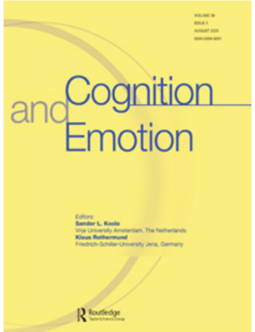

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Isolating delayed attentional disengagement from biased orienting to signals of threat in anxiety – not there yet

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ABSTRACT

It is often argued that increased "attentional bias to threat" in anxiety is due to delayed attentional disengagement from threat stimuli, rather than increased attentional orienting towards such signals. In 2013, [Clarke, P. J. F., Macleod, C., & Guastella, A. J. (2013). Assessing the role of spatial engagement and disengagement of attention in anxiety-linked attentional bias: A critique of current paradigms and suggestions for future research directions. *Anxiety, Stress and Coping: An International Journal*, *26*(1), 1-19. https://doi.org/10.1080/10615806.2011.638054] critiqued this literature, pointing out that most studies used paradigms that could not isolate attentional disengagement from attentional orienting. Since this critique, over fifty studies claiming to measure attentional disengagement from threat in anxiety have been published, many using suboptimal methods. In this (preregistered) systematic review and meta-analysis, we outline why many of these paradigms fail to provide a valid measure of attentional disengagement from stimuli with different emotional content. We also highlight studies where the paradigms and task parameters allowed for the valid measurement of attentional disengagement and include a meta-analysis (759 participants) of this subset. Some evidence was observed for slowed disengagement from threat images (relative to neutral) in high-anxious individuals, but heterogeneity across studies was high, and the effect disappeared when restricting the analysis to paradigms that could rule out behavioural freezing as an alternative explanation. Overall, these findings highlight the need for better-quality research in this area and suggest best practices for the field moving forward.

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Attentional bias; attentional disengagement; threat; anxiety; meta-Analysis; attentional bias modification

Anxiety disorders are one of the most prevalent mental health disorders, affecting up to a third of the population during their lifetime (Bandelow & Michaelis, 2015; Baxter et al., 2013). Attention, the process of prioritising relevant information in the environment for further analysis or action, is argued to play a significant role in the development and maintenance of anxiety. A tendency to focus attention on threat-provoking stimuli can lead to exaggerated perceptions of threat which in turn increases monitoring for threat signals, thus creating a vicious cycle (Mathews & MacLeod, 1994; Mogg & Bradley, 1998; Rapee & Heimberg, 1997).

Much of the evidence that has been taken to indicate a key role for attention in development and maintenance of anxiety comes from studies examining attentional interference from task-irrelevant but anxiety-provoking stimuli. These stimuli are typically related to personal threat, such as threat-related words or images, angry faces, electric shock or aversive noises. Attentional interference is commonly assessed with spatial cueing tasks or emotional

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Stroop tasks. Spatial cueing tasks typically involve measuring response time (RT) to a target in the presence of different task-irrelevant distractors. Slower responding when the distractor image is threat-related (relative to neutral) is taken as indexing the degree of interference from that threat-related stimulus. In emotional Stroop tasks the time taken to name the colour of threat words is compared to the time taken to name the colour of neutral words; again, the degree to which responses are slower for threat words is used to index interference. Many variants of these tasks have shown that anxiety-provoking stimuli slow responding (relative to neutral stimuli) in those scoring high on various anxiety measures, compared to low-anxious individuals (see for reviews: Bar-Haim et al., 2007; Cisler & Koster, 2010; Goodwin et al., 2017; Mogg & Bradley, 2005). This has led to an explosion in clinical research attempting to modify these "attentional biases" through simple, computerised training protocols in which high-anxious individuals are repeatedly trained to shift their attention away from threat stimuli towards neutral stimuli (Basanovic et al., 2021; Chelliah & Robinson, 2020; Lee et al., 2015; Liang & Hsu, 2016; see for reviews: Jones & Sharpe, 2017; MacLeod & Mathews, 2012; Mogg & Bradley, 2016).

Attention, however, is not a unitary process. For example, following initial orienting to a particular spatial location (e.g. the location of a threat-related distractor), attention must then *disengage* from that location if it is to subsequently shift elsewhere, such as to a target (Posner & Petersen, 1990; Theeuwes et al., 2004). Slow responding to a target on trials where attention was cued to an invalid spatial location by a threatening image could, therefore, reflect an influence of threat on either (or both) orientation and disengagement. That is, attention might be more likely to orient to the spatial location of a threatening stimulus (relative to a neutral stimulus), and/or attention might be more likely to be held at that location for longer, delaying disengagement. Both processes would slow overall RT in the presence of the threat-related distractor and isolating one of these processes is not trivial.

Many authors have argued that attentional disengagement from threatening stimuli is functionally impaired in high-anxious individuals relative to low-anxious individuals (see for reviews: Cisler & Koster, 2010; Richards et al., 2014). Specifically, it has been argued that high-anxious individuals are not necessarily more likely to orient to signals of threat or punishment, but that once their attention is on such a signal it lingers there for (Amir et al., 2003; Fox et al., 2002; Koster et al., 2006). This is potentially an important distinction. Understanding whether anxiety is related to increased attentional orienting to signals of threat or delayed disengagement from such signals, could allow for improved attentional bias modification treatments for anxiety. For example, individuals could be repeatedly trained to not attend to such stimuli in the first place, or it might be more beneficial to try and train fast and efficient disengagement from threat signals (MacLeod & Mathews, 2012; Mogg & Bradley, 2016). Furthermore, understanding whether these tendencies are voluntary (i.e. purposeful prioritisation of threat signals) or involuntary (i.e. occurring even when individuals are motivated to attend elsewhere/disengage attention quickly) would further inform appropriate treatment strategies. If attentional prioritisation of threatening images is goal-directed and voluntary then it could feasibly be treated via motivational techniques that aim to reduce the outcome value of such behaviour (Rollnick & Miller, 1995; Senay et al., 2010). By contrast, if attentional prioritisation of threatening images is largely involuntary, shifts in explicit motivation are unlikely to reduce the bias and instead behavioural retraining techniques, such as attentional bias modification, may offer a more effective route towards behaviour change (Jones & Sharpe, 2017; Wiers et al., 2013).

In 2013, Clarke, MacLeod and Guastella published a critical review paper, pointing out that most experimental designs that had been used to investigate the nature of the relationship between anxiety and attention to threat were not able to adequately disentangle attentional disengagement from attentional orienting. The first critique was that many studies attempted to simultaneously manipulate attentional orienting and disengagement. Because attentional disengagement is measured subsequent to the initial orienting of attention, any measure of disengagement time would be influenced by whether or not attention had shifted to the critical (threat or neutral) stimulus in the first place. For example, in one version of a spatial cueing task (the *exogenous cueing* task, discussed in more detail later) two stimuli appear on either side of the screen: a cue image depicting a threatening or neutral stimulus on one side, and an empty box on the other. These stimuli are then replaced by a target probe that can appear at either stimulus location, and participants must respond to this target (see Figure 1).

It has been found that responses are typically slower when the target appears opposite the location

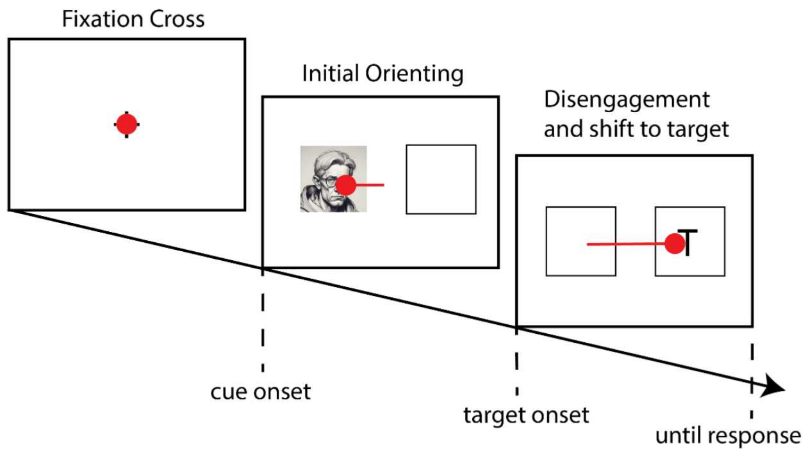

Figure 1. Schematic of a "Cue-Invalid" trial of the exogenous cueing task.

Note. Red lines and dots represent attentional shifts and fixations respectively. RT (the measure of disengagement speed) is measured from target onset until response. RT to the target (here represented by T) is compared on trials where the initial cue (here a face stimulus) is threatening versus neutral. Images not to scale. All exemplar face stimuli used in these figures were made using generative AI.

of a threatening image ("invalid-threat" trials) versus a neutral image ("invalid-neutral" trials; see e.g. Fox et al., 2001, 2002). This pattern has often been taken as diagnostic of an influence of threat on attentional disengagement, with the difference in response time (RT) indexing the relative ease of disengaging attention from the location of the threatening/ neutral image and re-orienting to the target (Fox et al., 2001, 2002; Price et al., 2019; Sagliano et al., 2014; Sagliano et al., 2018; Sagliano, D'Olimpio, Taglialatela Scafati, et al., 2016). However, an alternative possibility is that this pattern reflects a difference in the likelihood of initial attentional orienting to threat vs neutral images. If attention is more likely to orient towards threat stimuli, relative to neutral stimuli, the result would be slower RT on invalid-threat trials (since attention would more often be in the "wrong" location when the target probe appeared) than on invalid-neutral trials, even if time-to-disengage was similar for both classes of image. Consequently, in studies using the exogenous cueing task the difference in RT on invalid-threat versus invalid-neutral trials typically falls short as a diagnostic index of disengagement, as it does not allow us to measure disengagement independently of attentional orientating, which we term the *independence-from-orientation criterion* (though later we describe exogenous cueing studies using informative cues that may meet this criterion).

A related critique noted by Clarke et al. was that in many previous studies it was not possible to verify where attention was located, prior to the assessment of orientation towards, or disengagement from, a threat stimulus. As mentioned above, in the exogenous cueing task, slower RTs on invalid-threat trials compared to invalid-neutral trials have been taken as evidence that participants are slower to move the locus of their attention away from the threat-image location, when the probe appears. This assumes, however, that attention is maintained at the location of the cue image for the entire time it is presented (typically up to 1000 ms). This may not always be the case, especially given that the cue is typically uninformative about the location in which the probe will subsequently appear. So, even if attentional orientating to threat or neutral cue images was equally likely at image *onset*, there is no reason why participants should not begin shifting their attention back to the centre of the screen in anticipation, before the target probe appears (and this behaviour may differ as a function of anxiety group). Indeed, voluntary shifts of attention can occur within 200–300 ms (Born et al., 2011; Godijn & Theeuwes, 2002; Theeuwes et al., 2004) meaning that attention could be located anywhere on screen (or offscreen) at the end of the cue-presentation interval, when the target appears. For an isolated measure of disengagement, we must be confident that attention is located on the critical stimulus when a shift to the target is required: we label this the *locus-of-attention criterion*.

Another possibility raised by Clarke et al. (2013) was that when measuring attentional processes in the context of threat, there is a risk that behavioural freezing may contaminate measures of biased attentional orienting towards or disengagement away from threat stimuli. Specifically, the pattern of slower responding on disengagement trials featuring a threatening image, versus a neutral image, may not reflect an attentional process at all, but may instead result from an evoked fear response (freezing). This would slow RT on threatening relative to neutral trials – and this pattern of behavioural freezing may be particularly likely to occur in high-anxious individuals. This is a particular issue when using tasks – such as the exogenous cueing task – where only one image category is presented on each trial. The authors argued that for any study to provide valid evidence of delayed disengagement in high anxiety individuals, it must be possible to rule out behavioural freezing accounts; hence, the *behavioural-freezing criterion*.

Clarke et al. (2013) thus identified three criteria that must be met for diagnostic evidence of delayed attentional disengagement from threat, that we are calling the independence-from-orientation, locus-of-attention, and behavioural-freezing criteria. Despite this clear critique of the common paradigms used to measure attentional disengagement from signals of threat, it is noticeable that these paradigms are still regularly used. In fact, since December 2011 (when the Clarke et al. critique was published online) more than 50 studies claiming to measure attentional disengagement from threat in the context of anxiety have been published, the majority of which fail to meet the criteria outlined above. We formally assessed these studies in the current (pre-registered) systematic review and meta-analysis. We first discuss the paradigms commonly being used in these experiments and outline why they fail in providing a valid measure of attentional disengagement from threat as a function of anxiety. We highlight studies that have used paradigms where it seems reasonable to disentangle attentional disengagement from possible differences in the orienting of attention. We then examine, using meta-analysis, the evidence for a pattern of delayed disengagement from threat as a function of anxiety severity. Only studies meeting the independence-from-orientation and locus-of-attention criteria were included in the first meta-analysis. That is, we included only paradigms where it was possible to disentangle attentional disengagement from possible differences in the orientation of attention, and in which it was reasonable to assume that attention was at the location of the threat stimulus at the time that the process of disengagement was assumed to begin. We then repeated the meta-analysis, examining whether restricting the analysis to those studies that also controlled for behavioural freezing (meeting the behavioural freezing criterion) would change the pattern of results. Finally, we suggest best practice for the field moving forward.

1. Method

All systematic review and meta-analysis design choices were preregistered at https://osf.io/wge2j.

1.1. Inclusion criteria

To be considered for inclusion in the systematic review, studies had to meet the following (pre-registered) criteria:

(1) The article was published in a peer-reviewed journal between January 2012 and September 2024.
(2) The article was written in English.
(3) The study participants were at least 18 years old.
(4) The study used a paradigm that claimed to measure attentional disengagement from threatening relative to neutral images.
(5) The study reported the means and SD of the attentional disengagement measure for the between-group comparison of high anxiety versus low anxiety (or the article provided enough information for this data to be estimated), or the study reported the correlation coefficient for the relationship between attentional disengagement and anxiety scores. Authors were contacted when this information could not be retrieved from the manuscript.

1.2. Literature search

The literature search was performed in March 2022 and updated in September 2024. Searches were performed in Ovid, APA PsycInfo and PubMed databases by searching for abstract, keyword and title terms (punishment OR threat$) AND disengagement, where $ is a wildcard. Returned searches were limited to (NOT children) and (NOT adolescen$). Google Scholar was also used to search for similar terms, with the first 100 records of each search being added to the database of candidate papers for meta-analysis. After removal of duplicates, this resulted in a total of 2, 388 publications. The first author then read all the abstracts to create a longlist of 82 suitable publications. After reading the full publication, 26 of these were excluded for not fulfilling the five inclusion criteria noted above. Fifteen publications did not look at differences in performance as a function of anxiety (Amir & Taylor, 2012; Barry et al., 2015; Basanovic et al., 2021; Berggren, 2020; Boettcher et al., 2012; Chen et al., 2012; Clauss et al., 2021, Gupta et al., 2021; Julian et al., 2012; Vromen, 2016; Vromen et al., 2015; Yan et al., 2022; Zainal & Jacobson, 2024; Zhang et al., 2023), four publications did not use threatening stimuli in the attention tasks (Heeren et al., 2015; Moriya & Sugiura, 2012; Oehlberg et al., 2012; Sarapas et al., 2017), four were studies that attempted to modify attentional bias in anxiety and did not report baseline measures (Lee et al., 2013; Li & Liang, 2024; Liang & Hsu, 2016; Taylor et al., 2014), one study used a motor rather than attentional definition of disengagement (failure to inhibit responding in a go/no-go task; Gole et al., 2012), one study used attentional disengagement score as a moderator rather than a dependent variable (Richey et al., 2012), and one study reported neuroimaging rather than behavioural data (McTeague et al., 2018). This resulted in a shortlist of 56 publications. Two of these publications included two experiments (measuring disengagement using different paradigms with different participant samples), meaning that there were 58 datasets for the review (and eventual meta-analyses).

1.3. Paradigms used to measure attentional disengagement

The majority of studies included in the systematic review studied non-clinical populations that were pre-screened for anxiety symptoms on scales such the State Trait Anxiety Inventory (STAI-T; Spielberger et al., 1983), the Brief Fear of Negative Evaluation (BFNE) scale (Leary, 1983) or the Liebowitz Social Anxiety Scale (Liebowitz, 1987). Often those scoring in the first and third terciles of the scale were designated as low and high anxiety groups, respectively, with the middle group removed. Some studies investigated attentional disengagement from threat in clinical populations such as patients with generalised or social anxiety relative to controls (Chen et al., 2012; Lazarov et al., 2016, 2021; Yiend et al., 2015). The majority of studies used stimuli featuring faces depicting neutral, fearful, angry or happy emotions, though a handful of studies (Berdica et al., 2018; McSorley & Morriss, 2017; Pizzie & Kraemer, 2017; Sagliano et al., 2014) instead used affective images, maths 2012 equations or pictures of spiders as threat-inducing stimuli.

1.3.1. Dot-probe task

Four studies used a simple *dot-probe task* where on each trial both a threatening and a neutral image were presented (e.g. on the left and right sides of the screen: see Figure 2). These cue images then disappeared and the target probe was presented, at the location previously occupied by one of the images. A

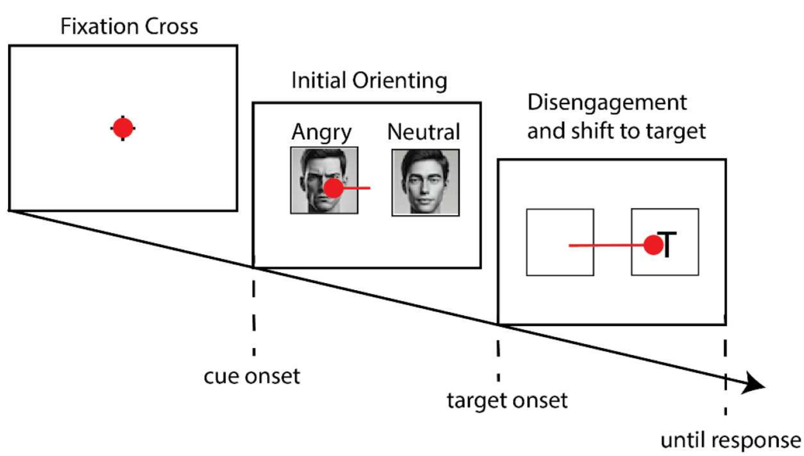

Figure 2. Schematic of an "Invalid-Threat" trial in the dot-probe task.

Note. Red lines and dots represent attentional shifts and fixations respectively. RT (the measure of disengagement speed) is measured from target onset until response. RT to the target (here represented by T) is compared on trials where the target appears at the opposite location of the threatening versus neutral cue. Images not to scale.

number of these studies simply compared RT on invalid-threat trials (when the probe appeared "behind" the neutral image) relative to RT on valid-threat trials (when the probe appeared "behind" the threatening image) as the measure of attentional disengagement (Pizzie & Kraemer, 2017; Rossignol et al., 2013; Yuan et al., 2021). It is clear however that individual differences in the degree of initial orienting to threat relative to neutral images will influence the disengagement measure on this task. It does not therefore meet the independence-from-orientation criterion and is not suitable for measuring attentional disengagement.

In an attempt to mitigate the issue of initial attentional orienting in the standard dot probe, Taylor et al. (2014) tried to control where attention was on the screen by instructing participants that they should always look first at the image located at a specific spatial location, e.g. the image appearing to the left of the screen. Only trials where the probe appeared at the opposite location from where participants were asked to look were included in the calculation of disengagement duration (invalid-threat minus invalid-neutral). Although this approach aimed to address the locus-of-attention issue identified by Clark et al. (2013), it suffers from a major flaw. Previous studies have demonstrated that attention can be involuntarily captured by signals of threat and punishment, regardless of participants' intentions to ignore such signals (Mikhael et al., 2021; Nissens et al., 2017). Simply instructing participants to try and look at the neutral image first on threat-neutral trials would not ensure that attention is consistently located at that spot when the probe is presented (and no manipulation check was carried out by Taylor et al. to verify where attention was located at the start of each trial). Thus, even using this approach, the simple dot-probe is not suitable for measuring attentional disengagement and none of these studies were deemed suitable for inclusion in the meta-analysis.

1.3.2. Modified dot-probe task

The *modified dot-probe task*, first introduced by Koster et al. (2004), has been frequently used to measure attentional disengagement with ten studies taking this approach since 2011 (Albery et al., 2021; Blekić et al., 2021; Evans et al., 2016, 2020; Jhang & Liang, 2023; Lee et al., 2013; O'Toole & Dennis, 2012; Packard et al., 2022; Schofield et al., 2012; Zheng et al., 2023). This task is the same as the standard dot-probe task shown in Figure 2, but also includes trials with two neutral cue images (neutral-neutral trials), in addition to trials where a threatening and a neutral image appear together (threat-neutral trials). Time taken to disengage is calculated as RT on invalid-threat trials (where the probe appears behind the neutral cue on a threat-neutral trial) minus RT on neutral-neutral trials.

The benefit of this approach is that it is possible to control for baseline responding on neutral trials, but the modified dot-probe task remains unable to separate attentional disengagement from the initial orienting of attention. Even if we make the unlikely assumption that attention will remain fixed at the spatial location of one of the cues during the entire cue presentation time (i.e. setting aside the locus-of-attention criterion), this task fails to meet the independence-from-orientation criterion. On neutral-neutral trials there will be a 50% chance that attention is at the location of the target when it appears, since the two neutral cue images are equivalent, and the participant may orient to either image. By contrast, if the initial orienting of attention is reliably to the threatening image (rather than the neutral image) on threat-neutral trials, then RT will be consistently slower on invalid-threat trials (relative to neutral-neutral) since attention will typically be in the "wrong" location when the target appears on these trials. Critically, this slowing in RT on invalid-threat relative to neutral-neutral trials could be entirely driven by differences in orienting on the two trial types even if the time taken to disengage attention from neutral and threatening images was the same (see Watson et al., 2020, for a detailed discussion of this issue).

One exception to the issues raised above was the study by Schofield et al. (2012), who used a modified dot-probe task in conjunction with eye tracking. Eye tracking is a particularly useful methodology in this context, because eye movements and shifts of attention are closely coupled (Deubel & Schneider, 1996). Consequently, eye tracking can provide a relatively direct, moment-by-moment measure of the locus of attention, potentially allowing researchers to disentangle processes related to orienting versus disengagement of attention. In Schofield et al.'s study, time taken to respond to the probe was taken as the measurement of disengagement, specifically on the subset of trials where participants' gaze (and hence presumably their attention) was at the opposite location to the probe when it appeared, such that a shift of attention to the target was required. Consequently, RT can be compared on trials in which participants are known to be shifting away from a threatening versus a neutral image, providing a measure of the effect of threat on disengagement that meets both the "independence from orientation" and "locus of attention" criteria. This approach demonstrates that for many behavioural tasks, the validity of claims that the disengagement process (specifically) is being measured can be improved by the use of eye-tracking to filter out trials in which attention was located somewhere other than the stimulus of interest.

1.3.3. Exogenous cueing task

The *exogenous cueing task* has been used in ten studies attempting to measure attentional disengagement from threatening cues as a function of anxiety (Cocia et al., 2012; Crump et al., 2013; Curby & Collins, 2024; Price et al., 2019; Sagliano et al., 2014, 2018; Sagliano, D'Olimpio, Panico, et al., 2016; Sagliano, D'Olimpio, Taglialatela Scafati, et al., 2016; Stefan et al., 2020; see Wang et al., 2019 for an auditory version). This task is similar to the dot probe but only one cue image is presented on each trial (see Figure 1). As outlined earlier, this task makes two (unlikely) assumptions: (1) that, at cue onset, attention is likely to orient to all cues to the same degree, regardless of whether they are threat or neutral images, and (2) that attention is maintained at the location of the cue image to an equivalent degree on both neutral and threat trials, prior to the target appearing in the opposite location. In most studies reviewed here, the cue was uninformative as to the location of the upcoming target (i.e. 50% validity), meaning that it could be safely ignored. However, given that threatening images are more likely than neutral images to involuntarily capture attention (Mikhael et al., 2021; Nissens et al., 2017), a difference in the likelihood of capture to the location of the threat cue versus neutral cue could explain any RT slowing on invalid-threat relative to invalid-neutral trials: that is, this procedure fails the independence-from-orientation criterion.

Furthermore, the majority of recent studies using the exogenous cueing task presented the cue for a long duration, typically on the order of 500–1000 ms. This is problematic as we cannot be confident that attention remains focused on the cue at the critical point at which the target appears, i.e. the time at which we wish to start measuring the duration of disengagement. As mentioned earlier, voluntary shifts of attention can occur very rapidly (around 200–300 ms) following initial fixation (Born et al., 2011; Theeuwes et al., 2004) so it seems implausible to assume that participants would not move their attention back to the centre of the screen in preparation for the onset of the probe – particularly if the location of the cue is entirely uninformative. Such studies therefore also fail the locus-of-attention criterion.

It should be noted that some studies using the exogenous cueing task have been exceptions to this pattern, employing brief cue presentation (less than 250 ms), and arranging for 75–80% of trials to be valid, i.e. the target typically occurred at the location of the cue image (Curby & Collins, 2024; Sagliano et al., 2014, 2018; Sagliano, D'Olimpio, Taglialatela Scafati, et al., 2016). At these short presentation times with a spatially informative cue, it may seem reasonable to assume that participants initially orient attention to the cue image when it appears and that voluntary shifts of attention away from that spatial location have not yet taken place at the time that the probe appears (Theeuwes et al., 2004). We therefore included these four studies in the meta-analysis although we note that even with these task parameters (valid cue and brief cue presentation) the assumption that initial orienting of attention to the image cue is equivalent for both threat and neutral cues may be unwarranted and use of this task should probably be curtailed.

1.3.4. Attentional Response to Distal vs. Proximal Emotional Information (ARDPEI)

In recent years researchers have modified the exogenous cueing task in attempts to have more control over where attention is located, at the time that the target probe appears. Seven studies used the *Attentional Response to Distal vs. Proximal Emotional Information* (ARDPEI) task (Boal et al., 2018; Delchau et al., 2020; Grafton & MacLeod, 2014; Mao et al., 2020; Miller et al., 2023; Rudaizky et al., 2014; Xia et al., 2018) to measure disengagement speed independently from orientation. In the ARDPEI, a target first appears on the left or right of the screen; for example, a line that could be orientated horizontally or vertically (see Figure 3). This disappears and is immediately replaced by a cue image (threatening or neutral) that is presented either at the same or opposite spatial location. The cue image is then followed by a probe – another horizontal or vertical line – also presented in the left or right spatial location.

Participants' task is to identify whether the probe is oriented the same way as the initial target. In this way, it is assumed that attention is in one spatial location

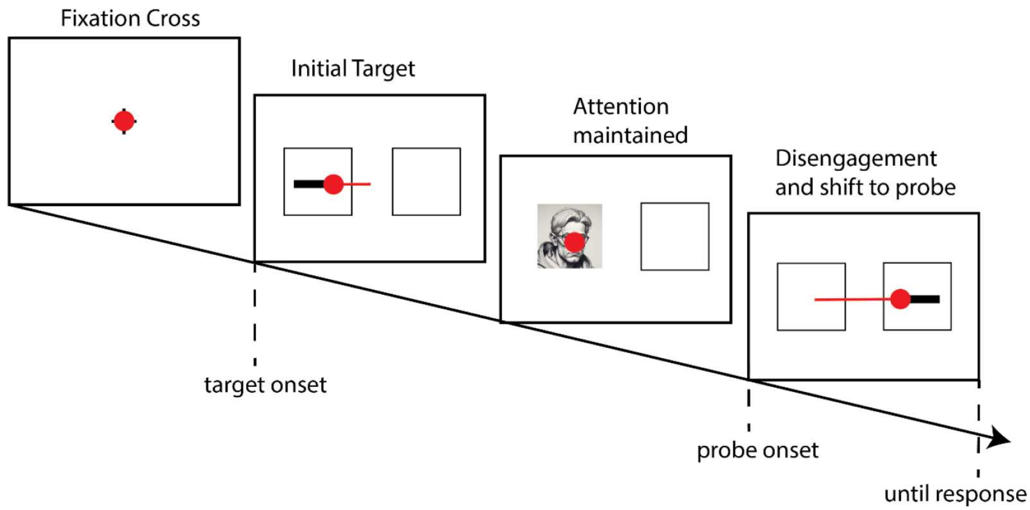

Figure 3. Schematic of the Attentional Response to Distal vs. Proximal Emotional Information (ARDPEI).

Note. Red lines and dots represent attentional shifts and fixations respectively. RT (taken as the measure of disengagement speed) is measured from probe onset until response, on the subset of trials where the cue appears at the same location as the initial target. RT to the probe (here represented by the solid line) is calculated as the RT difference on trials where the probe appears at the opposite vs the same location of the threatening image. This disengagement index is then compared for neutral vs threatening images. Images not to scale.

(at the initial target), at the time that the cue image appears on the screen. When the cue image appears in the *same* location as the initial target, then it is assumed that attention is maintained there for some time before disengagement in search of the probe. A disengagement index for both threat and neutral stimuli is calculated on the subset of trials where the cue image appeared in the same location as the initial target. Specifically, RT to respond to the probe on trials where the probe appeared at the opposite location from the cue image minus RT when the probe appeared at the same location is calculated for both threatening and neutral images. Although this design represents a significant improvement in terms of meeting the independence-from-orientation criterion, most of these studies had cue presentation times of 500–1000 ms, meaning that participants may well have shifted attention away from the cue image back to the centre of the screen during cue presentation (particularly as the cue image was non-informative as to the location of the upcoming probe; Boal et al., 2018; Delchau et al., 2020; Mao et al., 2020; Miller et al., 2023; Rudaizky et al., 2014; Xia et al., 2018). This means that it is impossible to know where spatial attention was located at the time that the disengagement process was expected to begin. An exception to this was Grafton and MacLeod (2014) who used a 100-ms cue-presentation. Attention should not have shifted from the cue-image location during this short presentation time (therefore meeting the locus-of-attention criterion).

1.3.5. Shifting attention from central fixation

The simplest approach to measure attentional disengagement in a manner that is not confounded by attentional orienting is simply to measure the time taken to shift attention away from centrally presented threatening or neutral images, to probes appearing at other locations. This approach was taken by eight studies (Azarian et al., 2016; Fernandes et al., 2018; Leleu et al., 2014; MacDonald et al., 2024; Manoli et al., 2021; McGlade et al., 2020; Richards et al., 2014; Yiend et al., 2015). By using a relatively short cue presentation time (preceding target onset by 0–300 ms), this paradigm provides a simple way of measuring attentional disengagement from threatening and neutral images that meets both the "independence-from-orientation" and "locus-of-attention" criteria (see Figure 4).

The only assumption this protocol makes is that participants' attention is located at the central fixation point at the beginning of each trial, which seems to be a reasonable assumption given that it is the only stimulus present at the start of the trial. This assumption can be verified using eye tracking (Azarian et al., 2016; Manoli et al., 2021; Richards et al., 2014) or by requiring participants to attend to an initial probe stimulus that is presented at fixation

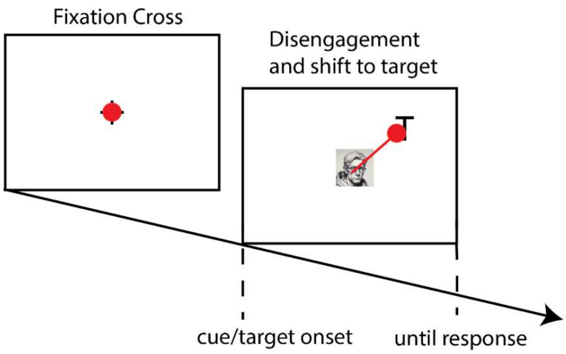

Figure 4. Schematic of central-stimulus disengagement tasks.

Note. Red lines and dots represent attentional shifts and fixations respectively. RT (the measure of disengagement speed) is measured from cue and target onset until response. RT to the target (here represented by T) is compared on trials where centrally presented stimulus (here a face) is threatening versus neutral. Images not to scale.

before the image cue (see e.g. the ARDPEI task). The approach of presenting a cue image at fixation (immediately after the disappearance of the initial fixation point) significantly mitigates the contamination of the attentional disengagement measure with biased attentional orienting. Furthermore, in these studies the cue image remained on-screen until participants responded to the target, meaning that participants had to actively disengage attention from the cue image to be able to identify and respond to the target.[1]

Some studies introduced the possibility of contamination to this simple measure of disengagement, however, by presenting the target for only 50 ms. Specifically, following 600 ms presentation of either a threatening or neutral cue image at the central location, a target letter was briefly presented for 50 ms at a peripheral location. The cue image then remained on screen until participants made a response as to the identity of the briefly-presented – and now vanished – target letter, and RT to respond to the target was used as the index of disengagement (Leleu et al., 2014; MacDonald et al., 2024; McGlade et al., 2020; Yiend et al., 2015, Exp 1). This variant of the paradigm is problematic because after the 50-ms target disappears, participants may re-orient their attention to the central image cue (the only stimulus remaining on-screen), interfering with ongoing response preparation – and this re-orienting may be more likely for emotional rather than neutral images, thus inflating RT estimates for trials with emotional stimuli. The situation is further complicated because this scenario also creates the potential for inhibition of return: a phenomenon observed in studies of visual search wherein attention is less likely to return to a location that has already been attended than a novel location (Klein, 2000). Inhibition of return would tend to oppose re-orienting to the central image, but importantly its impact may again differ for emotional versus neutral images: although not well studied, individual differences in the timescale and magnitude of inhibition of return for emotional stimuli have been reported (Bielas et al., 2021) and participants with high anxiety did not show inhibition of return for negative words presented at previously cued locations (Pérez-Dueñas et al., 2009). Therefore, to minimise complications arising from the potential for interference from emotional stimuli during the response preparation period – allowing the disengagement process to be isolated – it is advisable to continue presenting the target on the screen, as an alternative (goal-directed) stimulus that can support timely responding regardless of the current trial type.

Finally, Clarke et al. (2014) used a task requiring a conceptual rather than spatial shift of attention away from threatening images. Using a modified Stroop task with words as stimuli, participants had to report both the meaning of words (threatening or neutral) and the colour of the words. These two responses were made sequentially, in randomised order. Time taken to disengage attention from threatening information was calculated as the time taken to respond to the colour, on trials where participants had first reported the meaning of the threat word.

1.3.6. Visual search tasks

Six studies published since 2011 have used visual search tasks where threatening or neutral images functioned as distractors. McSorley and Morriss (2017) used eye tracking and presented a target either to the left or right of the screen while simultaneously a distractor (a spider image or neutral household image) appeared above or below the target. On trials where participants' first saccade went to the distractor, the dwell time on the distractor (i.e. time taken to initiate the second, corrective, saccade away from the distractor) was taken as an index of disengagement speed. Although this is a *valid* measure of disengagement (and this paper was included in the meta-analysis), it should be noted that dwell time is often not a particularly *sensitive* measure of disengagement under these conditions because corrective saccades towards the target can be prepared in parallel during the initial

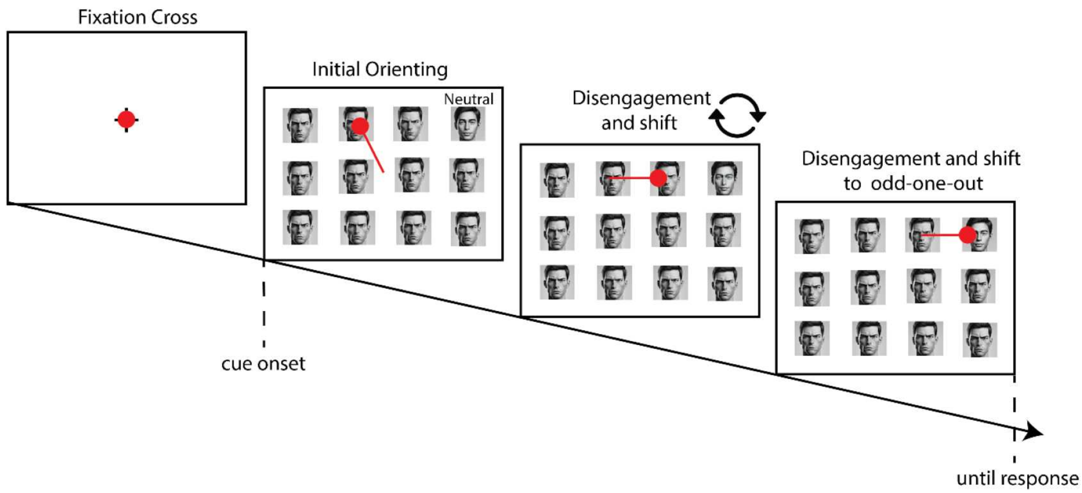

Figure 5. Schematic of visual search task (odd-one-out paradigm).

Note. One neutral face is presented amongst eleven angry faces and participants must indicate the presence or absence of an emotional face singleton. Red lines and dots represent attentional shifts and fixations respectively. RT (the measure of disengagement speed) is measured from cue onset until the participant responds. Multiple cycles of orientation, disengagement and shift are likely to take place within a trial. Images not to scale.

(erroneous) saccade to the distractor (Born et al., 2011; Watson et al., 2020).

In an alternative approach based on visual search, two studies used an odd-one-out paradigm (Sharma et al., 2022; Wermes et al., 2018) in which a matrix of images appeared showing either neutral, happy or angry faces. On some trials one of the images was an odd-one-out (e.g. a single neutral face among multiple angry faces). The disengagement-from-threat bias was measured as the increase in time to identify a neutral odd-one-out target (measured either using manual RTs or latency to first fixation on the target) when it was surrounded by angry faces versus when it was surrounded by happy faces (see Figure 5).

Notably, however, this paradigm cannot dissociate an influence of threat on attentional disengagement from an influence on attentional orienting (thus failing to meet the independence-from-orientation criterion). Even if the time taken to disengage attention from negative or positive images was equivalent, slower RT on neutral-among-angry trials compared to neutral-among-happy trials could result from a greater likelihood of attentional orienting towards the angry distractors than happy distractors, a pattern that may be more pronounced in high-anxiety participants than low-anxiety participants (see also Berggren et al., 2012).

Mulckhuyse et al. (2017) used a visual search paradigm and compared participants' RT to identify a target in the presence of either a coloured distractor circle that had previously been paired with electric shock, or a differently coloured distractor circle that had never been paired with shock. Slower RTs on trials with a shock-associated distractor were taken as evidence of delayed disengagement from a signal of threat. Once again, however, any such difference in RT could instead reflect a greater likelihood of attentional capture by the shock-associated distractor relative to the neutral distractor; hence this is not a reasonable method to disentangle potential effects on orienting and disengagement.

Finally, in an interesting variant of a visual search paradigm, Sheppes et al. (2013) had participants identify a coloured target which could appear at one of four locations. On half of trials a peripheral distractor, of the same colour as the target, appeared 50–350 ms before target onset. In "threat blocks", the distractor was sometimes paired with shock, whereas in "safe blocks" participants knew that no shock would occur. The influence of threat on disengagement was measured by the difference in RT to respond to the target on distractor-present trials of threat vs. safe blocks. This is problematic however because there is significant motivation to attend to the occurrence of the distractor in threat blocks, as it provides a useful signal of potentially imminent shock. As such, participants would presumably come to orient attention to the distractor in these threat blocks in a goal-directed manner, since this would allow them to prepare for the signalled upcoming shock. By contrast, in safe blocks the distractor has no significance and can be safely ignored; hence there is less motivation for participants to orient to this distractor. Consequently, any difference in RT in threat vs. safe blocks may reflect a difference in (motivated) orienting to the distractor, rather than a difference in disengagement: once again, this task does not meet the independence-from-orientation criterion as a measure of disengagement.

1.3.7. Free viewing with eye tracking

Free-viewing paradigms with eye tracking have been used in ten recent studies to measure whether attention lingered more on threatening or neutral images (Berdica et al., 2018; Chen et al., 2012; Fernandes et al., 2018; Lazarov et al., 2016, 2021; Liang et al., 2017; Nelson et al., 2015; Shechner et al., 2017; Singh et al., 2015; Xing et al., 2022). For example, in the study of Liang et al. four images (happy, sad, angry and neutral faces) were simultaneously presented on screen for 10 s (see Figure 6). The initial orienting of attention to the four picture types was relatively well distributed and the duration of these first fixations on the different facial expressions was taken as the disengagement index.

These tasks meet the independence-from-orientation and locus-of-attention criteria when measuring the period for which attention is initially maintained at threatening relative to neutral images. Some studies were exceptions to this, summing total fixation time on threat and neutral images across each trial rather than focusing on first fixation duration (Berdica et al., 2018; Shechner et al., 2017; Singh et al., 2015; Xing et al., 2022). The issue with the entire-trial dwell time approach is that multiple cycles of orientation and disengagement throughout the trial likely contributed to the disengagement measure such that these four studies do not meet the independence-from-orientation criterion.

1.3.8. The behavioural-freezing criterion

Many of the tasks reviewed above typically present only one type of cue – either a threatening or neutral image – on each trial (e.g. the exogenous cueing task, and tasks requiring a shift of attention from central fixation). Procedures using this approach fail to meet the behavioural-freezing criterion, because slower responding on trials with a threat cue versus a neutral cue could potentially be due to behavioural freezing in the presence of a threat image rather than differential attentional disengagement on threat vs. neutral trials (Clark et al., 2013). By contrast, procedures in which both threat and neutral images are presented simultaneously allow for any impact of freezing to be equated across critical trials and hence meet the behavioural-freezing criterion (e.g. the dot-probe task, and some implementations of visual search tasks and free viewing with eye tracking). An alternative approach, used with the ARDPEI task, involves calculating a

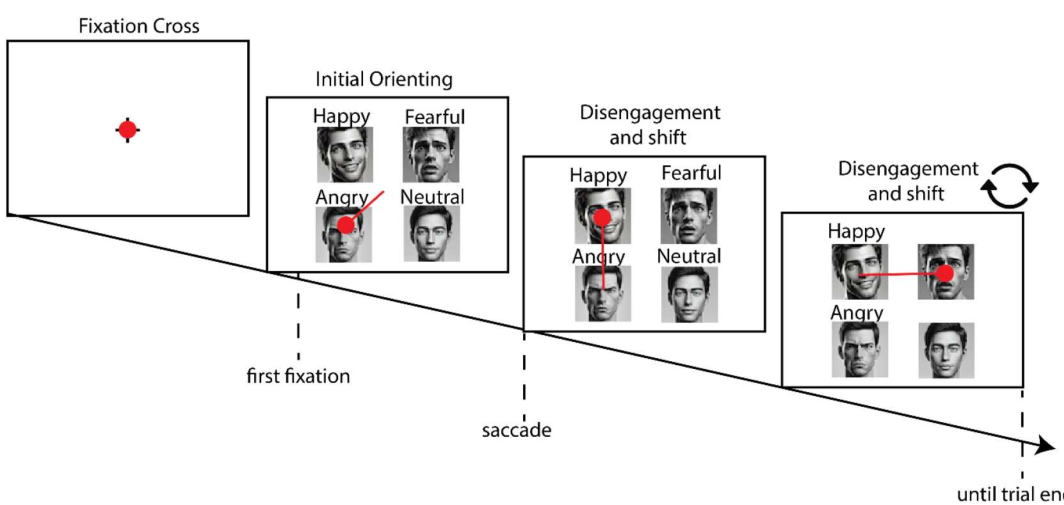

Figure 6. Schematic of free-viewing tasks with eye tracking.

Note. Images displaying different emotional faces are presented for a fixed trial duration. Potential eye movements (saccades) and subsequent fixations are indicated by red lines and dots. First fixation dwell time (the measure of disengagement speed) is measured from the start of the first fixation until the next saccade. Images not to scale.

disengagement index by comparing RT on two different trial types (valid vs invalid) for threat and neutral images: since any freezing would occur equally on both threat trial types, it is partialled out in the calculation of the disengagement index.

1.3.9. Interim conclusions of systematic review

In summary, although many studies have claimed to measure delayed disengagement from threatening images in high versus low anxious individuals, only a small subset of these have used task designs that could theoretically disentangle attentional disengagement from attentional orientation, using a procedure in which we can be reasonably confident that attention is actually on the threatening (or neutral) image when a shift in attention occurs. Even fewer studies used paradigms that meet the behavioural-freezing criterion. A summary of the different paradigms and the criteria that they meet are outlined in Table 1.

1.4. Meta-analysis

As preregistered the first meta-analysis included all studies that were assessed to have met the independence from orientation and “locus of attention” criteria outlined by Clarke et al. (2013), without consideration of the stricter “behavioural freezing” criterion. As outlined in Table 1, eighteen studies were considered to have used valid measures of disengagement meeting both these initial criteria and these studies were included in the short-list for the meta-analysis. Of these studies, seven papers did not include the statistics necessary for inclusion in the meta-analysis. Authors of these articles were contacted, and in five cases the required data were provided.

Ultimately, five studies could not be included in the meta-analysis. Participants in the study of Nelson et al. (2015) participated in either a calm or an anxious mood induction procedure before the attention task (there was no neutral control group) and both manipulations may have impacted the speed at which participants disengaged from threat images during the task. Chen et al. (2012) compared first fixation duration on happy versus angry faces (there was no neutral face baseline condition for the first-fixation-duration analysis; see also Manoli et al., 2021). Similarly, two other studies reported non-baseline-corrected disengagement speed from threat (i.e. without correction for disengagement speed from neutral images) and were not included in the meta-analysis (Richards et al., 2014; Schofield et al., 2012).

Of the thirteen studies that remained, one of them contained two experiments (resulting in fourteen datasets that could be included in the initial meta-analysis). Twelve data sets were from between-subjects experiments and the remaining two were correlational. We therefore deviated from the original preregistration by deciding to convert the correlation coefficient from these latter two studies to Hedge’s g, which allowed us to pool the fourteen studies in one meta-analysis.

1.4.1. Coding of data

We first extracted either: (1) the mean and SD for groups of high-anxious versus low-anxious individuals for between-groups studies, or (2) the zero-order correlation coefficients for the correlation between anxiety and disengagement score for the correlational studies. As preregistered, the following considerations were taken:

(1) When a study included an experimental manipulation (e.g. negative mood induction), we included data only from the control condition (e.g. neutral mood induction).
(2) Only one effect size from each participant sample was included in the meta-analysis, to prevent violation of the assumption of independent effect sizes. To prioritise which effect size should be included; the following (preregistered) criteria were followed
    (2.1) In the case where multiple tasks were completed by the same group of participants, the effect size was extracted from the task that was most common to the other studies in the meta-analysis. For example, the exogenous cueing task was prioritised over the dot-probe task.
    (2.2) In studies that used the dot-probe or exogenous cueing tasks, we took data from the condition with the shortest-reported cue presentation time. This is because longer cue presentation times are more likely to reflect strategic attentional control and larger effect sizes have been reported with shorter cue-target onset asynchrony (Pool et al., 2016). We note that disengagement effects can be observed at distractor-target onset asynchronies as short as 50–100 ms (Blakely et al., 2012;

Table 1. Common paradigms used to measure attentional disengagement from signals of threat in anxiety.

Paradigm	Meets independence-from-orientation criterion?	Meets locus-of-attention criterion?	Meets behavioural-freezing criterion?	Comments	Reviewed as not able to isolate disengagement process	Reviewed as acceptable (18 studies comprising 19 datasets)
Dot-probe	No	No	Yes	Limitations can be overcome if using eye tracking and calculating disengagement speed only on trials where eyes are fixated on opposite cue at time of target presentation.	Pizzie and Kraemer (2017), Rossignol et al. (2013), Taylor et al. (2014), Yuan et al. (2021)	
Modified dot-probe	No	No	No	Some limitations can be overcome if using eye tracking and calculating disengagement speed only on trials where eyes are fixated on opposite cue at time of target presentation.	Albery et al. (2021), Blekić et al. (2021), Evans et al. (2016, 2020), Jhang and Liang (2023), Lee et al. (2013), O'Toole and Dennis (2012), Packard et al. (2022), Zheng et al. (2023)	Schofield et al. (2012)
Exogenous cueing task	Must assume equivalent capture by all cue types	If cue presentation time <500 ms and cue is informative as to location of upcoming target	No	Cue that is >50% informative as to location of upcoming probe may increase likelihood that participants attend to cue when it appears and that attention remains at that location until target.	Cocia et al. (2012), Crump et al. (2013), Price et al. (2019), Sagliano, D'Olimpio, Panico, et al. (2016), Stefan et al. (2020), Wang et al. (2019)	Curby and Collins (2024), Sagliano, D'Olimpio, Taglialatela Scafati et al. (2016), Sagliano et al. (2014, 2018)
ARDPEI	Yes	If cue presentation time <500 ms	Yes	Because disengagement from threat index is calculated as RT difference on threat invalid minus threat valid trials, behavioural freezing is controlled for.	Boal et al. (2018), Delchau et al. (2020), Mao et al. (2020), Miller et al. (2023), Rudaizky et al. (2014), Xia et al. (2018)	Grafton and MacLeod (2014)
Shifting from central fixation	Yes	Yes – provided target remains on screen until response	No	Extra tests where cues and targets are spatially co-located can be conducted to rule out a behavioural freezing account.	Leleu et al. (2014), MacDonald et al. (2024), McGlade et al. (2020), Yiend et al. (2015) (Exp 1)	Azarian et al. (2016), Manoli et al. (2021), Richards et al. (2014), Yiend et al. (2015) (Exp 2), Clarke et al. (2014)
Visual Search with cues as distractors	No	No	Only if multiple cues presented on each trial	Limitations can be overcome if first fixation time on distractor cues is measured with eye tracking (although may not be very sensitive).	Berggren et al. (2012), Mulckhuyse et al. (2017), Sharma et al. (2022), Sheppes et al. (2013), Wermes et al. (2018)	McSorley and Morriss (2017)
Free viewing with eye tracking	Yes	Yes	Only if multiple cues presented on each trial	First fixation duration is a valid measure of disengagement; summed dwell time across trial is not.	Berdica et al. (2018), Shechner et al. (2017), Singh et al. (2015), Xing et al. (2022)	Chen et al. (2012), Fernandes et al. (2018), Lazarov et al. (2016, 2021), Liang et al. (2017), Nelson et al. (2015)

Boot & Brockmole, 2010; Fukuda & Vogel, 2011; Grafton & MacLeod, 2014).

(2.3) In the case that different threatening stimuli were used in the same experiment (e.g. threatening faces vs. threatening animals) or different neutral stimuli were used (e.g. neutral faces vs. neutral objects), the mean was taken across conditions.

(3) To facilitate cross-study comparisons, we extracted the same dependent variables from studies of the same type. Where studies reported other dependent variables but nonetheless included summary statistics from the conditions of interest, we first calculated baseline-corrected disengagement scores (for each anxiety group), and these were then entered in the meta-analysis to allow for comparison between anxiety groups. For example, for exogenous cueing tasks, rather than using RT on invalid-threat trials, which does not have baseline-correction for RT on invalid-neutral trials, we calculated the difference in RT on invalid-threat minus invalid-neutral conditions. However, it is necessary to know the correlation between these two scores to be able to calculate the standard deviation of these within-group difference scores, taking the pooled variance into account (Lakens, 2013). As the correlation between performance on within-subject conditions is rarely reported it was necessary to estimate this correlation based on existing datasets. As a conservative measure, we assumed a within-subjects correlation of .8 based on a number of correlations calculated from data provided by authors: $r = .86$ between threat-incongruent and neutral-incongruent in a spatial cueing task (Stefan et al., 2020); $r = .86$ between speed of threat word colour naming and neutral-word colour naming in a modified-Stroop task (Clarke et al., 2014); and $r = .94$ between RT to respond to probe presented left/right of central cue on threat and neutral conditions in an attention shifting task (Yiend et al., 2015; Exp. 2).

(4) We used WebPlotDigitizer (https://automeris.io/WebPlotDigitizer/) to extract means and variance measures from published figures in the case that between-group means and SD were not reported in the text.

(5) Scores were calculated as RT on threat minus neutral trials such that larger scores represent slower attentional disengagement from threat relative to neutral stimuli. Between-group difference scores were calculated as high anxiety minus low anxiety such that positive difference scores indicate slower disengagement in the high-anxiety group and negative difference scores indicate slower disengagement in the low-anxiety group.

Table 2 provides details of each study included in the meta-analysis and the process used to extract data. Extracted statistics and transformed data can be found at https://osf.io/ce39w/. Note that a potential limitation of the current study is that neither psychometric properties (i.e. reliability statistics) nor demographic data (age, gender, racial identification, cultural background or socioeconomic status) were extracted from studies nor analysed in any way.

1.4.2. Meta-analysis procedures

The *R* packages meta (Balduzzi et al., 2019), metafor (Viechtbauer, 2010) and dmetar with accompanying materials (Harrer et al., 2019) were used for all analyses. For each of the twelve between-group studies, the mean and SD of disengagement scores were extracted for each anxiety group. A random-effects model was used to calculate standardised mean difference between high-anxious and low-anxious groups (Hedges' *g*). For the pooled analysis of all fourteen studies, correlation coefficients were transformed to Hedge's g using the esc function in R (Lüdecke, 2016) before being included in the random-effects model. As recommended by simulation studies (Kontopantelis & Reeves, 2012; Langan et al., 2019; Viechtbauer, 2005), a restricted maximum likelihood estimator was used to estimate τ2. Heterogeneity between studies was assessed with both *Q* (X^2 statistic of heterogeneity and degrees of freedom) and I^2. The latter is the percentage of total inconsistency between studies that is due to heterogeneity and not due to chance and is directly calculated from *Q* (Higgins et al., 2003, 2016). Unlike *Q*, which can be overly sensitive with larger meta-analyses (detecting significant yet clinically irrelevant heterogeneity) yet underpowered for small meta-analyses, I^2 is beneficial in that it can be directly compared between meta-analyses. I^2 values of 25%, 50% and 75% can be respectively interpreted as indicating low, medium and high inconsistency due to heterogeneity (Higgins et al., 2003). For completeness, when samples are sufficiently large, we also report *Q* statistics. All meta-analysis design choices were preregistered at https://osf.io/wge2j.

Table 2. Datasets included in the meta-analysis.

Publication	Negative/threat stimuli	Participants	Anxiety measure	High Anx. Mean (SD)	Low Anx. Mean (SD)	Task used: dependent variable	Process
Azarian et al. (2016). *Evidence from the eyes: Threatening postures hold attention.*	Angry posture images	Non-clinical PD	STAI-T	54.3 (NR)	29.9 (NR)	Shift from central task with eye-tracking (100 ms CTOA). Time to move eyes to target presented left/right of central cue on threat minus neutral conditions.	2
Clarke et al. (2014). *Is selective attention in anxiety characterised by biased attentional engagement with or disengagement from threat: Evidence from a colour-naming paradigm.*	Threatening words	Non-clinical PS	STAI-T	45.80 (8.60)	30.80 (3.38)	Modified Stroop Task. RT to name colour of word, after reporting word meaning. Threat RT minus neutral RT.	1
Curby and Collins (2024). *When It's Not Worn on the Face: Trait Anxiety and Attention to Neutral Faces Semantically Linked to Threat.* (Experiment 1)	Neutral faces conditioned with angry words	Non-clinical MS	STAI-T	48.5 (6.0)	36.5 (3.4)	Exogenous Cueing Task (75% valid; 100 ms CTOA). RT for invalid threat minus RT for invalid neutral.	2
Curby and Collins (2024). *When It's Not Worn on the Face: Trait Anxiety and Attention to Neutral Faces Semantically Linked to Threat.* (Experiment 2)	Angry faces	Non-clinical MS.	STAI-T	51.29 (4.33)	34.16 (6.36)	Exogenous Cueing Task (75% valid; 100 ms CTOA). RT for invalid threat minus RT for invalid neutral.	2
Fernandes et al. (2018). *Eye-Tracking Evidence of a Maintenance Bias in Social Anxiety.*	Angry faces	Non-clinical TS.	SAASPI	234.68 (24.88)	139.47 (23.24)	Free viewing eye-tracking task. Duration of first fixation on threat minus neutral images.	3
Grafton and MacLeod (2014). *Enhanced probing of attentional bias: The independence of anxiety-linked selectivity in attentional engagement with and disengagement from negative information.*	Negative IAPS images	Non-clinical PS	STAI-T	46.21 (4.57)	32.08 (6.99)	ARDPEI (100 ms CTOA). 1. RT to invalid probe minus RT valid probe, on subset of trials where cue appeared in same location as first target, calculated separately for threat and neutral conditions. 2. Threat difference score minus neutral difference score.	4
Lazarov et al. (2016). *Social anxiety is related to increased dwell time on socially threatening faces.*	Disgusted faces	Clinical SAD vs. Non-clinical[a] (low self-reported anxiety).	LSAS	74.20 (17.56)	17.30 (12.91)	Free viewing eye-tracking task. Duration of first fixation on threat minus neutral images.	1
Lazarov et al. (2021). *Increased attention allocation to socially threatening faces in social anxiety disorder: A replication study.*	Disgusted faces	Clinical SAD vs. healthy controls	LSAS	85.40 (14.69)	7.50 (6.98)	Free viewing ET task. Duration of first fixation on threat minus neutral images.	1
Liang et al. (2017). *Sustained Visual Attention for Competing Emotional Stimuli in Social Anxiety: An Eye Tracking Study.*	Angry faces	Non-clinical QS[b]	BFNE	BFNE: 51.56 (4.60) STAI-T: 54.72 (9.09)	BFNE: 28.10 (5.96) STAI-T: 37.60 (6.74)	Free viewing eye-tracking task. Duration of first fixation on threat minus neutral images.	2,3
McSorley and Morriss. (2017). What you see is what you want to see: Motivationally relevant stimuli can interrupt current resource allocation.	Spider images	Non-clinical PS (spider fearful vs. not fearful)	FoS	58.3 (36.1)	1.9 (2.5)	Visual Search Task. Dwell time on distractor (before corrective saccade to target).	2,3

(*Continued*)

Table 2. Continued.

Publication	Negative/threat stimuli	Participants	Anxiety measure	High Anx. Mean (SD)	Low Anx. Mean (SD)	Task used: dependent variable	Process
Sagliano, D'Olimpio, Taglialatela Scafati et al. (2016). Eye movements reveal mechanisms underlying attentional biases towards threat.	Threatening images (animals, people, natural events).	Non-clinical (correlational)	STAI-T Mean (SD) 40.80 (8.28)	N/A	N/A	Exogenous cueing task (80% valid; 100 ms CTOA). RT for invalid threat minus RT for invalid neutral.	2
Sagliano et al. (2018). Attentional biases for threat after fear-related autobiographical recall.	Threatening images (animals, people, natural events).	Non-clinical (correlational)	STAI-T Mean NR	N/A	N/A	Exogenous cueing task (80% valid; 100 ms CTOA). RT for invalid threat minus RT for invalid neutral.[c]	1
Sagliano et al. (2014). *Attentional biases toward threat: The concomitant presence of difficulty of disengagement and attentional avoidance in low trait anxious individuals.*	Threatening images (animals, people, natural events).	Non-clinical PS	STAI-T	59.18 (NR)	31.11 (NR)	Exogenous Cueing Task (80% valid; 100 ms CTOA). RT for invalid threat minus RT for invalid neutral.	2
Yiend et al. (2015). *Mechanisms of selective attention in generalised anxiety disorder* (Experiment 2).	Fearful faces	Clinical GAD vs. non-clinical (high self-reported anxiety)	STAI-T	57.76 (10.99)	35.19 (7.46)	Shift from central task (300 ms CTOA). RT to respond to target presented left/right of central cue on threat minus neutral conditions.	1

[a]This study had an additional (third) group of non-clinical high-anxious participants (see text for details).
[b]Actually took upper quartile (high anxiety group) and lower two quartiles (low anxiety group).
[c]Only for neutral mood induction group (excluded fear and happy mood induction groups).

1.5. Results

1.5.1. Study characteristics

As can be seen in Table 2 the majority of studies used non-clinical populations that were pre-screened for trait anxiety on the State Trait Anxiety Inventory (STAI-T; Spielberger et al., 1983). Only three studies investigated attentional disengagement from threat in clinical populations. Yiend et al. (2015) studied patients with generalised anxiety disorder and compared them to a high-anxious non-clinical population. Lazarov and colleagues (2016, 2021) studied patients with social anxiety disorder (SAD) and compared them to low-anxious healthy controls (2021), as well as both high- and low-anxious individuals (defined by scores on the Lebowitz Social Anxiety Scale; 2016). For the purposes of the meta-analysis, we excluded the high-anxiety group from the 2016 study and entered SAD vs. low-anxious groups as the critical comparison, but we note that the pattern of results does not change if the high-anxiety group is included instead of the SAD group. Three further studies defined groups on the basis of different questionnaires. Liang et al. (2017) used the Brief Fear of Negative Evaluation (BFNE) to define groups; STAI-T scores were also measured in this study, with the low anxious group having a relatively high score on this measure compared to other studies in this meta-analysis. Fernandes et al. (2018) used the "Scale of Anxiety and Avoidance in Social Performance and Interaction" to define high- and low-anxiety groups. Finally, in a study examining disengagement from spider stimuli McSorley and Morriss (2017) pre-screened participants on the Fear of Spiders questionnaire.

1.5.2. Meta-analysis across all studies

Figure 7(A) shows results of the meta-analysis when pooling effect sizes across all 14 studies (759 participants in total). There was a small but significant effect indicating delayed disengagement from threatening stimuli versus neutral stimuli in high-anxious relative to low-anxious individuals in this analysis: meta-analytic standardised mean difference (Hedges' g) = 0.32, 95% confidence interval (CI_{95}) [0.01, 0.62], $p = .042$. Heterogeneity across studies was high as indicated by both I^2 and Q, with $I^2 =$ 75%, CI_{95} [58%, 85%], $Q_{13} = 51.8$, $p < .001$. Visual inspection of the funnel plot indicated that while the largest positive effect could be attributed to the smallest study in the sample, there did not appear to be significant evidence of asymmetry (indicative of publication bias). Given the high heterogeneity and small number of studies it was deemed not appropriate to run Egger's regression test (Sterne et al., 2011).

1.5.3. Pre-registered meta-analysis controlling for behavioural freezing

Of the fourteen eligible data sets, nine used procedures in which only one type of image was presented on each trial – either threatening or neutral images – such that any delay in RT on threat trials could be attributed to behavioural freezing in the presence of threat rather than slowed disengagement per se: these nine studies failed the "behavioural freezing" criterion described earlier (see Section 2.3.8). By contrast, the remaining five (between-subjects) studies used paradigms in which both threatening and neutral images were presented on each trial (Fernandes et al., 2018; Lazarov et al., 2016, 2021; Liang et al., 2017) or studies where a disengagement index was calculated as RT on two different trial types (valid vs. invalid), separately for threat and neutral images (Grafton & MacLeod, 2014), thus partialling out any influence of freezing. As pre-registered, we reran the initial meta-analysis, restricted to these five studies that met the "behavioural freezing" criterion (261 participants in total). Heterogeneity was low, albeit with wide confidence intervals, $I^2 = 0\%$, CI_{95} [0%, 79%], $Q_4 = 2.9$, $p = .572$, when restricted to these five studies. There was no significant evidence for delayed disengagement from threat as a function of anxiety in the subset of studies that controlled for potential behavioural freezing, Hedge's $g = 0.20$, CI_{95} [−0.11, 0.50], $p = .147$.

2. Discussion

Since Clarke et al. (2013) published their critique of common paradigms used to measure attentional disengagement, more than 50 studies have attempted to measure disengagement from signals of threat as a function of anxiety. In the current systematic review, we first examined the task designs that have been commonly used and assessed whether these could feasibly be deemed to provide a specific index of the time taken to disengage attention from stimuli differing in emotional content. We then used meta-analysis to examine whether a pattern for slowed disengagement from threat images (relative to neutral) emerged in high-anxious individuals.

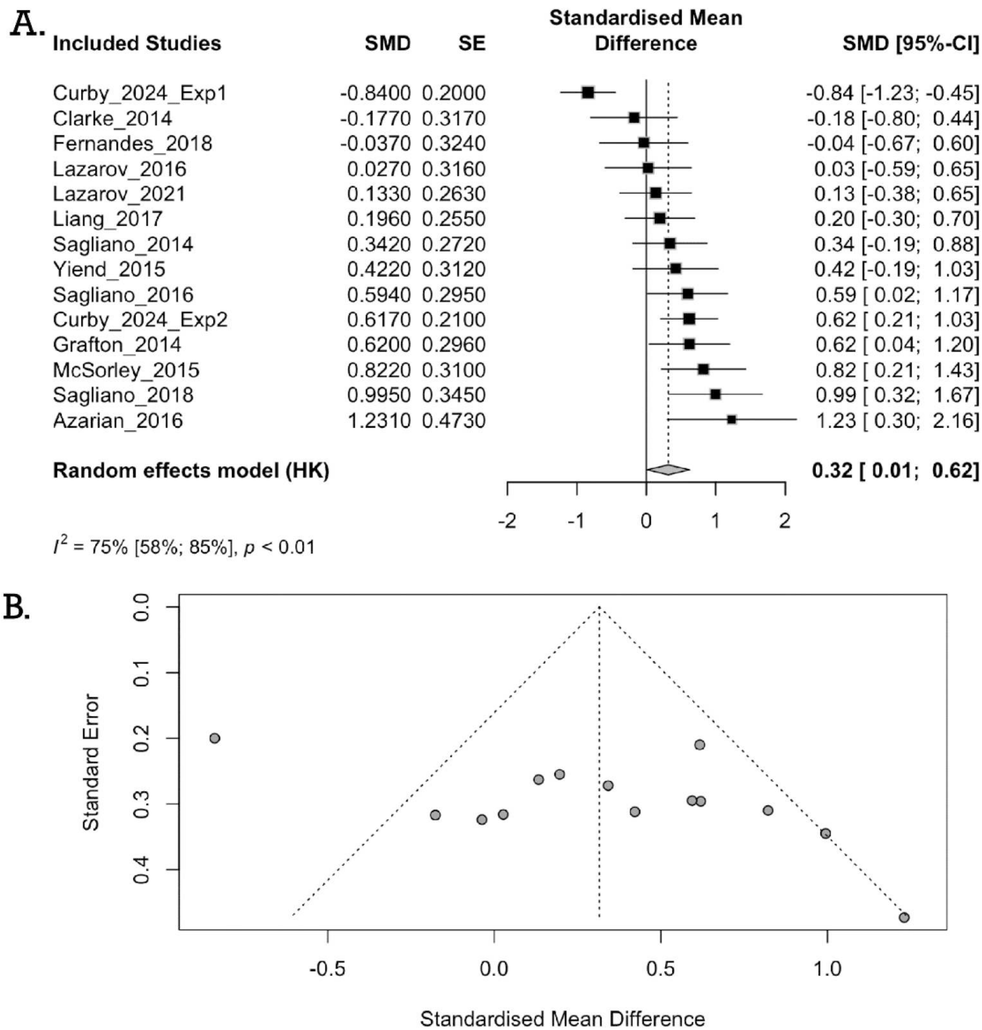

Figure 7. (A) Results of the combined meta-analysis. Hedge's *g* was calculated from high anxiety and low-anxiety disengagement scores for twelve between-group studies and pooled with data from two correlational studies (correlation coefficients were converted to Hedges' g). The grey diamond represents the overall meta-analytic effect size (and 95% CI). The black lines represent the prediction interval (i.e. dispersion of effect sizes). Heterogeneity, as assessed with I^2, was high. (B) There was limited evidence of publication bias as assessed by visual inspection of the funnel plot.

As the systematic review makes clear, most of the literature in the last ten years that has claimed to measure delayed attentional disengagement from signals of threat as a function of anxiety, did not use appropriate paradigms or protocols. Most studies either used paradigms that could not reliably dissociate differences in the orienting of attention from subsequent attentional disengagement and/or made the unlikely assumption that attention remained fixated at specific locations on screen for extended periods of time (500–2000 ms) before target onset. This review also highlighted paradigms that are better suited to measure attentional disengagement, and these should ideally be adopted by the field moving forward. Studies that were deemed to be able to disentangle attentional disengagement from attentional orienting used the ARDPEI (Grafton & MacLeod, 2014; Mao et al., 2020), tasks where attention was required to be shifted from a centrally presented cue (Azarian et al., 2016; Yiend et al., 2015, Experiment 2) or free-viewing paradigms with eye-tracking (where the first fixation duration was compared for threatening and neutral images; Fernandes et al., 2018; Lazarov et al., 2016, 2021; Liang et al., 2017; Nelson et al., 2015). Critically these studies used parameters that justified the assumption that attention was located at the threatening or neutral stimulus, at the time that the disengagement measurement began.

The main meta-analysis included fourteen datasets (with 759 participants in total) using paradigms that were deemed to have met the locus-of-attention and independence-from-orientation criterion raised by Clarke et al. (2013). This meta-analysis showed a small but significant effect of delayed disengagement from threat stimuli in participants high in anxiety relative to those reporting low anxiety. However, this result needs to be interpreted with caution because heterogeneity was high ($I^2 = 75\%$). Although this might be expected given the different types of paradigms being used, with unknown psychometric properties, the considerable variability and inconsistency among studies suggest a broad range of effect sizes and imply that the different paradigms may not be assessing the same construct (Borenstein et al., 2009; Higgins, 2008).

By contrast, when we restricted the meta-analysis to studies that controlled for behavioural freezing (five studies with a total of 261 participants), we observed lower heterogeneity and a negligible effect of anxiety status on disengagement speed. These studies used RT paradigms such as the ARDPEI (specifically designed to overcome the flaws identified by Clarke et al., 2013) and the duration of first fixation in free viewing tasks (using eye tracking). However, this meta-analysis was possibly underpowered due to the small set of studies that could be included. This highlights the need for future research using rigorous paradigms to measure attentional disengagement.

2.1. Future considerations

2.1.1. The role of motivation

Most paradigms highlighted in the review required participants to locate and respond to a target on each trial. Exceptions to this are free-viewing paradigms where there is no task requirement for participants to disengage their attention from any of the images and participants are not instructed to search for a target probe. As such, free-viewing tasks are measuring the speed at which participants *tend* to disengage from stimuli differing in emotional content. This is in contrast to paradigms where participants must disengage from such stimuli (in order to locate the target, end the trial and progress with the experiment) that are putatively measuring the ability to disengage attention quickly. That being said, it should be noted that none of the paradigms reviewed here provide a strong test of the participant's ability to disengage, because there is no cost to participants for disengaging attention more slowly from threat versus neutral stimuli. As such, delayed disengagement could be entirely voluntary, and easily overcome if sufficient motivation were provided for them to try and disengage quickly from threat stimuli. It is therefore premature to suggest that slower responding on trials featuring signals of threat is due to "difficulty" with disengaging attention (despite this being a frequent refrain in the literature). For such claims to be substantiated, tasks should be designed so that delayed disengagement incurs some cost for the participant, thus demonstrating that it is occurring despite negative consequences (see Watson et al., 2020, for an example).

2.1.2. The nature of the response to the target

Common behavioural paradigms used to measure biased orienting or disengagement frequently require participants to respond with a left or right key press to the spatial location of the target probe (left or right side of the screen). When the cue is generally informative as to the upcoming location of the target probe, as it was in some studies reviewed earlier (Curby & Collins, 2024; e.g. Sagliano et al., 2014, 2018; Sagliano, D'Olimpio, Taglialatela Scafati, et al., 2016), response preparation processes can be initiated at the time of cue presentation. Mulckhuyse and Crombez (2014) argue that threatening cues that offer reliable information about the upcoming probe location may simply prime action-preparation responses more rapidly or more strongly than neutral cues (resulting in faster responding in the threat condition on valid trials and slower responding on invalid trials). It is therefore best practice for studies in this domain to ensure that participants are asked to respond to *features* of targets (shape, colour, size) rather than their spatial location. This means that participants are not able to prepare their response to the upcoming target during the cue presentation window.

2.1.3. Psychometric properties

Difference scores (computed for example by subtracting RT in one condition from another) typically have poor internal consistency and test-retest reliability

(Edwards et al., 2024; Green et al., 2016; Pronk et al., 2022). This is argued to arise from the fact that these measures have low variance between individuals, making them powerful at the group level for easily replicable experimental effects, but potentially limited in their utility in individual difference analyses (Hedge et al., 2018). This is problematic in the current context, where researchers routinely examine the correlation between difference scores (e.g. RT on invalid-threat vs. invalid-neutral trials) and individual differences in anxiety scores. Notably few of the studies included in the meta-analysis reported reliability statistics (as is common across neuroscience and psychology; Green et al., 2016). The exceptions to this were Lazarov and colleagues (2016, 2021) who reported excellent test-retest reliability for eye-tracking metrics (e.g. dwell time on threat images) in their studies, although reliability for difference scores was not reported. Reliability of tasks such as the dot-probe was recently argued to be near-zero across a variety of task parameters (Xu et al., 2024) and reliability of the ARDPEI for body image stimuli was reported to be around 0.4 (Dondzilo et al., 2024), which falls short of the 0.7 threshold widely cited as acceptable (George & Mallery, 2003; Nunnally, 1978).

Parameters that have been seen to improve reliability estimates for difference scores in various cognitive tasks include the use of more trials and filtering of outlier RTs for each participant (Farkas et al., 2024; Garre-Frutos et al., 2024). Moving forward, reporting psychometric properties of the paradigms in use should be standard practice. Two commonly used methods are the Cronbach's Alpha coefficient (measuring internal consistency) and Spearman-Brown Prophecy corrected split-half reliability. Both methods involve first arbitrarily splitting the trials into two halves (e.g. even vs odd trials) and then calculating difference scores for each participant. The Cronbach Alpha coefficient can then be calculated as the covariance between these scores, relative to the variance of the sum of scores (Green et al., 2016; see Farkas et al., 2024 for a worked example). Alternatively, the corrected split-half reliability can be calculated by correlating the difference scores for the two halves and applying the Spearman-Brown Prophecy Formula (Brown, 1910; Spearman, 1910) to convert this to a reliability estimate for the full test. Consideration should be given to the type of splitting procedure, as this is reported to affect reliability estimates (Pronk et al., 2022).

2.1.4. Covert vs. overt attention

Another factor potentially influencing the measurement of attentional disengagement relates to differences between overt and covert attention. Shifts in covert attention necessarily precede a shift in gaze (Peterson et al., 2004). As such, it has been suggested that tasks using manual RT as dependent variable may be measuring the summation of both covert and overt disengagement effects whereas tasks that rely on eye-tracking metrics are only tapping into the effect of threatening stimuli on overt attentional disengagement (Armstrong & Olatunji, 2012; Garner et al., 2006). Given the high level of heterogeneity in the current meta-analysis and the small number of studies it was not appropriate to run subgroup analyses comparing patterns of disengagement when using eye-tracking metrics vs manual RT (Cuijpers et al., 2021). However, this question of the relative contributions of covert vs. overt attention seems less pertinent than the critical questions of (a) whether, when using appropriate tasks individual scoring high in anxiety demonstrate delayed disengagement from stimuli that signal threat; and (b) whether such delayed disengagement is truly involuntary.

Hopefully, with the use of more valid paradigms that can meet all three of the criteria identified by Clarke et al. (2013) (such as the ARDPEI and eye-tracking metrics of first fixations in free-viewing tasks) further progress can be made on the question of whether anxiety is characterised primarily by biased orienting towards signals of threat or delayed disengagement from such signals (or both). This research has important implications for standard treatment protocols for anxiety (understanding whether individuals notice threats more readily or get cognitively "stuck" on them) as well as for the refinement of attentional bias modification treatments for anxiety. The need to improve methods for measuring attentional disengagement goes beyond the field of anxiety disorders, with these problematic tasks also commonly used to examine delayed disengagement from signals of reward as it pertains to addictive behaviours (Heitmann et al., 2020; Heuer et al., 2021; Mogg et al., 2003).

2.2. Summary and recommendations

In summary, when restricting to studies utilising a valid measurement of disengagement, there was some evidence for delayed attentional disengagement from threat in those with high anxiety, with high heterogeneity across studies. Current data cannot rule out the possibility that this observed effect may be (partially) attributed to general response slowing in the presence of threat rather than disengagement *per se*.

Our key recommendations for those interested in studying the process of attentional disengagement are:

(1) If a shift of attention toward the cue is required before measuring disengagement, the disengagement measure may be confounded by orienting differences. Use eye tracking, or a task such as the ARDPEI to address this issue.
(2) Keep cue presentation duration brief (<500 ms) to ensure that attention has not already shifted away from the image cue, before starting measurement of the disengagement process.
(3) Ensure participants are responding to a feature of the target (e.g. its orientation, colour or size) rather than its spatial location, to avoid the possibility that response time differences are the result of response preparation priming.
(4) To rule out behavioural freezing effects, do not rely on a direct comparison of response time on a trial featuring only emotional image(s) with response time on a trial featuring only neutral image(s).
(5) To justify the claim that participants find it "difficult" to disengage attention from a stimulus, demonstrate that delayed disengagement persists despite negative consequences.

Note

1. This approach can be contrasted with procedures in which onset of the target coincides with offset of the cue image (an approach commonly used in the modified dot-probe and exogenous cueing task), such that the cue image is no longer visible when participants must shift their attention to the target. It may be questioned whether participants need to disengage from a stimulus that has already been removed from the screen; however research in psychophysics has demonstrated that visual sensation and perception are temporally separable and that visual representations may linger even if the stimulus has been removed (Breitmeyer & Ogmen, 2006).

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