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Anxiety disorders and executive functions:A three-level meta-analysis of reaction time and accuracy

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ABSTRACT

Anxiety disorders, one of the most common classes of psychological disorders, have been shown to result in a decreased quality of life. Although some research suggests that anxiety disorders are linked to impairments in executive functioning, the inconsistency in the current literature yields an unclear conclusion on the relationship between the two. The current meta-analysis systematically investigated 55 records ($N = 4601$; $k_{ReactionTime} = 44$, $k_{Accuracy} = 79$) that compared various groups with anxiety disorders to healthy controls on executive function tasks. Overall, our meta-analysis showed that individuals with anxiety disorders exhibited significant deficits in performance efficiency (reaction times) on executive function tasks. However, we also found that individuals with anxiety disorders may outperform their healthy peers in performance effectiveness (task accuracy) in some conditions. Type of anxiety disorders, domain of executive functions, and mediation use were identified to moderate the overall relations between anxiety disorders and executive functioning. Nevertheless, the results were robust across important demographic and other clinical moderators (e.g., anxiety severity and comorbidity).

1. Introduction

1.1. Anxiety disorders and executive functions

Anxiety disorders, characterised by constant and unsubstantiated fear or worry (American Psychiatric Association [APA], 2015), are argued to be one of the most common classes of psychological disorders, with an estimated lifetime prevalence of 28.8% in the United States (for review, see Kessler et al., 2005). The pervasiveness of anxiety disorders is worrying, given their adverse impact on one's quality of life by worsening social functioning, self-esteem, and physical health (e.g., Gariepy et al., 2010; Khan et al., 2002; Lochner et al., 2003; Olatunji et al., 2007). Importantly, research suggests that anxiety disorders are associated with deficits in executive functioning (EF; e.g., Castaneda et al., 2008)—a set of higher-order cognitive control processes crucial for goal achievement (Miyake et al., 2000). However, inconsistent results have been reported. Given the predictive value of EF for important outcomes including academic success (e.g., Gathercole et al., 2004), job performance (e.g., Bailey, 2007), social behaviour (e.g., Hughes et al., 2000), and family functioning (e.g., Hooven et al., 1995; Shaffer and Obradović, 2017), clarifying the link between anxiety disorders and EF may have important implications for the diagnosis, management, and treatment of anxiety disorders (Hosenbocus and Chahal, 2012). In view of mixed findings regarding the association between anxiety disorders and EF, our research goals are two-fold. First, we sought to conduct a comprehensive meta-analysis to examine the relation between anxiety disorders and EF. Second, we aimed to explore the potential moderating effects of variables (e.g., outcomes measures type of anxiety disorder, demographic factors, medication use, severity, and emotional saliency) which could have contributed to discrepant findings in the literature.

It has been proposed that anxiety interferes with EF via attentional biases; anxiety is related to the preferential allocation of attention to threat-related stimuli, both internal (e.g., worries) or external (e.g., threatening task-irrelevant stimuli), leaving fewer attentional resources to process other, more relevant information (Derryberry and Reed, 2002; Eysenck et al., 2007). An alternative proposal suggests that even in the

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absence of threat-related stimuli, high trait anxiety is associated with impoverished recruitment of prefrontal regions of the brain (Bishop, 2008; Forster et al., 2013)—a key brain structure supporting EF (Funahashi and Andreau, 2013). Accordingly, studies have found that, compared to controls, individuals with social anxiety disorder and generalised anxiety disorder performed worse on neurocognitive tasks (e.g., Fujii et al., 2013; Tempesta et al., 2013) and were less able to ignore irrelevant information, especially when the information was threatening (Bar-Haim et al., 2007). However, contradictory results have been reported in other studies, where researchers found no significant differences in executive control performance between controls and individuals with anxiety disorders (e.g., Airaksinen et al., 2005; Rosa-Alcazar et al., 2019).

These discrepant findings may be due to several methodological issues present in the extant literature. First, previous studies have failed to delineate the multifaceted construct of EF, which has been theorized to comprise three distinct, yet interrelated, processes: inhibition, shifting, and updating (Friedman et al., 2008; Miyake et al., 2000). *Inhibition* involves the suppression of automatic responses to irrelevant stimuli, *shifting* reflects the ability to flexibly switch between different tasks, and *updating* involves working with new information and removing old information from the working memory (for review, see Diamond, 2013; Snyder, 2013). Empirical studies, however, have mostly examined these facets in isolation and generalised their deficits to represent EF impairment, which may not accurately reflect the multifaceted construct of EF. Further, others have adopted a unidimensional perspective of EF (i.e., utilising a single task to measure multiple components of EF), which fails to account for construct-specific variance present in measurement models of EF (Karr et al., 2018). To account for both the unity and diversity of EF, we aimed to investigate the association between a unified construct of EF (i.e., comprising the facets of inhibition, shifting, and updating) and different types of anxiety disorders, and to specify the relation between each facet and anxiety disorders in general.

Second, it is plausible that inconsistent findings may be due to the various performance outcome measures used across studies. Drawing on the attentional control theory, high-anxiety individuals who have poor attentional control often employ more cognitive resources in order to compensate for their deficits, especially for inhibition and shifting tasks (Eysenck et al., 2007; Eysenck and Derakshan, 2011). Therefore, high-anxiety individuals may not necessarily perform worse than their low-anxiety counterparts in terms of accuracy, but instead, have a lower processing efficiency which is indexed by a smaller ratio of performance effectiveness to the use of processing resources, usually measured by reaction time (RT; Edwards et al., 2015; Eysenck and Derakshan, 2011; Hartanto and Yang, 2022). In line with this theory, studies measuring only performance effectiveness (i.e., accuracy) might display null results, while others measuring only RT might show that high-anxiety groups perform weaker in EF tasks than control groups. For instance, Korenblum et al. (2007) found that individuals with anxiety disorders did not differ from healthy controls in terms of accuracy, but exhibited slower response times on an inhibition task. Taken together, it is plausible that the attentional control theory may be able to reconcile mixed findings due to different outcome measures. To this end, our meta-analysis aimed to assess both accuracy and RT on EF tasks across multiple studies to attain a more coherent interpretation of the association between anxiety disorders and performance effectiveness and efficiency on EF tasks. To reiterate, inspired by the attentional control theory (Eysenck et al., 2007), performance effectiveness in the current paper is indexed as the accuracy of responses on EF task whereas performance efficiency is defined as RT on EF task with reference to performance effectiveness, such that impaired RT combined with comparable levels of performance effectiveness would serve as an indicator of lower performance efficiency.

Third, varied emotional salience of task stimuli in different studies may contribute to discrepant findings. According to the attentional control theory, adverse effects of anxiety on task performance caused by task-irrelevant stimuli are greater when stimuli are threat-related rather than neutral (Eysenck et al., 2007). In support of this view, various studies have suggested that groups with anxiety disorders performed worse than controls in cognitive tasks when presented with threatening stimuli as opposed to neutral stimuli (e.g., Galderisi et al., 2008; McNally et al., 1994; Mogg and Marden, 1990). Therefore, we sought to consider the emotional salience of the task stimuli as a moderator in the meta-analysis to investigate this proposition.

Lastly, another factor contributing to the heterogeneity in research findings might be tied to the diversity of the samples used across studies which varied in comorbidity, psychotropic medication use and/or treatment, severity of anxiety disorder, age, and gender. These demographic variables might account for variances in findings due to their differential relationships with cognitive ability. Specifically, medication use and/or treatment may have different effects on cognitive abilities depending on the type of medication. For example, the use of certain medications, such as benzodiazepines (e.g., Stewart, 2005), is associated with weaker executive control, whereas the use of treatments, such as cognitive behavioural therapy (e.g., Ritchey et al., 2011), and the administration of other medications, such as selective serotonin reuptake inhibitors (e.g., Skandali et al., 2018), are associated with lower cognitive impairment. Similarly, studies have shown that comorbidity burden either increases (e.g., Kaplan et al., 2006; Graver and White, 2007), decreases (e.g., Bradley et al., 1995; Graver and White, 2007; Musa et al., 2003), or may not affect (e.g., Castaneda et al., 2011; Topçuoğlu et al., 2009) cognitive impairment, depending on the type of comorbidity and the type of EF task used to measure cognitive ability. For example, Graver and White (2007) reported that individuals with comorbid social phobia and major depression performed worse than socially phobic individuals and healthy controls on the Trail-Making Task B under stressful conditions, whereas Topçuoğlu et al. (2009) found that patients with comorbid social phobia and depression did not perform worse than individuals with social phobia on the Wisconsin Card Sorting Task. Finally, research has also shown that older adults display lower EF (e.g., Berg, 1948; Kirova et al., 2015; Schneider-Garces et al., 2010) and that females are more likely to have anxiety disorders (e.g., McLean et al., 2011; Remes et al., 2016). Given that these variables have been reported to interact with EF in previous studies, it is crucial to include these as moderators in our analysis.

Taken together, these inconsistent findings underscore the need for a meta-analytic approach to illuminate the relation between anxiety disorders and impaired EF while accounting for potential moderators of this relation. To this end, we synthesized previous research findings and used meta-analytic methods to test the conflicting hypotheses about the relationship between anxiety disorders and EF. To explore the source of variance in precedent findings, we examined the potential moderating effects of methodological discrepancies (unified/diversified EF, types of measured outcomes, types of anxiety disorders tested, and emotional salience of task stimuli), as well as demographic (age and gender) and clinical (severity of anxiety disorder, use of psychotropic medication/ treatment, and comorbidity) variables on effect sizes.

Based on the predictions of attentional control theory (Eysenck et al., 2007), it was hypothesized that anxiety disorders would affect RT, but not accuracy, on EF tasks that assess inhibitory control and task-switching ability. However, anxiety disorders would be less likely to affect RT or accuracy on EF tasks assessing updating ability, since those tasks do not require attentional control (Eysenck et al., 2007). Furthermore, given that the subtypes of anxiety disorders are characterized by distinct diagnoses, specific hypotheses for each type of anxiety disorder and performance on EF tasks were proposed. Generalised anxiety disorder, in particular, is characterized by persistent worry and thoughts on a variety of topics (Roemer et al., 1997), which may serve as an internal distraction and impair attentional control (Stefanopoulou et al., 2014). In contrast, other forms of anxiety disorders (e.g., social anxiety disorder and specific phobia) are characterized by worry and anxiety in response to specific events and stimuli. For example, individuals with social anxiety disorder have an acute dread of social evaluation, and so their anxiety relates exclusively to social stimuli or circumstances that involve a risk of being evaluated (e.g., Graver and White, 2007; Moriya and Tanno, 2011; Wieser et al., 2009). Likewise, individuals with panic disorder are more biased towards internal and external panic-related stimuli and pay less attention to non-panic-related stimuli (Hayward et al., 2000; Rentzsch et al., 2019). As a result, attentional control is unlikely to be impaired in individuals with anxiety disorders other than generalised anxiety disorder when they are performing neutral tasks in general situations. Consistent with attentional control theory, which states that anxiety affects processing efficiency but not performance effectiveness (Eysenck et al., 2007), it was hypothesized that generalised anxiety disorder would result in slower response time but a comparable level of accuracy on EF tasks when compared to healthy controls. Individuals suffering from social phobia, panic disorder, specific phobia, or selective mutism, on the other hand, would show no significant difference in RT and accuracy on EF tasks when compared to healthy controls.

1.2. Transparency and openness

The current meta-analysis was not pre-registered. A detailed description of the inclusion and exclusion criteria, documentation of full-text records excluded with their corresponding reasons, as well as R code used for the current meta-analysis, are publicly available on ResearchBox (#283; https://researchbox.org/283). Analyses for overall effect size estimates, as well as tests of publication bias, were conducted in R version 3.6.3 (R Core Team, 2020) using the meta-analytic package *metafor* version 2.4–0 (Viechtbauer, 2010) with restricted maximum likelihood estimation.

2. Method

2.1. Search strategy

A literature search was conducted in *ERIC, PsycINFO*, *PubMed*, and *Web of Science* using the keywords ("anxiety disorder*" OR "acute stress disorder*" OR "general* anxiety disorder*" OR agoraphobi* OR phobia OR "obsessive%compulsive" OR "post%traumatic stress" OR "separation anxiety" OR "panic disorder*") AND ("executive function*" OR "cognitive function*" OR "neuropsychological function*" OR "working memory" OR updating OR inhibition OR "self%control" OR "cognitive control" OR "interference control" OR "executive control" OR shifting OR "task%switch*" OR "mental *shift*" OR "cognitive flexibilit*" OR "mental flexibilit*" OR "visuo%spatial sketchpad" OR "visuo%spatial memory" OR "visual memory" OR "phonological loop" OR "central executive" OR "verbal fluen*" OR "processing speed" OR "reaction time" OR "cognitive performance"). Manual searches were conducted in *Journal of Anxiety Disorders*, *Psychiatry Research,* and *Google Scholar*. To supplement these searches, we examined the reference sections of previous reviews related to anxiety disorders and EF (e.g., Harber et al., 2019; Lipszyc and Schachar, 2010). Additionally, a manual search was conducted in *ProQuest Dissertations & Theses* to capture unpublished literature.

The search terms ("acute stress disorder*" OR "obsessive%compulsive" OR "post%traumatic stress") were included because acute stress disorder, obsessive-compulsive disorder, and post-traumatic stress disorder have been classified as subtypes of anxiety disorders under DSM-IV, and previous studies often examined different subtypes of anxiety disorders together and compared how the subtypes of anxiety disorders differentially affect neuro-cognition in the same study (e.g., Borges et al., 2011; Cheng et al., 2015; Kim et al., 2019). Therefore, these keywords were included to ensure that studies that examined subtypes of anxiety disorders not classified under DSM-5 and subtypes of anxiety disorders classified under DSM-5 together were incorporated in the current meta-analysis. In addition, the terms "central executive", "phonological loop" and "visuospatial sketchpad" were included because they represent the different components of working memory as proposed by Baddeley's (1992) model of working memory. Other working memory related search terms, such as "verbal fluency", were also incorporated based on previously published meta-analyses of EF and working memory (e.g., Forbes et al., 2008; Henry and Crawford, 2004; Kasper et al., 2012; Martinussen et al., 2005). Overall, the inclusion of these search terms contributed to the rigour of the current meta-analysis by ensuring that no constructs relevant to EF, working memory, inhibitory control, switching, or anxiety disorders were neglected.

2.2. Inclusion and exclusion criteria

The PRISMA flowchart, which outlines the overall process for selecting studies for inclusion in this meta-analysis (Moher et al., 2009), is shown in Fig. 1. The search resulted in 43,681 potentially eligible records, following which duplicates were removed using Mendeley Desktop version 1.19.4 (Mendeley, n.d.) by one of the authors, resulting in 37,563 potentially eligible records being screened for inclusion. The potentially eligible records were then split among three of the authors (i.e., each was responsible for approximately 12,500 records). The authors took two months to screen their records based on abstracts and eliminated a total of 37,350 irrelevant records.

The same three authors then split the remaining 213 full-text records (i.e., each was responsible for approximately 70 records) and took one month to screen their records based on predetermined inclusion and exclusion criteria. Specifically, studies from each record were included if participants in the anxiety disorder group currently met the criteria of having an anxiety disorder listed in the Diagnostic and Statistical Manual of Mental Disorders (DSM-5; APA, 2013) or the International Classification of Diseases (ICD-10; World Health Organization, 2004) and had no brain damage or intellectual disability; there was a control group free from any current or lifetime psychiatric diagnosis, and both groups were tested on at least one measure of EF without any form of manipulation or intervention and without the use of any intrusive methods (e.g., MRI, blood samples) and behavioural outcomes (RT and/or accuracy) were available. Studies were excluded if they contained data from samples that could be found in a larger study that was available and relevant to the current meta-analysis. If a study was eligible but did not report the appropriate statistics, the original authors of the study were contacted directly to obtain useable data.

In total, seventeen records were excluded due to missing data while nineteen studies were excluded due to inaccessibility as the original authors did not respond to repeated requests. Fifty-six records were excluded because the constituent studies did not measure performance on EF tasks, twenty-seven records were excluded because the constituent studies did not examine participants with anxiety disorder or participants had an anxiety disorder that was not clinically diagnosed, twelve records were excluded because intrusive measures were used during task performance, ten records were excluded because they did not include a control group free from medication or any current or lifetime psychiatric diagnosis, four records were excluded because they included participants with non-anxiety related disorder as the primary diagnosis, four records were excluded because they involved anxiety-related interventions or manipulations but did not report baseline measures of EF, four records were excluded because they were either review articles or a letter to the editor, three records were excluded because participants in the anxiety group had comorbid disorders, two records were excluded because participants were exposed to electric shocks while working on EF tasks, two records were excluded because another version of the record (i.e., published version and English translated version) was already included in the meta-analysis, and one record was excluded because the constituent study investigated anxiety disorders in participants with brain injury. A more detailed description of the inclusion and exclusion criteria, as well as the documentation of full-text records excluded with their corresponding reasons, is publicly available on ResearchBox (#283).

Based on the examination of the potentially eligible full-text records by the three authors, 55 records (3.64% unpublished) met all criteria and

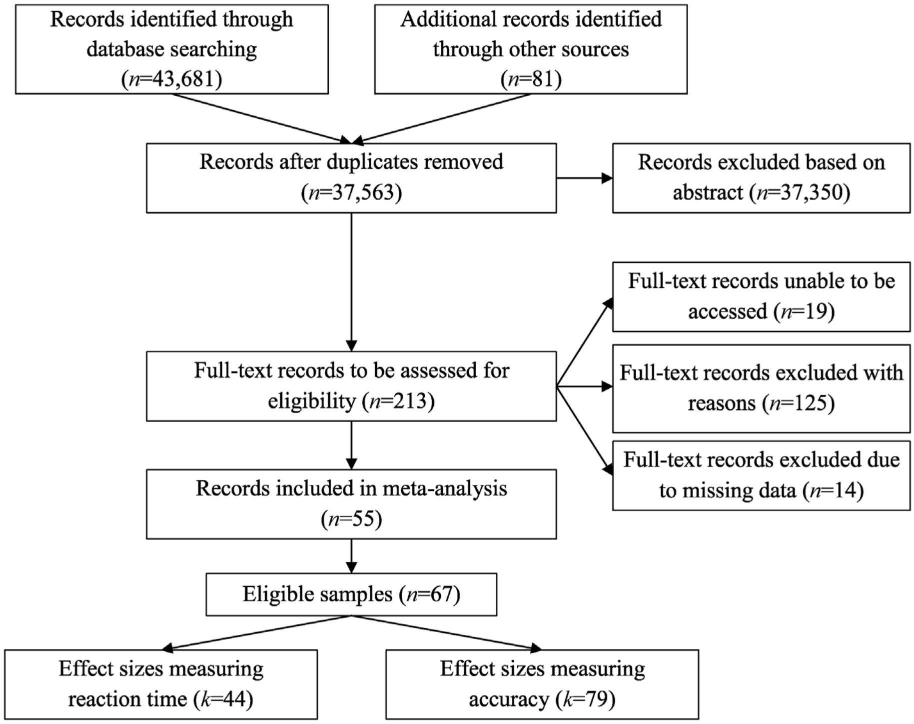

Fig. 1. PRISMA flowchart.

had sufficient data to compute effect sizes (Airaksinen et al., 2005; Amir et al., 1996; Andrews and Anderson, 1998; Asmundson et al., 1994; Boldrini et al., 2005; Bourke et al., 2012; Carter et al., 1992; Castillo et al., 2010; Cody et al., 2014; Cohen et al., 1996; De Cort et al., 2008; Del-Monte et al., 2013; Demetriou et al., 2018; Dorahy et al., 2006; Dupont et al., 2000; Fujii et al., 2013; Galderisi et al., 2008; Graver, 2004; Günther et al., 2004; Hardin et al., 2007, 2009; John, 2005; Kampman et al., 2002; Kaplan et al., 2006; Kim et al., 2019; Korenblum et al., 2007; Kurt et al., 2017; Ladouceur et al., 2005, 2006; Lautenbacher et al., 2002; Lea et al., 2018; Lim and Kim, 2005; Manassis et al., 2007; Mantella et al., 2007; Martin et al., 1991; Mattia et al., 1993; McNally et al., 1990, 1994; Mogg et al., 2015; Olatunji et al., 2008; O'Toole et al., 2015; Price and Mohlman, 2007; Purcell et al., 1998; Rosa-Alcazar et al., 2019; Rosnick et al., 2013; Stefanopoulou et al., 2014; Tempesta et al., 2013; Thorpe and Salkovskis, 1997; Topçuoğlu et al., 2009; Toren et al., 2000; Waechter et al., 2018; Wen et al., 2019; Yoon et al., 2014, 2017; Zhou and Ni, 2017). All eligible studies were conducted from 1990 to 2019, in 20 countries across five continents. 20 records (36.36%) contributed one sample each, with the remaining contributing multiple samples each, providing a total of 67 samples with a median sample size of 50 (M = 81.9, SD = 126.52). Based on available data, the range of the mean age of the samples was 8.23–73.46 years (Mdn = 31.24, M = 28.99, SD = 14.23) with a median gender proportion of 53% female (M = 57.23%, SD = 16.31%).

2.3. Coding of variables

Information was coded independently by two of the authors, who then discussed and resolved discrepancies after the initial coding process. Disagreements were resolved via discussion with the rest of the authors. The agreement for all variables was generally good. For categorical variables, an average agreement of 97% (range = 70%–100%) was obtained. For non-categorical variables, an average agreement of 99% (range = 70%–100%) was obtained. A summary of the descriptive statistics related to the various moderators is available in Table 1. Information about each record was obtained directly from the Method sections of the respective studies, tables of descriptive statistics provided in the articles, or authors who responded to email requests.

Table 1
Descriptive statistics of moderators.

Moderator	Reaction time			Accuracy		
	k	*M* (*SD*) or %	Range	*k*	*M* (*SD*) or %	Range
Emotional salience of task (% emotional)	44	40.91%		79	8.86%	
Comorbidity with non-anxiety disorders (% Yes)	12	83.33%		65	56.92%	
Proportion on medication and/or treatment	23	.35 (.45)	.00–1.00	68	.26 (.37)	.00–1.00
Anxiety severity	12	43.22 (25.5)	3.58–76.44	41	40.98 (16.97)	3.88–76.44
Mean age	42	33.59 (13.98)	9.04–73.46	78	27.53 (14.40)	8.23–73.46
Proportion of females	39	.6 (.19)	.33–1.00	78	.57 (.15)	.29–.91

Note. k = number of effect sizes.

In terms of study characteristics, we coded the publication source of the record (journal article, unpublished data, dissertation, conference paper) and the country where the study was conducted. We coded the following participant characteristics: (a) the type of anxiety disorder(s) present in the group with anxiety disorders, (b) the severity of anxiety symptoms[2] in the group with anxiety disorders and measure used, (c) the proportion of participants in the group with anxiety disorders who were undergoing medication and/or treatment, (d) comorbid anxiety disorders in the group with anxiety disorders, (e) the proportion of participants in the anxiety disorder group who were diagnosed with non-anxiety comorbid disorders such as depression, (f) the number of participants in each group (anxiety disorder vs. control), (g) the mean age and age range of the whole sample, and (h) the gender proportion of the whole sample.

In terms of measures of EF, the means and standard deviations of scores achieved by both groups (anxiety disorders vs. control) on various tasks assessing EF were recorded whenever available. The task used (e.g., Stroop task) was recorded and categorised into one of the three main components of EF, namely inhibition, shifting, and updating. Common EF tasks used to assess inhibition the ability to suppress automatic responses to irrelevant stimuli include the Stop-signal Task (Logan, 1994) and the Stroop task (Stroop, 1935), which tests participants' ability to control their dominant reaction and refrain from responding, and their ability to suppress a pre-potent reaction to make another response, respectively. Participants' ability to transition between different tasks (i.e., shifting) was frequently measured using paradigms such as Trail-Making Test B (Partington and Leiter, 1949), which tests the ability to alternate between numbers and letters. Finally, updating, which involves working with new task-relevant information and removing old task-irrelevant information from working memory was assessed using tasks such as the Backward Digit Span Task (Wechsler, 1997) and the Letter-Number Sequencing task (Wechsler, 1997), as these tasks test whether participants are able to retain and work on information in their working memory (for a review, see Diamond, 2013; Snyder, 2013). Both RTs and accuracy scores were coded whenever possible. Additionally, we coded whether the task stimuli were emotional or neutral, as previous research has found that anxious individuals tend to perform worse on emotional tasks, compared to tasks that lacked emotional content (Eysenck and Byrne, 1992; Yu et al., 2018). In cases where a task had multiple conditions (e.g., low vs. high frequency of social threat words) or multiple outcomes (e.g., omission errors and false alarms), we coded for the most salient task condition and outcome reported by the paper. When a task contained more than one condition that varied in task demand, we coded the results from the condition with the highest task demand to maximise the sensitivity of the task. A summary of the included tasks is publicly available on ResearchBox (#283).

2.4. Meta-analytic approach

To correct for positive bias when small samples are used, Hedges' (1981) standardised *g*, which represents the difference between two group means divided by their pooled weighted standard deviation with an adjustment for positive bias, was used as the effect size index. Hedges' *g* was calculated such that negative values indicated that individuals diagnosed with anxiety disorder(s) would perform worse on tasks assessing EF, reflecting proposed theories in the previous literature that individuals with anxiety disorder(s) have impaired EF. Positive effect sizes, on the other hand, would indicate that individuals with anxiety disorder(s) outperform healthy controls.

To investigate if groups with anxiety disorders would perform differently on EF tasks compared to controls, an overall meta-analytic effect size was computed across the three discrete EF (inhibition, shifting, and updating) in terms of RT and accuracy separately (i.e., an overall RT effect size and an overall accuracy effect size). Afterwards, a meta-analytic effect size for RT and accuracy was computed for each of the three EFs (inhibition: $n = 40$; shifting: $n = 28$; updating: $n = 32$). In addition, we examined whether the extent of these differences between the groups with anxiety disorders and control groups differed significantly after accounting for various moderators such as the type of anxiety disorder.

As many samples (20.59% in RT, 38.24% in accuracy) contributed more than one effect size by completing more than one measure (e.g., Boldrini et al., 2005; Bourke et al., 2012), the assumption that effect sizes were independent was violated. Hence, multilevel meta-analyses were conducted as per Harrer et al. (2019), with effect sizes being nested within samples. Additionally, as meta-analyses violate the assumption that all studies come from one single population (Schwarzer et al., 2015), all analyses were conducted with random- and mixed-effects.

3. Results

3.1. Tests of publication bias

To first rule out potential threats to the validity of the meta-analysis, tests of publication bias were run for overall RT and overall accuracy. Funnel plots were created, allowing the examination of potential biases via visual inspection of symmetry (Fig. 2). Additionally, Egger's test of publication bias was conducted to statistically test for asymmetry. Asymmetry, indicated by a significant slope in Egger's test, would indicate that publication bias was present in the included data. We found that $b = -2.10, p = .501$ for RT and $b = 4.04, p = .518$ for accuracy, indicating that publication bias was not present in the current meta-analysis.

Furthermore, to examine if publication status could significantly contribute to the relationship between anxiety disorders and EF, we entered dummy-coded publication type (0 = *Journal article*, 1 = *Dissertation*) as a moderator. Publication status did not play a significant role in predicting the effect size of the anxiety disorder-EF relationship for RT, $Q(1) = 3.24, p = .072$, nor for accuracy, $Q(1) = 0.93, p = .336$, suggesting that the anxiety disorder-EF relationship remained consistent regardless of the publication type.

3.2. Overall reaction times and accuracies

Two overall meta-analytic effect sizes were first calculated, in terms of RT and accuracy, across all tasks, samples, and domains of EF (see Table 2). Groups with anxiety disorders significantly underperformed in terms of RTs, $g = -0.29$, 95% CI = $[-0.43, -0.16]$, $p < .001$ for $n = 40$, $k = 44$. In contrast, in terms of accuracy,[3] groups with anxiety disorders significantly outperformed controls, $g = 0.35$, 95% CI = $[0.11, 0.59]$, $p = .004$ for $n = 42$, $k = 79$. These results suggest that, while individuals with anxiety disorders displayed slower RTs, they also displayed improved accuracy.

3.3. EF domains

3.3.1. Inhibition

Groups with anxiety disorders significantly underperformed in terms

[2] Mean anxiety severity was measured through various measures such as self-reports and interviews. The Hamilton Anxiety Rating Scale (HARS), Panic Disorder Severity Scale (PDSS), and the Multidimensional Anxiety Scale for Children (MASC) were the most common measures of anxiety severity used. As each measure was scored differently and hence would not be comparable (e.g., $HARS_{range} = [0, 58]$, $PDSS_{range} = [0, 28]$), we transformed all scores such that the minimum score (mildest) was equal to 0 and the maximum score (most severe) was equal to 100 for all measures. This was done by subtracting the lowest possible score on the measure from the mean score of the sample, dividing the resulting number by the highest possible score on the measure, and then multiplying the resulting number by 100, as per the POMP procedure by Cohen et al. (1999).

[3] Of note, when examining accuracy scores, there were seven cases where $g > 2.00$. In order to examine if these cases exerted extreme influence on the overall accuracy effect size, we also computed the overall accuracy effect size after excluding these seven cases and found consistent results, $g = 0.22$, CI = $[0.09, 0.34]$, $p = .001$ for $n = 42$, $k = 72$.

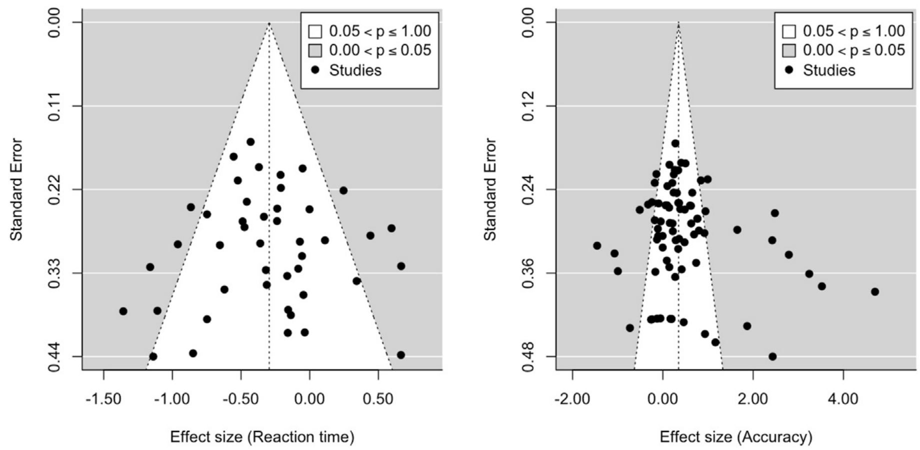

Fig. 2. Funnel plots for reaction time (left) and accuracy (right).

Table 2
Overall effect sizes across the three EF domains.

	n	k	g	95% CI_g	z
Reaction time	**40**	**44**	**−0.29**	**[-0.43, -0.16]**	**−4.38*** **
Inhibiting	25	28	−0.27	[-0.43, −0.10]	−3.19**
Shifting	13	13	−0.36	[-0.56, −0.16]	−3.54***
Updating	3	3	−0.28	[-1.30, 0.74]	−0.54
Accuracy	**42**	**79**	**0.35**	**[0.11, 0.59]**	**2.86** **
Inhibiting	15	16	0.47	[-0.04, 0.98]	1.82
Shifting	15	15	0.51	[0.11, 0.91]	2.50*
Updating	29	48	0.38	[0.06, 0.70]	2.32*

Note. n = number of samples, k = number of effect sizes, g = standardised mean difference. *$p < .05$, **$p < .01$, ***$p < .001$.

of RTs on inhibition tasks, $g = -0.27$, 95% CI = [−0.43, −0.10], $p < .001$ for $n = 25$, $k = 28$. On the other hand, in terms of accuracy on inhibition tasks, differences between groups with anxiety disorders and controls were found to be non-significant, $g = 0.47$, 95% CI = [−0.04, 0.98], $p = .069$ for $n = 15$, $k = 16$. The results are displayed in Fig. 3.

3.3.2. Shifting

Groups with anxiety disorders significantly underperformed in terms of RTs on shifting tasks, $g = -0.36$, 95% CI = [−0.56, −0.16], $p < .001$ for $n = 13$, $k = 13$. On the other hand, in terms of accuracy on shifting tasks, groups with anxiety disorders significantly outperformed controls with a medium effect size, $g = 0.51$, 95% CI = [0.11, 0.91], $p = .012$ for $n = 15$, $k = 15$. The results are displayed in Fig. 4.

3.3.3. Updating

The difference between groups with anxiety disorders and controls in terms of RTs on updating tasks was non-significant, $g = -0.28$, 95% CI = [−1.30, 0.74], $p = .586$ for $n = 3$, $k = 3$. On the other hand, in terms of accuracy on updating tasks, groups with anxiety disorders significantly outperformed controls with a small effect size, $g = 0.38$, 95% CI = [0.06, 0.70], $p = .020$ for $n = 29$, $k = 48$. The results are displayed in Fig. 5.

3.4. Type of anxiety disorder

We examined whether the meta-analytic effect sizes for RTs and accuracies were significantly different from zero when each anxiety disorder was isolated (Fig. 6). As no studies reported results for separation anxiety disorder in isolation, no analyses could be performed for separation anxiety disorder. Additionally, there was insufficient data to investigate RT differences for selective mutism groups.

3.4.1. Generalised anxiety disorder

For RT ($n = 9$, $k = 10$), the differences in scores between the generalised anxiety disorder groups and control groups was found to be significant with a small effect size, $g = -0.42$, 95% CI = [−0.73, −0.12], $p = .006$, such that generalised anxiety disorder groups underperformed compared to control groups. However, for accuracy ($n = 9$, $k = 20$), the difference in the performance between those with generalised anxiety disorder and those in the control group was non-significant, $g = 0.40$, 95% CI = [−0.20, 1.00], $p = .191$. This suggests that while generalised anxiety disorder is associated with slower RTs, accuracy scores were not significantly different between groups with generalised anxiety disorder and control groups.

3.4.2. Social anxiety disorder

In terms of RT ($n = 9$, $k = 10$), the difference in performance between social anxiety disorder and control groups was non-significant, $g = -0.26$, 95% CI = [−0.60, 0.08], $p = .129$. Similarly, for the accuracy outcome ($n = 10$, $k = 17$), the difference in performance between both the groups was also non-significant, $g = 0.43$, 95% CI = [−0.23, 1.10], $p = .197$.

3.4.3. Panic disorder

For RT ($n = 10$, $k = 11$), performance between those with panic disorder and control group was found to be significantly different, with a medium effect size, $g = -0.37$, 95% CI = [−0.55, −0.19], $p < .001$, such that panic disorder groups underperformed compared to control groups. However, for accuracy ($n = 9$, $k = 23$), panic disorder groups significantly outperformed control groups, with a medium effect size, $g = 0.56$, 95% CI = [0.22, 0.89], $p = .001$. This suggests that panic disorder is associated with worse RT, but improved accuracy, in line with overall findings on anxiety disorders in general.

3.4.4. Specific phobia

We found no significant difference in RT ($n = 5$, $k = 5$) between groups with specific phobia and control groups, $g = 0.31$, 95% CI = [−0.02, 0.63], $p = .062$. A subgroup analysis on accuracy could not be conducted due to insufficient data.

3.4.5. Selective mutism

No effect sizes were available for the relationship between selective mutism and RT. Only one sample, contributing two effect sizes, investigated the relationship between selective mutism and accuracy. Subgroup analysis indicated that those with selective mutism significantly outperformed controls, with a medium effect size, $g = 0.77$, 95% CI = [0.37, 1.16], $p < .001$, implying that those with selective mutism exhibit greater accuracy. However, it should be noted that both effect sizes were drawn from the same study, and as such, the results should be interpreted with extreme caution due to low generalisability.

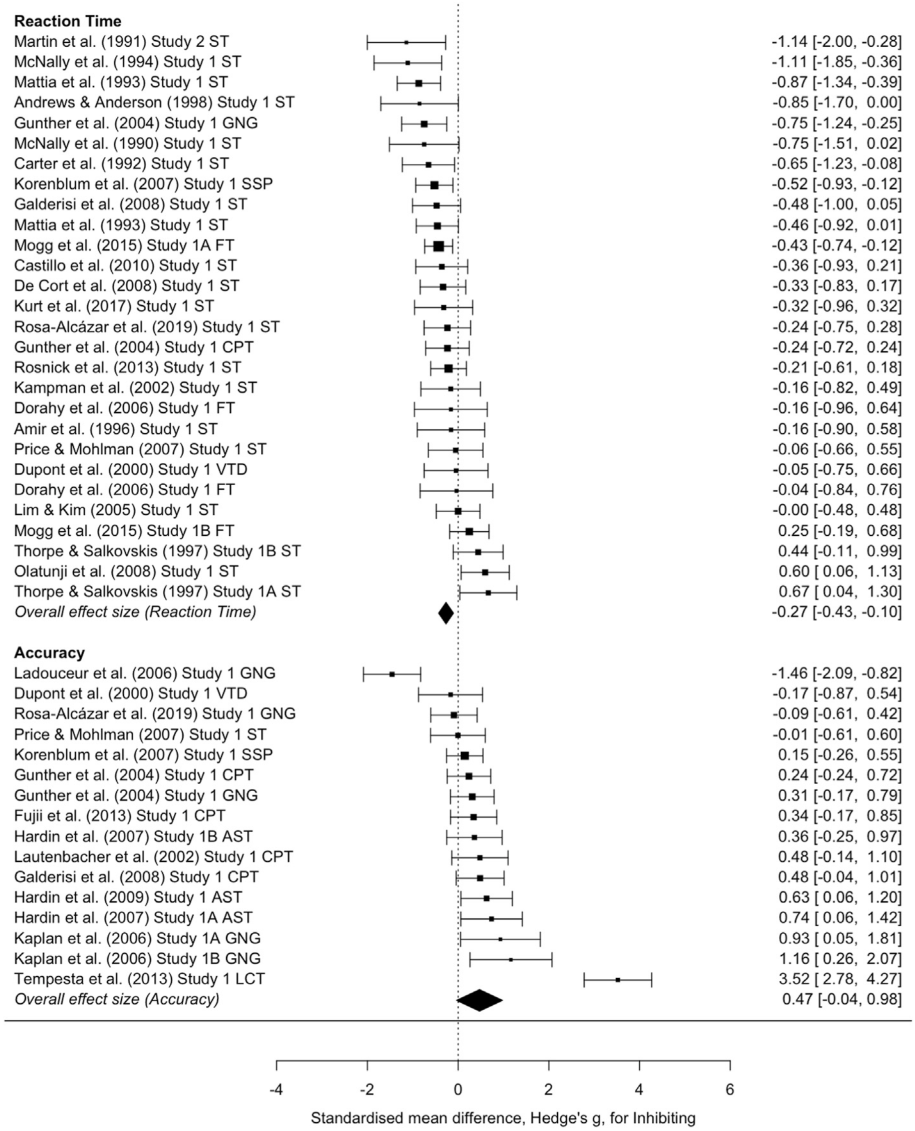

Fig. 3. Forest plots for reaction time and accuracy for inhibition tasks.
Note. Diamond represents overall meta-analytic effect size. Position of each square indicates the effect size contributed by each sample on each task. Size of each square indicates sample size. Whiskers indicate 95% confidence intervals. Positive effect sizes indicate better performance for those with anxiety disorder.

3.5. Moderation analyses

Lastly, using meta-regressions (Table 3), we investigated three main categories of moderators in this section, namely clinical factors (use of medication and/or treatment, anxiety severity, absence vs presence of comorbidity with non-anxiety disorders), demographic factors (mean age and gender proportion), and a methodological factor (emotional salience of the task). In addition, we conducted subgroup analyses (Fig. 7), splitting our full dataset by the choice of exact EF task used, to obtain task-specific effect sizes in order to preliminarily observe whether effect sizes varied for each EF task.

3.5.1. Clinical factors

In terms of RT, the test of medication/treatment status as a moderator variable was non-significant, $b = 0.06$, 95% CI $= [-0.21, 0.32]$, $p = .683$, for $n = 27$, $k = 30$. Interestingly, in terms of accuracy, the test for medication/treatment as a moderator was significant, $b = 0.58$, 95% CI $= [0.02, 1.13]$, $p = .043$, for $n = 34$, $k = 69$, such that people with anxiety disorders who received medication or treatment during the experiment performed significantly better than people with anxiety disorder who did not receive medication or treatment in terms of accuracy. However, the tests for anxiety severity (operationalised on a continuum or spectrum) and comorbidity (operationalised as absence vs. presence) as separate moderators were non-significant (*ps* $\geq$ .215), suggesting that anxiety severity and comorbidity in the anxiety disorder group did not moderate the anxiety disorder-EF relationship.

3.5.2. Demographic factors

The tests of mean age and gender proportion as separate moderators were non-significant (*ps* $\geq$ .065). Therefore, the relationship between anxiety disorder and EF was not moderated by either mean age or gender.

3.5.3. Methodological factors

The results suggest that emotional salience does not moderate the anxiety disorder-EF relationship (*ps* $\geq$ .261). However, effect sizes varied depending on what task was used (Fig. 7). Studies that used tasks such as the Wisconsin Card Sorting Test reported a stronger anxiety disorder-EF relationship ($g = 0.70$, 95% CI $= [0.12, 1.27]$) such that groups with anxiety disorders performed better than groups without anxiety disorders, as seen from the larger task-specific effect sizes, while studies that

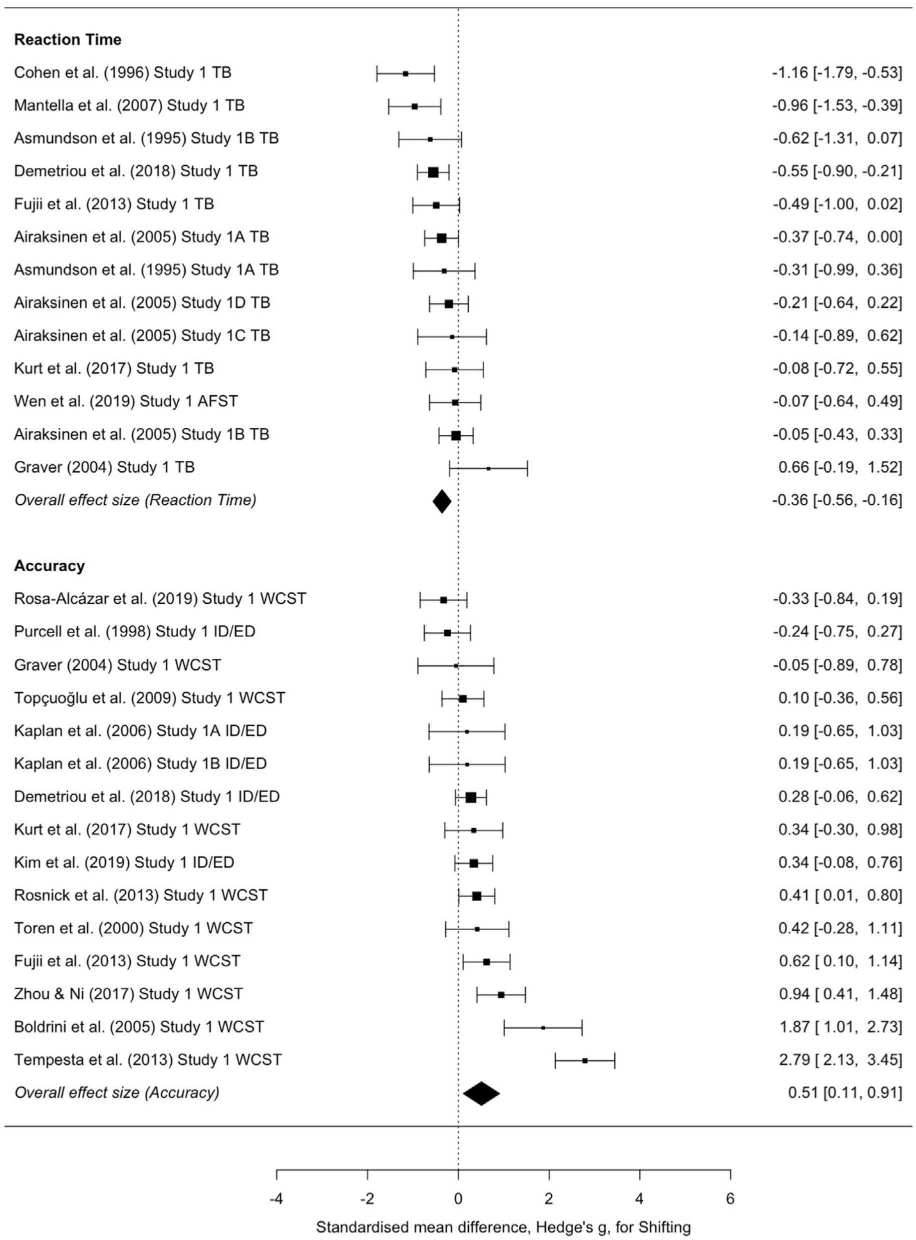

Fig. 4. Forest plots for reaction time and accuracy for shifting tasks.
Note. Diamond represents overall meta-analytic effect size. Position of each square indicates the effect size contributed by each sample on each task. Size of each square indicates sample size. Whiskers indicate 95% confidence intervals. Positive effect sizes indicate better performance for those with anxiety disorders.

used other tasks such as the Continuous Performance Task reported a weaker relationship ($g = 0.37$, 95% CI = [0.11, 0.64]), albeit still statistically significant and in the same direction. In contrast, the use of other tasks such as the Self-Ordered Pointing Task was associated with non-significant associations between anxiety disorders and EF ($g = 0.00$, 95% CI = [−0.29, 0.29]). These patterns preliminary suggest that the choice of task used could have an impact on the magnitude of the anxiety disorder-EF relationship.

4. Discussion

Given the inconsistent research findings on EF deficits in anxiety disorders, the goal of our meta-analysis was to provide a holistic evaluation of the association between anxiety disorders and EF. We also accounted for various moderators—such as methodological discrepancies, demographics, and clinical variables—that could potentially explain the inconsistent findings in the existing literature. Overall, our results suggest that individuals with anxiety disorders react slower while outperforming their healthy peers in terms of accuracy on EF tasks. According to attentional control theory, highly anxious people might employ more cognitive resources to compensate for impairments in inhibition and shifting tasks, resulting in reduced performance efficiency but comparable levels of performance effectiveness when compared to less anxious people (Eysenck et al., 2007). Based on our results, it is possible that individuals with anxiety disorders demonstrated a slower RT on EF tasks to ensure higher levels of accuracy and hence, sacrificed performance efficiency for performance effectiveness. Therefore, anxiety leading to higher accuracy on EF tasks should not be misconstrued as a strength in this context. However, it is also important to note that these associations between a broad classification of anxiety disorders and a unity of EF are moderated by different types of anxiety disorder, subdomains of EF, and the use of medication/treatment.

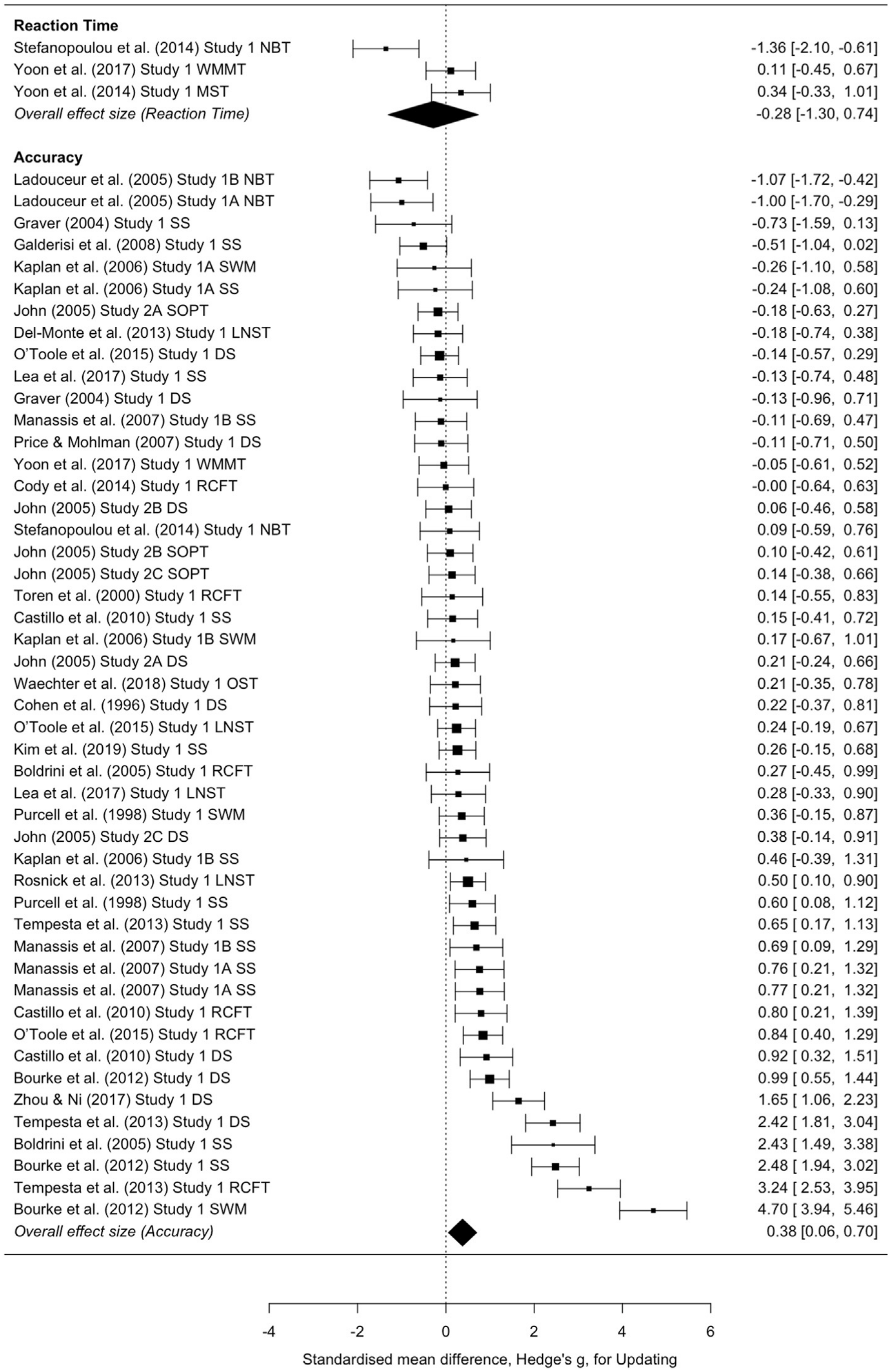

Fig. 5. Forest plots for reaction time and accuracy for updating tasks.
Note. Diamond represents overall meta-analytic effect size. Position of each square indicates the effect size contributed by each sample on each task. Size of each square indicates sample size. Whiskers indicate 95% confidence intervals. Positive effect sizes indicate better performance for those with anxiety disorder.

4.1. *Type of anxiety disorders*

Within anxiety disorders, we found that generalised anxiety disorder groups had slower RT but comparable accuracy in performance against control groups, suggesting deficits in EF due to a lower performance efficiency. For individuals with generalised anxiety disorder, their persistent and excessive worrying about various domains of life (APA, 2015) consumes cognitive resources, leaving fewer resources for the task at hand (Butters et al., 2011). Consequently, these individuals may engage in compensatory strategies such as enhanced effort and resource use to achieve reasonable performance effectiveness, thus reducing processing efficiency (Eysenck and Derakshan, 2011). Additionally, given that generalised anxiety disorder exhibits the nature of trait anxiety (Hirsch et al., 2013; Kennedy et al., 2001), which is found to be related to lower performance efficiency (e.g., Ansari et al., 2008; Pacheco-Unguetti et al., 2010), our findings corroborate previous studies. Since generalised anxiety disorder is linked to deficits in EF, it is imperative for clinicians to account for these deficits when curating treatment plans to ensure their effectiveness.

In contrast, panic disorder was related to both greater RT and

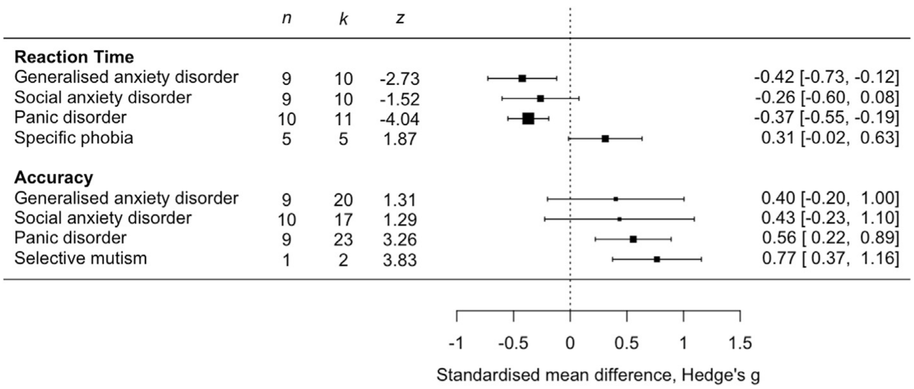

Fig. 6. Results of subgroup analyses on reaction times and accuracies by type of anxiety disorder.
Note. n = number of samples, k = number of effect sizes. Numbers on the right indicate standardised mean differences (outside the square brackets) and 95% CIs (inside the square brackets). Reaction time effect sizes for separation anxiety disorder, selective mutism, and agoraphobia and accuracy effect sizes for separation anxiety disorder, specific phobia and agoraphobia were not reported due to there being too few cases.

Table 3
Results of moderation analyses on reaction times and accuracies.

	Reaction Time					Accuracy				
Moderator	*n*	*k*	*b*	95% CI	*Q*	*n*	*k*	*b*	95% CI	*Q*
Clinical Factors										
Medication/treatment	27	30	0.06	[-0.21, 0.32]	0.17	34	69	0.58	[0.02, 1.13]	4.11
Anxiety severity	12	12	0.000	[-0.012, 0.012]	0.00	24	41	0.002	[-0.01, 0.02]	0.11
Comorbidity	12	12	−0.12	[-0.68, 0.44]	0.17	32	65	−0.37	[-0.95, 0.21]	1.54
Demographic Factors										
Mean age	38	42	−0.004	[-0.012, 0.005]	0.64	41	78	0.01	[-0.004, 0.03]	2.11
Proportion of females	35	39	0.71	[-0.04, 1.47]	3.40	41	78	0.34	[-1.43, 2.10]	0.14
Methodological Factors										
Emotional salience	40	44	0.14	[-0.12, 0.40]	1.13	42	79	−0.38	[-1.04, 0.28]	1.26

Note. n = number of samples, *k* = number of effect sizes, *b* = slope coefficient.

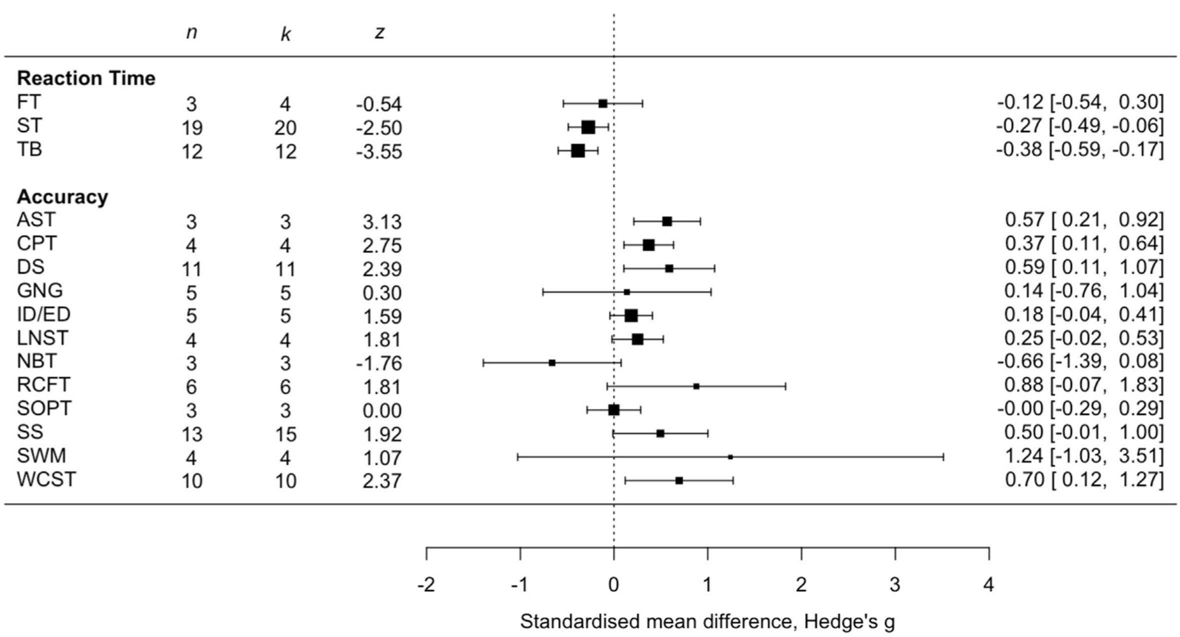

Fig. 7. Effect sizes of tasks assessing EF
Note. n = number of samples, k = number of effect sizes, FT=Flanker test, ST=Stroop Test, TB = Trials B, AST = Anti-Saccade Task, CPT=Continuous Performance Task, DS = Digit Span, GNG = Go/NoGo Paradigm, ID/ED = The Intra-Extra Dimensional Set Shift, LNST = Letter-Number Sequencing Task, NBT=N-Back Task, OST=Operation Span Task, RCFT = Rey-Complex Figure Test, SOPT=Self-Ordered Pointing Task, SS=Spatial Span, SWM=CANTAB Spatial Working Memory, WCST=Wisconsin Card Sorting Test.

accuracy in task performance, indicating unimpeded performance efficiency in comparison to their healthy counterparts. This finding is in line with past research demonstrating that temporal lobe abnormalities resulting from panic disorder resemble that of healthy controls experiencing state anxiety (Reiman et al., 1989). Indeed, researchers theorize that the trigger-dependent and transient nature of anxiety in panic disorder are similar to that of state anxiety experiences (Başoğlu et al., 1992) which have been reported to have a positive or null influence on EF (e.g., Kofman et al., 2006; Pacheco-Unguetti et al., 2010; Visu--Petra et al., 2013).

Similarly, there were no differences in RT and accuracy between the social anxiety disorder and control groups. Our results are consistent with past studies that found no group differences in EF performance (e.g., Airaksinen et al., 2005; Graver and White, 2007) but are incongruent with Fujii et al.'s (2013) finding that individuals with social anxiety disorder demonstrated impaired performance in terms of accuracy on the Wisconsin Card Sorting Task. However, it is important to note that their results may be task-specific, given our finding that the Wisconsin Card Sorting Task was associated with a stronger anxiety disorder-EF relationship. Further, researchers suggest that impaired cognitive performance in social anxiety disorder is likely a result of situational stress, rather than a trait-like cognitive dysfunction (O'Toole and Pedersen, 2011). Supporting this, Graver and White (2007) found that individuals with social anxiety disorder demonstrated poorer EF performance only during the stress condition. Taken together, our results clarify that individuals with panic and social anxiety disorders may not necessarily experience deficits in EF.

4.2. Domain of EF

Regarding the subdomains of EF, we found that RT was only delayed for individuals with anxiety disorders on the inhibition and shifting, but not updating, tasks. At the same time, higher accuracy scores held true only for the shifting and updating, but not inhibition, tasks. Taken together, individuals with anxiety disorders exhibited lower performance efficiency on the inhibition, but not shifting, task, while they displayed enhanced performance efficiency on the updating task. These results are congruent, in part, with the attentional control theory, which argues that anxiety impairs performance efficiency for inhibition but does not influence performance efficiency for updating unless the task is stressful.

While the current meta-analysis found that the anxiety disorder group demonstrated enhanced performance efficiency on the updating task, only three studies were included to compute the effect size for RT. The small sample size was due to the limited number of updating EF tasks that assessed RT since most updating tasks are accuracy-based. For example, updating tasks like the Operation Span Task (Unsworth et al., 2005), Rey Complex Figure Task (Osterrieth, 1944), and Spatial Span Task (Robbins et al., 1994) frequently employed accuracy-based outcome measures such as span length, accuracy rates, or error rates. In contrast, only a few updating EF tasks, such as the Modified Sternberg Task (Joormann and Gotlib. 2008) and N-Back Task (Owen et al., 2005), utilized response time as an outcome measure. Furthermore, most studies included in the meta-analysis employed updating tasks with accuracy-based outcome measures to assess working memory (e.g., Ladouceur et al., 2005; Kaplan et al., 2006), resulting in a small sample size used to compute the effect size for RT on Updating EF tasks. The lack of association between anxiety disorder and RT on Updating EF tasks could be due to the small sample size rather than a true null effect. Hence, our results should be interpreted with caution.

Contrary to attentional control theory, performance efficiency was not compromised for the shifting tasks for the anxiety disorder group compared to healthy controls. It should be highlighted that the effect size for RT on the shifting task was computed exclusively from the Trail-Making Task B, with the exception of one study which measured RT using the Affective Switching Task. In contrast, accuracy on shifting tasks is taken from the Wisconsin Card Sorting Task and Intra-Extra Dimensional Set Shift Task, an adaptation of the Wisconsin Card Sorting Task. The different types of task-switching paradigms used to compute accuracy and RT effect sizes may provide the illusion that the performance efficiency of the anxiety disorder group was not compromised for the set-shifting task. This is also supported by previous research finding that although the Wisconsin Card Sorting Task and Trail-Making Task B measure cognitive flexibility, outcomes measured with the two tasks only demonstrate a modest correlation at best (Miles et al., 2021). Indeed, the study by Fujii et al. (2013) found that the performance of patients with social phobia compared to healthy controls on task-switching differed according to the switching task - patients with social phobia performed worse than healthy controls on the Wisconsin Card Sorting Task, but there was no significant difference in performance on the Trail-Making Task-B. Therefore, our finding that anxiety disorder lowers RT but enhances accuracy on shifting tasks should not be combined as an indicator of the null effects of anxiety disorder on performance efficiency in the set-shifting task given the homogeneity in set-shifting tasks used to assess accuracy and RT, respectively.

Another possible reason for the current pattern of findings for shifting tasks could be due to the methodological issues associated with assessing the construct of switching. In particular, in their review of the evidence supporting attentional control theory, Eysenck and Derakshan (2011) acknowledged that there is a lack of consistent evidence that supports attentional control theory's prediction that anxiety impairs performance efficiency on shifting tasks given that outcomes measured by task-switching are determined by a variety of factors, such as after-effects from previous mental sets contributing to cost of switching (Hartanto and Yang, 2016; Monsell, 2003). Hence, task-shifting outcomes are hard to decipher without taking into account the specific processing component of task-switching that is impaired by anxiety, such as task-set reconfiguration and proactive interference (Hartanto and Yang, 2022). This is further complicated by the use of the Wisconsin Card Sorting Task to measure shifting deficits in many of the studies included in the current meta-analysis, given that performance on the Wisconsin Card Sorting Task requires other cognitive functions, such as inhibition and working memory, in addition to task switching (Buchsbaum et al., 2005; Konishi et al., 1999). Furthermore, Miles et al. (2021) highlighted that there is a substantial discrepancy in the present research regarding how outcomes in the Wisconsin Card Sorting Task should be computed and how these outcomes evaluate switching ability. Therefore, other factors, such as differential effects of task-set activation, could have contributed to the current pattern of results, resulting in a deviation from the predictions of attentional control theory.

4.3. Moderating factors

Our results suggest that medication use/treatment was a significant moderator of the anxiety disorder and EF relationship, where medication use/treatment resulted in significant increases in accuracy rates but no significant differences in RT on EF tasks compared to individuals with anxiety disorder but who were not taking medication/undergoing treatment. Based on attentional control theory, to the extent that medication use/treatment help to reduce anxiety and/or symptoms of anxiety (e.g., worry), it is likely that medication use/treatment will help to increase the performance efficiency of individuals with anxiety disorder on EF tasks. However, while some research has demonstrated that medication use/treatments, such as antidepressants and cognitive-behavioural therapy, can be effective in reducing anxiety levels or worrying (e.g., Bouwer and Stein, 1998; Hendriks et al., 2008), other studies found that the use of medication/treatment can result in side effects, such as increase fatigue and lowered concentration on tasks (e.g., Popovic et al., 2015). Thus far, the limited number of research that has examined the effect of medication/treatment on cognitive functioning has not provided consistent evidence of the impact of medication/treatment on EF. For example, Tempesta et al. (2013) found that medication resulted in a higher number of errors on the Wisconsin Cards Sorting Task. In contrast, the treatment group in Butters et al. (2011) study demonstrated better performance on the Delis–Kaplan Executive Function System (D–KEFS) sorting test compared to the placebo group. While our results provide preliminary evidence that medication/treatment can improve accuracy rates on EF tasks among individuals with anxiety disorders, these results should be interpreted with caution given that the efficacy of medication use/treatment differs by various factors, such as type of anxiety disorder (Bespalov et al., 2010) and age (Kishita and Laidlaw, 2017).

The null finding for comorbidity as a moderator could be due to the effects of comorbidity on EF task performance differing as a function of comorbidity and EF task type (e.g., Castaneda et al., 2011; Kaplan et al., 2006; Graver and White, 2007; Topçuoğlu et al., 2009). For example, Kaplan et al. (2006) found that individuals with panic disorder and comorbid major depressive disorder had higher levels of accuracy on the affective go/no go task compared to healthy controls, but this finding did not hold for individuals with panic disorder only. In contrast, Graver and White (2007) found that individuals with comorbid social anxiety and major depressive disorder perform worse on EF tasks than those with social anxiety under stress conditions. Therefore, it is possible that comorbidity was not a significant moderator in the current meta-analysis due to the variety of factors that were not controlled for but could have influenced the comorbidity and EF performance relationship.

We found that emotional salience did not interact with anxiety disorders and EF. While our findings appear to contradict attentional control theory, which predicts that the adverse effects of anxiety on task performance caused by task-irrelevant stimuli are greater when stimuli are threat-related rather than neutral (Eysenck et al., 2007), the null association between emotional salience of EF task and EF task performance amongst individuals with an anxiety disorder could be attributed to the lack of power because of the small number of samples available instead. In addition, it is also well-established in the literature that groups with anxiety disorders performed worse than controls in cognitive tasks when presented with threatening stimuli as opposed to neutral stimuli (e.g., Galderisi et al., 2008; McNally et al., 1994; Mogg and Marden, 1990).

Overall, given that majority of the moderation factors (i.e., demographics, severity of anxiety and comorbidity) were non-significant, our results provide evidence for the robustness of the relationship between anxiety disorders and EF across the different moderators included in the analysis. However, these non-significant findings could also be attributed to the lack of power in our moderation analyses due to the limited number of samples available. Hence, they should be interpreted with caution.

4.4. Limitations

Despite its strengths, the present meta-analysis is not without limitations. First, most of the eligible samples were from Europe or North America, with minimal records based in other continents such as Asia, South America and Africa. Hence, a wider breadth of research across multiple sample characteristics would be imperative in allowing for our findings to be generalisable across other cultural groups. Second, insufficient data was provided for some of our clinical moderators, namely anxiety severity and comorbidity, resulting in a lack of comprehensive analysis. Third, most of the existing studies were cross-sectional, thus we could not infer causality. Overall, future studies should aim to explore the relationship between anxiety disorders and EF in populations with varying cultural backgrounds for a more comprehensive analysis while considering potential moderators such as comorbid non-anxiety disorders.

5. Conclusion

In conclusion, our results showed a nuanced relation between anxiety disorder and EF, depending on performance effectiveness and efficiency, type of anxiety disorders, the domain of EF, and mediation use. Our study is valuable in that it provides a comprehensive review of the relationship between anxiety disorders and EF, which was muddled in inconsistent findings derived from past research. Examining each anxiety disorder and its relationship with EF revealed moderated associations, providing clinicians and researchers with a guide for treatment and future research.

Author note

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Data availability

Additional details and R code are available online on ResearchBox (#283) at https://researchbox.org/283.

Author statement

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Declaration of competing interest

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

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