University of Southampton

FACULTY OF ENVIRONMENTAL AND LIFE SCIENCES

School of Psychology

An Exploration of the Impact of Anxiety on Cognitive and Social Functioning in Children and Adolescents

by

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Abstract

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Researchers have increasingly focused on the role of attentional control in understanding social and cognitive outcomes in anxiety. Attentional Control Theory (ACT; Eysenck et al., 2011) suggests that anxious individuals exert increased effort to achieve academic and social goals. Compared with non-anxious peers this process can be reflected in lowered processing efficiency (i.e., processing time is slowed down to ensure that goals are met). This thesis provides a systematic review of empirical research to explore evidence supporting the proposition that increased anxiety impacts processing on cognitive tasks via reduced processing efficiency in children and young people. In addition, it utilised this framework to explore known links between anxious affect and increased challenges with peer relationships. Specifically, it investigated whether reduced efficiency in the processing of cognitive (i.e., time taken to complete a picture naming task) and social information (i.e., longer durations to respond to peers in a social interaction task with shared goals) may provide some explanation for links between poor peer relationships and increased anxiety symptoms in childhood. 91 children aged 9-10 years took part in a sociometry task, providing a measure of peer acceptance. Of these children, N = 51 self-reported anxiety symptoms, completed measures of cognitive processing and took part in dyadic peer interactions. Mediation analysis found verbal cognitive processing speed mediated the relationship between social anxiety and academic attainment, as well as between social anxiety and social performance (i.e. number of inappropriate comments during peer interaction). No relationship was found between social anxiety and peer acceptance (as measured by sociometry). The results have implications for the prevention and intervention of difficulties with social functioning in anxiety that focus on the role of attention.

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Research Thesis: Declaration of Authorship

Print name:	Hayley Louise Rose White

Title of thesis:	An Exploration of the Impact of Anxiety on Cognitive and Social Functioning in Children and Adolescents

I declare that this thesis and the work presented in it are my own and has been generated by me as the result of my own original research.

I confirm that:

1. This work was done wholly or mainly while in candidature for a research degree at this University;
2. Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated;
3. Where I have consulted the published work of others, this is always clearly attributed;
4. Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work;
5. I have acknowledged all main sources of help;
6. Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself;
7. None of this work has been published before submission.

Signature:		Date:	07/06/2019

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Definitions and Abbreviations

ACT: Attentional Control Theory

AWMA: Automated Working Memory Assessment

CANTAB: Cambridge Neuropsychological Test Automated Battery

CBCL: Child Behaviour Checklist

CE: Central executive

CTAS: Children's Test Anxiety Scale

CYP: Children and Young People

DLPFC: Dorsolateral Prefrontal Cortex

DSM-V: Diagnostic and Statistical Manual—Fifth edition

GAD: Generalised Anxiety Disorder

LD: Learning Disorder/difficulty

PET: Processing Efficiency Theory

RSME: Rating Scale of Mental Effort

RT: Response time

SAD: Social Anxiety Disorder

SIP: Social Information Processing Theory

STAIC: State-Trait Anxiety Inventory for children

TAI: Trait anxiety inventory

TEP: Trainee Educational Psychologist

WIAT-III: Wechsler Individual Achievement Test–Third Edition

WM: Working Memory

WMC: Working Memory Capacity

Chapter 1 Systematic Literature Review: What is the Evidence for Attentional Control Theory in Children and Adolescents?

Introduction

Anxiety is an intense worry or fear in response to or in anticipation of a perceived threat, which is associated with avoidant behaviour (Craske et al., 2009). Some individuals experience trait anxiety, which is associated with a predisposition for elevated worry and distress across situations, alongside increased likelihood of transitory state anxiety when faced with an actual or potential threat (Meijer, 2001). The American Psychiatric Association (APA; 2013) defines several anxiety disorders that emerge across development that are differentiated by the feared object or event. These include selective mutism, separation anxiety disorder, specific phobia, social anxiety disorder (SAD), generalised anxiety disorder (GAD). The prevalence of anxiety disorders in children and young people (CYP) is reported to be between 15% and 20% (Beesdo, Knappe, & Pine, 2009). While some anxiety disorders typically develop in childhood (e.g., selective mutism, separation anxiety disorder, specific phobia), others emerge early in adolescence (e.g., SAD) or emerging adulthood (e.g., GAD). The most common age for an anxiety disorders to develop is 9-10 years (Miers, Blöte, de Rooij, Bokhorst, & Westenberg, 2013).

A large body of research has found that anxiety during childhood and adolescence can negatively impact development, placing children and adolescents at increased risk of poorer health, financial, and interpersonal outcomes (Copeland, Angold, Shanahan, & Costello, 2014; de Lijster et al., 2018). A recent review by de Lijster et al. (2018) details two studies which found adolescents with anxiety were able to maintain similar academic performance (i.e. accuracy) to adolescents with low levels of anxiety. However, the review also found that anxious adolescents perceived their progress to be slower and parents reported more difficulty in concentrating on academic tasks for children with anxiety. With respect to interpersonal functioning, social anxiety in adolescence has been found to be associated with lower social competence (i.e., low levels of assertiveness, friendliness, and initiating and maintaining relationships) and increased interpersonal negativity linked to loneliness and bullying (de Lijster et al., 2018; Pickering, Hadwin, & Kovshoff, 2019). Studies have found, for example, that adolescents with anxiety disorders are less likely to

be accepted by their peers (e.g. Early et al., 2017). Additionally, when rated by their parents, children with SAD were considered to have fewer friends and to be less socially competent (i.e. when rating friendships, social activities and cooperation using the Child Behaviour checklist (CBCL; Achenbach & Rescorla, 2001) when compared with children with no anxiety disorder or GAD (Scharfstein, Alfano, Beidel, & Wong, 2011).

Challenges with social functioning are also evident in individuals with elevated but non-clinical symptoms of anxiety (Early et al., 2017). For example, adolescents who reported elevated symptoms of social anxiety were found to be less successful in understanding the perspective of hypothetical (computerised) peers, suggesting an impact of anxious affect on social cognition (Pile, Haller, Hiu, & Lau, 2017). Moreover, chronic and elevated anxiety can impact on social adaptation; adolescents with persistently higher (vs. moderate or low) levels of social anxiety throughout adolescence were more likely to have difficulties with peers (i.e., peer acceptance and fewer friendships). Furthermore, during a public speaking task, those with higher levels of social anxiety symptoms reported more self-focused attention (i.e. attention towards their own physiology) and observers rated poorer social skills (i.e. not looking at the audience) (Miers, Blöte, de Rooij, Bokhorst, & Westenberg, 2013).

To inform the development of prevention and intervention methods for anxiety, research has focused on understanding mechanisms that place CYP at increased risk of its development. While several theoretical frameworks recognise that the development of anxiety reflects the interaction of genetic, as well as cognitive and environmental risk factors (e.g. Spence & Rapee, 2016) other researchers have aimed to capture the role of specific cognitive factors in its emergence.

Cognitive processing and social adaptation

Increasingly, research has explored the intersection of cognitive and social processing to understand individual differences in social adaptation. Researchers have highlighted the role of cognitive processes in social interaction via social information processing theory (SIP; Crick & Dodge, 1994). SIP outlines a number of distinct cognitive stages required in social situations to process information (i.e. to selectively attend to and interpret relevant social cues, to use the situation and existing knowledge and memory to think through goals, and to make decisions about how to respond). Anxiety has been

shown to lead to more negative social information processing in children (age 8-13 years): anxious children are more likely to choose avoidant or aggressive, rather than prosocial, responses on social vignettes (Luebbe, Bell, Allwood, Swenson, & Early, 2010). Further research has found that anxious CYP are more likely to interpret social situations negatively. For example, Vassilopoulos and Banerjee (2008) found CYP (aged 11-13 years) with social anxiety were more likely to catastrophise mildly negative social situations and discount positive social situations. Similarly, building on theoretical frameworks of anxiety and attention, a large body of work has found that children, adolescents and adults diagnosed with SAD selectively attend to threat stimuli (e.g. Abend et al., 2018; Wieser, Pauli, & Mühlberger, 2009). Adults with SAD show hypervigilance (i.e. longer time scanning) when looking at faces, especially angry faces (Horley, Williams, Gonsalvez, & Gordon, 2004) indicating a hypervigilance for environmental threat.

Further studies have considered the speed of processing social information in anxiety. For example, Benner, Allor and Mooney (2008) considered the cognitive processing speed (time taken to complete maths, English and picture naming tasks) of 163 American children and adolescents, aged 4-19 years, with emotional and behavioural disorders. The study found that teachers rated children and adolescents with deficits in processing speed (i.e. poorer scores in academic fluency and random autonomic naming) lower on ratings of social adjustment compared to those without processing speed deficits. Scharfstein & Beidel (2015) further explored social-cognitive problem solving and observed children and young adolescents interacting with peers. Children diagnosed with SAD (versus those diagnosed with GAD or typically developing children) were slower to think through solutions to hypothetical social situations and to respond to peers in social interactions. Peers also rated children diagnosed with SAD as less likeable. The authors suggested that children with SAD may experience difficulty responding in a socially appropriate time in peer interactions, and that this slowing down of responses impacts on judgements by others of the child and ultimately affects the development of friendships. The focus on both attention and processing speed in social interaction links to cognitive theories of anxiety and attention.

Anxiety and attention

Attentional control theory (ACT) is a theoretical framework that seeks to understand the impact of anxious affect on information processing (Eysenck, Derakshan, Santos and

Calvo (2007). ACT was developed from an earlier framework- Processing Efficiency Theory (PET; Eysenck & Calvo, 1992). PET proposed that increased anxiety symptoms are linked to attention being directed away from relevant task goals to an individual's perceptions of external or internal threat, leading to lowered accuracy on cognitive tasks. PET suggested that the impact of anxiety would be most evident on cognitive processes that involved WM (working memory); i.e., reducing accuracy in tasks that use WM skills.

PET outlined the negative impact of anxiety on WM using Baddeley's (1986) three-factor model, which includes the central executive (CE), phonological loop and visuo-spatial sketchpad. It proposed that anxious affect would negatively affect tasks involving core attention processes in the CE and associated verbal information from the phonological loop, and that this impact would be most evident when state anxiety is high. PET further proposed that worry about task performance effectiveness (i.e. accuracy) would lead to individuals adopting task strategies that increased effort to meet task goals (e.g., taking more time or increasing focus), therefore resulting in a reduction in processing efficiency. In support of PET, a recent meta-analysis showed that, across researchers, a reliable association (with a small to medium effect size; g= -.334) between anxiety and WM skills has been found (Moran, 2016).

Eysenck et al. (2007) developed Attentional Control theory (ACT) to clarify the specific impact of anxiety on the CE, and focused on an individual's ability to inhibit task irrelevant stimuli, to shift mental set, and (to a lesser extent) update information in WM in the pursuit of task goals. Consistent with PET, ACT suggested that the greatest impact of anxiety would be evident on indices of processing efficiency in order to maintain performance effectiveness. However, Eysenck et al. (2007) proposed that task effectiveness would worsen when cognitive demands of the task utilise the CE (thus anxious individuals with stronger WM would be less affected). This process happens due to the use of the stimulus-driven attentional system (i.e. from directing attention to, and processing, threatening stimuli) rather than a goal-directed system. Consequently, anxious individuals would struggle to inhibit attention away from threatening distractors leading to an additional cognitive load on attentional resources. Several studies have used this framework to capture the relationship between performance effectiveness and processing efficiency in anxious adults. Derakshan, Ansari, Hansard, Shoker, and Eysenck (2009), for example, measured eye movements in an anti-saccade task to consider inhibitory control in anxious adults. They asked adult participants to look towards or away from an object and

then to indicate the direction of an arrow either on the same or opposite side to the original object (a behavioural measure of effectiveness). When inhibition was required (i.e. when asked to look away from an object), participants with higher self-reported anxiety made the same number of correct eye movements and correctly identified the direction of the arrow (i.e. effectiveness). However, their saccade latencies were slower than less anxious participants and this reduced efficiency was most evident when threatening stimuli were presented.

In support of increased effort, further studies have found increased activation in brain areas linked to CE processing (i.e., dorsolateral prefrontal cortex (DLPFC)) in inhibition tasks when task demands were high (e.g. Basten, Stelzel, & Fiebach, 2011). These findings contrast with research that has shown difficulty in recruiting prefrontal cortices to meet task goals, evidenced by reduced activation in the DLPFC during inhibition tasks (Bishop, 2009). Berggren and Derakshan (2013) suggested that differences in findings reflect an interaction between motivation and task demands. In the context of a complex task with clear goals, they proposed that anxious individuals will be motivated to increase effort, and this approach will be reflected in associated increased neural activity. In contrast, when demands are low, Berggren & Derakshan (2013), argued that motivation and effort decrease, leading to poorer task performance effectiveness and reduced prefrontal neural activity.

In support, Hepsomali and colleagues manipulated cognitive load in an antisaccade task (i.e. by increasing delay before target stimuli was shown) and found that adults with elevated trait anxiety showed more effort during a more complex long (versus a short) delay condition. Increased effort was reflected in larger pupillary responses and a greater contingent negative variation (CNV; a negative EEG wave associated with cognitive effort) (Hepsomali, Hadwin, Liversedge, Degno, & Garner, 2019).

Aims and objectives

To inform the development of prevention and intervention methods for anxiety, research has focused on understanding mechanisms that place CYP at increased risk of its development. The results from adult literature, using behavioural and neuroscientific measures, suggest anxiety can affect processing efficiency of cognitive tasks (Derakshan et al., 2009; Hepsomali et al., 2019). Moreover, researchers have highlighted the complex nature of social interaction (Crick & Dodge, 1994; Dodds & Blake, 2015; Luebbe et al., 2010) and studies have found slowed processing during social tasks (Scharfstein & Beidel,

2015). These findings suggest that ACT could be usefully applied to understand processing efficiency in anxiety in everyday social interactions. However, the extent to which challenges with processing efficiency, as outlined by ACT, applies to anxiety in CYP is unclear. The current review therefore explores the extent to which empirical evidence supports the proposition that anxiety impacts processing efficiency on tasks associated with the CE in CYP.

Methods

Search strategy

The systematic search took place in October 2018. Three databases were included (Web of science, PsychInfo and PubMed) and searched using terms refined from key literature (see Table 1 for a full list of terms and appendix A for search phrases used). For PsychInfo it was possible to apply these limiters: human participants, journal articles, age 0-18 years. For Web of Science the search results were limited to not include chemical indexes and to include relevant journals (e.g. psychology, psychiatry, social Sciences, educational, behavioural science etc.). No filter was applied to PubMed. In total, 891 results were returned, 227 of which were duplicates. The final 664 papers were then screened by title, abstract and methods, leaving 22 articles which were examined in more detail. These 642 articles were rejected due incorrect participant sample (e.g. incorrect age group, participants with neurodevelopmental, other mental health or physical disorders, or animal participants) or because the article was not investigating the topic of interest (i.e. attentional bias, medical case study, measurement tool) or was not an empirical paper (see appendix B).

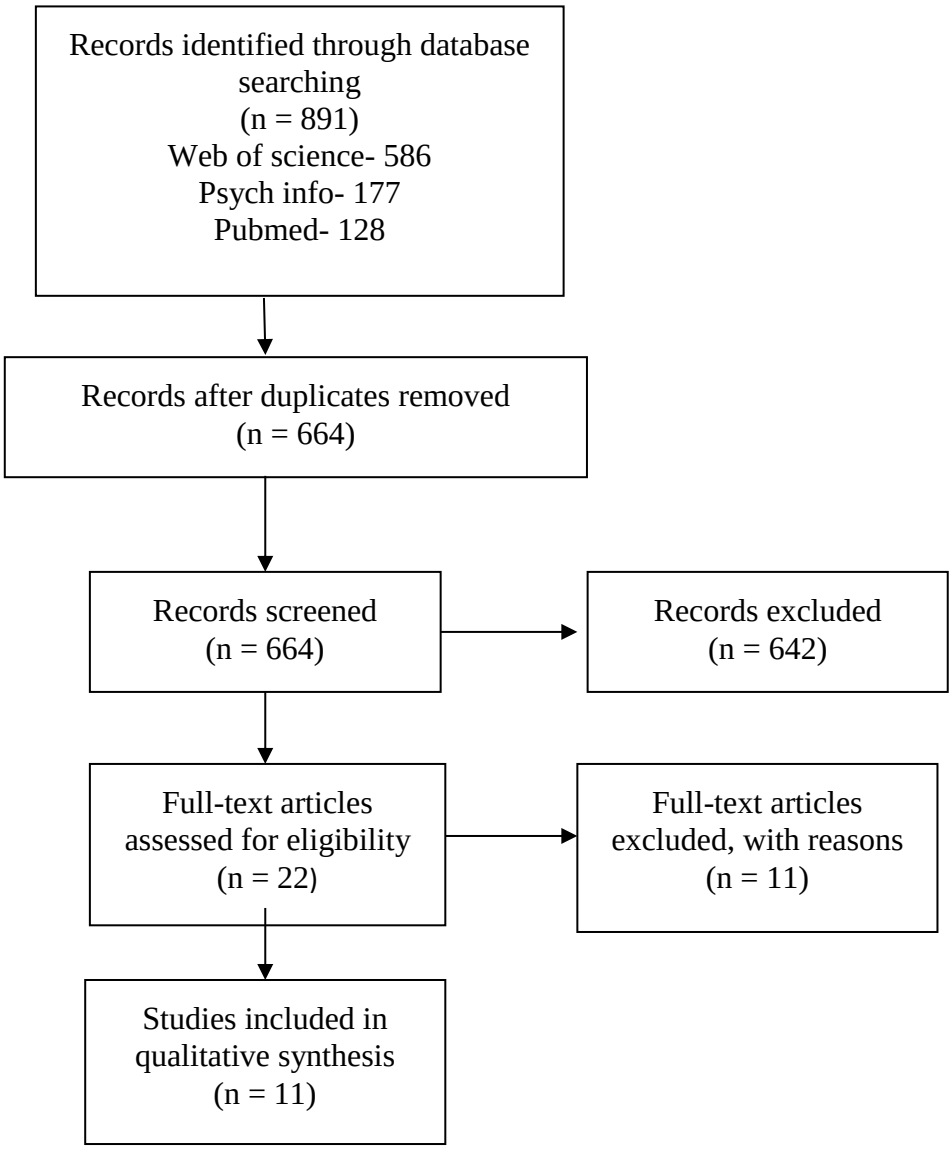
Eleven articles were then further excluded because they did not measure processing efficiency (see appendix C for list of articles excluded). This led to a final 11 articles which met exclusion and inclusion criteria, see figure 1 for Prisma flowchart. To establish reliability for the search process, a subset of articles (177 (27%) articles from PsychInfo) from the original search were also screened by a second researcher using the inclusion and exclusion criteria. The same articles were excluded by the main researcher and the reliability check was 100% consistent.

Table 1.

Key search terms used in Web of Science, PsychInfo and PubMed to search for articles relating to processing efficiency theory (OR similar terms) AND CE (OR similar terms) AND anxiety (OR similar terms) AND child (OR adolescence OR similar terms).

Processing efficiency theory	CE	Anxiety	Age
Processing speed	CE	Anxiety	Teen*
Processing efficiency	Executive function	Worry	Child*
Processing effectiveness	WM	Trait anxiety	Young person
Cognitive processing	Inhibition	State anxiety	Pre-school
Cognitive speed	Shifting	Social anxiety	Nursery
Information processing speed	Focus	Separation anxiety	Adolesce*
Information processing	Load	Phobia	Infan*
RT	Attention	Generalised anxiety disorder	
Attentional control theory	Updating	Panic disorder	
Processing efficiency theory	Switching		
Effort			

Figure 1. Prisma flowchart of systematic review process



Inclusion and exclusion criteria

The aim was to review studies that investigated processing efficiency and performance effectiveness on cognitive tasks in children and adolescents from any country and dated anytime until October 2018. Only peer-reviewed empirical papers were included. As a result, the following inclusion/exclusion criteria were used.

Table 2.

The inclusion/ exclusion criteria that papers were judged upon to be included in analysis.

Criteria	Description
Age	Studies in which participants were only aged above 18 years were excluded.
Human	Non-human participants were excluded.
Neurodevelopmental disorder	Any neurodevelopmental disorder, learning disorders, physical health condition or mental health condition (other than anxiety) were excluded.
Anxiety	Only studies that measured or manipulated anxiety were included. Obsessive compulsive disorder (OCD) was excluded to reflect changes in the DSM-5 criteria.
Cognitive task	Participants must have completed a cognitive or academic task which utilised the CE to measure processing efficiency.
Processing efficiency and performance effectiveness	Studies that did not include a measure of processing efficiency and performance effectiveness were excluded.
Attentional bias	Studies investigating attentional bias were excluded.
Measurement tool	Studies designing or assessing a measurement tool were excluded.
ACT	All studies included assessed the role of ACT in children and therefore included measures of both efficiency and effectiveness. Literature which did not research this topic (e.g. prevalence, epidemiology etc.) was excluded.

Data extraction, synthesis and quality assessment

Key information for each study was extracted and is presented in Table 3. This includes information about the study aims, participants, measures used (to measure

processing efficiency, i.e. time taken, and processing effectiveness, i.e. accuracy, on a CE task) and key findings. The Critical Appraisal Skills Program (CASP; 2018) for cohort studies was used to quality assess the methods used across studies. The CASP is a useful resource to appraise the quality of research developed by a multidisciplinary working group and piloted by non-expert professionals. It asks about three broad areas (is the study valid, what are the results and do the results help locally) across 14 questions (see Table 4). For each question the study could receive either a score of two for met the criteria, one for partially met or a score of zero for not met. Partially met was considered if the study fulfilled the criteria in some, but not all, of the description. If there was not sufficient information in the journal article to answer a score of zero was given. Where some questions were not applicable (n/a) to all studies a final proportion score was given. Studies with a score higher than 75% were considered good quality and scores below 25% were considered poor.

Table 5 details the results of the quality assessment. The highest score given was 75% (Trezise, Reeve, Kane, & Lemaire, 2014) and the lowest score was 63% (Imbo & Vandierendonck, 2007; Ng & Lee, 2016), the remaining studies scored between 67% and 74%. Nearly all studies used valid measures, an acceptable sample and measured a focused issue that was applicable to previous research and to the population. The limitations of most studies was the lack of a follow-up to track anxiety and performance over time and the limited control of potentially confounding factors such as academic attainment, intelligence and age. There was large variability in the results sections of the studies with many providing limited information to answer the CASP questions, particularly when reflecting on whether results were considered to be precise (question 8) as a number of studies did not detail information about confidence intervals. Giving a rated score (rather than a binary score) allowed the analysis to be more fine-grained as a number of studies partially met the criteria (i.e. received a score of 1). This occurred often for question 5a and 5b as a number of studies identified and controlled for some but not all confounding factors. This also occurred for assessing question 3 (whether exposure of anxiety was accurately measured to minimise bias) as a number of studies used adapted measures of anxiety which were theoretically sound but non-standardised with age norms.

Table 3.

Summary table of papers with details of authors, origin, participants, type of anxiety, measurement of effectiveness and efficiency and key results.

Authors, publication date, origin	Participants	Anxiety measured	DV Measurement: Effectiveness	DV Measurement : Efficiency	Other measures	Key results
1. Allen & Vallée-Tourangeau (2016) Ireland	N= 59 (40 male), 9-11 years. Five mainstream primary schools	Maths anxiety (MA) via self-reported questionnaire	Number of errors on simple and complex addition tasks in low and high interactivity conditions	Proportion correct on addition task divided by time taken by time in low and high interactivity conditions	WMC	Effectiveness: MA correlated positively with errors made in the low interactivity condition, (r=-.38, p=.003), but not high interactivity condition (r=-.185, p=.161). Efficiency: MA correlated negatively with efficiency in low interactivity condition (r=.409, p=.001), but not high interactivity condition (r=.12, p=.363). Other: MA correlated negatively with WM span, r=-.363, p=.005.
2.Hadwin, Brogan & Stevenson (2005) UK	N=30 (15 male) 9-10 years One mainstream primary school	State anxiety via self-reported questionnaire	Verbal WM: average number correct Visual WM: number of errors on spatial WM task	Self-report effort on WM tasks and Time taken to complete WM tasks.		Effectiveness: no effect of anxiety on performance (F<1). Efficiency: significant difference between high and low anxious for effort in forward digit span (F[1,29] = 5.04, p < .05, partial η2 = .157) and time taken in backward digit span (F[1,29] = 6.49, p < .05, partial η2= .194). No difference in time or effort for Spatial WM task (F<1).

Authors, publication date, origin	Participants	Anxiety measured	DV Measurement: Effectiveness	DV Measurement : Efficiency	Other measures	Key results
3.Imbo & Vandierendonck (2007) Belgium	N=63 (30 male) 10-12 years One mainstream elementary school	Maths anxiety via self-report questionnaire	Accuracy on arithmetic attainment task and a dual task: 1.Maths addition tasks in 5 conditions (naming, choice of strategy and 3 no-choice of strategy) 2.WM load task	RT for strategy used on dual task. Processing speed (visual number matching task).	Age [4th, 5th, 6th grade]	Effectiveness: Significant negative correlation between maths anxiety and arithmetic skill, r=-.19, p<.05, and between processing speed and arithmetic skill, r=-.58, p<.01. Efficiency: no significant correlation between maths anxiety and strategy efficiency or processing speed Other: main effect of age on processing speed task, $F(2,58=16,80$, p<.01) and arithmetic skill, $F(2,58)=19.76$, p<.01.
4.Khng (2017) Singapore	N=154 (63 male) 10-11 years Four mainstream elementary schools.	Trait test anxiety via self-report questionnaire	Accuracy on maths task	RT difference between relevant and irrelevant distractors on selective attention task.		Effectiveness: deep breathing exercise is significantly related to improved maths accuracy (p<.05) and this relationship is mediated by reducing state anxiety and improved state of mind (p<.05). Efficiency: selective attention improvement did not mediate the relationship between deep breathing and maths performance.

Authors, publication date, origin	Participants	Anxiety measured	DV Measurement: Effectiveness	DV Measurement : Efficiency	Other measures	Key results
5.Ng & Lee (2010) Singapore	N=90 (?) 10 years Three public schools.	Trait and state test anxiety, via self- report questionnaire	Accuracy on dual experimental task 1. Mental arithmetic 2. Memory recall task	RT of experimental task	Working memory capacity (WMC)	Effectiveness: no significant impact of trait test anxiety on performance. Unclear impact of state test anxiety on processing efficiency but the decline in accuracy was greater in evaluative condition for trait anxious participants. Efficiency: significant impact of trait test anxiety on processing efficiency, $F(1, 88)=16.01$, $p<.01$, partial $\eta 2=.15$. Other: no significant impact of individual differences in WM on dual-task performance or efficiency.
6.Ng & Lee (2015) Singapore	N=128 (55 male) 10-11 years Seven public primary schools.	Trait and state test anxiety, via self- report questionnaire	Accuracy on dual experimental task 1. Mental arithmetic 2. Memory recall task	RT for arithmetic task and memory recall task.		Effectiveness: trait anxiety impacted accuracy (via memory recall accuracy) only at high load; indirect effect=-.01, $p<.05$. State anxiety did not impact performance. Efficiency: trait anxiety impacted at any load level, with a larger relationship at medium and high load, $r=.20$-$.30$, $p<.05$. State anxiety did not impact efficiency.

Authors, publication date, origin	Participants	Anxiety measured	DV Measurement: Effectiveness	DV Measurement : Efficiency	Other measures	Key results
7.Ng & Lee (2016) Singapore	N=113 (54 boys) 11 years Five public primary schools	Trait and state test anxiety, via self- report questionnaire, and stress level, via Cortisol	Accuracy on dual experimental task 1. Mental arithmetic 2. Memory recall task to increase load	RT for arithmetic task and memory recall task.		Effectiveness: trait anxiety did not correlated with task performance, $p>.05$. No significant impact of self-reported state anxiety for either arithmetic or memory task performance, $p>.05$ Efficiency: trait anxiety significantly correlated with arithmetic efficiency, $r(112) = -.25$, $p < .05$. No significant impact of self-reported state anxiety for either arithmetic or memory task efficiency, $p>.05$
8.Patel et al. (2016) U.S.A	N=22 (13 male) 10-17 years County public school system. Compared to 22 adults.	State anxiety, via self-report questionnaire	Accuracy on WM tasks (at no-load, low load and high load conditions)	WM task RT.	Anxious arousal measured with startle eye-blink response.	Effectiveness: threat impacted accuracy at low and medium load but not at high load, $F(2,96)=52.84$, $p=.064$, $\eta 2=.056$ Efficiency: threat increased RTs at high load but not at low and medium loads, $F(2,96)=13.88$, $p<.001$, $\eta 2=.22$. Other: greater startle response in low and medium load compared to high load, $p<.01$

Authors, publication date, origin	Participants	Anxiety measured	DV Measurement: Effectiveness	DV Measurement : Efficiency	Other measures	Key results
9.Trezise & Reeve (2014) Australia	N=126 (89 male) 14 years Mixed gender schools.	Maths anxiety via self-report scale Grouped participants into six WM-worry relationships- high/moderate/low WM and high/low worry (HH,MH,LH, HL, ML, LL)	Accuracy on algebraic WM task	RT on algebraic WM task.	Visuo-spatial WM Inhibition	Effectiveness: HL lead to highest accuracy. HH impacted accuracy as problems became harder. LH led to poor accuracy. Efficiency: HH lead to slowest RT. LH lead to fastest RT. Other: No impact of anxiety on accuracy of visuo-spatial WM task at easy difficulty but there was at hard difficulty. There was an impact of inhibition on problem-solving accuracy on WM tasks
10.Visu-Petra, Miclea, Cheie & Benga (2009) Romania	N=76 (46 boys) 3-6 years Kindergarten	Trait anxiety, via parent questionnaire	Accuracy verbal WM measures.	Response timing when correct recall: preparatory interval, word duration and interword pause	Articulation rate	Effectiveness: significant correlation between anxiety and accuracy scores. Anxiety accounted for 4 to 7% of variance in scores. Efficiency: Significant correlation between anxiety and preparatory interval at time 2, r=-.30, p<.01. Anxiety significantly explained 7% of variance in efficiency scores. Other: No significant correlation between anxiety and articulation rate.

Authors, publication date, origin	Participants	Anxiety measured	DV Measurement: Effectiveness	DV Measurement : Efficiency	Other measures	Key results
11.Visu-Petra, Cheie, Benga & Alloway (2011) Romania	Study 1: N= 116 (66 male), 3-7 years Study 2: N= 98 (53 male), 4-7 years Kindergarten	Trait anxiety, via parent questionnaire	Study 1: accuracy on verbal WM task Study 2: accuracy on primary WM task when present alongside a secondary WM tasks	Study 1: Total RT on verbal WM tasks: sum of time of preparatory interval, word duration and interword indirect Study 2: Indirect measure- performance on a secondary memory task.		Effectiveness: Study 1: No significant impact of anxiety on accuracy on WM task. Study 2: Significant impact of anxiety on WM performance for verbal tasks only, $F(1, 91)= 9.6$, $p=.003$, $\eta 2=.10$ and $F(1, 91)= 10.76$, $p < .01$, $\eta 2=.15$. Efficiency: Study 1: Significant effect of anxiety on digit span RT, $F(1, 106)= 4.28$, $p=.041$, $\eta 2=.04$. Study 2: Indirect measure- performance on a secondary memory task. Significant impact of anxiety on measure of efficiency, for one verbal tasks only, $F(1, 91)=20.71$, $p < .01$, $\eta 2=.19$.

Table 4.

Twelve questions, across sections A, B and C, from the CASP criteria for cohort studies used for quality assurance.

Topic	Abbreviated question	Question
Section A: Is the study valid?	1. Focused issue	Did the study address a clearly focused issue?
	2. Acceptable recruitment	Was the cohort recruited in an acceptable way?
	3. Exposure measure	Was the exposure accurately measured to minimise bias?
	4. Outcome measure	Was the outcome accurately measured to minimise bias?
	5. Confounding factors	a) Have the authors identified all important confounding factors? b) Have they taken account of the confounding factors in the design and/or analysis?
	6. Follow-up	a) Was the follow up of subjects complete enough? b) Was the follow up of subjects long enough?
Section B: What are the results?	7. Sufficient results	What are the results?
	8. Precise results	How precise are the results?
	9. Believable results	Do your believe the results?
Section C: Will the results help locally?	10. Apply to population	Can the results be applied to the local population?
	11. Other evidence	Do the results of this study fit with other available evidence?
	12. Implications	What are the implications of this study for practice?

Table 5.

Quality assurance results for the final papers using the CASP checklist.

	1 Focused issue	2 Acceptable recruitment	3 Exposure measure	4 Outcome measure	5a Confound factors a)	5b Confound factors b)	6a Follow-up a)	6b Follow-up b)	7 Sufficient Results	8 Precise results	9 Believe results	10 Apply to population	11 Other evidence	12 Implications	Score
1.Allen & Vallée-Tourangeau (2016)	2	1	1	2	1	0	0	n/a	2	2	2	2	2	2	70%
2.Hadwin, Brogan and Stevenson (2005)	2	1	2	2	0	0	0	n/a	2	2	2	2	2	1	69%
3.Imbo & Vandierendonck (2007)	2	2	1	2	2	1	0	n/a	0	0	2	2	2	1	63%
4.Khng (2017)	2	2	2	2	1	0	0	n/a	1	2	2	2	2	2	74%
5.Ng & Lee (2010)	2	2	1	2	1	1	0	n/a	2	?	2	2	2	1	67%
6.Ng & Lee (2015)	2	2	2	2	0	0	0	n/a	2	2	2	2	2	1	70%
7.Ng & Lee (2016)	2	2	2	2	0	0	0	n/a	2	?	2	2	2	1	63%
8.Patel et al. (2016)	2	2	1	2	1	0	0	n/a	2	2	2	1	1	2	67%
9.Trezise & Reeve (2014)	2	2	1	2	2	0	2	0	2	1	2	2	1	2	75%
10.Visu-petra et al. (2009)	2	2	2	2	0	0	2	1	2	?	2	2	1	2	71%
11.Visu-Petra, Cheie, Benga & Alloway (2011)	2	2	2	0	1	1	0	n/a	2	0	2	2	2	2	70%

Results

Demographics of papers

The eleven papers reviewed were dated from 2005 to 2017 and originated from seven countries (Ireland, Belgium, Australia, UK, USA, Romania (2), & Singapore (4)). The age of participants ranged from 3 to 17 years with two studies working with young children (3-7 years), seven working with those in late childhood (8-12 years) and three working with adolescents (10-17 years). The sample size ranged from 30 to 154 participants and participants in all studies were recruited from mainstream schools or preschools. Three studies analysed results developmentally; Visu-Petra, Miclea, Cheie and Benga (2009) followed 3-6 years olds over 8 months, Imbo and Vandierendonck (2007) compared children in 4th, 5th and 6th grade and Patel et al. (2016) compared adolescents (10-17 years) with adults (22-46 years).

All studies explored the association between anxiety and processing efficiency; this was either the core aim of the study (N=8) or formed part of a broader design (N=3; e.g. an intervention study). Many (N =10) used a correlational design, with only one using a group design. Several different anxieties were measured including maths anxiety (3), trait anxiety (2), state anxiety (2) and test anxiety (6). Five studies (Hadwin, Brogan, & Stevenson, 2005; Khng, 2017; Ng & Lee, 2010; 2015; 2016) used standardised self-reported measures of anxiety, e.g. State-Trait Anxiety Inventory for Children; STAIC (Spielberger, Edwards, Lushene, Montuori, & Platzek, 1970), Test Anxiety Inventory; TAI (Shabbir, 2013), and Children's Test Anxiety Scale; CTAS (Wren & Benson, 2004). Two studies (Visu-Petra, Cheie, Benga, & Packiam Alloway, 2011; Visu-Petra et al., 2009) used standardised parent report measures of anxiety, e.g. Spence Preschool Anxiety Scale (Spence, Rapee, Mcdonald, & Ingram, 2001). Two studies adapted standardised measures of anxiety (maths anxiety rating scales) (Allen & Vallée-Tourangeau, 2016; Patel et al., 2016) and two created their own measure of maths anxiety (Imbo & Vandierendonck, 2007; Trezise & Reeve, 2016). One study, Ng and Lee (2016), also measured cortisol levels to measure stress levels before and after (and at 10- and 20-minute follow-up) completing a cognitive dual task.

All studies used behavioural measures (using cognitive tasks). Ten studies utilised the same task to measure effectiveness and efficiency. Cognitive tasks included set-shifting (Khng, 2017) and WM tasks (Hadwin et al., 2005; Patel et al., 2016; Trezise et al., 2014; Visu-Petra et al., 2011, 2009). One study used an addition task which relied on WM to

complete it (Allen & Vallée-Tourangeau, 2016). Four studies used a dual-task: simultaneous maths and WM tasks (Imbo & Vandierendonck, 2007; Ng & Lee, 2010; 2015; 2016). Six studies used tasks either created by the researcher or adapted tasks from previous studies and five studies used standardised measures (i.e. Wechsler Intelligence Scale for Children; WISC (Wechsler, 2014), Wechsler Individual Achievement Test; WIAT (Wechsler, 2017), Automated Working Memory Assessment; AWMA (Alloway, Gathercole, Kirkwood, & Elliott, 2008), Cambridge Neuropsychological Test Automated Battery; CANTAB (Cambridge Cognition Ltd.). Eight studies used computerised stimuli and the rest were presented by a researcher.

Effectiveness was most often measured by the number of correct trials (10 studies). However, Allen and Vallée-Tourangeau (2016) measured effectiveness as the mean absolute calculation error from the actual total. Efficiency was typically defined as the mean time taken to complete a task (8 studies). However, Visu-Petra, Cheie, Benga and Packiam Alloway (2011; study 1) and Visu-Petra, Miclea, Cheie and Benga (2009) used more specific measures of efficiency on verbal WM tasks by measuring preparatory interval (i.e. time taken to reply to each WM item), word duration (i.e. time take to verbalise each word) and inter-word pause (i.e. time between words) of verbalised responses. Visu-Petra et al. (2011; study 2) used an indirect measure of efficiency by using the accuracy on a primary task of the AWMA (Automated WM Assessment; Alloway et al., 2008) as a measure of effectiveness and the accuracy on a simultaneous secondary task as efficiency. The authors used this method as the AWMA does not provide a measure of speed though this is not considered a measure of efficiency in ACT literature (Eysenck et al., 2007). Allen and Vallée-Tourangeau (2016) calculated an efficiency ratio as the proportion correct divided by the ratio of average time taken over the slowest quartile of participants (the authors did not detail why this measure was used). Hadwin, Brogan and Stevenson (2005) used an additional measure of efficiency: the Rating Scale for Mental Effort (RSME). Lastly, in addition to measuring response time (RT) on a dual task, Imbo and Vandierendonck (2007) measured general processing speed, in which participants were asked to cross out identical numbers from 30 rows of numbers as quickly as they can. One study used two different tasks to measure the relationship between efficiency and effectiveness. Khng (2017) used RT on a selective attention task (computerised flanker task) to measure efficiency and looked at its association with accuracy on a maths task.

A number of additional variables were also measured. Patel et al. (2016) measured startle eye-blink response, a biological measure of anxious arousal. Visu-Petra et al. (2009) measured articulation rate - the time taken to repeat a word five times. Trezise et al. (2014) measured inhibition via accuracy on a go-no go task. Lastly, Allen & Vallée-Tourangeau (2016), Ng & Lee (2010) and Trezise et al. (2014) used additional measures of working memory capacity (WMC). See Table 3 for a summary of all 11 papers.

Anxiety and performance effectiveness

The results across studies indicated that anxiety was associated with effectiveness under certain experimental conditions. Ng and Lee (2010, 2016) found no impact of trait anxiety on children's dual-task (simultaneous maths and memory recall tasks) effectiveness. Similarly, Hadwin et al. (2005) found no impact of state anxiety on effectiveness in verbal WM and simple spatial span tasks in late childhood. Some evidence suggests, however, that the impact of anxiety on effectiveness is most evident as the complexity of the task increases. Ng and Lee (2015) found no link between anxiety and effectiveness on a dual task (i.e. simultaneous maths task and memory recall of letter strings task) at low (e.g. "AAAAAA") and medium (e.g. "ABCDE") memory load in late childhood, but did find an association when load was high (e.g. "DAECBF"). In contrast, Patel et al. (2016) found feelings of threat (presentation of an unpredictable scream, compared to a no-threat condition) impacted accuracy at low and medium load but not at high load in adolescents. This study differed from Ng and Lee (2015) by the age of participants (late childhood versus adolescence) and also the cognitive task used. Patel et al. (2016) used an n-back task in which participants were asked to say whether a presented letter was the same or different to a letter shown previously (at no load or low 1-back, medium 2-back and high 3-back loads).

Further studies suggested that anxiety was most associated with efficiency decrements due to the nature of the task, not just the complexity. Visu-Petra et al. (2009) found trait anxiety impacted accuracy scores on a verbal WM task. Study 2 of Visu-Petra et al. (2011) found trait anxiety impacted accuracy for verbal WM and not spatial WM tasks (see also Hadwin et al., 2005 for similar results with regards to efficiency). In contrast, study 1 of Visu-Petra et al. (2011) did not find links between anxiety on an aggregate WM score, combining verbal and visual WM measures. This difference suggests that anxiety impacts verbal but not visual processes.

Three studies focused on maths anxiety. Allen and Vallée-Tourangeau (2016), for example, found that children aged 9 to 11 years of age who reported increased symptoms of maths anxiety made more errors on an addition task of 7 and 11 counters (where the participants were not allowed to touch the counters; low interactivity). Unfortunately, Imbo and Vandierendonck (2007) did not provide an analysis for effectiveness and maths anxiety due to ceiling effects on a dual-task. Trezise, Reeve, Kane and Lemaire (2014) investigated maths anxiety and compared 14 year olds with different WMC-worry relationships (i.e., there were six groups made up of high (H), moderate (M) and low (L) WMC and high (H) and low (L) worry; HH, MH, LH, HL, ML and LL). Their groupings of children's WMC/worry relationship were linked to accuracy on a maths problem-solving task. Children with high WMC and low worry (HL) had the highest scores. Those with moderate WMC achieved lower scores, especially if they also had high worry. Conversely, low WMC, regardless of worry level had the lowest scores. For those with high WMC and high worry (HH) their scores were only impacted as the tasks became more difficult.

Anxiety and processing efficiency

Several studies investigated the effects of anxiety on efficiency using a variety of tasks. For WM tasks, Hadwin et al. (2005) split 9-10-year-olds into two groups reflecting high and low state anxiety. They found that while there was no difference between groups on effectiveness in visuospatial and verbal WM tasks, children in the high state anxiety group took longer to complete the verbal WM task and reported more effort compared with children in the low state anxiety group. Visu-Petra et al. (2009) found that trait anxiety was associated with processing efficiency, and anxiety symptoms were positively associated with time taken to give a verbal response on verbal WM tasks (across word and non-word digit span tasks). In addition, Visu-Petra et al. (2011) found that pre-schoolers who were allocated to a high (versus a low) trait anxiety group showed increased RT on a verbal forwards digit span task (Experiment 1). In addition, in experiment 2, they showed a negative relationship between trait anxiety and effectiveness on a secondary simple processing task (argued to indirectly reflect efficiency). Visu-Petra et al. (2011) found at low load, only efficiency was impacted but at higher loads both efficiency and effectiveness were negatively impacted by anxiety. Consistently, Patel et al. (2016) found children's RTs increased on WM tasks when in a threatening condition (but only at high

load). Similar results were found in dual-task studies; for example, Ng and Lee (2010, 2015, 2016) found efficiency was significantly impacted by trait anxiety in all three studies, as reflected in slower RTs on dual maths and WM tasks. However, Ng and Lee (2015) found efficiency was only impacted at medium and high load, not at low load (and effectiveness was only impacted at high load). Ng and Lee (2010) did not find a difference between high and low trait anxious participants' relationship between load and efficiency. The authors suggested the participants with high trait anxiety were more motivated to complete the task and so completed it faster. Ng and Lee (2010) also found no correlation between children's WMC with efficiency or effectiveness results.

Three studies assessed the relationship between maths anxiety and efficiency. Allen and Vallée-Tourangeau (2016) calculated an efficiency ratio (proportion correct divided by the ratio of average time taken over the slowest quartile of participants) and found maths anxiety significantly positively correlated with efficiency ratio scores for both easier and more difficult calculations (i.e. there was no difference in load). However, a separate measure of WMC was found to correlate with efficiency (and effectiveness). In contrast, Imbo and Vandierendonck (2007) compared the efficiency of strategy used on a dual maths and WM task and found no significant correlation between strategy efficiency (i.e. solving a maths problem quickly and accurately based on the strategy used) and maths anxiety. The authors also measured general processing speed but found no correlation between maths anxiety and processing speed. Trezise et al. (2014) found that children with high WM and high worry had the slowest RTs when asked to complete an algebraic problem-solving task and participants with low WM and high worry had faster RTs. The authors commented that worry impacted efficiency and effectiveness more so than WM, as when load increased, worry still impacted efficiency even when participants had a high WMC. Also, participants with low WM/ high worry responded very fast with poor accuracy. The authors also measured these WM-worry relationships over two time points (in the same day). Some of the WM-worry relationships were found to be more stable than others, with the most stable being high WM/ low worry. They found WM to reduce over time for children with high WM/ high worry suggesting that worry reduced WM over time. However, this change was only measured within one day and later follow-up is required.

Ng & Lee (2010, 2015, 2016) investigated both state and trait and anxiety. The authors found an impact of trait anxiety on efficiency (RT), but not effectiveness, on a dual-task. However, this finding was not replicated for state anxiety. Ng and Lee (2010) attempted to create a state of test anxiety by creating an evaluative condition where they

told the participants that failed test results would be recorded on school transcripts. However, this manipulation of state anxiety was unsuccessful and so no conclusions could be made about the impact of state anxiety. Alternatively, Ng & Lee (2015, 2016) successfully manipulated state anxiety by instead providing false negative performance feedback after each trial (i.e. told participants they failed every item). The authors found no impact of state anxiety, when measured via self-report, on effectiveness or efficiency. However, it could be questioned whether the authors were able to successfully manipulate state anxiety as they did not find that the manipulation raised cortisol stress levels, suggesting anxiety was not raised enough to see a physiological impact.

Developmental differences

Visu-Petra et al. (2009) found that as 3-6 year old pre-schoolers aged over 8 months, their effectiveness (i.e. accuracy) and efficiency (i.e. RT) on memory span tasks improved. Imbo and Vandierendonck (2007) compared children in 4th, 5th and 6th grades and found improved effectiveness with age on general processing speed and arithmetic skill tasks. They also found that as children grew older, increased task demands had less of a negative impact on effectiveness. The authors noted that this was likely because as children develop, less WM is needed to solve a maths task as they have more procedural knowledge. Patel et al. (2016) compared adolescents (10-17 years) and adults (22-46 years) and found adolescents had slower RTs on the n-back task than adults, but there were no differences between the two groups in how anxiety related to efficiency and effectiveness on the n-back task.

Intervention studies

Interactivity in maths. Allen and Vallée-Tourangeau (2016) investigated the impact of using interactivity in 9-11 year olds when solving maths sums. Interactivity allows students to touch objects when counting them and so combines the use of the environment with cognitive skills to solve maths problems. Effectiveness was measured by accuracy on an addition task and efficiency was measured via the proportion correct responses divided by time invested to complete the task. They compared this intervention manipulation to a control (no interactivity condition), where students kept their hands on the table when counting objects. In the control condition, anxiety and WM correlated with processing

effectiveness and efficiency (i.e., invested more time for the proportion correctly answered). However, in the interactivity condition WM and efficiency were unrelated.

Efficient strategy use in maths. Imbo and Vandierendonck (2007) investigated the effects of children using four different maths problem-solving strategies. These included retrieval (retrieve the answer from memory), counting (count the items), transformation (relate the problem to similar operations or known facts) and any other strategy used. They compared these strategies to no strategy (directly naming the answer). Children were asked to complete a dual maths and memory load task. Processing effectiveness was measured by number of correct items and efficiency was measured by RT. The authors found that naming was the fastest method, followed (in order of fastest) by retrieval, transformation, and then counting. Increased WM load on the dual-task had less impact on effectiveness when the retrieval strategy was used. WM load had the largest impact on transformation RTs as this strategy required more WM resources. WM load also impacted retrieval more than naming which suggests retrieving information from memory still required some WM resources. Also, children's WMC predicted which strategy they chose to use; children with higher WMC were more likely to choose the retrieval strategy. As children developed, they chose to use retrieval strategies more often as they had more maths knowledge stored in memory. Children also became more efficient in naming, retrieval and counting strategies as they aged, but efficiency in transformation did not improve with age. Children with high anxiety were less likely to choose the retrieval strategy, i.e. they were less likely to choose efficient strategies.

Deep breathing. Khng (2017) investigated the impact of a deep breathing exercise before a test on test effectiveness for children separated into high and low anxiety groups (based upon self-reported symptoms of trait test anxiety). The authors found the deep breathing exercise to be effective for children with high trait test anxiety but not for children with low anxiety.

Discussion

ACT hypothesises that when an individual experiences elevated anxiety when completing cognitive tasks utilising the CE, processing efficiency, rather than effectiveness, will be most impacted (Eysenck et al., 2007). The 11 papers reviewed here included an index of processing efficiency, effectiveness and anxiety. Seven papers reported a relationship between anxiety and processing efficiency, but not effectiveness (Hadwin et al., 2005; Ng & Lee, 2010, 2015, 2016; Patel et al., 2016; Trezise et al., 2014;

Visu-Petra et al., 2011), whereas, two papers found both efficiency and effectiveness were related to anxiety level (Allen & Vallée-Tourangeau, 2016; Visu-Petra et al., 2009). The demands of the task appeared to alter the relationship between anxiety with both efficiency and effectiveness (Ng & Lee, 2015; Patel et al., 2016). Moreover the type of task altered results such that anxiety affected verbal processing, rather than visual-spatial processing (Hadwin et al., 2005; Visu-Petra et al., 2011). This small set of findings implicate the auditory loop (versus the visual-spatial sketchpad) in linking performance effectiveness with anxiety on WM tasks (Eysenck et al., 2007).

With respect to processing efficiency, the results of this review support adult studies that have found similar results in behavioural data (see reviews by Berggren & Derakshan, 2013; Derakshan & Eysenck, 2009; Eysenck et al., 2007). For example, in relation to time taken to meet task goals as an index of efficiency, eye- movement studies have found that adults with high (versus low) anxiety symptoms were accurate but slower to re-direct their eye movement on an antisaccade task (Derakshan et al., 2009). In the current review, Hadwin et al., (2005) was the only study to provide an additional self-report measure of efficiency (i.e., self-reported effort). Children with high (versus low) state anxiety symptoms reported increased effort when completing a verbal WM task. This result supports further studies that measured additional indices of effort including pupillometry and EEG (e.g., Hepsomali et al., 2019).

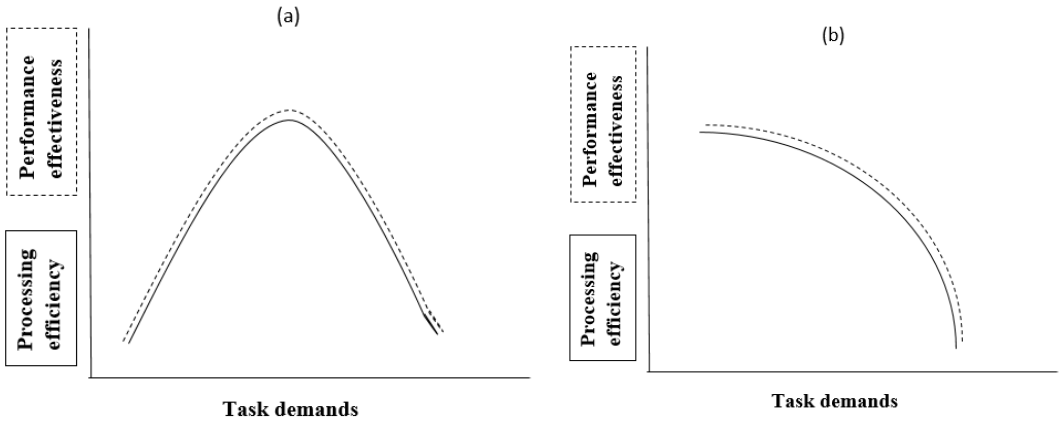
Three papers in the current review reported an association between anxious affect and performance effectiveness on CE tasks (Allen & Vallée-Tourangeau, 2016; Ng & Lee, 2015; Visu-Petra et al., 2009). In line with ACT, Ng & Lee (2015) found anxiety impacted efficiency (i.e. time taken to complete dual-task) at low, medium and high cognitive load whereas anxiety impacted effectiveness only in the high load condition. Conversely, Allen and Vallée-Tourangeau, (2016) found anxiety was related to both efficiency and effectiveness at low load, but not high load. Growing evidence suggests that a certain level of task demand is required for anxious individuals to be motived to use additional effort (i.e. reduced efficiency) and when individuals lack motivation, this compromises goal-based attentional systems (Berggren & Derakshan, 2013). It is possible that the absence of increased efficiency as task load increases in Allen & Vallée-Tourangeau's (2016) study is the result of including tasks that required little cognitive load which did not motivate participants. When a task becomes more complex, processing efficiency/effort increases as anxious children become more motivated to avoid failure, meaning performance

effectiveness is more likely to be maintained on these more complex tasks (Hadwin et al., 2005; Ng & Lee, 2010; 2016; Trezise et al., 2014; Visu-Petra et al., 2011). However, if task difficulty continues to increase, anxious children may lack sufficient cognitive resources to maintain performance effectiveness, leading to decreased accuracy scores (Ng & Lee (2015).

Patel et al. (2016) reported complementary findings in adolescents: performance effectiveness was impacted by state anxiety on an n-back task at low and medium but not high load and efficiency was impacted at high load only. This suggests a certain level of task demand was required to engage additional effort to improve effectiveness at high load. The n-back loads used were relatively simple for adolescents which explains why high load (rather than medium load in Ng & Lee, 2015) was needed to motivate increased effort. A follow-up study by Patel, Stoodley, Pine, Grillon, & Ernst (2017) supports this finding in adult participants for both state and trait anxiety.

The findings of this review suggest a curvilinear relationship between task complexity and performance effectiveness and processing efficiency for anxious individuals, similar to the Inverted-U hypothesis/Yerkes-Dodson law (1908; as cited by Cohen, 2011) (see figure 2 below). This curvilinear relationship is supported by neuroscientific methods with adults (e.g. Fales et al., 2008), which find that at rest anxious adults show reduced neural processing activity in DLPFC, but as task demands are placed on a participant, their neural activity increases. In this review, no neuroscientific methods were used to investigate ACT in children and young people, highlighting a gap in the literature.

Figure 2. Theoretical curvilinear relationship between task demand and performance effectiveness (dotted) and processing efficiency (solid) for anxious individuals (a) and for non-anxious individuals (b).



Most of the studies reviewed here utilised either WM tasks alone or a combination of WM tasks and maths tasks (which require a number of CE functions) (Allen & Vallée-Tourangeau, 2016; Hadwin et al., 2005; Ng & Lee, 2010, 2015, 2016; Patel et al., 2016; Visu-Petra et al., 2011, 2009). Adult literature has focused on the inhibition and shifting functions and there is a little research of the updating WM function (Derakshan & Eysenck, 2009). The results of the studies that employ the updating WM function find mixed support for ACT. Eysenck et al. (2007) originally hypothesised that there would be more of an impact of anxiety on inhibition and shifting functions than on updating WM function. Further research which uses tasks solely requiring inhibition and shifting would be beneficial to better understand ACT in children.

Intervention implications for achievement and social functioning

Eysenck et al. (2007) hypothesised that the ACT effect is more pronounced when there is more demand on the WM and therefore individuals with a larger WMC will be less affected. Trezise et al.'s (2014) exploration of WM/worry relationships supports ACT and suggests a more complex relationship. Participants with high WMC and high worry had the slowest RTs (i.e. they are giving additional effort) and so their performance effectiveness was only impacted as the task became more difficult. Conversely, participants with low WMC and high worry had the fastest RTs and the lowest scores. Under conditions of high worry, low WMC and high task demands, children may lack the cognitive resources to compensate or moderate worry, impairing performance effectiveness further. The results suggest that WMC can be a protective factor for individuals with high anxiety as it allows them the ability to increase effort to achieve the same performance effectiveness.

In an applied context of the classroom, conditions of high worry and high task demands could be a frequent occurrence and the increased effort required by anxious CYP could lead to cognitive fatigue. Therefore, interventions are required to support CYP with anxiety. Interventions could aim to reduce the anxiety a child experiences and there are many interventions available that have demonstrated success in a classroom setting, for example, cognitive behavioural therapy (Hadwin & Richards, 2016). Deep breathing is another strategy CYP can use to reduce their anxiety and improve performance effectiveness (Khng, 2017). Deep breathing can be effective by reducing state anxiety and improving state of mind (more positive, on-task and coping thoughts). This may be a helpful short-term intervention to reduce the impact of anxiety during tests. Although this

intervention is low cost and simple to use, a number of children chose not to use it and so it may not be suitable for all anxious children. It is important to find interventions that work for all individuals in a variety of contexts. Alternatively, interventions can aim to teach children strategies during classroom activities to reduce demands. For example, by simply touching objects when counting (interactivity), performance improves (Allen & Vallée-Tourangeau, 2016). This suggests interactivity may moderate the impact of anxiety, as having the opportunity to access resources in the environment the WM load required is reduced. An alternative explanation could be that interactivity redirects attention to the task rather than to irrelevant information, using a top-down (goal-orientated) rather than a bottom-up (stimulus-orientated) process. Either way interactivity provides a simple strategy that children experiencing anxiety can use independently to support performance in the classroom. Furthermore, Imbo and Vandierendonck's (2007) findings suggest CYP should choose maths strategies based on their WMC and how much WM the strategy requires. It could be helpful for teachers to understand a child's WMC if they are feeling anxious and to teach children which strategies to use when they are feeling anxious. There are also a number of changes to the environment that teachers can make to reduce WM demands for children, such as using objects/visuals and simplifying information (Gathercole & Packiam Alloway, 2007). WM mediates the relationship between anxiety and academic performance, this is because anxiety is related to decreased WM which relates to poorer academic performance, especially for tasks requiring WM resources (Owens, Stevenson, Hadwin, & Norgate, 2012). Therefore, interventions which aim to improve WM could be used which have been found to have short-term success in reducing the effects of anxiety on attentional control, such as CogMed (Hadwin & Richards, 2016; Roughan & Hadwin, 2011).

In the classroom, children not only have to contend with cognitive tasks but also social tasks and anxious children often experience social difficulties (Miers et al., 2013). For example, Scharfstein & Beidel (2015) found anxious children were slower to respond in social interactions. ACT could be used to explain these social difficulties. It may be that the stimulus-driven system often distracts an anxious individual's attention during social interactions leading to poorer performance. However, when an anxious individual is motivated to form a relationship they use the goal-driven system leading to additional effort and slower processing efficiency. To better understand this, research is required that investigates the relationship between anxiety, processing efficiency in social tasks and social competence. This may help to better understand the relationship between anxiety

and social competence in order to provide appropriate social skills interventions for CYP with anxiety.

Limitations

This literature review provides a comprehensive summary of research investigating attentional control in CYP using a variety of methods, types of anxiety and age of participants. However, the review may be limited by this methodological variation as it makes comparisons between studies difficult. This review has discussed the differences in results and further research is required using similar methods longitudinally, across development, to better understand ACT in CYP. A second limitation is the use of the CASP checklist. Although this checklist creates a more standardised way of evaluating studies the questions on the checklist itself are broad and therefore subjective to the individual evaluator's personal understanding of research methods and the questions asked. As a result, a second evaluator would be a useful addition to further enhance the reliability of this literature review.

Conclusions

In conclusion, this review aimed to synthesise evidence investigating the role of ACT in CYP. Eleven studies were found which provide some evidence that ACT is present in CYP. However, the relationships between anxiety and attentional control may be more complex than ACT first suggests. There were a number of inconsistencies between the studies reviewed here and these differences are likely explained by the tasks the participants completed, in particular, the task demands and the participants' motivation to complete the task well. However, more research is required to better understand how these factors inter-play to effect the relationship between anxiety and task efficiency/ effectiveness. This research suggests anxiety can negatively impact CYP's cognition, requiring them to provide additional effort to maintain the same performance effectiveness as peers with low anxiety. It is vital that educators are aware of CYP with high trait anxiety in their class in order to provide the right support. Interventions can be used that aim to reduce the anxiety or to reduce the effort required to complete tasks. The evidence suggests WMC is an important protective factor and so educators can support WMC by reducing task demands through task differentiation. However, educators need to carefully balance task demands, as tasks that are too easy can lead to poorer performance effectiveness due

to reduced motivation. It is also important that educators understand the cognitive processes required to complete the tasks they set students to understand when CYP with anxiety might need additional differentiation.

Chapter 2 Research paper: Does Processing Speed Mediate the Relationship between Anxiety and Performance on Cognitive and Social Tasks?

Introduction

Increasing numbers of children and young people (CYP) are seeking support for anxiety (NSPCC, 2016). Prevalence rates of anxiety disorders range between 15% and 20% and females are twice as likely to develop an anxiety disorder (Beesdo, Knappe, & Pine, 2009). Several anxiety disorders can emerge in childhood and adolescence including selective mutism, separation anxiety disorder, social anxiety disorder (SAD), generalised anxiety disorder (GAD), specific phobia and panic disorder (American Psychiatric Association, 2013). In addition, social anxiety disorder and generalised anxiety disorder peak in early adolescence and adulthood, respectively (Miers et al., 2013). Anxiety during childhood and adolescence can increase the risk of poor health, financial and social outcomes (Copeland et al., 2014; de Lijster et al., 2018), and the development of co-morbid depression (Hirschfeld, 2001) and substance misuse (Grant et al., 2004). In addition, children and adolescents who report elevated anxiety symptoms are more likely to have poorer social competence (i.e. friendliness and assertiveness; Alfano, Beidel, & Turner, 2006; de Lijster et al., 2018; Miers et al., 2013); difficulty with perspective-taking (Pile et al., 2017); more self-focused attention during social interaction (Miers et al., 2013), and peer difficulties (i.e. difficulties with peer acceptance, reciprocal friendships, isolation and bullying; de Lijster et al., 2018; Early et al., 2017).

The NICE guidelines recommend cognitive behavioural therapy (CBT) as the primary treatment for anxiety (NICE, 2013), however, a meta-analysis has indicated that CBT is only effective for around 60% for CYP (James, Soler, & Weatherall, 2008). Moreover, researchers have also argued that CBT on its own may not be as effective for CYP who experience social anxiety (Creswell, Waite, & Cooper, 2014). Therefore, research has increasingly aimed to understand causal mechanisms underpinning anxious affect with a view to target these in the development of novel prevention and intervention methods, to effect positive outcomes for CYP who experience anxiety.

A large body of research has investigated the cognitive risks for anxiety. Historically, theoretical frameworks (see Cisler & Koster, 2010 for a review) and related

research (e.g. Vassilopoulos & Banerjee, 2008; Wieser, Pauli, & Mühlberger, 2009) have focused on attentional biases for the processing of threat information. This research suggests high trait anxious individuals are hypervigilant and so their attention system is biased towards threatening stimuli. Consistently, socially-anxious individuals are quicker to process threatening stimuli (e.g. angry or fearful faces) than neutral stimuli (e.g. neutral or happy faces), compared to non-anxious individuals (see Bar-Haim et al., 2007 for a review). For example, Vassilopoulos and Banerjee (2008) found 11-13 year olds who score higher on measures social anxiety were more likely to catastrophise mildly negative social situations and to discount positive social situations, as measured by a self-report questionnaire.

Alongside this body of work, further studies have aimed to explore how pre-occupation with potential or actual threat impacts individuals' ability to utilise core attentional processes that underpin goals in daily life. Attentional control theory (ACT; Eysenck, Derakshan, Santos, & Calvo, 2007) aims to better understand the impact of anxiety on core cognitive mechanisms including inhibition and shifting of attention, and updating working memory. A core part of this framework makes a distinction between how well an individual uses attention to achieve goal outcomes, versus the efficiency with which they reach this goal (i.e. time and effort taken). It is proposed that high anxious individuals can achieve the same level of performance (i.e. their effectiveness or accuracy) on a task as low anxious individuals, however, this equivalence requires additional effort or time, making overall performance less efficient. ACT research suggests this is because an anxious individual's default information processing system is stimulus-driven. Therefore, attentional resources are occupied by threatening stimuli or worrying thoughts (e.g. mind-wandering and rumination) and this reduces the cognitive capacity available to process information. However, if an anxious individual is motivated to perform well on complex tasks (i.e. with high task demands/cognitive load) they may switch into a goal-directed system. In this goal-directed system, they may increase their effort to complete the task as accurately as their low-anxious peers, but in a less efficient way. This additional effort requires more cognitive resources, so if task demands become too high, anxious individuals may no longer be able or sufficiently motivated to process task information.

ACT has been applied to central executive tasks in a number of adult, adolescent and child studies (Berggren & Derakshan, 2013; Derakshan & Eysenck, 2009; Eysenck et al., 2007; Patel et al., 2017, 2016). In support of ACT, Hadwin and colleagues (2005)

asked 9 and 10 year olds to complete timed verbal and spatial working memory (WM) tasks and then report how much effort they felt it took to complete the tasks. Participants with higher symptoms of state anxiety reported more effort and took longer to complete a verbal WM task, while maintaining the same accuracy as low anxious peers. More recently, younger children, aged 3-7 years, completed WM tasks and researchers recorded the time taken for children to respond with an answer on each question and the time taken to complete the entire task (Visu-Petra et al., 2011). High trait anxious individuals took longer to verbally respond to WM questions (i.e. they were less efficient) but were just as accurate in their answers, than low trait anxious peers. In a further task, 11-year-old children with elevated trait anxiety took longer to complete WM tasks simultaneously with maths tasks. Yet there was no relationship between anxiety and task performance (Ng & Lee, 2016). In a similar study, with 11-year-olds, trait anxiety was found to be related to reduced efficiency on a simultaneous WM and maths task, but only when the task demands were higher (i.e. when the stimuli to remember was 'DABCEF') rather than medium ('ABCDEF') or low ('AAAAAA'). Interestingly, performance was also impacted at high load, indicating that at high loads anxious individuals find it difficult to maintain performance (Ng & Lee, 2015).

These core attentional processes are also known to impact (Hubber, Gilmore, & Cragg, 2014; Maehler & Schuchardt, 2016) and to predict (Lechuga, Pelegrina, Pelaez, Martin-Puga, & Justicia, 2016) achievement in school. Investigating the relationship between attentional effectiveness and efficiency in the pursuit of task goals may be important for understanding how anxiety impacts achievement in school. Several studies have found that attentional processes used in WM, for example, may be important in understanding anxiety related underachievement (Allen & Vallée-Tourangeau, 2016; Imbo & Vandierendonck, 2007; Owens, Stevenson, Hadwin, & Norgate, 2014; Trezise et al., 2014), and in the development and application of interventions that improve attention for achievement in school (Allen & Vallée-Tourangeau, 2016; Hadwin & Richards, 2016; Khng, 2017). For example, Owens et al. (2014) found, in adolescents, higher anxiety can led to lower WMC which in turn relates to poorer academic performance when academic tasks require WM. As a result, interventions can be developed, e.g. WM training, which aim to improve WMC to reduce the impact of anxiety on academic performance (Hadwin & Richards, 2016).

Further research has investigated the role of cognitive processing in social performance. Social information processing theory (SIP) suggests there are a number of

cognitive stages required in social situations to process social information (i.e. perceiving and interpreting social cues), thinking of suitable responses and then choosing and enacting a response (Crick & Dodge, 1994). In addition, there are a number of cognitive processes (i.e., attentional focus, shifting and inhibitory control) involved in successful social interactions; e.g., understanding the goal of the interaction and then ensuring appropriate response options are retrieved and inappropriate responses are inhibited or masked (Lemerise & Arsenio, 2000). In support, adults that are rated as more charismatic by their friends show better performance on a processing speed task (speeded naming task), than those rated as less charismatic (von Hippel, Ronay, Baker, Kjelsaas, & Murphy, 2016). This suggests more efficient social processing may be related to better social performance.

Similar findings have been shown in developmental research. For example, Alfano et al. (2006) observed 7-16 years olds diagnosed with SAD complete social role-play tasks with a confederate peer. The confederate directed a standard statement at their peer who was asked to respond how they would in real-life. The authors found that socially anxious CYP were slower to verbally respond to the confederate, compared to healthy controls. This difference was more apparent in younger children compared to adolescents. Observers also rated the videoed interactions and rated socially anxious individuals as less socially effective in their role-play. This finding was further supported using a more naturalistic social task; playing a Wii game. Children and adolescents, aged 6-13 years, completed the game with a confederate peer before completing a social vignettes task to assess social cognition. The confederate peer rated the child on the peer likability scale and independent observers rated social behaviours (i.e. instances of talk, time taken to verbally respond and type of talk). Analysis found CYP with social anxiety disorder (SAD) were slower to verbally respond to their peer (i.e. were less efficient in the interaction) and were rated as less likeable by their peer (i.e. were less effective), than non-anxious controls or children with GAD. Participants with SAD were also slower to provide a response on the social vignette task (Scharfstein & Beidel, 2015). Collectively, these studies suggest an impact of anxiety on efficiency and effectiveness in social interactions.

The aim of the current project was to extend these findings to explore individual differences in efficiency and effectiveness in a social interaction task, and to investigate whether these are associated with child self-reported symptoms of anxiety, general cognitive processing efficiency and peer acceptance. Previous studies have analysed associations between these factors, but no study has investigated whether general measures

of cognitive processing speed, as well as specific measures of social processing speed, mediate the relationship between anxiety and academic or social performance. Consequently, correlational analysis was utilised to answer the following research questions:

1. Is there a relationship between anxiety and processing efficiency/speed?

2. Is there a relationship between anxiety and social (and academic performance?

3. Does processing efficiency/speed mediate the relationship between anxiety and social (and academic) performance?

Specifically, the application of ACT was investigated to further understand social interactions in a community sample of child dyads, aged 9-10 years, who completed measures of anxiety. Social interactions involved each member of the dyad working together to complete two tasks (planning an adventure together and creating an advertisement for an unknown object from Holbein, Zebracki, & Holmbeck, 2014). Analysis of the social interaction included indices of processing efficiency (i.e. verbal response time to peer verbalisation) as well as performance effectiveness (i.e. proportion of appropriate vs. inappropriate talk). Children's cognitive processing abilities were also measured and included processing speed measures of verbal and non-verbal efficiency. Peer acceptance was measured using a sociometry task (Košir & Pečjak, 2017).

Based on ACT, it was anticipated that self-reported higher anxiety symptoms would be positively associated with slower processing speed in the cognitive tasks and within the social interactions (indicating reduced efficiency). It was anticipated that a

Figure 1. Hypothesised conceptual model for academic performance.

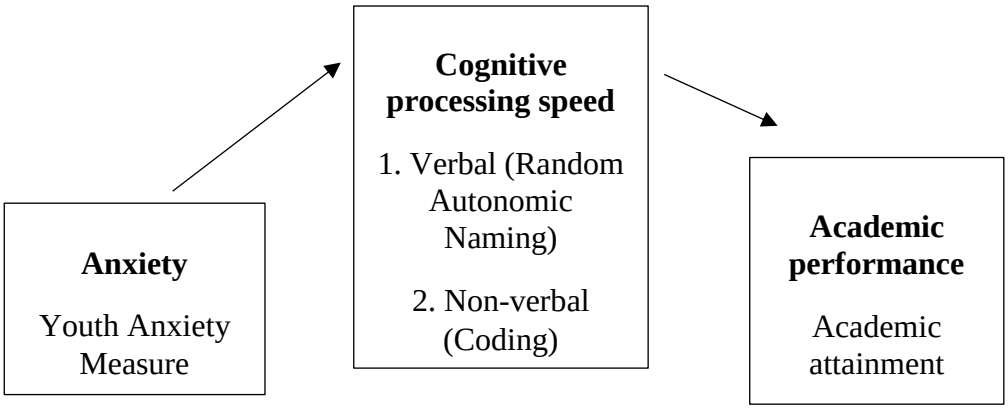


Figure 1. Hypothesised relationship between anxiety and academic performance, via cognitive processing speed.

stronger relationship would exist between anxiety and verbal speed versus non-verbal (visual-motor) speed (hypothesis 1). Further, it was hypothesised that anxiety would be associated with academic performance, and that cognitive processing speed would mediate the relationship between anxiety and academic performance (hypothesis 2, see Figure 1 for the hypothesised conceptual model).

Conversely, poorer social performance (i.e. inappropriate comments and social acceptance scores) were predicted to be associated with both slower cognitive and social processing speed and higher anxiety. Thus, it was hypothesised that cognitive and social processing speed would mediate the relationship between anxiety and social performance (hypothesis 3, see figure 2). The two models were analysed statistically using a number of simple mediation models, depending on the statistically significant correlations found between variables.

Figure 2. Hypothesised conceptual model for social performance.

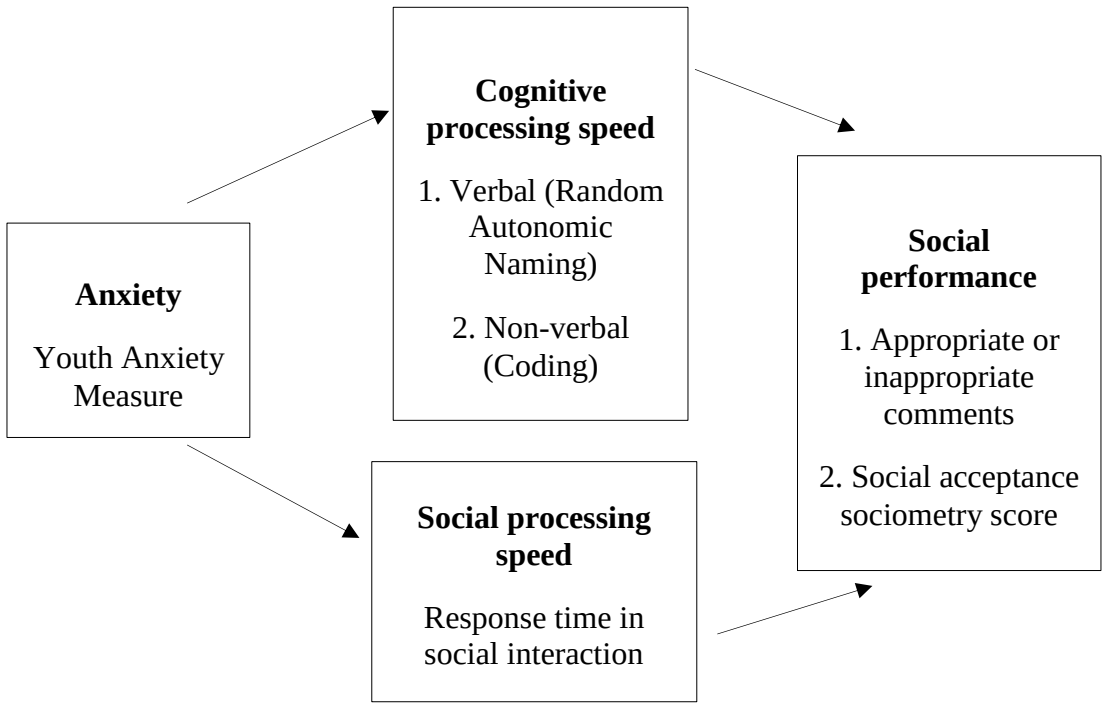


Figure 2. Hypothesised relationship between anxiety and social performance, via cognitive and social processing speed.

Method

Participants

Children were recruited from one large mainstream junior school (6 classes per year group; 689 pupils on roll) in the South East of England, rated as Outstanding by Ofsted. 91 children took part in a sociometry (see measures below) as part 1 and then 51 children provided consent to continue with the study and take part in part two: 24 males, 27 females, mean age=9.93 years (standard deviation (S.D)=.47, min.=9.08, max.= 10.75). There was no significant difference in social acceptance scores between children who only took part in the sociometry and those who continued onto part two, $p>.05$.

The school consisted of 6.4% of children eligible for free school meals over the past 6 years (compared to 24.3% nationally), 10.7% children with English as an additional language (21.3%), 9.1% children requiring special educational needs support (11,7%), 1% with an education, health and care plan or statement (2.9%), overall absence is 3.2% (4.0%), and the pupil to teacher ratio is 24.7 (20.9) (Department for Education, 2018). The ethnicity demographics for the South East are 85.2% White British (80.5% nationally), 5.4% White other (4.4%), 5.2% Asian (7.5%), 1.6% Black (3.3%), 1.9% Multiple ethnicity (2.2%), 0.6% other ethnic groups (1%) (Office for National Statistics, 2018).

There were two rounds of recruitment. In the first round of recruitment, summer 2018, 46 children took part in part 1 (sociometry only) and 29 in part two (all other measures): 14 males, 15 females, mean age= 10.25 (min.=9.67, max.=10.75). The second cohort of year five children were recruited in autumn 2018. 45 took part in the sociometry and 22 in part two: 10 males, 12 females, mean age= 9.50 years (min.=9.08, max.=10.00). Although cohort one were on average seven months older than cohort two, an independent samples t-test found no significant differences between the two cohorts for attainment or anxiety, $p>.05$.

Measures

Anxiety. Self-reported anxiety levels were measured using the Youth Anxiety Measure (YAM-5; Muris et al., 2017). This measure was designed in line with the DSM-5 (American Psychiatric Association, 2013) and consists of two parts. The first part has 28 items, providing a score for specific anxiety disorders: separation anxiety, social anxiety disorder, selective mutism, panic disorder and general anxiety disorder. The second part

(not used in this study) has 22 items and provides a score for specific phobias. For each item, the child responds 'never', 'sometimes', 'often' or 'always' (e.g. to the statement 'I'm afraid to go anywhere without my parents') to indicate how frequently they experience it, providing a total score 0 – 84 for the first scale. The scale has been found to have good validity and is simple for children to complete, and it is considered to be suitable for children 8 years and over (Muris et al., 2017). To account for any reading difficulties researchers read aloud each question. Cronbach's alpha was calculated for the YAM-5 scale and good internal consistency, (α=.93) was found. All item-total correlations were above .30. Social anxiety was the focus of analysis; however, we have reported analysis for all sub-tests and total anxiety in appendix G, H and I.

Academic performance. Children's most recent (year 4) maths and English attainment scores were provided by their head teacher. These were in-school assessments using the progress test series (GL Assessments). A standardised score (mean=100, S.D=15, min.=40, max.=160) was provided for each maths and English assessment. A composite attainment score was created by finding the mean of each child's maths and English score. Of the final sample, the mean maths attainment was 113 (S.D=18.06, min.=73, max.=141, and mean English attainment was 115 (S.D=14.67, min.=83, max.=141.). As a result the mean composite attainment score was 114 (S.D=15.02, min.=83, max.=141).

Cognitive processing speed. Two measures of cognitive processing speed were utilised (a non-verbal and a verbal measure).

Non-verbal processing speed: Coding. To measure non-verbal processing speed the 'Coding' sub-test of the Wechsler Intelligence Scale for Children (WISC-V; Wechsler, 2014) was used. In the coding task, children are shown a number of shapes with corresponding symbols and they are asked to draw the corresponding symbols inside empty shapes. The child is given 120 seconds to fill as many empty shapes with their corresponding symbols as possible. Errors are not counted. Processing speed is indexed by the number of correctly completed shapes in 120 seconds.

Verbal processing speed: Rapid Autonomic Naming (RAN). The RAN sub-test of the Clinical Evaluation of Language Fundamentals (CELF-IV; Semel, Wiig & Secord, 2006) was used. The RAN is comprised of two practice conditions that collectively generate a composite score of basic processing: (1) children are shown a page of black and white shapes and asked to name them as fast as they can whilst being timed and (2)

children are asked to name the colour of a page of coloured circles. The final test condition (complex processing speed), asks children to name the shape and the colour of a page of coloured shapes. For each trial, the child receives a score of speed (in milliseconds) and a score of errors. Complex verbal processing speed was the focus of the mediation analysis.

Social processing speed. Pairs of children were video-recorded completing two 5-minute tasks from Holbein, Zebracki and Holmbeck (2014). These tasks were 'planning an adventure' and 'advertising an ambiguous object'. Children were provided pens and paper to complete these tasks (the script for these activities is detailed in appendix E). Social interaction was coded using the Noldus Observer behavioural observation system, similar to Scharfstein and Beidel (2015). The task was used to generate an index of time taken to respond to the peer between every reciprocal interaction. The response time was taken from when a peer finished speaking and the participant verbally responded to their comment, to give a mean response time (in milliseconds) for each video. Response times were averaged across two videos to give a total mean response time. Two undergraduate coders were trained using two videos the TEP researcher had coded and then on-going discussions with four more videos. Inter-rater analysis used five [1]double-coded videos (from the two undergraduates) which was 10% of the total sample (see Chorney, Mcmurtry, Chambers, & Bakeman, 2015). The coders were blind to participants' anxiety and processing speed scores. Intra-class correlation (ICC) was calculated for response time data (two-way, mixed model for absolute values) and poor reliability, ICC=.22, was found between the two undergraduate raters (see Hallgren, 2012 for ICC methods used).

Social performance. We measured children's social performance in two ways. One score was taken from the dyad interaction tasks: the number of appropriate and inappropriate comments made. The second was derived from the sociometry and reflected an index of social acceptance.

Appropriate and inappropriate comments. The social interaction tasks were also coded by the same two undergraduate coders for instances of talk and whether each instance of talk was socially appropriate or inappropriate**.** A verbalisation was considered appropriate if it helped to build a positive relationship between peers that was appropriate to the social context they were in, for example, they used conversation to find out each other's perspectives on the task, commented on shared experience or supported each other

[1] Due to practical issues, it was not possible to calculate ICC for the sixth video.

to complete the task. Verbalisations which were negative (i.e. were unsupportive or irrelevant to building a relationship) were considered inappropriate. The scores were summed across videos and then divided by the total number of comments made in the two videos. This provided a score for the proportion of inappropriate (and appropriate) verbalisations each child made during the interaction task relative to the overall number of verbalisations. As the primary interest was in the social errors children made, analysis focused on inappropriate comments. The Noldus Observer program provided Cohen's Kappa score for nominal data. Cohen's Kappa scores for the 5 videos (10% of total sample) double-coded by the two undergraduates ranged between 0.45 (moderate agreement) and 0.76 (substantial agreement) with an average of 0.59 (moderate agreement; based on criteria by; Landis & Koch, 1977).

Social acceptance. Peer acceptance was measured using a sociometry task (Košir & Pečjak, 2017). Children were asked to state the three children in their class they liked the most and three they liked the least. As a result, each child received a score for most liked (ML) nominations and least liked (LL) nominations and a standardised social acceptance difference z-score was created (ML nominations z-score minus LL nominations z-score). A higher difference z-score indicated increased social acceptance (Banerjee & Watling, 2005).

Procedure

To recruit, emails with an attached letter detailing the aims and methods of the study were sent to local primary schools. Three schools showed initial interest in the study and the researcher met with senior leadership teams to discuss the project further. In return for participation, schools were offered teacher training by a Trainee Educational Psychologist (TEP) focusing on a subject relevant to the research topic, such as social and emotional well-being. One school agreed to take part and the head teacher signed an agreement form. Parents (N=117) were sent an information sheet and an opt-out consent form for part one of the study (14 parents opted-out). Two weeks later, the researcher visited each class and explained the aims of the study and sociometry task to all children whose parents did not opt-out. The children then had the opportunity to opt-out themselves and those who wanted to continue gave signed assent (12 opted-out). The final 91 children then completed the sociometry within the classroom; they completed a form naming three children they liked the most and three they liked the least. The children were not allowed to write the names of

any children who opted-out of the study or to share answers. The teacher was highlighted as a person the children could talk to if they had questions or concerns.

A second parent letter was distributed to all children (including those who opted-out to part one) explaining part two of the study. The parents were required to provide written consent for their child to take part study and had two weeks to return their forms. The TEP researcher and a trained undergraduate researcher then visited the school and each met with children (whose parents provided consent) one by one in a large, quiet room within the school. Each researcher explained the study and received the child's signed assent before completing three tasks (YAM-5, Coding and RAN) with each child. One child who did not assent to take part in the sociometry in part one did assent to take part in part two. The children were randomly assigned to 25 same-sex pairs with one from each class. However, due to practical difficulties, two pairs were opposite-sex and eight pairs were from the same class. Due to an odd number, one child did not complete the videoed activities. For two pairs, there were technical difficulties and only one social task was filmed. Dyads were seen individually. The tasks were explained sequentially and for task each the researcher checked the children's understanding. Children were left alone for 5 minutes to complete each task. The completion of tasks was counter-balanced between dyads.

As children completed each part of the study they stamped a progress chart and once all tasks were completed they chose an animal rubber prize. Once all parts were completed, the children were debriefed and given a debrief letter to take home. All data were then scored and inputted by the TEP researcher. The researcher trained two further undergraduate students, who were not involved in data collection, to code the videos. Videos were coded as described above.

Ethical considerations.

Due to the potentially upsetting nature of the questions in the sociometry task there were some concerns from parents and children about taking part. As sociometry is a commonly used task by both researchers and educators, to gather information about peer relationships, it was considered appropriate to use. Opt-out consent was required to ensure a good sample size and therefore the task was carefully managed by school staff and researchers by ensuring parents had access to the consent form, gaining informed assent from children, ensuring children did not share their answers and providing follow-up support for children from the class teacher.

Results

Approach to data analysis

One child did not complete the dyad tasks. One dyad only completed the first task (n=2 children) and one dyad only completed the second task (n=2 children). For these four cases, the proportion of comments and response time from one video was taken to be in indicative of their interaction style on the other video.

Scatterplots and histograms for all variables were scanned to assess linearity, normality and outliers. One-sample Kolmorogov-Smirnov tests were used to statistically test for normality. Basic and complex verbal processing errors, proportion of appropriate and inappropriate comments, social processing speed response time and four anxiety sub-scales (separation anxiety, selective mutism, social anxiety, panic disorder) were statistically different from normal, $p<.05$. An outlier was found for proportion of inappropriate comments (.33; 3 S.D from the mean; next highest score was .15), and when removed, key associations were smaller but still significant (except with academic performance, $r=-.281$, $p=.50$) therefore this outlier was still included.

Pearson's correlations (r) were conducted to analyse the relationship between all normally-distributed variables and point biserial correlations were used for gender. Spearman's Rho (rs) was used for non-normally distributed variables. An r (or rs) value between .1 and .3 was considered small, between .3 and .5 was moderate and .5 and 1 was large. Mediation analysis was carried out using PROCESS, Model 4 by Hayes (2017) to investigate (1) the mediating role of processing speed (verbal and non-verbal cognitive processing speed) between anxiety and academic performance, and (2) the mediating role of processing speed (verbal and non-verbal cognitive processing speed and social processing speed) between anxiety and social performance (proportion of inappropriate comments and social acceptance). Bias corrected bootstrapping (BCa) was used with 1000 samples to calculate 95% confidence intervals. If confidence intervals were different from zero (i.e. did not straddle zero) then mediation was considered significant at the $p<.05$ level (Field, 2014). The unstandardised coefficients and the completely standardised indirect effect sizes are reported.

Descriptive statistics

The time taken to complete the first and second trials of RAN (verbal processing speed) were significantly correlated, *rs*=.66, *p*<.01. There was no significant correlation between number of errors on the two practice trials, *p*>.10. For correlation analysis, a composite score was used for basic verbal processing speed and for errors (average of trial one and two).

Table 1 shows the number of appropriate and inappropriate comments children made for each video task and overall. It highlights that most verbalisations were appropriate, and the mean number of inappropriate verbalisations was low. Considering the frequency of inappropriate verbalisations, further exploration of the data showed that across both tasks, 20% of children (10/50) did not make any inappropriate verbalisations. For the analysis, we created two scores that reflected the number of appropriate and inappropriate verbalisations as a proportion of the overall number of verbalisations (see table 2). Table 2 summarises the descriptive statistics of the sample, including social anxiety (see appendix G for all other anxiety sub-tests), performance on the cognitive processing and social tasks as well as the social acceptance z-scores (derived from the

Table 1.

The mean number of verbalisations, appropriate and inappropriate comments for each interaction task (N = 48) and the two tasks combined (N=50).

	Task 1 (N= 48)			Task 2 (N=48)			Overall (N=50)		
Verbalisations	Mean	SD	Range	Mean	SD	Range	Mean	SD	Range
Total	30.08	9.16	11-53	30.23	9.78	13-43	61.22	14.97	34-90
Appropriate	28.92	8.79	10-50	29.27	9.99	12-46	58.78	14.69	33-86
Inappropriate	1.15	2.07	0-12	1.17	1.14	0-3	2.62	3.84	0-24

Note. The number of appropriate and inappropriate verbalisations was not significantly correlated between tasks, p>.05. The number of total verbalisations was correlated in each task with the number of appropriate verbalisations (r > .9 and p< .001). The correlation between appropriate and total number of verbalisations between tasks was not significant, p>.05.

sociometry measure). The mean and standard deviation of the social anxiety score for this sample was 4.75 and 3.54 respectively. The average academic attainment standard score for the sample was 114, and there was medium variation in the sample with a range from 83 to 141 (S.D= 15.02).

Table 2.

Descriptive statistics. Sample size (N), Mean, Standard deviation, Minimum and Maximum scores for age, social anxiety, academic attainment, cognitive processing speed, social processing speed and social performance.

Measure	N	Mean	Standard deviation	Minimum	Maximum
Age (years)	51	9.93	0.47	9.08	10.75
Social anxiety [min.=0, max.=18]	51	4.75	3.54	0	16
Academic performance (standard score)	51	114	15.02	83	141
Cognitive processing speed					
Non-verbal processing speed (T-score- number correct)	51	43.82	9.71	28	63
Basic verbal processing speed (seconds)	51	29.04	5.54	18.50	45.00
Basic verbal processing errors	51	.23	.49	.00	2.50
Complex verbal processing speed (seconds)	51	67.53	14.22	36	104
Complex verbal processing errors	51	.96	1.52	0	7
Social processing speed					
Response time (milliseconds)	50	950.71	359.12	478.68	2150
Social performance					
Proportion appropriate comments	50	.96	.06	.67	1.10
Proportion inappropriate comments	50	.04	.05	.00	.33
Sociometry z-score	50	0.11	1.54	-3.16	+3.57

Correlations between variables.

Table 3 summarises the correlations between all variables (see appendix H for correlations of anxiety sub-scales). Considering basic demographic information, Table 3 shows a relationship between gender and social acceptance: girls achieved significantly higher social acceptance scores (M=.68, S.D=1.49) than boys (M=-.49, S.D=1.38),

t(48)=2.88, $p<.01$. Age was negatively correlated with self-reported symptoms of social anxiety[2] as well as basic verbal speed.

Correlations within task domains. All anxiety sub-scales correlated with total anxiety, and with each other (in all cases $r > .40$, see appendix H). Similarly, performance on cognitive processing tasks indicated that better performance on non-verbal tasks related to improved performance on verbal tasks. Moreover, complex and basic verbal speed were significantly correlated.

Anxiety and processing efficiency. Considering links between anxiety with basic cognitive processing, Table 3 highlights that social anxiety[3] was significantly associated with lower scores on non-verbal cognitive tasks. Complex verbal processing speed was correlated with social anxiety[4]. There was no significant relationship between verbal response time in the peer interaction tasks (social processing speed) and any other variable.

Anxiety and processing effectiveness. Concerning academic performance, there was no relationship found between performance and social anxiety[5]. All three cognitive processing speed measures correlated moderately with academic performance[6]. Faster cognitive processing speed related to improved academic performance. There was no relationship found between academic performance and social processing speed, appropriate comments or social acceptance, however there was a moderate significant correlation between academic performance and inappropriate comments. The higher the academic performance the fewer inappropriate comments made.

Regarding social performance, there was no significant relationship found between anxiety and proportion of appropriate comments or social acceptance scores. However, a moderate relationship was found between social anxiety[7] with proportion of inappropriate comments made. As expected, there was a strong significant correlation between proportion of appropriate and inappropriate comments made. Both basic and complex verbal processing speed were moderately correlated with appropriate and inappropriate comments. However, non-verbal speed was not. Social acceptance was not significantly correlated with any cognitive or social processing speed measures.

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[2] This negative correlation also held for selective mutism and panic disorder.
[3] All other sub-scales, except panic disorder, were also correlated.
[4] Separation anxiety and selective mutism also correlated with verbal processing speed.
[5] Only separation anxiety correlated (negatively) with academic performance.
[6] Correlations between basic verbal speed and academic performance held when controlling for age, $p<.01$.
[7] Also, a moderate relationship with separation anxiety was found.

Table 3.

Correlation coefficients and significance between gender, age, cognitive processing speed, academic performance, social processing speed and social performance.

Measure	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
1. Gender	-											
2. Age (years)	-.09	-										
3. Social anxiety	.09	-.32*	-									
4. Academic attainment	-.01	.04	-.19	-								
Cognitive processing												
5. Non-verbal speed	.22	.27	-.31*	.28*	-							
6. Basic verbal speed	-.04	-.30*	.20	-.36*	-.57**	-						
7. Basic verbal errors	-.24	-.15	.04	-.18	-.27	.10	-					
8. Complex verbal speed	.17	-.27	.28*	-.51**	-.39**	.76**	.14	-				
9. Complex verbal errors	.04	-.08	-.02	-.26	-.11	.05	.17	.36**	-			
Social processing speed												
10. Response time	.19	-.01	-.10	-.06	-.08	.25	.11	.09	-.11	-		
Social performance												
11. Proportion appropriate comments	-.09	.23	-.27	.27	.09	-.35*	-.08	-.40**	-.04	-.05	-	
12. Proportion inappropriate comments	.15	-.27	.35*	-.31*	-.05	.34*	.06	.37*	.02	-.16	-.94**	-
13. Sociometry z-score	.38**	0.14	-.11	.19	.17	-.10	.17	-.07	-.11	.21	-.05	.10

*Note. *p<.05, **p<.01.* Spearman's correlations was used for basic and complex verbal processing errors, proportion of appropriate and inappropriate comments, response time and social anxiety (see appendix H for total anxiety, separation anxiety, selective mutism, social anxiety, panic disorder).

Mediation

Several mediation models were tested using PROCESS v3 (Hayes, 2017). The direct effect between self-reported social anxiety symptoms (see appendix I for mediation results of anxiety sub-scales) on academic performance and on indices of social outcome (i.e., proportion of inappropriate comments), and via an indirect effect of processing speed was explored. Models that focused on cognitive processing speed as reflected in the number correct on the non-verbal coding task and time taken to complete the verbal RAN (complex) task were included. Social processing speed was not included as a mediator due to lack of significant correlations with any variables. The analysis used bootstrapping across 1000 resamples and indirect effects between variables were determined by confidence intervals that did not cross zero. Completely standardised indirect effect sizes and significant models are reported below.

Anxiety and academic performance via cognitive verbal processing speed. The model in figure 3 shows there is no significant direct relationship between social anxiety scores and academic performance, $p>.10$. However, the model also shows that the indirect mediated effect between social anxiety and academic performance via verbal processing speed is significant. This analysis indicates that symptoms of social anxiety[8] are positively associated with verbal cognitive processing which is then linked to lower academic performance. The completely standardised indirect effect, b =-.175, 95% CI [-.3.50,-.014], highlights a partially mediated effect of social anxiety on academic performance. Figure 3 shows the coefficients for each pathway in the model, as well as the total effect and direct effects.

[8] Similar mediation results were also found for total, separation and generalised anxiety.

Figure 3. Mediation model for social anxiety and academic performance via verbal processing speed, with coefficients for each pathway and total and direct effects.

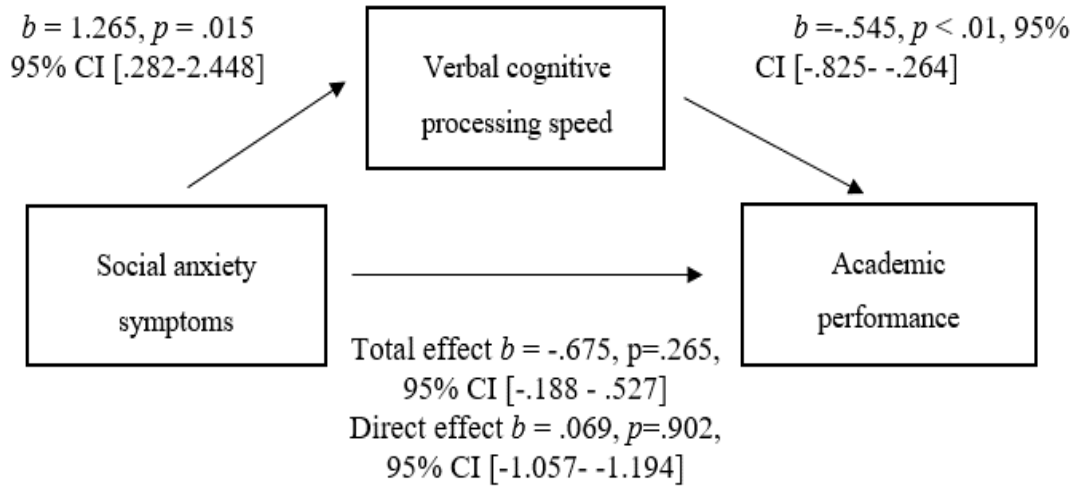

Figure 3. Unstandardised coefficients (b), significance level (p) and 95% confidence interval (95% [-]) for each pathway and direct and total effects.

Figure 4. Mediation model for social anxiety and inappropriate comments via verbal processing speed, with coefficients for each pathway and total and direct effects.

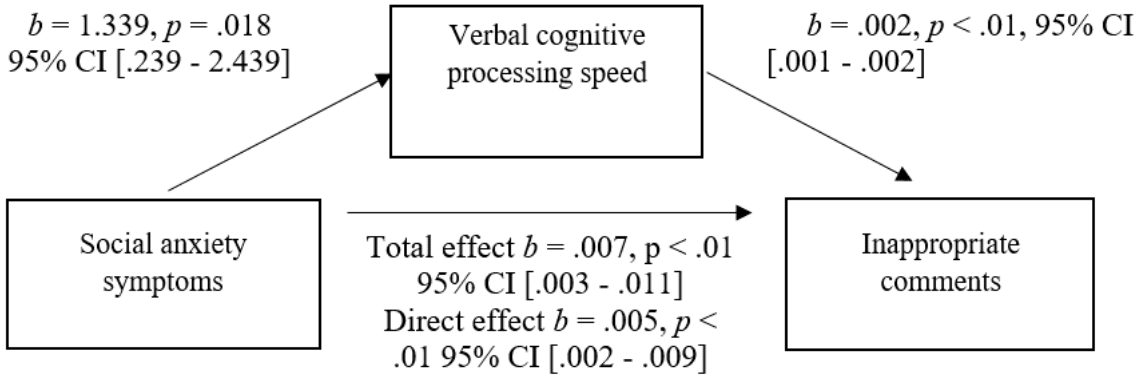

Figure 4. Unstandardised coefficients (b), significance level (p) and 95% confidence interval (95% [-]) for each pathway and direct and total effects.

Anxiety and inappropriate comments via cognitive verbal processing speed. The model in figure 4 shows a significant direct relationship, highlighting that increased social anxiety scores were associated with a greater proportion of inappropriate comments in speech (standardised $b = .482$, $p < .01$). Figure 4 shows that this relationship remains significant when the mediator is added to the model. In addition, it shows the indirect

mediated effect between social anxiety and the number of inappropriate comments via verbal processing speed is significant. This analysis indicates that symptoms of social anxiety[9] are positively associated with slower verbal cognitive processing which is then linked to a higher number of inappropriate comments. The completely standardised indirect effect, *b* = .133, 95% CI [.004 - .263], highlights a partially mediated effect of social anxiety on the number of inappropriate comments in social interaction. Figure 4 shows the coefficients for each pathway in the model, as well as the total effect and direct effects.

Discussion

This study was the first to apply attentional control theory (ACT) to social functioning. We collected measures of anxiety, cognitive processing and sociometric status from 51 children (aged 9 and 10 years; 53% female) and observed their social interaction in dyads. The children were recruited from a well-resourced primary school with few children from low socioeconomic status backgrounds. This is reflected in slightly higher than average attainment scores (114 vs 100). In addition, the sample reported larger average (M=4.75) and a more varied distribution (S.D= 3.54) of social anxiety scores than previous studies (e.g. Simon, Bos, Verboon, Smeekens, & Muris, 2017; M=2.92, S.D=2.66). Similar to previous studies, generalised anxiety received the highest average score followed by social anxiety and separation anxiety (e.g. Simon et al., 2017) and girls received a significantly higher social acceptance score from their peers, than boys (Cillesen & Mayeus, 2014).

Anxiety and academic performance

As expected, higher social anxiety levels were related to slower processing of verbal and non-verbal cognitive tasks in 9 and10 year old children. However, social anxiety was not directly related to academic performance; slower verbal (but not non-verbal) processing speed mediated the relationship between social anxiety and academic performance. This suggests academic challenges associated with social anxiety are underpinned by a basic slowing of cognitive processing. These results support ACT (Eysenck et al., 2007) highlighting a negative association with anxiety and academic performance, via verbal cognitive processing speed. This aligns with previous research in

[9] Mediation was also found for total and separation anxiety and selective mutism.

which eleven year olds completed a simultaneous WM and arithmetic task. Increased anxiety was related to reduced efficiency (i.e. increased time to complete the task) but was not related to reduced performance (i.e. accuracy), as analysed via mediation analysis (Ng & Lee, 2016). ACT also posits that anxiety is more likely to impact verbal tasks due to the auditory nature of worrying thoughts, which reduces the capacity for processing verbal information (i.e. the auditory loop; Eysenck et al., 2007). Consistently, in studies of 10-year-old children, high trait anxious participants showed reduced efficiency (i.e. they were slower to complete the task and self-reported more effort), but not performance (i.e. accuracy) on verbal WM tasks. However, this finding was not replicated in non-verbal tasks (Hadwin et al., 2005).

Previous research has found that the cognitive load of a task interacts with the relationship between anxiety, efficiency and performance. For example, working memory capacity (WMC) moderates the relationship between social anxiety and academic performance. Adolescents with low WMC and high trait anxiety experience poorer academic performance, whereas for adolescents with high WMC, higher trait anxiety led to higher academic performance (Owens et al., 2014). When task demands increase, anxious individuals apply more effort (i.e. reduced efficiency) on a task to maintain the same level of performance (Hepsomali et al., 2019; Ng & Lee, 2015). The current study found a relationship between higher anxiety and slower processing speed on both basic and complex verbal tasks. The non-verbal task however only had a basic component and it would be interesting to investigate whether the relationship with non-verbal speed changes if task demands are increased.

Anxiety and social performance

With regards to social acceptance, no relationship was found between social anxiety and peer acceptance scores. However, the current study relied on peer acceptance rated by children who already knew them (i.e. attended the same school). Previous research has found children with social anxiety are less likely to be rated as likeable by an unknown peer after their first meeting (Scharfstein & Beidel, 2015). While the current study included only adult ratings of children's social functioning (as opposed to peer report), a relationship was found between social anxiety and social performance in the dyad tasks. Increased self-reported anxiety symptoms were related to a higher proportion of inappropriate comments made. This suggests that socially anxious children are more likely

to make social errors, and that this relationship is mediated by verbal cognitive processing speed. This finding is supported by adult literature in which undergraduates scoring slower on measures of cognitive verbal processing speed were rated as less charismatic by their friends (von Hippel et al., 2016). Similarly, children (aged 4-19 years) with emotional and behavioural disorders who scored lower on measures of academic fluency and verbal processing speed (e.g. RAN) also scored lower on teacher-rated measures of social adjustment (Benner, Allor, & Mooney, 2008). Furthermore, children with social anxiety were more likely to show impaired social functioning and to make more spontaneous comments in a peer interaction task (playing on a Wii), as rated by adult observers (Scharfstein & Beidel, 2015). Nonetheless, the current study did not find a relationship between verbal response times with anxiety or social performance. This difference in findings may be due to limitations of the response time coding, for example the poor inter-rater reliability. Future development of this research could focus on better understanding the role of social anxiety on social processing speed.

The finding that higher anxiety relates to slower processing speed and therefore leads to more social performance errors supports ACT (Eysenck et al., 2007); anxiety reduces the efficiency of cognitive processes due to attention being diverted to fearful stimuli or worrying thoughts. As worry is an auditory process, cognitive resources for processing verbal information are reduced and so the efficiency of these processes is also reduced. However, ACT would also suggest that although anxiety reduces efficiency, performance should be maintained. The current study found anxiety was related to impaired social performance. This may be explained by task demands and participant motivation (Berggren & Derakshan, 2013). To maintain performance through increased effort, an anxious participant requires motivation to reach a certain social goal, and increased task demands are required for this motivation.

These findings also link to mind-wandering, where a person experiences task-unrelated thoughts when completing a task. Undergraduates with higher anxiety self-reported a higher rate of unintentional mind-wandering, via mind-wandering questionnaires (Seli et al., 2019). Mind-wandering can be a helpful process in planning and problem-solving to meet future social goals (Poerio & Smallwood, 2016). However, mind-wandering has also been found to impact performance on academic tasks such as reading comprehension (see review by Mooneyham & Schooler, 2013) as well as social functioning. For example, when undergraduates experienced ruminating thoughts (i.e. repetitive, fixed thoughts) they had more difficulty copying the pitch of a computerised

peer and showed more distracted eye gaze (i.e. increased blinking), in a computerised social interaction (Da Silva, Rusz, & Postma-Nilsenová, 2018). This finding supports the results in the present study; increased inappropriate comments in a social interaction could be the result of increased unintentional mind-wandering in anxious children. This unintentional mind-wandering likely reduces the cognitive capacity available for anxious children to think of appropriate comments, as their attention is diverted to un-related thoughts. In a review of mind-wandering adult literature, Mooneyham and Schooler (2013) reported that increased mind-wandering was related to poorer attentional control (as measured by the sustained attention to response task). The authors also noted a relationship between WMC and mind-wandering.

WMC has been found to interact with worry. Children with high worry and high WMC show slower reaction times in a cognitive task (i.e. they exert additional effort) but maintain performance. Conversely, those with high worry but low WMC have faster reaction times, and poorer performance (Trezise et al., 2014). This suggests WMC can be a protective factor and mitigate the impact of anxiety on performance, as those with a higher WMC are able to exert additional effort. Perhaps, anxious individuals with a higher WMC are able to exert additional effort, which helps to mitigate the impact of anxiety on social performance. However, anxious individuals with a lower WMC do not have the resources to mitigate the impact of anxiety on social performance. Poorer verbal WMC (as measured by the forwards digit span) is related to teacher ratings of peer rejection in children aged 9-12 years. Furthermore, poorer central executive function (as measured by the backwards digit span) is related to teacher ratings of lower social competence, peer rejection, increased aggression and poorer conflict resolution skills (Mcquade, Murray-Close, Shoulberg, & Hoza, 2013). When a daily task is perceived to require concentration and attention, undergraduates with a low WMC (as measured by operation, reading and symmetry span tasks) record more instances of mind-wandering than participants with a high WMC (Kane et al., 2007). The current study has focused on a general domain of processing efficiency; a focus for future research could be to investigate the role of specific executive functions, such as WMC and how it mediates the role between anxiety, processing efficiency and social functioning.

Limitations

The two undergraduate researchers who coded the videos for appropriateness of social responses had limited experience of observing children's social skills. As a result, further analysis of the videoed social interactions by a more experienced individual would be beneficial.

Conclusion and implications for educational psychology

The current study has found support for ACT in a community sample of 9 and 10 year old children. This highlights that increased symptoms of social anxiety are associated with academic functioning and less adaptive social interaction behaviours, via slower verbal cognitive processing speed.

The results have implications for education. Classroom practitioners should be aware of children who experience higher levels of anxiety to support children's processing efficiency of academic tasks to maintain performance. It is important that practitioners provide tasks that promote motivation and have medium WM demands to promote an appropriate increase in effort that is beneficial to the anxious learner. However, when task demands are low in the classroom, practitioners should be aware that anxious individuals may need additional support to maintain attention to academic content. Interventions which aim to develop verbal processing efficiency of children with anxiety may be beneficial for performance in the classroom.

With regards to social functioning, further research may be beneficial to better understand the role of social processing speed and WMC in mediating the relationship between social anxiety and social performance. Currently, the research suggests interventions which aim to reduce anxiety or promote social skills would be beneficial. Furthermore, interventions which aim to develop the verbal processing efficiency skills of children with higher anxiety may be beneficial in reducing the impact of anxiety on social functioning.

Appendix A **Literature review: search phrases**

TS=("Processing speed" OR "Processing efficiency" OR "processing effectiveness" OR "Cognitive processing" OR "Cognitive speed" OR "Information processing speed" OR "Information processing" OR "Reaction time" OR "Attentional control theory" OR "Processing efficiency theory" OR effort)

AND

TS=("Executive function" OR "Central executive" OR "Working memory" OR inhibition OR Shifting OR focus OR load OR attention OR updating OR switching)

AND

TS=(Anxiety OR Worry OR "Trait anxiety" OR "State anxiety" OR "Social anxiety" OR "Social anxiety" OR "Separation anxiety" OR phobia OR "Generalised anxiety disorder" OR "Panic disorder")

AND

TS=(Teen* OR Child* OR "Young person" OR Pre-school OR Nursery OR Adolesce* OR Infan*)

Appendix B **Literature review: reasons for articles excluded**

Exclusion Reason	Title	Abstract	After reading methods	After reading article
Age	22	5	5	0
Neurodevelopmental disorder/ other mental health condition/ health condition/ LD/ traumatic experiences/brain injury/ attachment needs/ behavioural issues	213	22	0	0
Not anxiety	8	10	4	0
Not Executive function	1	22	0	0
Not processing efficiency	0	10	9	11
Processing bias: Attention bias/Threat bias/ emotion bias / distractor tasks	18	70	4	0
Measurement tool/ research technique	9	1	0	0
Not empirical paper	1	5	3	0
Non-human participant	10	0	0	0
Not topic- Medical, prevalence or epidemiology	106	3 3	0	0
Not topic-other	81	0	0	0
Total	469	148	25	11

Appendix C **Literature review: final eleven articles excluded with reasons**

Study	Reason for exclusion
Grimley, Dahraei, & Riding (2008)	No measure of processing efficiency
Hadwin & Richards (2016)	No measure of processing efficiency
Justicia-Galiano, Martin-Puga, Linares, & Pelegrina (2017)	No measure of processing efficiency
Owens, Stevenson, Norgate, & Hadwin (2008)	No measure of processing efficiency
Owens, Stevenson, Hadwin, & Norgate (2012)	No measure of processing efficiency
Owens, Stevenson, Hadwin, & Norgate (2014)	No measure of processing efficiency
Passolunghi, Caviola, De Agostini, Perin, & Mammarella (2016)	No measure of processing efficiency
Pnevmatikos & Trikkaliotis (2013)	No measure of processing efficiency
Ramirez, Chang, Maloney, Levine, & Beilock (2016)	No measure of processing efficiency
(Trezise & Reeve, 2016)	No measure of processing efficiency
Visu-Petra, Stanciu, Benga, Miclea, & Cheie (2014)	No measure of processing efficiency

Appendix D **Research paper: Youth Anxiety Measure**

ID number: .....

How old are you? ..... years old. Are you a boy or a girl? .....

What are you to do?
On the following pages there are statements that have to do with being afraid. Read every statement and fill in either **never**, **sometimes**, **often** or **always** as it applies to you. Don't skip any question.

1. I'm afraid to go anywhere without my parents. □ never □ sometimes □ often □ always

2. At school I don't speak to the teacher at all. □ never □ sometimes □ often □ always

3. I find it scary to meet new people. □ never □ sometimes □ often □ always

4. I panic for no reason. □ never □ sometimes □ often □ always

5. I worry about a lot of things. □ never □ sometimes □ often □ always

6. I get frightened if my parents leave the house without me. □ never □ sometimes □ often □ always

7. I find it scary to eat or drink if other people are looking at me. □ never □ sometimes □ often □ always

8. I suffer from anxiety or panic attacks. □ never □ sometimes □ often □ always

9. I think a lot about what can go wrong. □ never □ sometimes □ often □ always

10. I'm afraid that my parents will leave and never come back. □ never □ sometimes □ often □ always

11. If I meet a new person, I don't speak at all. □ never □ sometimes □ often □ always

12. I'm afraid that others will see that I blush. □ never □ sometimes □ often □ always

13. All of a sudden I become so scared that my heart starts to beat very quickly. □ never □ sometimes □ often □ always

14. I find it hard to stop worrying. □ never □ sometimes □ often □ always

15. I'm afraid that something bad will happen, so I'll never see my parents again. □ never □ sometimes □ often □ always

16. I'm afraid I'll do something embarrassing. □ never □ sometimes □ often □ always

17. When I panic, I'm afraid that I could die. □ never □ sometimes □ often □ always

18. I worry a lot about not doing well at school. □ never □ sometimes □ often □ always

19. I have very scary dreams that I lose my parents. □ never □ sometimes □ often □ always

20. At school I don't speak at all to the kids in my class. □ never □ sometimes □ often □ always

21. I have severe anxiety attacks during which I tremble all over my body. □ never □ sometimes □ often □ always

22. I worry a lot about all the bad things that happen in the world. □ never □ sometimes □ often □ always

23. I'm very afraid that other kids don't like me. □ never □ sometimes □ often □ always

24. I don't feel well when I have to go somewhere without my parents. □ never □ sometimes □ often □ always

25. I don't speak at all when there is a new visitor at our home. □ never □ sometimes □ often □ always

26. I'm afraid of having a new anxiety or panic attack. □ never □ sometimes □ often □ always

27. I don't feel well because I worry so much. □ never □ sometimes □ often □ always

28. I am afraid that I might do or say something stupid in front of others. □ never □ sometimes □ often □ always

Appendix E **Research paper: Social interaction task**

PEER TASK 1: PLAN AN ADVENTURE TOGETHER

"We would like for you to spend the next 5 minutes working together thinking of a fun adventure you could experience together. It could be anything that you think you would enjoy doing together. For example, it could be something like going to a park, putting on a play, or going swimming with dolphins at Sea World. There is no limit on what you can do or where you can go. Together you and your friend should think about the most adventurous thing you both want to do. After you have discussed your ideas and picked the adventure you would like to have together, we want you to draw a picture or to come up with a plan, like an activity log, of your adventure for us. [Hand the children the paper and coloured pencils] Have fun! We'll be back in 5 minutes."

[After this task is done, be sure to take the picture with you when you leave.]

PEER TASK 2: SELLING AN UNFAMILIAR OBJECT

[Place the object in front of the children, then read the following:]

"A group of inventors have just made this new item, but are unsure what to call it. You and your friend have been requested to come up with a name for the object, decide what it can be used for, and who might use it. Finally, together, create a commercial (advert) to sell it to people who might be interested in buying it. You have 5 minutes to get your commercial (advert) ready before we come back. When we return, we would like you to tell us about your commercial (advert) together."

[If the children know what the object is used for, say the following…]

Pretend that you have to come up with new uses for this object, and make a commercial for that.

[When you return, provide the children with option of acting out their commercial by asking,] "Would you like to show your commercial to us?"

The Object is a jar opener as pictured here:

*This is task is from Holbein, C. E., Zebracki, K., & Holmbeck, G. N. (2014). Development and validation of the Peer Interaction Macro-Coding System Scales (PIMS): A new tool for observational measurement of social competence in youth with spina bifida. Psychological assessment, 26(4), 1235. doi: 10.1037/a0037062

Appendix F **Research paper: Sociometry task**

ID number:

Question 1: Name three children in your class you like most?

1.
2.
3.

Question 2: Name three children in your class you like least?

1.
2.
3.

Appendix G **Research paper: Anxiety sub-scales descriptive statistics**

Descriptive statistics. Sample size (N), Mean, Standard deviation, Minimum and Maximum for total anxiety, separation anxiety, selective mutism, social anxiety, panic disorder and generalised anxiety disorder.

Measure	N	Mean	Standard deviation	Minimum	Maximum
Total anxiety [min.=0, max.=84]	51	20.24	13.00	2	56
Separation anxiety [min.=0, max.=18]	51	4.55	3.52	0	13
Selective mutism [min.=0, max.=12]	51	2.06	1.69	0	6
Social anxiety [min.=0, max.=18]	51	4.75	3.54	0	16
Panic disorder [min.= 0, max.=18]	51	2.86	2.72	0	12
Generalised anxiety [min.=0, max.=18]	51	6.02	3.82	0	15

Appendix H **Research paper: Anxiety sub-scales correlations**

Correlation coefficients and significance between gender, age, cognitive processing speed, academic performance, social processing speed and social performance.

Measure	1.	2.	3.	4.	5.	6.	7.	8.
1. Gender								
2. Age (years)								
Anxiety								
3. Total anxiety	.12	-.27	-					
4. Separation anxiety	.27	-.17	.82**	-				
5. Selective mutism	.10	-.30*	.62**	.50**	-			
6. Social anxiety	.09	-.32*	.92**	.62**	.49**	-		
7. Panic disorder	.09	-.32*	.78**	.62**	.40**	.68**	-	
8. Generalised anxiety	.10	-0.12	.90**	.70**	.48**	.86**	.68**	-
9. Academic attainment			-.23	-.46**	-.14	-.19	-.17	-.12
Cognitive processing								
10. Non-verbal speed			-.38**	-.28*	-.15	-.31*	-.36*	-.35*
11. Basic verbal speed			.32*	.33*	0.21	.20	.28*	0.20
12. Basic verbal errors			-.01	-00	.06	.04	-.03	-.04
13. Complex verbal speed			.37**	.39**	.32*	.28*	.17	.26
14. Complex verbal errors			-.02	-.04	.27	-.02	-.18	-.06
Social processing speed								
15. Response time			-.09	-.06	-.02	-.10	-.09	-.06
Social performance								
16. Proportion appropriate comments			-.16	-.26	.03	-.27	-.08	-.06
17. Proportion inappropriate comments			.26	.33*	.07	.35*	.17	.14
18. Sociometry z-score			-.10	-.04	-.09	-.11	-.21	-.08

*Note. *p<.05, **p<.01.* Spearman's correlations was used for basic and complex verbal processing errors, proportion of appropriate and inappropriate comments, response time and four anxiety sub-scales (separation anxiety, selective mutism, social anxiety, panic disorder).

Appendix I **Research paper: Mediation analysis for anxiety sub-scales**

Anxiety and academic performance, via verbal processing speed

The mediation findings were replicated for total and generalised anxiety; no significant direct or total effect was found but there was a significant mediation. Verbal processing speed mediates the relationship between anxiety (total and generalised) and academic performance. Table 1 summarises the coefficients for total effect and direct effects and 95% confidence intervals for significant indirect effects.

Table 1.

Coefficients (b), significance levels (p) and 95% confidence intervals (CI) for the relationship (Total effect and direct effects) between anxiety (total and generalised anxiety) and academic performance, and via complex verbal processing speed (completely standardised indirect effect).

	Total effect			Direct effect			Indirect effect	
Anxiety	*b*	p	95% CI	*b*	p	95% CI	*b*	95% CI
Total	-.*266*	.104	[-.589- .057]	-.*055*	.722	[-.366- .255]	-.182	[-.359- -.026]
Generalised	-.480	.394	[-1.601- .641]	.045	.929	[-.972- 1.062]	-.134	[-.274- -.004]

The model in figure 1 shows a significant total effect between separation anxiety and academic performance. Increased separation anxiety symptoms is related to lower academic performance, standardised $b = .392$, $p < .01$. This significant effect is not maintained when a mediator is added to the model. The model does show that the indirect mediated effect between separation anxiety and the number of inappropriate comments via verbal processing speed is significant. This analysis indicates that symptoms of separation anxiety are positively associated with verbal cognitive processing which is then linked to decreased academic performance. The completely standardised indirect effect, $b = -.158$, 95% CI [-.295 - -.041], highlights a partially mediated effect of separation anxiety on

academic performance. Figure 1 shows the coefficients for each pathway in the model, as well as the total effect and direct effects.

Figure 1. Mediation model for separation anxiety and academic performance via verbal processing speed, with coefficients for each pathway and total and direct effects.

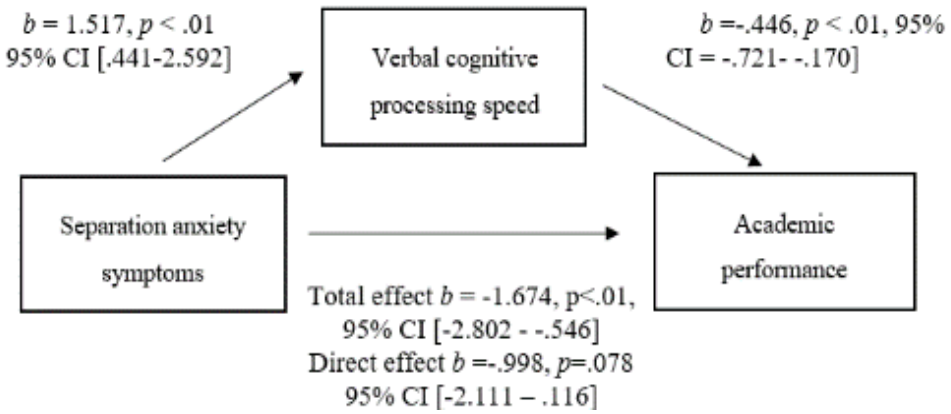

Figure 1. Coefficients (b), significance level (p) and 95% confidence interval (95% [-]) for each pathway and direct and total effects.

Anxiety and social performance, via verbal processing speed

These findings were replicated for total and separation anxiety; significant direct, total and indirect effects were found. Furthermore, a significant mediation (but not direct

Table 2.

Coefficients (b), significance levels (p) and 95% confidence intervals (CI) for the relationship (Total effect and direct effects) between anxiety (total and separation anxiety and selective mutism) and proportion of inappropriate comments, and via complex verbal processing speed (indirect effect).

	Total effect			Direct effect			Indirect effect	
Anxiety	*b*	p	95% CI	*b*	p	95% CI	*b*	95% CI
Total	*.002*	<.01	[.001-.003]	*.001*	.033	[.000-.002]	.150	[.014-.288]
Separation	.007	<.01	[.003-.011]	.005	.011	[.001-.009]	.145	[.024-.269]
Selective mutism	.005	.267	[-.004-.014]	-.001	.865	[-.009-.008]	.183	[.035-.36]

or total effect) was found for selective mutism. Table 2 summarises the coefficients for total effect and direct effects and 95% confidence intervals for significant indirect effects.

Appendix J **Research paper: Ethical approval**

Submission ID: 31660.A3
Submission Title: Does Processing Speed Mediate the Relationship between Anxiety and Social Acceptance in Children? (Amendment 3)
Submitter Name: Hayley White

The Research Integrity and Governance team have reviewed and approved your submission.

You can begin your research unless you are still awaiting specific Health and Safety approval (e.g. for a Genetic or Biological Materials Risk Assessment) or external ethics review (e.g. NRES/HRA/MHRA etc).

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