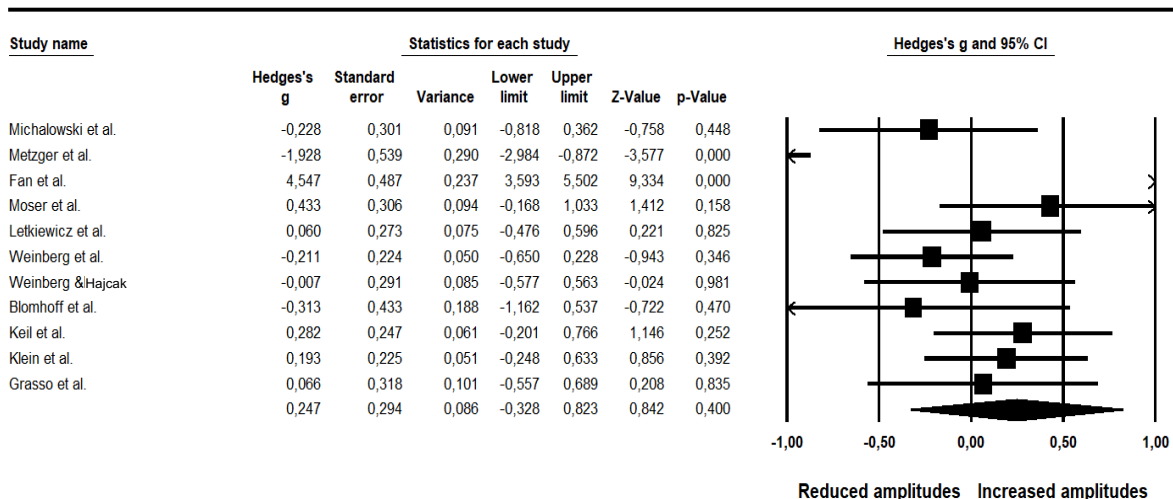


3.2. Positive Stimuli

A total of 13 effects were included in the estimation of the meta-analytical overall effect for the positive stimuli (Figure 3). The overall effect was not statistically significant, $g = 0.247$, CI 95% $[-0.328, 0.823]$, $p = .400$. The overall effect was affected by significant heterogeneity, $Q(10) = 103.3$, $p < .001$, $I^2 = 90.3$. No evidence for publication bias was found on the overall effect, $b = -2.30$, $p = .354$.

Figure 3

Positive Stimuli: Forest Plot



3.3. Negative Stimuli

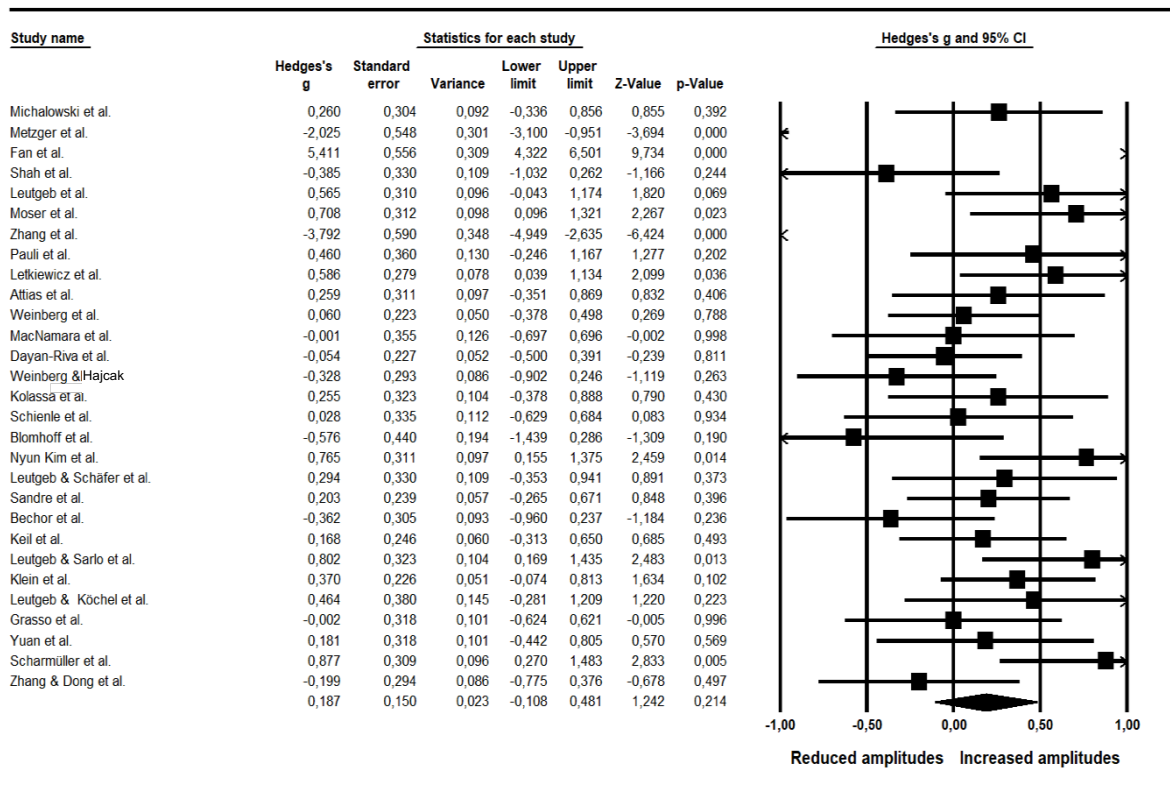
A total of 75 effects were included in the estimation of the meta-analytical overall effect for the negative stimuli. Despite the expected positive direction of the results (Figure 4), the overall effect was not statistically significant, $g = 0.87$, CI 95% $[-0.108, 0.481]$, $p = .214$.

When equating the subgroups in the model (relevant, unpleasant, threat/fear stimuli), we observed a small to medium effect in the relevant subcondition, $g = 0.344$, CI 95% $[0.06, 0.63]$, $p = .019$, but not in other subconditions (Fear/Threat: $g = 0.023$, CI 95% $[-0.26, 0.30]$, $p = .875$; Unpleasant: $g = 0.171$, CI 95% $[-0.07, 0.42]$, $p = .169$).

The overall effect was affected by significant heterogeneity, $Q(28) = 186.7$, $p < .001$, $I^2 = 85.4$. No evidence for publication bias was found on the overall effect, $b = -0.57$, $p = .801$.

Figure 4

Negative Stimuli: Forest Plot



4. Moderation Analyses

A meta-regression revealed that percentage of females, $b = 0.84$, CI 95% $[-0.49, 2.17]$, $p = .216$, and age, $b = -0.02$, CI 95% $[-0.06, 0.02]$, $p = .246$, did not impact the overall results.

Moderation analyses in the negative stimuli effects (Table 2) showed that medication (presence or absence) moderated the findings. Even though no effect was found for the medicated samples, a medium to large effect was found for unmedicated samples. Likewise, comorbidity (presence or absence) moderated the findings: though a medium effect was found in samples without comorbidities, no effect was found for samples with comorbidities.

The findings were moderated by the type of task implemented: a small to medium effect was found for Affective Processing Tasks only. The sample type also moderated the findings: while no effect was found for clinical samples, a small effect was found for community-dwelling samples.

ERP type (P3, LPP) and ERP measure (mean or peak amplitudes) did not moderate findings, but the topographical region from where the P3 and LPP were extracted did. While a large negative effect was found for P3 and LPP amplitudes averaged from frontocentral electrodes (only two samples included), a small to medium positive effect was found for P3 and LPP amplitudes averaged from parietal electrodes. P3 and LPP amplitudes averaged from all electrodes, central electrodes, centroparietal electrodes, frontal electrodes (only one sample included), and parietooccipital electrodes did not reveal significant effects.

Finally, the HiTOP Internalizing Spectrum moderated findings: while no effect was found for the Distress Subfactor, a small effect was found for the Fear factor.

Table 2

Moderator analysis statistics (Hedges' g, Confidence Interval – 95%, and p-value)

Moderator	Category	Hedges' g	Confidence Interval - 95%		p-Value
			Lower limit	Upper limit	
ERP Type	P3	0.191	- 0.11	0.49	.208
	LPP	0.170	- 0.04	0.30	.110
Sample Type	Community-dwelling	0.214	0.08	0.35	.002
	Clinical	0.123	- 0.17	0.41	.405

Moderator	Category	Hedges' g	Confidence Interval - 95%		p-Value
			Lower limit	Upper limit	
Medication	Yes	0.224	- 0.02	0.47	.071
	No	0.470	0.26	0.68	<.001
Comorbidity	Yes	0.177	- 0.49	0.14	.272
	No	0.509	0.20	0.82	<.001
Task Type	Affective Processing Tasks	0.337	0.21	0.46	<.001
	Dot Probe Task	0.226	- 0.16	0.61	.245
	Emotional Stroop Task	- 0.560	- 0.143	0.31	.208
	Oddball Paradigm	- 0.031	-0.32	0.26	.837
	Cue Reactivity Task	0.765	0.16	0.38	.014
	Eriksen Flanker Task	0.708	0.10	1.32	.023
Electrode Topographical Region	All	2.076	0.608	4.76	.129
	Central	- 0.718,	-1.97	0.530	.260
	Centroparietal	- 0.012	- 0.25	0.22	.918
	Frontal	- 0.181	- 0.442	0.805	.569
	Frontocentral	- 4.29	- 5.17	- 3.41	<.001
	Parietooccipital	0.135	-0.117	0.387	.293
ERP Measure	Parietal	0.389	0.255	0.523	<.001
	Mean	0.194	- 0.04	0.43	.106
	Peak	0.093	- 0.15	0.33	.446
HiTOP	Fear	0.250	0.02	0.48	.003
Internalizing Spectrum	Distress	0.011	- 0.20	0.22	.920

Discussion

Behavioral data highlight the importance of attentional bias in anxiety. However, systematic analyses of the literature are scarcer when examining the brain correlations of attentional bias in anxiety. For instance, there is no clear evidence in favor or against an attentional bias to threat considering the alterations on P3 and LPP amplitudes across the anxiety spectrum. The present meta-analytic study aimed to address this gap in the literature. Given the existing behavioral meta-analytic studies, we hypothesized anxious groups would show a different pattern of P3 and LPP modulation comparing to controls. A meta-analytic analysis was then conducted across 32 studies, with a total of 1,372 participants. Overall effects were calculated for each stimulus category (neutral, positive, and negative) while also considering important moderators.

1. Overall effect

The overall effect was not statistically significant for the neutral, positive, or negative conditions. Therefore, P3 and LPP amplitudes did not differ across anxious groups and controls, which could suggest the lack of an attentional bias to threat in anxiety. However, when considering the negative stimuli and their subcategories, a small to medium positive effect was found for the disorder-relevant stimuli, reflecting higher P3 and LPP amplitudes compared to the non-anxious sample. Thus, anxious subjects showed an attentional bias when the negative stimulus was disorder-congruent. The specificity of this effect partly corroborates our hypothesis, since it shows that the P3 and LPP amplitudes in response to such stimuli are modulated by the presence of an anxiety-related disorder. This also suggests that anxious individuals allocate more attention resources at later stages of threat-relevant content processing.

This finding is in line with previous research (for a review, see Pergamin-Hight, 2015) supporting the importance of personally relevant threat information to the onset of an attentional bias in the anxious population. It also supports the role of schema-driven processing threat-bias in anxiety (e.g., Bar-Haim et al., 2007; Beck & Clark, 1997; Mogg & Bradley, 1998). Moreover, these results moderately support the delayed disengagement theory (Fox, 2001; 2002) since heightened P3 and LPP amplitudes reflect late stages of stimulus processing. Therefore, the present findings are consistent with the notion that anxious participants have difficulties in disengaging attention away from personal threat-related stimuli, which is thought to be a core mechanism of anxiety disorders (Fox, 2001). Furthermore, since the P3 and LPP are sensitive to the processing of emotionally salient stimuli (Harrewijn et al., 2017), increased amplitudes could suggest deficits in attentional control, secondary to impaired “top-down” processing (Cisler & Koster, 2010; Shi et al., 2019), as theorized by Attention Control Theory (Eysenck et al., 2007). Inversely, results do not support the Emotionality Hypothesis (Martin et al., 1991), since the effect was specific to negative stimuli and not to positive ones.

2. Moderators

The type of sample moderated the findings, revealing a small positive effect for community-dwelling samples. Specifically, subjects without a prior diagnosis showed

higher P3 and LPP amplitudes for negative stimuli. It can be theorized that non-diagnosed anxious samples are likely to be treatment-naïve, i.e., not subject to pharmacological or psychological interventions, which in turn might impact the degree of the attentional bias to threat and ERP modulations. That being the case, medication and psychological interventions (e.g., Attention Bias Modification Treatment; Eye Movement Desensitization and Reprocessing Therapy; Cognitive Behavioral Therapy) may lessen the attentional bias shown by anxious individuals (Bandelow et al., 2015; Khoury-Malhame et al., 2011; Mogg & Bradley, 2018). In fact, our results revealed a medium to large positive effect for medication-free samples. According to the aforementioned, pharmacological interventions could diminish the anxiety symptoms and the attentional bias to threatful stimuli with them. Such hypothesis is supported by studies demonstrating that anxiety medication is effective in reducing anxiety symptoms (Bandelow et al., 2015), and since attentional bias to threat is thought to be a core mechanism of anxiety, it might be eased by pharmacological interventions.

The absence of comorbidities also moderated the findings, revealing a medium positive effect. Since the presence of comorbidities mitigates the attentional bias, this strengthens the above arguments. Depression is highly comorbid with anxiety disorders (Groen et al., 2020), and no attentional bias is reported in depression and comorbid conditions (for a review see Rogers, 2020).

The task type moderated findings, demonstrating a small to medium positive effect for the affective processing tasks. This may suggest that when a task does not recruit substantial cognitive resources other than processing the stimulus, subjects can pay undivided attention to it, focusing more on the emotional valence of the stimulus. This explanation remains to be tested in further studies.

ERPs extracted from frontocentral and parietal electrodes revealed a large negative effect and a small positive effect, respectively. Hence, P3 and LPP amplitudes were highest at parietal electrodes and smallest at frontocentral electrodes. Indeed, research states that the P3 and LPP can be found across centroparietal and frontocentral regions (Harrewijn et al., 2017; Luck & Kappenman, 2011; Polich, 2007).

Finally, the Fear dimension of HiTOP Internalizing Spectrum had a small positive effect on P3 and LPP amplitudes. Therefore, the attentional bias to threat may not be a transdiagnostic biomarker across all anxiety dimensions (Garland & Howard, 2014), but rather a more fine-grained transdiagnostic biomarker for anxiety-related disorders included in the HiTOP Fear dimension (e.g., phobia, panic disorder, OCD). This finding

may be of great importance for the treatment of anxiety disorders included in the Fear dimension, suggesting that Attention Bias Modification Treatments targeting relevant-threatful stimuli may be more effective. Since attentional bias, fear, and anxiety have a bidirectional relationship, it is plausible to expect that intervening on the first will ameliorate the symptoms of anxiety (Van Bockstaele et al., 2014).

3. Limitations, recommendations, and future directions

The current study has some limitations that should be acknowledged. First, even though the literature search was exhaustive and no publication bias was found, some unpublished studies or non-included in online databases may have been missed.

Second, the studies included in the meta-analytic review varied significantly in the P3 and LPP time windows, which in turn may jeopardize the functional interpretation of these ERPs (e.g., differences between early LPP and late LPP). Future studies should address this limitation, and focus on a common criterion to analyze the time windows of these brain potentials, to reach a satisfactory homogeneity across the field.

Third, the samples of the reviewed studies did not include enough children/adolescents nor elderly subjects, restraining the interpretation of our results to young and middle-aged adults. Future studies should address this gap, as developmental aspects can be an interesting input in how we conceptualize threat bias in anxiety-related disorders.

Lastly, anxiety conceptualization has changed in recent years, and so has the diagnostic criteria for anxiety disorders (CID, DSM) (Stein, 2014). This might have influenced the threshold of the number/severity of symptoms needed to be included in the clinical samples, given that most research uses these criteria to select participants. For instance, a between-group design was used to code clinical/subclinical and control groups. This classification of included samples may not be in agreement with how anxiety is currently conceptualized: a spectrum of symptoms with a normal distribution across the population, in which levels of severity vary (Kotov et al., 2017). Therefore, future studies should conduct correlational analysis to reliability estimate the full range continuum of the anxiety spectrum and its associations with ERP measures.

Conclusion

The current meta-analysis examined attentional bias mechanisms across the anxiety spectrum, at late processing-stages of threat-relevant stimuli. Our findings suggest that anxious individuals show enhanced P3 and LPP amplitudes for negative relevant stimuli, reflecting the role of anxiety in the modulation of these ERPs. Specifically, anxious individuals seem to allocate more attentional resources towards disorder-congruent negative stimuli. Upcoming empirical research should attempt to replicate these findings by exploring the attentional bias to relevant threat in comparison to non-relevant threat while controlling the shared variance between anxiety subdimensions included in the Fear dimension of the HiTOP Internalizing Spectrum.

References

- American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). <https://doi.org/10.1176/appi.books.9780890425596>
- Amso, D., & Scerif, G. (2015). The attentive brain: insights from developmental cognitive neuroscience. *Nat Rev Neurosci*, 16(10), 606–619. <https://doi.org/10.1038/nrn4025>
- Armstrong, T., & Olatunji, B. O. (2012). Eye tracking of attention in the affective disorders: A meta-analytic review and synthesis. In *Clinical Psychology Review* (Vol. 32, Issue 8). <https://doi.org/10.1016/j.cpr.2012.09.004>
- *Attias, J., Bleich, A., Furman, V., & Zinger, Y. (1996). Event-Related Potentials in Post-Traumatic Stress Disorder of Combat Origin. *Biological Psychiatry*, 40(5), 373–381. [https://doi.org/10.1016/0006-3223\(95\)00419-X](https://doi.org/10.1016/0006-3223(95)00419-X)
- Bandelow, B., Reitt, M., Röver, C., Michaelis, S., Görlich, Y., & Wedekind, D. (2015). Efficacy of treatments for anxiety disorders: A meta-analysis. *International Clinical Psychopharmacology*, 30(4), 183–192. <https://doi.org/10.1097/YIC.0000000000000078>
- Bar-Haim, Y., Lamy, D., Pergamin, L., Bakermans-Kranenburg, M. J., & Van Ijzendoorn, M. H. (2007). Threat-related attentional bias in anxious and nonanxious individuals: A meta-analytic study. *Psychological Bulletin*, 133(1), 1–24. <https://doi.org/10.1037/0033-2909.133.1.1>
- *Bechor, M., Ramos, M. L., Crowley, M. J., Silverman, W. K., Pettit, J. W., & Reeb-Sutherland, B. C. (2019). Neural Correlates of Attentional Processing of Threat in Youth with and without Anxiety Disorders. *Journal of Abnormal Child Psychology*, 47(1), 119–129. <https://doi.org/10.1007/s10802-018-0424-8>
- Beck, A. T., & Clark, D. A. (1997). An information processing model of anxiety: Automatic and strategic processes. *Behaviour Research and Therapy*, 35(1), 49–58. [https://doi.org/10.1016/S0005-7967\(96\)00069-1](https://doi.org/10.1016/S0005-7967(96)00069-1)
- Beesdo, K., Knappe, S., & Pine, D. S. (2009). Anxiety and Anxiety Disorders in Children and Adolescents: Developmental Issues and Implications for DSM-V. *Psychiatric Clinics of North America*, 32(3), 483–524. <https://doi.org/10.1016/j.psc.2009.06.002>
- Bishop, S. J. (2008). Neural Mechanisms Underlying Selective Attention to Threat. *Annals of the New York Academy of Sciences*, 1129, 141–152.

<https://doi.org/10.1196/annals.1417.016>

- *Blomhoff, S., Reinvang, I., & Malt, U. F. (1998). Event-Related Potentials to Stimuli with Emotional Impact in Posttraumatic Stress Patients. *Biological Psychiatry*, 44(10), 1045–1053. [https://doi.org/10.1016/S0006-3223\(98\)00058-4](https://doi.org/10.1016/S0006-3223(98)00058-4)
- Brotman, M. A., Rich, B. A., Schmajuk, M., Reising, M., Monk, C. S., Dickstein, D. P., Mogg, K., Bradley, B. P., Pine, D. S., & Leibenluft, E. (2007). Attention Bias to Threat Faces in Children with Bipolar Disorder and Comorbid Lifetime Anxiety Disorders. *Biological Psychiatry*, 61(6), 819–821. <https://doi.org/10.1016/j.biopsych.2006.08.021>
- Buodo, G., Sarlo, M., Codispoti, M., & Palomba, D. (2006). Event-related potentials and visual avoidance in blood phobics: is there any attentional bias? *Depression and Anxiety*, 23, 304–311. <https://doi.org/10.1002/da.20172>
- Cisler, J. M., Bacon, A. K., & Williams, N. L. (2009). Phenomenological Characteristics of Attentional Biases Towards Threat: A Critical Review. *Cognit Ther Res*, 33(2), 221–234. <https://doi.org/10.1007/s10608-007-9161-y>
- Cisler, J. M., & Koster, E. H. W. (2010). Mechanisms of attentional biases towards threat in anxiety disorders: An integrative review. *Clinical Psychology Review*, 30(2), 203–216. <https://doi.org/10.1016/j.cpr.2009.11.003>
- Cochran, W. G. (1954). The Combination of Estimates from Different Experiments. *Biometrics*, 10(1), 101–129.
- Craske, M. G., Rauch, S. L., Ursano, R., Prenoveau, J., Pine, D. S., & Zinbarg, R. E. (2009). What is an anxiety disorder? *Depression and Anxiety*, 26(12), 1066–1085. <https://doi.org/10.1002/da.20633>
- *Dayan-Riva, A., Berger, A., & Anholt, G. E. (2018). Early cognitive processes in OCD: An ERP study. *Journal of Affective Disorders*, 246, 429–436. <https://doi.org/10.1016/j.jad.2018.12.109>
- Dennis-Tiway, T. A., Roy, A. K., Denefrio, S., & Myruski, S. (2019). Heterogeneity of the Anxiety-Related Attention Bias: A Review and Working Model for Future Research. *Clinical Psychological Science*, 7(5), 879–899. <https://doi.org/10.1177/216770261983847>
- Dudeney, J., Sharpe, L., & Hunt, C. (2015). Attentional bias towards threatening stimuli in children with anxiety: A meta-analysis. *Clinical Psychology Review*, 40, 66–75. <https://doi.org/10.1016/j.cpr.2015.05.007>
- Egger, M., Smith, G. D., Schneider, M., & Minder, C. (1997). Bias in meta-analysis

- detected by a simple, graphical test. Graphical test is itself biased. *BMJ*, 315(7109), 629–634. <https://doi.org/10.1136/bmj.315.7109.629>
- Eysenck, M. W., Derakshan, N., Santos, R., & Calvo, M. G. (2007). Anxiety and Cognitive Performance: Attentional Control Theory. *Emotion*, 7(2), 336–353. <https://doi.org/10.1037/1528-3542.7.2.336>
- *Fan, J., Zhong, M., Zhu, X., Lei, H., Dong, J., Zhou, C., & Liu, W. (2014). An attentional inhibitory deficit for irrelevant information in obsessive-compulsive disorder: Evidence from ERPs. *International Journal of Psychophysiology*, 94, 420–426. <https://doi.org/10.1016/j.ijpsycho.2014.11.002>
- Felmingham, K. L., Stewart, L. F., Kemp, A. H., & Carr, A. R. (2016). The impact of high trait social anxiety on neural processing of facial emotion expressions in females. *Biological Psychology*, 117, 179–186. <https://doi.org/10.1016/j.biopsycho.2016.04.001>
- Fox, E., Russo, R., Bowles, R., & Dutton, K. (2001). Do threatening stimuli draw or hold visual attention in subclinical anxiety? *Journal of Experimental Psychology: General*, 130(4), 681–700. <https://doi.org/10.1037/0096-3445.130.4.681>
- Fox, E., Russo, R., & Dutton, K. (2002). Attentional bias for threat: Evidence for delayed disengagement from emotional faces. *Cognition and Emotion*, 16(3), 355–379. <https://doi.org/10.1080/02699930143000527>
- Fu, X., & Perez-Edgar, K. (2019). Threat-related attention bias in socioemotional development: A critical review and methodological considerations. *Developmental Review*, 51, 31–57. <https://doi.org/10.1016/j.dr.2018.11.002>
- Funder, D. C., & Ozer, D. J. (2019). Evaluating Effect Size in Psychological Research: Sense and Nonsense. *Advances in Methods and Practices in Psychological Science*, 2(2), 156–168. <https://doi.org/10.1177/2515245919847202>
- Garland, E. L., & Howard, M. O. (2014). A Transdiagnostic Perspective on Cognitive, Affective, and Neurobiological Processes Underlying Human Suffering. *Research on Social Work Practice*, 24(1), 142–151. <https://doi.org/10.1177/1049731513503909>
- Gignac, G. E., & Szodorai, E. T. (2016). Effect size guidelines for individual differences researchers. *Personality and Individual Differences*, 102, 74–78. <https://doi.org/10.1016/j.paid.2016.06.069>
- *Grasso, D. J., & Simons, R. F. (2012). Electrophysiological responses to threat in youth with and without Posttraumatic Stress Disorder. *Biological Psychology*, 90(1), 88–

96. <https://doi.org/10.1016/j.biopsycho.2012.02.015>
- Groen, R. N., Ryan, O., Wigman, J. T. W., Riese, H., Penninx, B. W. J. H., Giltay, E. J., Wichers, M., & Hartman, C. A. (2020). Comorbidity between depression and anxiety: assessing the role of bridge mental states in dynamic psychological networks. *BMC Medicine*, *18*, 1–17. <https://doi.org/10.1186/s12916-020-01738-z>
- Hagemann, J., Straube, T., & Schulz, C. (2016). Too bad: Bias for angry faces in social anxiety interferes with identity processing. *Neuropsychologia*, *84*, 136–149. <https://doi.org/10.1016/j.neuropsychologia.2016.02.005>
- Hakamata, Y., Lissek, S., Bar-Haim, Y., Britton, J. C., Fox, N., Leibenluft, E., Ernst, M., & Pine, D. S. (2010). Attention Bias Modification Treatment: A meta-analysis towards the establishment of novel treatment for anxiety. *Biological Psychiatry*, *68*(11), 982–990. <https://doi.org/10.1016/j.biopsycho.2010.07.021>.
- Harrewijn, A., Schmidt, L. A., Westenberg, P. M., Tang, A., & van der Molen, M. J. W. (2017). Electrocortical measures of information processing biases in social anxiety disorder: A review. *Biological Psychology*, *129*, 324–348. <https://doi.org/10.1016/j.biopsycho.2017.09.013>
- Hedges, L. V. (1981). Distribution Theory for Glass's Estimator of Effect size and Related Estimators. *Journal of Educational Statistics*, *6*(2), 107–128. <https://doi.org/10.3102/10769986006002107>
- Henderson, H. A., Pine, D. S., & Fox, N. A. (2015). Behavioral Inhibition and Developmental Risk: A Dual-Processing Perspective. *Neuropsychopharmacology Reviews*, *40*, 207–224. <https://doi.org/10.1038/npp.2014.189>
- Henderson, H. A., & Wilson, M. L. J. G. (2017). Attention Processes Underlying Risk and Resilience in Behaviorally Inhibited Children. *Current Behavioral Neuroscience Reports*, *4*, 99–106. <https://doi.org/10.1007/s40473-017-0111-z>
- Higgins, J. P. T., Thompson, S. G., Deeks, J. J., & Altman, D. G. (2003). Measuring inconsistency in meta-analysis. *Br. Med. J*, *327*(414), 557–560. <https://doi.org/10.1136/bmj.327.7414.557>
- Insel, T., Cuthbert, B., Garvey, M., Heinssen, R., Pine, D. S., Quinn, K., Sanislow, C., & Wang, P. (2010). Research Domain Criteria (RDoC): Toward a New Classification Framework for Research on Mental Disorders. *Am J Psychiatry*, *167*(7), 748–751. <https://doi.org/10.1176/appi.ajp.2010.09091379>
- *Keil, V., Uusberg, A., Blechert, J., Tuschen-Caffier, B., & Schmitz, J. (2018). Facial gender but not emotion distinguishes neural responses of 10- to 13-year-old children

- with social anxiety disorder from healthy and clinical controls. *Biological Psychology*, 135, 36–46. <https://doi.org/10.1016/j.biopsycho.2018.02.004>
- Khoury-Malhame, M., Lanteaume, L., Beetz, E., Roques, J., Reynaud, E., Samuelian, J., Blin, O., Garcia, R., & Khalfa, S. (2011). Attentional bias in post-traumatic stress disorder diminishes after symptom amelioration. *Behaviour Research and Therapy*, 49, 796–801. <https://doi.org/10.1016/j.brat.2011.08.006>
- *Kim, S. N., Kim, M., Lee, T. H., Lee, J. Y., Park, S., Park, M., Kim, D. J., Kwon, J. S., & Choi, J. S. (2018). Increased attentional bias toward visual cues in internet gaming disorder and obsessive-compulsive disorder: An event-related potential study. *Frontiers in Psychiatry*, 9, 1–9. <https://doi.org/10.3389/fpsyt.2018.00315>
- *Klein, F., Schindler, S., Neuner, F., Rosner, R., Renneberg, B., Steil, R., & Iffland, B. (2019). Processing of affective words in adolescent PTSD-Attentional bias toward social threat. *Psychophysiology*, 56(11), 1–14. <https://doi.org/10.1111/psyp.13444>
- *Kolassa, I., Musial, F., Mohr, A., Trippe, R. H., & Miltner, W. H. R. (2005). Electrophysiological correlates of threat processing in spider phobics. *Psychophysiology*, 42, 520–530. <https://doi.org/10.1111/j.1469-8986.2005.00315.x>
- Kotov, R., Waszczuk, M. A., Krueger, R. F., Forbes, M. K., Watson, D., Clark, L. A., Achenbach, T. M., Althoff, R. R., Ivanova, M. Y., Michael Bagby, R., Brown, T. A., Carpenter, W. T., Caspi, A., Moffitt, T. E., Eaton, N. R., Forbush, K. T., Goldberg, D., Hasin, D., Hyman, S. E., ... Zimmerman, M. (2017). The hierarchical taxonomy of psychopathology (HiTOP): A dimensional alternative to traditional nosologies. *Journal of Abnormal Psychology*, 126(4), 454–477. <https://doi.org/10.1037/abn0000258>
- Lang, P. J., McTeague, L. M., & Bradley, M. M. (2016). RDoC, DSM, and the reflex physiology of fear: A bi-dimensional analysis of the anxiety disorders spectrum. *Psychophysiology*, 53(3), 336–347. <https://doi.org/10.1111/psyp.12462>
- *Letkiewicz, A. M., Sifton, R. L., Mimnaugh, K. J., Miller, G. A., Heller, W., Fisher, J., & Sass, S. M. (2020). Childhood abuse history and attention bias in adults. *Psychophysiology*, 57(10), 1–21. <https://doi.org/10.1111/psyp.13627>
- *Leutgeb, V., Sarlo, M., Schöngassner, F., & Schienle, A. (2014). Out of sight, but still in mind: Electro-cortical correlates of attentional capture in spider phobia as revealed by a “dot probe” paradigm. *Brain and Cognition*, 93, 26–34. <https://doi.org/10.1016/j.bandc.2014.11.005>
- *Leutgeb, V., Schäfer, A., Köchel, A., Scharmüller, W., & Schienle, A. (2010).

- Psychophysiology of spider phobia in 8- to 12-year-old girls. *Biological Psychology*, 85(3), 424–431. <https://doi.org/10.1016/j.biopsycho.2010.09.004>
- *Leutgeb, V., Schäfer, A., & Schienle, A. (2009). An event-related potential study on exposure therapy for patients suffering from spider phobia. *Biological Psychology*, 82, 293–300. <https://doi.org/10.1016/j.biopsycho.2009.09.003>
- *Leutgeb, V., Schäfer, A., & Schienle, A. (2011). Late cortical positivity and cardiac responsivity in female dental phobics when exposed to phobia-relevant pictures. *International Journal of Psychophysiology*, 79(3), 410–416. <https://doi.org/10.1016/j.ijpsycho.2011.01.003>
- Luck, S. J. (2014). *An introduction to the event-related potential technique* (2nd ed.). MIT Press: Cambridge.
- Luck, S. J., & Kappenman, E. S. (2011). The Oxford Handbook of Event-Related Potential Components. In *The Oxford Handbook of Management Information Systems: Critical Perspectives and New Directions*. Oxford University Press, Inc. <https://doi.org/10.1093/oxfordhb/9780199580583.003.0010>
- Macleod, C., Grafton, B., & Notebaert, L. (2019). Anxiety-Linked Attentional Bias : Is It Reliable ? *Annual Review of Clinical Psychology*, 15, 11.1-11.26. <https://doi.org/10.1146/annurev-clinpsy-050718-095505>
- MacLeod, C., Mathews, A., & Tata, P. (1986). Attentional Bias in Emotional Disorders. *Journal of Abnormal Psychology*, 95(1), 15–20. <https://doi.org/10.1037/0021-843X.95.1.15>
- *MacNamara, A., & Hajcak, G. (2010). Distinct electrocortical and behavioral evidence for increased attention to threat in generalized anxiety disorder. *Depression and Anxiety*, 27, 234–243. <https://doi.org/10.1002/da.20679>
- Mansell, W., Harvey, A., Watkins, E. R., & Shafran, R. (2008). Cognitive Behavioral Processes Across Psychological Disorders: A Review of the Utility and Validity of the Transdiagnostic Approach. *International Journal of Cognitive Therapy*, 1(3), 181–191. <https://doi.org/10.1680/ijct.2008.1.3.181>
- Martin, M., Williams, R. M., & Clark, D. M. (1991). Does anxiety lead to selective processing of threat-related information? *Behaviour Research and Therapy*, 29(2), 147–160. [https://doi.org/10.1016/0005-7967\(91\)90043-3](https://doi.org/10.1016/0005-7967(91)90043-3)
- Mathews, A., & Mackintosh, B. (1998). A Cognitive Model of Selective Processing in Anxiety. *Cognitive Therapy and Research*, 22(6), 539–560. <https://doi.org/10.1023/A:1018738019346>

- Mathews, A., & Macleod, C. (1985). Selective processing of threat cues in panic disorder. *Behaviour Research and Therapy*, 23(5), 407–412. [https://doi.org/10.1016/0005-7967\(90\)90160-K](https://doi.org/10.1016/0005-7967(90)90160-K)
- Mathews, A., & Macleod, C. (1994). Cognitive Approaches to Emotion and Emotional Disorders. *Annual Review of Psychology*, 25(1), 25–50. <https://doi.org/10.1146/annurev.ps.45.020194.000325>
- Mathews, A., & MacLeod, C. (2002). Induced processing biases have causal effects on anxiety. *Cognition and Emotion*, 16(3), 331–354. <https://doi.org/10.1080/02699930143000518>
- Mathews, A., & MacLeod, C. (2005). Cognitive vulnerability to emotional disorders. *Annual Review of Clinical Psychology*, 1(February 2005), 167–195. <https://doi.org/10.1146/annurev.clinpsy.1.102803.143916>
- *Metzger, L. J., Orr, S. P., Lasko, N. B., McNally, R. J., & Pitman, R. K. (1997). Seeking the source of emotional Stroop interference effects in PTSD: a study of P3s to traumatic words. *Integrative Physiological and Behavioral Science*, 32(1), 43–51. <https://doi.org/10.1007/BF02688612>
- *Michalowski, J. M., Melzig, C. A., Weike, A. I., Stockburger, J., Schupp, H. T., & Hamm, A. O. (2009). Brain Dynamics in Spider-Phobic Individuals Exposed to Phobia-Relevant and Other Emotional Stimuli. *Emotion*, 9(3), 306–315. <https://doi.org/10.1037/a0015550>
- Mogg, K., & Bradley, B. P. (1998). A cognitive-motivational analysis of anxiety. *Behaviour Research and Therapy*, 36(9), 809–848. [https://doi.org/10.1016/S0005-7967\(98\)00063-1](https://doi.org/10.1016/S0005-7967(98)00063-1)
- Mogg, K., & Bradley, B. P. (2018). Anxiety and Threat-Related Attention: Cognitive-Motivational Framework and Treatment. In *Trends in Cognitive Sciences* (Vol. 22, Issue 3, pp. 225–240). Elsevier Ltd. <https://doi.org/10.1016/j.tics.2018.01.001>
- Mogg, K., Bradley, B. P., De Bono, J., & Painter, M. (1997). Time course of attentional bias for threat information in non-clinical anxiety. *Behaviour Research and Therapy*, 35(4), 297–303. [https://doi.org/10.1016/S0005-7967\(96\)00109-X](https://doi.org/10.1016/S0005-7967(96)00109-X)
- Mogg, K., Mathews, A., & Weinman, J. (1987). Memory Bias in Clinical Anxiety. *Journal of Abnormal Psychology*, 96(2), 94–98. <https://doi.org/10.1037/0021-843X.96.2.94>
- Mogg, K., Philippot, P., & Bradley, B. P. (2004). Selective Attention to Angry Faces in Clinical Social Phobia. *Journal of Abnormal Psychology*, 113(1), 160–165.

- <https://doi.org/10.1037/0021-843X.113.1.160>
- Moher, D., Liberati, A., Tetzlaff, J., & Altman, D. G. (2009). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *PLoS Medicine*, 6(7). <https://doi.org/10.1371/journal.pmed.1000097>
- *Moser, J. S., Huppert, J. D., Duval, E., & Simons, R. F. (2008). Face processing biases in social anxiety: An electrophysiological study. *Biological Psychology*, 78, 93–103. <https://doi.org/10.1016/j.biopsycho.2008.01.005>
- Öhman, A., Flykt, A., & Esteves, F. (2001). Emotion Drives Attention: Detecting the Snake in the Grass. *Journal of Experimental Psychology: General*, 130(3), 466–478. <https://doi.org/10.1037/0096-3445.130.3.466>
- Öhman, A., & Soares, J. J. F. (1998). Emotional Conditioning to Masked Stimuli: Expectancies for Aversive Outcomes Following Nonrecognized Fear-Relevant Stimuli. *Journal of Experimental Psychology: General*, 127(1), 69–82. <https://doi.org/10.1037//0096-3445.127.1.69>
- *Pauli, P., Dengler, W., Wiedemann, G., Montoya, P., Birbaumer, N., Flor, H., & Buchkremer, G. (1997). Behavioral and Neurophysiological Evidence for Altered Processing of Anxiety-Related Words in Panic Disorder. *Journal of Abnormal Psychology*, 106(2), 213–220. <https://doi.org/10.1037/0021-843X.106.2.213>
- Pérez-Edgar, K., Bar-Haim, Y., McDermott, J. M., Chronis-Tuscano, A., Pine, D. S., & Fox, N. A. (2010). Attention Biases to Threat and Behavioral Inhibition in Early Childhood Shape Adolescent Social Withdrawal. *Emotion*, 10(3), 349–357. <https://doi.org/10.1037/a0018486>
- Pérez-Edgar, K., Kujawa, A., Nelson, S. K., Cole, C., & Zapp, D. J. (2013). The relation between electroencephalogram asymmetry and attention biases to threat at baseline and under stress. *Brain and Cognition*, 82(3), 337–343. <https://doi.org/10.1016/j.bandc.2013.05.009>
- Pergamin-Hight, L., Naim, R., Bakermans-Kranenburg, M. J., van IJzendoorn, M. H., & Bar-Haim, Y. (2015). Content specificity of attention bias to threat in anxiety disorders: A meta-analysis. *Clinical Psychology Review*, 35, 10–18. <https://doi.org/10.1016/j.cpr.2014.10.005>
- Polich, J. (2007). Updating P300: An integrative theory of P3a and P3b. *Clinical Neurophysiology*, 118(10), 2128–2148. <https://doi.org/10.1016/j.clinph.2007.04.019>
- Price, R. B., Kuckertz, J. M., Siegle, G. J., Ladouceur, C. D., Silk, J. S., Ryan, N. D.,

- Dahl, R. E., & Amir, N. (2015). Empirical Recommendations for Improving the Stability of the Dot-Probe Task in Clinical Research. *Psychological Assessment*, 27(2), 365–376. <https://doi.org/10.1037/pas0000036>
- Rodebaugh, T. L., Scullin, R. B., Langer, J. K., Dixon, D. J., Huppert, J. D., Bernstein, A., Zvielli, A., & Lenze, E. J. (2016). Unreliability as a Threat to Understanding Psychopathology: The Cautionary Tale of Attentional Bias. *Journal of Abnormal Psychology*, 125(6), 840–851. <https://doi.org/10.1037/abn0000184>
- Rogers, D., Murphy, E., Winders, S. J., & Greene, C. M. (2020). *Attentional Bias Components in Anxiety and Depression: A Systematic Review*. <https://doi.org/10.31234/osf.io/2twux>
- Sallard, E., Hartmann, L., Ptak, R., & Spierer, L. (2018). Spatiotemporal brain dynamics underlying attentional bias modifications. *International Journal of Psychophysiology*, 130, 29–39. <https://doi.org/10.1016/j.ijpsycho.2018.06.001>
- Sandre, A., Ethridge, P., Kim, I., & Weinberg, A. (2018). Childhood maltreatment is associated with increased neural response to ambiguous threatening facial expressions in adulthood: Evidence from the late positive potential. *Cognitive, Affective & Behavioral Neuroscience*, 18(1), 143–154. <https://doi.org/10.3758/s13415-017-0559-z>
- *Sass, S. M., Heller, W., Stewart, J. L., Levin, R., Edgar, J. C., Fisher, J. E., & Miller, G. A. (2010). Time course of attentional bias in anxiety: Emotion and gender specificity. *Society for Psychophysiological Research*, 47, 247–259. <https://doi.org/10.1111/j.1469-8986.2009.00926.x>
- *Scharmüller, W., Leutgeb, V., Schäfer, A., Köchel, A., & Schienle, A. (2011). Source localization of late electrocortical positivity during symptom provocation in spider phobia: An sLORETA study. *Brain Research*, 1397, 10–18. <https://doi.org/10.1016/j.brainres.2011.04.018>
- *Schienle, A., Schäfer, A., & Naumann, E. (2008). Event-related brain potentials of spider phobics to disorder-relevant, generally disgust-and fear-inducing pictures. *Journal of Psychophysiology*, 22(1), 5–13. <https://doi.org/10.1027/0269-8803.22.1.5>
- Sewell, C., Palermo, R., Atkinson, C., & McArthur, G. (2008). Anxiety and the neural processing of threat in faces. *Neuroreport*, 19(13), 1339–1343. <https://doi.org/10.1097/WNR.0b013e32830baadf>
- *Shah, D., Cameron, C., Smith, D., Jaworska, N., Blais, C., Fisher, D., & Knott, V.

- (2018). An electrophysiological investigation of Attentional Bias in a PTSD population. *Psychological Trauma: Theory, Research, Practice, and Policy*, 10(5), 523–532. <https://doi.org/10.1037/tra0000339>
- Shi, R., Sharpe, L., & Abbott, M. (2019). A meta-analysis of the relationship between anxiety and attentional control. *Clinical Psychology Review*, 72, 101754. <https://doi.org/10.1016/j.cpr.2019.101754>
- Stein, D. J. (2014). Nosology and Classification. In P. Emmelkamp & Thomas Ehring (Eds.), *The Wiley Handbook of Anxiety Disorders: Vol. I* (1st ed., pp. 15–25). WILEY-Blackwell. <https://doi.org/10.1002/9781118775349>
- Van Bockstaele, B., Verschuere, B., Tibboel, H., De Houwer, J., Crombez, G., & Koster, E. H. W. (2014). A Review of Current Evidence for the Causal Impact of Attentional Bias on Fear and Anxiety. *Psychological Bulletin*, 140(3), 682–721. <https://doi.org/10.1037/a0034834>
- Wauthia, E., & Rossignol, M. (2016). Emotional Processing and Attention Control Impairments in Children with Anxiety: An Integrative Review of Event-Related Potentials Findings. *Frontiers in Psychology*, 7, 562. <https://doi.org/10.3389/fpsyg.2016.00562>
- *Weinberg, A., Hajcak, G., Weinberg, A., & Hajcak, G. (2011). Electrocortical evidence for vigilance-avoidance in Generalized Anxiety Disorder. *Psychophysiology*, 48, 842–851. <https://doi.org/10.1111/j.1469-8986.2010.01149.x>
- *Weinberg, A., Perlman, G., Kotov, R., & Hajcak, G. (2016). Depression and reduced neural response to emotional images: Distinction from anxiety, and importance of symptom dimensions and age of onset. *Journal of Abnormal Psychology*, 125(1), 26–39. <https://doi.org/10.1037/abn0000118>
- Williams, J. M. G., Mathews, A., & MacLeod, C. (1996). The Emotional Stroop Task and Psychopathology. *Psychological Bulletin*, 120(1), 3–24. <https://doi.org/10.1037/0033-2909.120.1.3>
- *Yuan, J., Mao, N., Chen, R., Zhang, Q., & Cui, L. (2019). Social anxiety and attentional bias variability: electrophysiological evidence of attentional control deficits. *Neuroreport*, 30(13), 887–892. <https://doi.org/10.1097/WNR.0000000000001294>
- *Zhang, X., Dong, Y., & Zhou, R. (2018). Examination stress results in attentional bias and altered neural reactivity in test-anxious individuals. *Neural Plasticity*, 2018. <https://doi.org/10.1155/2018/3281040>
- *Zhang, Z., Wang, M. Y., Guo, X., Miao, X., Zhang, T., Gao, D., & Yuan, Z. (2017).

Attentional avoidance of threats in obsessive compulsive disorder: An event related potential study. *Behaviour Research and Therapy*, 97, 96–104.
<https://doi.org/10.1016/j.brat.2017.07.011>

*Studies included in the quantitative meta-analysis.

Appendix

Search expressions used in PUBMED and Web of Knowledge:

PUBMED: ((anxi*[Title/Abstract] OR phobi* [Title/Abstract] OR "phobic disorders" [MeSH] OR "phobia, social" [MeSH] OR "obsessive-compulsive"[Title/Abstract] OR "obsessive-compulsive disorder" [MeSH] OR "obsessive behavior" [MeSH] OR "*traum*" OR "psychological trauma" [MeSH] OR "trauma and stressor related disorders" [MeSH] OR "stress disorders, traumatic" [MeSH] OR "stress disorders, traumatic, acute" [MeSH] OR "stress disorders, post-traumatic" [MeSH]) AND ("attention bias*" [Title/Abstract] OR "attentional bias*" [Title/Abstract] OR threat* [Title/Abstract] OR fear* [Title/Abstract]) AND ("event-related potentials" [Title/Abstract] OR "evoked potentials" [MeSH] OR ERP [Title/Abstract] OR "late positive potential" [Title/Abstract] OR LPP [Title/Abstract] OR P3 [Title/Abstract] OR P300 [Title/Abstract] OR "event-related potentials, P300" [MeSH] OR LPC [Title/Abstract] OR "late positive complex" [Title/Abstract])).

Web of Knowledge: TS = ((anxi* OR phobi* OR "obsessive-compulsive" OR traum* OR "post-traum*") AND ("attentional bias*" OR "attention* bias*" OR threat* OR fear) AND ("event-related potentials" OR ERP OR "late positive potential" OR "LPP" OR P3* OR LPC OR "late positive complex")).