The emotional Stroop task in anxious children

Nightingale, Z.C.; Field, A.P.; Kindt, M.

DOI
10.1002/9780470661468.ch3
Publication date
2010
Document Version
Final published version
Published in
Information processing biases and anxiety: a developmental perspective

INFORMATION PROCESSING BIASES AND ANXIETY

A Developmental Perspective

Edited by

Julie A. Hadwin and Andy P. Field

WILEY-BLACKWELL

A John Wiley & Sons, Ltd., Publication

3

The Emotional Stroop Task in Anxious Children

Zoë C. Nightingale, Andy P. Field and Merel Kindt
andyf@sussex.ac.uk

The original paradigm of Stroop (1935) has played a valuable theoretical role in the study of selective information processing and has been an important tool for understanding the processing of intrusive stimuli (MacLeod, 1991). The traditional Stroop task involves presenting participants the names of colours (green, purple, red, brown and blue) printed in different (conflicting) coloured inks. (For example, the word 'blue' is not printed in blue ink, but is printed an equal number of times in green, purple, red and brown ink.) Consequently, word and colour stimuli are presented simultaneously: each word represents the name of one colour, but is printed in the ink of another colour. The control condition consists of a set of coloured non-words. Participants are instructed to name the colour of ink in which the word (or non-word in the control condition) is printed as fast as possible. In a typical set of results, participants are reliably slower to name the colour of the ink when it is presented in a conflicting coloured ink than to name the same colours printed depicting non-words (see MacLeod, 1991; Stroop, 1935). This phenomenon is known as the *Stroop effect* and has been interpreted in terms of response competition: as a result of automatized semantic processing of the colour word, colour naming of the word is prioritized such that it conflicts with the task to name the colour of the ink (see MacLeod, 1991). This chapter discusses a variant of this task known as the *emotional Stroop task*, which has been used as an information processing approach to assess selective information processing of emotional stimuli. This chapter will present an overview of studies that have used the emotional Stroop task to explore cognitive processing in children and adolescents who experience elevated anxiety.

Information Processing Biases and Anxiety: A Developmental Perspective Edited by Julie A. Hadwin and Andy P. Field

The Emotional Stroop Task

The emotional Stroop task involves examining the response latency to name the colours of emotionally aversive words (e.g. 'cancer') relative to emotionally neutral words (e.g. 'plate'). In some experiments, pictures have been used instead of words and in these cases the participant might be required to name the colour of a schematic face, displaying either a neutral or an angry expression (Williams, Mathews and MacLeod, 1996). An important prediction from the task is that participants who are more attentive to threat in their environment, such as those who experience elevated or clinical levels of anxiety, should show a greater latency to colour name an emotionally aversive stimulus relative to an emotionally neutral stimulus, compared to non-anxious individuals (MacLeod, 1991). In many studies an 'interference score' is calculated, which is the time taken to name the colour of threat stimuli minus the time taken to name the colour of control stimuli. As such, a positive interference score indicates that the threat stimuli interfered with the participant's ability to name the colour compared to control stimuli.

Both the traditional and the emotional Stroop tests require the suppression of responses to distracting word information, while maintaining attention on the colour of the word (Compton *et al.*, 2003). In addition, they both elicit comparable behavioural effects (an increased latency to name the colour of words). It is argued, however, that these tests utilize distinct mechanisms of interference (McKenna and Sharma, 2004). The classic Stroop produces a conflict between an incongruent colour and word (the word red in font colour blue), whereas the emotional Stroop concerns only emotional and neutral words; colour does not affect latency because it does not conflict with word meaning.

Although studies using the emotional Stroop task all measure the speed to name colours of negative words or pictures, these stimuli can be presented in two different ways. First, the stimuli can be presented individually using either a tachistoscope or a computer monitor. We will call this the *single-trial format* because each stimulus appears alone as a single trial. An alternative format is the *card format* in which columns of words or pictures are presented on a single card. Unlike the single-trial format, in the card format many trials are presented simultaneously. The choice of format has important implications because processing biases shown using the card format can reflect mood effects (see Richards *et al.*, 1992) and measurement error (see the discussion in Kindt, Brosschot and Everaerd, 1997). As such, the card format might not be an appropriate measure of processing bias. This view should be remembered as we review the various studies.

What does the emotional Stroop task measure?

The emotional Stroop, unlike the traditional Stroop, does not involve an effect of conflict between a word meaning and a colour of ink, but is proposed to be a function of the emotional significance of the semantic content of the word to an individual where this significance leads to increased attention to this word and therefore interferes with the task of colour naming. As such it measures a processing bias[1] towards threat.

Processing bias towards threat has also been demonstrated through the use of other paradigms. For example, another commonly used task is the dot-probe task (see Chapters 4 and 8). Here, a threatening and a neutral cue (e.g. a word or face) are presented simultaneously on a screen; subsequently these cues disappear and a probe appears in the location of either the previous threatening or the neutral cue. High anxious individuals relative to non-anxious controls are faster to react to probes appearing in the location of threatening rather than neutral cues, suggesting that their attention is oriented towards threatening cues, thus facilitating response when the probe appears in that location (e.g. Field, 2006; Heim-Dreger *et al.*, 2006; Lipp and Derakshan, 2005). In visual dot-probe tasks, the emotional cue and the succeeding probe are physically and temporally separated and, therefore, the distribution of attention relates to the visuospatial field. In the emotional Stroop task, however, this is not the case: the emotional cue and the probe (i.e. the colour of the word or picture) are spatially and temporally integrated because the word or picture and colour appear at the same time and in the same physical location. Therefore, attention is distributed cognitively but not physically (i.e. in the visuospatial field). Therefore, the Stroop task and the visual dot-probe task differ in that the visual dot-probe task measures relative attention whereas the Stroop task is a measure of emotional interference (van Strien and Valstar, 2004).

The emotional Stroop task has been frequently employed to explore processing bias in anxious adults (see Logan and Goetsch, 1993; Williams, Mathews and MacLeod, 1996, for reviews). Research carried out since the 1980s has shown that the colour naming of emotionally negative words is typically slower in individuals who are anxious (relative to the colour naming of neutral words of equivalent frequency) and this difference is not found in non-anxious control groups. This phenomenon is proposed to reflect automatic processing of the semantics of the threatening words in anxious individuals, which causes interference with the main task of colour naming (e.g. Watts *et al.*, 1986). The disruption caused by selective attention to emotionally relevant stimuli in anxiety has led some researchers to argue that the emotional adaptation of the Stroop task could be utilized as a measure of psychopathology (Williams *et al.*, 1996). For example, if a person demonstrates a processing bias for spider-related material, it could imply that they have a spider phobia.

Williams, Mathews and MacLeod (1996) wrote an exceptional review of research using the emotional Stroop task and discussed the causes and mechanisms underlying the Stroop effect. On the basis of this review, they suggested that in adult research, both state (anxiety at a particular moment in time such as in a stressful situation) and trait (general feelings of anxiety an individual experiences) components of anxiety affect the degree of interference observed in the emotional Stroop task.

[1] Some people describe the emotional Stroop task as measuring attentional bias. However, the task cannot differentiate between the selective processes occurring early after a cue is presented (and in the wider context these early-onset processes are commonly referred to as *attentional bias*) and processing biases occurring later after stimulus onset. To acknowledge this fact we will use the term *processing bias* rather than 'attentional bias' to describe what the emotional Stroop measures.

Individual differences in state and trait anxiety, as assessed by tools such as The State-Trait Anxiety Inventory (Spielberger *et al.*, 1983), appear to interact to create interference effects. Specifically, although individuals high on trait anxiety show more interference for all threatening words, the presence of experimentally induced state anxiety is necessary for the disruption to be observed. Moreover, Williams, Mathews and MacLeod suggest that this interaction is more likely to occur if the current stressor has had time to develop (e.g. worrying about an impending examination), relative to if the current emotional disturbance is only short-lived (e.g. failing an experimental task).

When considering what the emotional Stroop paradigm measures, it is important to rule out the possibility that the observed interference effects are due to artefacts of the experimental procedure. Williams, Mathews and MacLeod (1996) identified three possible alternative explanations of the observed interference effects in adults. First, colour-naming interference could be due to priming effects of a word from a particular category on the subsequent presentation of a word from the same category. However, Williams, Mathews and MacLeod concluded that the available evidence suggests that this interpretation is not the case because several studies showing significant interference effects had used categorized neutral stimuli, which controlled for inter-category priming effects (e.g. Dalgleish, 1995). Second, because nearly all studies use a repeated presentation collection of emotional and neutral stimuli, the resulting interference effects could be due to the repetition of a small collection of emotional words. Williams, Mathews and MacLeod ruled out this explanation by arguing that this repetition is unlikely to influence the Stroop effect because neutral and emotional stimuli are typically presented an equal number of times. One further criticism of the Stroop paradigm is that participants might be consciously attending to the emotional words, undermining the idea of interference being a function of an automatic information processing bias to threat in anxiety. However, studies using subliminal Stroop tasks (e.g. Bradley *et al.*, 1995; Mogg *et al.*, 1993; Mogg, Kentish and Bradley, 1993) have shown that biases can be found using presentation times that do not allow participants time to construct strategies based on conscious awareness of the material. This finding suggests that emotional Stroop interference is not dependent on conscious strategies (Williams, Mathews and MacLeod, 1996). However, research has also shown that attributes of automatic processing, such as being capacity free, unconscious and involuntary, do not all apply to selective processing of threat associated with anxiety. Experimental and clinical findings suggest that processing biases are automatic in the sense of being involuntary (and sometimes unconscious), but not in the sense of being capacity free (McNally, 1995).

Apart from artefacts that might explain the interference effects measured by the emotional Stroop task, there are design issues that often obscure the inferences that can be made from the task. For example, the subjective (and sometimes actual) frequency of the threat stimuli used in the task is not always controlled. The subjective frequency is difficult to control because it will differ across patient groups and normal controls. For example, the subjective frequency with which a spider phobic experiences words such as 'web' or images of spiders is probably greater than for people experiencing social anxiety or controls. This lack of control over subjective prior experience with stimuli in the emotional Stroop task is problematic because performance on this task is not attributable to lexical frequency but to personal relevance (Riemann and McNally, 1995). A related suggestion is that the emotional Stroop effect reflects participant expertise rather than emotional interference. For example, Cohen, Dunbar and McClelland's (1990) connectionist model suggests that variation in colour-conflict Stroop interference could reflect variation in the amount of expertise that an individual has had with the emotional stimuli, the colour of which participants have to name (MacLeod and Dunbar, 1988). Here it is suggested that individuals characterized with elevated anxiety have a tendency to ruminate on negatively laden emotional stimuli and so will have had more practice in using and thinking about these particular concepts compared with non-anxious individuals. This process of rumination may lead to the development of some expertise in processing information associated with personal concern in anxious individuals (Segal *et al.*, 1995). However, emotional Stroop effects have been shown to decrease in anxious individuals after treatment (e.g. Lavy and van den Hout, 1993; Lavy, van den Hout and Arntz, 1993; Watts *et al.*, 1986). Given that treatment does not reduce the amount of expertise with emotional concepts, it can be argued that interference observed in the emotional Stroop task is attributable to the emotional valence of the stimuli and not to cognitive expertise. Furthermore, these findings indicate that the emotional Stroop can be used as an index of whether individuals have recovered from their emotional disturbance.

If we accept, bearing in mind the aforementioned caveats, that the emotional Stroop task is a measure of an automatic information processing bias, then we can move on to try to explain the underlying mechanism that drives this bias. Several cognitive models have been proposed to elucidate the mechanisms underlying the emotional Stroop effect in anxious adults (Williams, Mathews and MacLeod, 1996). The earliest explanatory models were Beck's schema theory (Beck, Emery and Greenberg, 1985) and Bower's (1981) network theory in which potentially threatening stimuli are thought to capture excessive attentional resources because of the activation of specific cognitive structures signifying personal danger (Mogg, Mathews and Weinman, 1989). Other models have proposed that the negative emotional content of the experimental stimuli trigger self-focusing processes that expend attentional resources that interfere with the main task of colour naming (Dawkins and Furnham, 1989) or require greater cognitive effort to override the perception of such stimuli (Holmes, 1974; Ruiter and Brosschot, 1994). However, these older models have been superseded by Mathews and MacLeod's (1994) prioritization model. In this model, anxiety functions to shift attention into a state of hyper-vigilance, resulting in the individual scrutinizing his or her environment for any potentially threatening stimulus, especially those environments that in past experience have been linked to threat. They suggest that in this hyper-vigilant state the cognitive system prioritizes the processing of threat stimuli, but not the deliberate rehearsal of the stimuli for explicit encoding into memory (see Williams, Mathews and MacLeod, 1996). This hyper-vigilance model has a lot of support (see Mathews and MacLeod, 2005, for a review); however, there is some evidence that in some individuals anxiety serves to create avoidance rather than vigilance (e.g. Hock and Krohne, 2004). Nevertheless, some researchers have argued that if the emotional Stroop effect consistently correlates with the presentation of an anxiety disorder, then it is useful (diagnostically or as a research tool) regardless of the underlying mechanism (Benoit *et al.*, 2007).

The Emotional Stroop Task in Children

Methodological and theoretical considerations

A strong aspect of the emotional Stroop task is that it is an experimental paradigm; it is a performance-based task and is therefore less sensitive to reporter bias. For example, Dubner and Motta (1999) concluded that the emotional Stroop shows potential as a research and diagnostic instrument in work with traumatized youths who are reluctant or incapable of revealing the presence of abuse. However, experimental measures of processing bias may suffer from methodological problems, especially when involving young children.

Throughout this section there are two general issues to consider that relate to both methodology and theory. The first is whether processing biases are specific or general. So, for example, do children with panic disorder show a general processing bias for all threat stimuli or for only stimuli related to panic (a specific bias)? The studies we review generally fall into categories of those looking at general anxiety and a processing bias for general threat, and those looking at processing biases for disorder-specific stimuli. The second issue is the downward application of adult models. Cognitively speaking, a 17-year-old is an adult, whereas a 6- or 12-year-old is not. The literature contains studies that have recruited youths with wide-ranging ages. The downward compatibility of adult models of anxiety (such as the hyper-vigilance model described earlier) might be influenced by aspects of cognitive development. So, although adult models of emotional Stroop effects should apply to older adolescents because cognitively they differ little from adults, these models might not extend back to the pre-teenage years in which the child is still developing his or her cognitive abilities. Cognitive development could affect both performance aspects of the task (e.g. younger children might find the task more confusing and get bored more easily, which will affect their reaction times) and also the underlying process (younger children have yet to develop a bias to threat). In Chapter 11 it is argued that the underlying associations that drive attentional biases should be acquired relatively early in life; therefore, age might not affect the underlying mechanism that drives the bias but could affect the expression or measurement of that mechanism. Studies have varied in whether they use word or picture stimuli and this manipulation might affect the strength of interference effects from the emotional Stroop task. Pictures may be the more appropriate stimuli for children because they do not depend upon linguistic skills, are more concrete, ecologically valid and closer to the original source of threat than more abstract word stimuli. As such, we might expect effects from picture-based Stroop tasks to be stronger than those from word-based versions.

The developmental trajectory of processing biases is discussed elsewhere in this book (e.g. Chapter 11), but theories differ in whether they assume a central role

for development. The *integral bias hypothesis* proposes that cognitive processes are an innate constituent of emotion (Martin, Horder and Jones, 1992; Martin and Jones, 1995). Specific emotions have evolved to bring about certain cognitive objectives. The integral bias hypothesis predicts that cognitive biases are present in childhood and remain fairly stable from childhood to adulthood (Martin, Horder and Jones, 1992; Rapee, 2000). According to this hypothesis, processing biases seen in adults should transfer downwards to children. As such, age and cognitive development should not affect interference effects and if they do, then it reflects measurement error (such as younger children finding the Stroop task more difficult to perform).

An alternative is to assume that anxiety-related processing biases do not emerge fully formed in a child and that their ongoing cognitive and emotional development and past experience will affect how they interpret information in their environment. Jones (1984, 1987) proposed that the cognitive effects of emotion are not, in general, innate consequences of that emotion but instead they are learned via previous experiences in which certain patterns of emotional and cognitive processing have been associated. As we said earlier, although the underlying associations might be formed early in life, the emotional biases driven by these associations will be influenced by the child's developing cognitive sophistication to think about these associations between certain events and particular emotional states, and also their ever-developing experience with different events as predictors of emotion. This *inferred bias hypothesis* would predict that processing biases should become greater with age.

A variant of this hypothesis assumes that development acts in a different way for anxious and non-anxious children. In essence, the anxiety status of the child sets them off on a different developmental trajectory. The idea is that a processing bias for threatening stimuli is a normal characteristic of young children but this bias decreases with age in non-anxious children and increases with age in the anxious children. This *inhibition hypothesis* suggests that from middle to late childhood normally developing children learn to inhibit automatic processing of potential threat, whereas anxious children do not develop this ability. In other words, anxious children maintain processing biases which are a normal characteristic of young childhood (Kindt, Bierman and Brosschot, 1997; Kindt and van den Hout, 2001). Kindt and van den Hout (2001) suggest that anxiety experienced during childhood creates a failure to inhibit selective attention to threat, which, in turn, increases susceptibility to developing an anxiety disorder in adulthood. This hypothesis is also consistent with Lonigan's temperament model (see Chapter 10), which argues that effortful control mediates the relationship between threat-related processing bias and the beginning of an anxiety disorder (Lonigan *et al.*, 2004). For example, young children (aged 8) may lack adequate effortful control to suppress attentional reactions to threat-related stimuli or information that is relevant to their developmental stage because some stimuli are not threatening for all developmental stages.

Evidence for anxiety-related emotional Stroop effects in children

Having considered what the task measures and some of the methodological and theoretical issues, we will now review the studies that have found threat-related interference effects in the context of childhood anxiety (Table 3.1). We will divide the research into studies from non-clinical and clinical populations because effects might be expected to be stronger in clinical populations. In non-clinical populations, research has looked at both general anxiety by splitting samples into high and low trait anxious children and also children with specific anxiety concerns by defining groups according to those concerns. For example, Martin, Horder and Jones (1992) used the card format of the emotional Stroop task on a group of spider-fearful and non-fearful children (6–13 years old). This study found that spider-fearful children showed greater latencies to colour name spider-related words (e.g. 'creepy' and 'hairy'), but not neutral words (e.g. 'table' and 'cars'). Non-spider-fearful children did not show this difference. Martin and Jones (1995) replicated this finding in a sample of children from three different age groups (4–5 years, 6–7 years and 8–9 years) using a pictorial adaptation of the emotional Stroop paradigm. Here, children were asked to name the ink colour of pictures (instead of words), where these were related to spiders, houses (control stimuli) or teddy bears (filler stimuli). This adaptation was important because it extended the investigation of processing bias to younger groups of children who may not have the necessary reading age to complete word-based tasks. Martin and Jones found that the magnitude of processing bias was consistent across development and was therefore not a function of age.

Another study that looked at interference effects for a specific anxiety focused on social concerns in late childhood (Martin and Cole, 2000). Here 8- to 12-year-olds were asked to colour name words related to acceptance (e.g. 'popular') and rejection (e.g. 'hated') in children who were rated by peers as popular or unpopular. Care was taken to ensure that the task was appropriate for use with children of this age group. For example, children were given the opportunity to practice the task until they clearly understood the procedure. In addition, subsequent to the Stroop task, the computer program repeated the presentation of the stimulus words and phrases but without colour variation (i.e. all words were in black letters on a white background). Children read the words aloud and word-reading reaction times were recorded. The experimenter coded whether or not the child was able to read the word fluently. Words that could not be read fluently by the child were excluded from the analysis. Martin and Cole found that children rated as unpopular showed significantly greater colour-naming interference towards words with a negative social content than were their more popular peers.

In terms of general anxiety, Richards *et al.* (2007) have utilized the emotional Stroop task in combination with a facial processing task in a group of children aged 10–11 years. This age was deemed suitable for children to cope with the task demands. The reading level of all children was assessed by a teacher and all children were found to be average or above in relation to their chronological age. One useful aspect of this study is the use of different methodologies which can tell us something about the convergent validity of the emotional Stroop task

Table 3.1. Details of experiments finding significant anxiety-related emotional Stroop effects in children

Authors	*Format*	*Sample characteristics*	*Presentation stimulus (word/picture/face)*	*Other measures/ control variables*	*Block/trials*	*Age/adjustments for use with children*
Dubner and Motta (1999)	Card	Clinical: PTSD (sexually abused)	Sexual abuse words (i.e. *sex, privates*), neutral (i.e. *pen, planet*), OCD-like stimuli (i.e. *germs, urine*) and positive stimuli (i.e. *happy, fun*). To assess the base rate for colour naming non-meaningful stimuli; also presented children with a control card of coloured zeroes	To ensure that the children were familiar with the colour names used on the MSP, they first named the colours of five vertical lines on a card Participants who were unable to read all of a sample of the Stroop words ($n = 3$) were excluded from the analysis	B1: Three practice cards, which consisted of coloured pictures and two cards of coloured words not related to the task stimuli B2: 200 test trials – words were printed on four sheets of white paper in a variety of colours (i.e. red, yellow, green, blue and black). Each sheet contained 50 words in capital letters	8–19 None
Hadwin *et al.* (2009)	Single trial (computer)	Non-clinical: Trait anxiety social concern	Angry, happy and neutral face stimuli made up the schematic faces, with each face being made up of a pair of eyes, eyebrows and a mouth (see Hadwin *et al.*, 2003). The facial features from each emotion face were rearranged to make control stimuli with scrambled facial features	None	B1: 72 randomly presented trials	6–12 Used non-integrated face stimuli. Children responded using coloured buttons on a key board

(*continued overleaf*)

Table 3.1. (*Continued*)

Authors	*Format*	*Sample characteristics*	*Presentation stimulus (word/picture/face)*	*Other measures/ control variables*	*Block/trials*	*Age/adjustments for use with children*
Martin, Horder and Jones (1992)	Card	Non-clinical: Spider anxious	Non-words: wpa, doat, ksuiv and mijcat. Colour words: red, blue, green and yellow (the sequence was subject to the constraint that a colour word was never written in ink of the same name). Control words: fly, colours, spots, wings, ladybird. Spider words: web, crawl, hairy, body, legs. Practice words: tail, purr, cute, paws, fluffy.	None	B1: 185 test trials	6–13 None
Martin and Cole (2000)	Single trial (computer)	Non-clinical: Popular vs. unpopular	(i) Negative social words such as 'lonely' and 'hated'; (ii) positive social words such as 'popular' and 'accepted'; (iii) negative control words such as 'broken' and 'smelly' and (iv) positive control words such as 'sweet' and 'easy'	Word-reading test. Pilot test: Children attempted to read each word aloud and quickly into a microphone attached to the timing device. Eliminated words if (i) the word or phrase was not easily pronounced by all children; (ii) the average reading time for the word was greater than 1000 ms (i.e. 1 s)	B1: Three practice trials that were repeated until the child clearly understood the task. B2: 48 test stimulus words and brief phrases	8–12 None
Martin and Jones (1995)	Card	Non-clinical: Spider anxious	Pictures of spiders, houses or teddy bears	None	B1: 20 practice trials B2: 120 test trials	4–9 Used pictures instead of words
Moradi *et al.* (1999b)	Single trial (computer)	Clinical: PTSD	Happy (e.g. pleased), categorized neutral (e.g. sheep), depression-related (e.g. helpless), general threat-related (e.g. terrified) and trauma-related (e.g. injured)	Vocabulary and reading tests administered	B1:120 test trials (Sixty words presented twice). These consisted of 12 words from each of the five word categories	9–17 None
Moradi *et al.* (1999a)	Single trial (computer)	Clinical: PTSD	Happy (e.g. pleased), categorized neutral (e.g. sheep), depression-related (e.g. helpless), general threat-related (e.g. terrified) and trauma-related (e.g. injured)	Vocabulary and reading tests administered	B1:120 test trials (60 words presented twice). These consisted of 12 words from each of the five word categories	9–17 None
Richards, Richards and McGeeney (2000)	Card	Non-clinical: Trait anxiety	Threat-related words and neutral words	None	B1: Practice trials (no description) B2: The authors state that there are 96 threat-related test trials and 96 non-threat-related test trials. However, based on their description it would appear that there are 64 trials of each	16–18 None
Richards *et al.* (2007)	Card	Non-clinical: Trait anxiety	Anxiety-related, positive and neutral words	Reading level assessed	B1: 96 practice trials (eight neutral words presented 12 times) B2: 288 test trials	10–11 None
Taghavi *et al.* (2003)	Single trial (computer)	Clinical: GAD	Depression-related, trauma-related, threat-related, happy and neutral words	The British Picture Vocabulary Scale and word-reading test administered	B1: 60 trials (12 words from each category)	$M = 13.47$ (GAD), 14.50 (control) None

(see later). The emotional Stroop task looked at children's processing bias to threat words and a second task investigated facial processing biases using morphed angry-neutral and happy-neutral expressions that varied in emotional intensity. The results produced the predicted emotional Stroop interference effect, with high trait anxious children demonstrating greater colour-naming interference for anxiety-related words than low trait anxious children. Both state and trait anxiety were found to play a role in this bias: Stroop interference was significantly correlated with both trait ($r = .40$, $p = .004$) and state anxiety ($r = .42$, $p = .002$). Williams, Mathews and MacLeod's (1996) model suggests that emotional Stroop effects in high trait anxious people should be exacerbated by high state anxiety, but this interaction between state and trait anxiety was not tested. The face processing task indicated that high trait anxious children were less able than the low trait anxious children at discriminating happy from angry facial expressions in cases where the happy expressions contained low levels of emotional intensity. The authors argued that both methodologies revealed differences between anxious and non-anxious children in the processing of emotional information and provided support for the suggestion that these two divergent tasks make use of general cognitive processes. Richards *et al.* proposed that the inability to inhibit threat cues (i.e. in the Stroop task) may be related to the inability to discriminate emotional expressions when the emotional intensity is weak.

A similar study was recently done but using picture rather than word stimuli in the Stroop task. Hadwin *et al.*, (2009) examined the effects of self-report trait anxiety, social concern and age on colour matching Stroop interference for angry (relative to neutral) schematic faces in children aged 6–12 years. The results demonstrated that increased social concern was associated with decreased ability to inhibit attention to angry faces (relative to neutral), $r = .24$, and that this relationship was not moderated by age. The failure to inhibit attention to angry faces was argued to be specific to increased social concerns. The authors argue that the developmental course of information processing biases in childhood anxiety can be best understood by matching specific anxieties (such as social concerns) with appropriate experimental stimuli (e.g. facial expressions). However, this conclusion is not as clear-cut as it might seem. First, trait anxiety correlated very highly with social concerns ($r = .83$), implying that they might measure essentially the same thing. Also, although the correlation between processing bias and trait anxiety was not significant, $r = .19$, it was similar in size to that of social concerns.

Processing biases for general anxiety stimuli have also been explored in adolescents. Richards, Richards and McGeeney (2000) used a card-based emotional Stroop paradigm consisting of eight threat-related words and eight matched neutral words in a sample of 16- to 18-year-olds who were classified as either high or low trait anxious adolescents. The results revealed that high trait anxious adolescents displayed comparable colour-naming interference effects to those obtained in the adult literature. Interestingly, their results showed a linear relationship between trait anxiety and the degree of colour-naming interference; specifically, they found that as anxiety increases, the amount of interference produced by the threat-related stimuli compared with the neutral stimuli also increased.

We now turn to studies that have used clinical samples. Taghavi *et al.* (2003) looked at processing bias using the emotional Stroop task in a sample of 19 child and adolescent patients with generalized anxiety disorder (GAD) aged 13 and 14 years. They found that adolescents with a diagnosis of GAD demonstrated significantly greater colour-naming latencies when asked to colour name emotionally aversive words (depression-related and trauma-related) compared with positive and neutral words relative to controls. The effect size for this negative word Stroop bias across groups was tending towards large (Cohen's $d = .75$). This result is consistent with the findings in studies with GAD in adults (Mathews and MacLeod, 1985) and supports the idea that the cognitive features of GAD are comparable across adult, adolescent and child populations (Taghavi *et al.*, 2003). The same research team found interference effects in the predicted direction in children and adolescents with post-traumatic stress disorder (PTSD) aged between 9 and 17 years (Moradi *et al.*, 1999b). In this study, vocabulary and reading tests subsequent to completing the emotional Stroop task were used to ensure that the words presented were not too difficult for this sample of youths. Moradi *et al.* found that youths suffering from PTSD were selectively slower to colour name trauma-related words (e.g. 'injured' and 'emergency') relative to non-emotional words (e.g. 'sheep' and 'duck') compared to non-clinical controls. Additionally, correlational analyses suggested that this effect was not dependent on age and was consistent across the age range of 9–17 years. These findings were replicated in a group of 9- to 17-year-olds with PTSD (Moradi *et al.*, 1999a) and are similar to processing bias effects found in adults with PTSD (Thrasher, Dalgleish and Yule, 1994).

Dubner and Motta (1999) used the modified Stroop procedure (MSP) to assess processing bias and intrusive cognitions of foster care children who had developed PTSD after being either physically or sexually abused. The sample included 40 preadolescents (8–12 years of age), 72 early adolescents (13–15 years of age) and 38 late adolescents (16–19 years of age). Their results showed that children who had been sexually abused demonstrated significantly longer colour-naming latencies of sexual-abuse-related words (e.g. 'naughty' and 'sex') than non-abused children. In addition, sexually abused children with PTSD showed significantly more interference in responding to the Stroop card containing sexual-abuse-related words than those without PTSD. Finally, sexually abused children diagnosed with PTSD were slower to identify the colour of words on the sexual abuse card than words on the obsessive-compulsive disorder (OCD), neutral and positive stimulus cards.

In summary, although the literature is small, several studies have replicated the basic emotional Stroop interference effect in child and adolescent samples: anxious children and adolescents are slower to name the colours of threat-related stimuli. Although some of these studies have used samples close in age to adults, others have used young children. In addition, when studies have specifically explored developmental effects between age and processing bias, none have been found (Martin and Jones, 1995; Moradi *et al.*, 1999b). These studies, therefore, support the integral bias theory (described earlier), which suggests that processing biases are an integral part of emotion that are unaffected by cognitive development. However, it is worth remembering that even the youngest children in the aforementioned research were aged 4 and quite a lot of development has gone on by this age. It is also important to bear in mind that many of the studies just described have used the card format (Table 3.1) and as we argued earlier this format probably does not rule out explanations other than the detection of a processing bias.

Evidence against anxiety-related emotional Stroop effects in children

Despite the apparent similarities between processing biases shown by the emotional Stroop task in anxious adults and children that we have described in the previous section, there have been many reported failures to replicate the anxiety-linked Stroop effect in children (Table 3.2). In some studies, non-anxious and anxious children have demonstrated a similar interference effect for threat stimuli. This set of findings raises questions about the causal role of processing bias towards threat in the onset of anxiety in childhood and adolescence (Kindt, Brosschot and Everaerd, 1997). Again, we will begin by looking at evidence from non-clinical samples and then move on to clinical samples.

Kindt, Brosschot and Everaerd (1997) tested children aged 8 to 9 years classified as non-clinically high and low anxious. A computerized single-trial emotional Stroop task was used in two situations: a neutral situation and a medically stressful situation (i.e. a vaccination session). All children passed tests for reading ability and colour blindness. Based on the hyper-vigilance model, the stressful situation should increase state anxiety and would, therefore, produce selective colour-naming interference for threat words relative to non-threat words in high but not low trait anxious children. This interference was expected to be most marked for concern-related words (i.e. the words associated with physical harm in a vaccination situation). However, contrary to these predictions both high and low trait anxious children demonstrated cognitive interference specific to information related to physical harm, irrespective of the presence of the vaccination stressor. Moreover, in the neutral situation (where the vaccination stressor was absent) both high and low trait anxious girls – but not boys – showed a processing bias for generally threatening information. Similar results were obtained in a subsequent experiment using a computerized single-trial emotional Stroop task (Kindt, Bierman and Brosschot, 1997). Kindt, Bierman and Brosschot compared the computerized and card formats of the emotional Stroop task for spider-fearful and non-fearful children aged 8–12 years and found a bias for spider words in both spider-fearful and control children, regardless of the format used. They also found that in low spider-fearful children spider Stroop interference decreased with age, while in high fearful children, spider Stroop interference increased with age. One explanation is that the fear memory networks are not fully developed such as in anxious adults resulting in less bias, but because the absence of a differential effect was not due to a lack of bias in the anxious group but to the presence of a bias in the control group, a more probable explanation is that the emotional stimuli used were significant not only for the anxious group but also for the non-anxious group.

Table 3.2. Details of experiments finding non-significant anxiety-related emotional Stroop effects in children

Authors	*Format*	*Sample characteristics*	*Presentation stimulus (word/picture/face)*	*Other measures/ control variables*	*Block/trials*	*Age range/ adjustments for use with children*
Benoit *et al.* (2007)	Single trial (computer)	Clinical: GAD Social phobia Separation anxiety Panic OCD PTSD Anxiety not otherwise specified	A photograph of either an adult or a child displaying one of four expressions: anger, disgust, happiness or neutral. For each expression in the adult group, there were two male and two female models	None	B1: 20 practice trials naming the colours of filters covering pictures of chairs. B2: 64 test trials involving adult faces, 48 trials involving child faces. A total of 112 trials. The 112 presentations occurred in eight blocks, each block consisting of one model/expression combination (i.e. adult happy, child disgust, etc.)	7–17 Used pictures of faces
Dalgleish *et al.* (2003)	Single trial (computer)	Clinical: GAD PTSD	Positive, categorized neutral, depression-related, threat-related and trauma-related	Vocabulary and reading tests administered	B1: 18 practice trials using uncategorized neutral words. B2: 120 test trials	7–18 None
Freeman and Beck (2000)	Single trial (computer)	Clinical: PTSD (sexually abused)	Abuse-related threat words (e.g. force and suck), developmentally relevant words (e.g. shame and abandoned), general threat words (e.g. cancer and knife), positive words (e.g. happy and smile) and neutral words (e.g. table and window)	Reading difficulty was no higher than fifth-grade level. Intelligence and achievement measures	B1: 20 practice trials using number words continued until at least 80% of the colours were named correctly. B2: 150 test trials	11–13 None

(*continued overleaf*)

Table 3.2. *(Continued)*

Authors	*Format*	*Sample characteristics*	*Presentation stimulus (word/picture/face)*	*Other measures/ control variables*	*Block/trials*	*Age range/ adjustments for use with children*
Heim-Dreger *et al.* (2006)	Card	Non-clinical: Trait anxiety	Drawings of faces showing either friendly or threatening expressions	Colour blindness	B1: One card (20 faces with ambiguous expressions) B2: 80 trials (two cards each of threat and friendly expressions with 20 facial expressions on each card)	7–10 Used drawings of facial expressions
Kindt and Brosschot (1999)	Single trial (computer)	Non-clinical: Spider anxious	Six categories of stimuli based on the following three types: (i) pictures (spider pictures versus neutral pictures, i.e. chairs), (ii) non-integrated words, non-integrated spider words (e.g. spider, web) and six neutral words (e.g. chair, table) vs. non-integrated neutral words) and (iii) integrated words (integrated spider words versus integrated neutral words)	Children were selected who had sufficient reading abilities as was verified by asking the teacher	B1: 20 practice stimuli B2: 96 test trials (48 words; integrated and non-integrated and 48 pictures; integrated and non-integrated)	8–12 Used non-integrated words and pictures (words and pictures were superimposed onto coloured circles to simplify the task)
Kindt, Bierman and Brosschot (1997)	Card and Single trial (computer)	Non-clinical: Spider anxious	Standard colour word: Stroop used *incongruent colour words* (red, blue, yellow and green) and *non-words* (loav, tmelw, ernif, muga). The word sets in the spider Stroop were:	Tests were administered to assure whether the subjects had sufficient general reading abilities	B1: 20 practice stimuli consisting of neutral words. B2: Both Stroop formats consisted of 80 test trials. The stimuli were presented in four blocks, each block	8–12 None
			spider words (spider, web, hairy, legs and crawl) and *control words* (sparrow, nest, feather, flying and bird)	and whether anyone suffered from colour blindness	consisting of one of the four word sets	8–12 None
Kindt, Bögels and Morren (2003)	Single trial (computer)	Clinical: Separation Anxiety Social phobia GAD Controls	Six word categories: separation-threat (e.g. lost, desolate) vs. neutral (e.g. bathroom, chair-leg), social-threat (e.g. boring, deride) vs. neutral (pine-tree, grass), and general threat (e.g. illness, damage) vs. neutral (noise, guitars)	Colour blindness test	B1: 'some' practice trials B2: 120 word test trials	7–18 None
Kindt, Brosschot and Everaerd (1997)	Single trial (computer)	Non-clinical: Trait anxiety	Standard Stroop. Emotional Stroop: concern-related threat; concern-related non-threat; concern-unrelated threat and concern-unrelated non-threat	Reading ability tested Colour blindness tested	B1: 18 practice words B2: 96 test stimuli presented in trials of six blocks, each block consisting of one of the six word categories	8–9 None
Kindt *et al.* (2000)	Single trial (computer)	Non-clinical: Spider anxious	Words (spider words and neutral words) and pictures (spider pictures and neutral pictures)	None	B1 12 practice trials B2: 48 picture test trials and 48 word test trials	8–11 The words and pictures were superimposed on coloured circles (i.e. non-integrated) Included linguistic training and also a manipulation check of the training

(continued overleaf)

Table 3.2. (*Continued*)

Authors	*Format*	*Sample characteristics*	*Presentation stimulus (word/picture/face)*	*Other measures/ control variables*	*Block/trials*	*Age range/ adjustments for use with children*
Morren *et al.* (2003)	Single trial (computer)	Non-clinical: Spider anxious	Spider words (e.g. spider and web), control words (e.g. stool and table). Presented as integrated and non-integrated stimuli Integrated stimuli comprised coloured letters on a black background. Non-integrated words were printed in black letters and superimposed on a coloured circle	Colour blindness tested	B1: Three practice trials B2:72 test trials B3: Short break + three practice trials B4: 72 test trials	7–11 Used non-integrated stimuli (which is supposedly easier to process) as well as integrated stimuli
Schneider *et al.* (2008)	Card	Non-clinical: Parent diagnosed with panic disorder or animal phobia	Panic-relevant words, spider-phobia-relevant words, and neutral words (the list can be requested from the authors)	Excluded children younger than 8 years of age. Selected age-appropriate words	B1: Practice run with a card containing neutral words. B2: 96 test trials	8–15 None.
Schwartz, Snidman and Kagan (1996)	Single trial (computer)	Non-clinical: Behaviourally inhibited vs. uninhibited	Threatening words (e.g. shy, lonely) positive words (e.g. smile, neutral words (e.g. dash, museum)	All words were at a sixth-grade reading level or below. Subjects were screened for reading ability by presenting the 12 most difficult words on index cards and asking the subject to read each word	B1: 54 test trials	12–13 None

In a similar study, Kindt and Brosschot (1999) tested spider-fearful and non-fearful girls aged between 8 and 12 years. Unlike their previous studies, Kindt and Brosschot used pictorial stimuli as well as word stimuli in the Stroop task and presented stimuli in both an integrated and a non-integrated form. In the traditional emotional Stroop paradigm, words and colours are integrated (they are presented simultaneously), which differs from, for example, dot-probe tasks in which stimuli and probes appear consecutively (non-integrated). By using a non-integrated form of the stimuli, Stroop, Kindt and Brosschot could determine whether previous failures to find interference effects in high and low anxious children was because of the integrated nature of the Stroop task. Consistent with their previous studies, Kindt and Brosschot found that the integrated spider words caused interference in both the spider-fearful girls and controls. Non-integrated words (but not pictures) produced some interference in spider-fearful girls, but not in control children. However, this effect was not significant and might have been due to the performance of the older children in the sample. Kindt *et al.* (2000) replicated this study in two experiments. In their first experiment, a group of spider-fearful and non-fearful girls aged between 8 and 11 years were falsely informed that they might have to complete a behavioural approach task, in which they would be faced with a real-life spider. This manipulation was intended to activate threat cognitions. Remember that in the hyper-vigilance model trait anxiety is predicted to cause interference only when state anxiety is high because state anxiety will activate the person's threat detection system. By getting girls to anticipate threat their threat schema should become activated, resulting in a processing bias. Children completed non-integrated forms of the word and picture spider Stroop task. The results showed no significant interference effect for spider-threat words or pictures. However, consistent with Kindt, Bierman and Brosschot (1997), the interference effect became greater with age in the spider-fearful girls and decreased with age in the non-spider-fearing girls. This study did reveal that in 8-year-olds, the presence of spider pictures facilitated colour naming in the spider-fearful group. This finding was followed up in a second experiment using a larger sample and only the word version of the spider Stroop task. Half of the children also completed the behavioural approach task subsequent to the Stroop task as an ecologically valid test of fear and avoidance differences between the spider-fearful and non-fearful children. All children demonstrated interference when colour naming the non-integrated spider words and the expectation of approach to a real spider did not significantly affect the processing bias. The authors suggested that at age 8 a bias to threat words is typical of all children; however, another explanation is that normal fears are focused on animals at this age (Field and Davey, 2001). We mentioned earlier that processing biases are present for personally relevant information; it is possible that there are sensitive periods in which specific stimuli evoke a processing bias. The onset of animal phobia peaks at around 7–9 years; therefore, processing biases for animal-related stimuli might be present in all children during this sensitive time, whereas, for instance, socially relevant stimuli might evoke a general processing bias later on in life.

These studies by Kindt *et al* gave rise to the aforementioned inhibition hypothesis, in which a processing bias is seen as a normal part of development that increases with age in anxious children but slowly withers in non-anxious children. However, one large-scale study seems to contradict this model. Morren *et al.* (2003) used a large sample of high ($N = 170$) and low spider-fearful children ($N = 215$) aged 7–11 years in an emotional Stroop task using both integrated and non-integrated stimuli. Contrary to the inhibition hypothesis, results did not show that all children had a processing bias for spider words; a reverse pattern was found in that children were *faster* to respond to spider-related words relative to control words. In addition, the hypothesis that anxiety group would interact with age in producing interference effects was not support. The authors suggest that the reverse bias that they observed is a consequence of avoidance: children may have avoided aversive processing of spider stimuli by responding speedily. This study supports the integral hypothesis in that age did not mediate interference effects; however, the interference observed was in the opposite direction. One interesting consideration is that this experiment contained significantly more trials (144) than previous studies and for the first block of trials a general bias appeared for the integrated spider stimuli, whereas avoidance appeared only on the second block of trials.

Similarly, Heim-Dreger *et al.* (2006) found evidence in two experiments for *avoidance* of drawings of faces depicting either friendly or threatening expressions in a card format emotional Stroop task. The stimuli in this study were similar to those used by Hadwin *et al.* (2009), but unlike this study, Heim-Dreger found inconsistent evidence of a processing bias: the interference effect was significantly different from zero only in Experiment 2. In both experiments trait anxiety did not significantly predict interference effects, $rs = .16$ and .14, and the sizes of these effects are very consistent with those of Hadwin *et al.* (see earlier). Most important in the current context, Heim-Dreger *et al.* found that trait anxiety was better predicted by the absolute values of interference scores (i.e. when you ignore whether the effect shows vigilance or avoidance), which is partly consistent with Morren *et al.*'s (2003) findings.

It could be argued that the inconsistent results that we have reviewed reflect the use of non-clinical samples (in which interference effects might be expected to be weak). However, there is evidence from 'at-risk' children and clinically diagnosed children that suggest that the emotional Stroop does not always consistently produce evidence of a processing bias. Schneider *et al.* (2008) used an 'at-risk' group of children aged 8–15 years who had one parent diagnosed with either panic disorder or animal phobia. Their Stroop task included panic-relevant, animal-phobia-relevant and neutral words that were considered to be age appropriate. Children whose parent was diagnosed with panic disorder showed similar interference scores for panic-related words as children whose parent was diagnosed with animal phobia and children of healthy controls. Schneider *et al.* concluded that their sample included children who were 'at risk', but who had never experienced a panic attack; therefore, they would not necessarily interpret the panic words as threatening. However, we do not know if their explanation is plausible because they did not perform a pretest measuring child threat ratings of the words used in the emotional Stroop. It is also possible that although the words were selected for their age appropriateness, the absence of reading and vocabulary tests in this study raises the possibility that children were simply unable to read (which is unlikely) or understand the words used. The explanation may be that reading of difficult words is less automatized and consequently less word meaning interference would be expected.

Another study using 'at-risk' children focused on the temperaments of the children. Schwartz, Snidman and Kagan (1996) used a computerized single-trial emotional Stroop task with adolescents (12- to 13-years old) who had been previously classified as either behaviourally inhibited or uninhibited when they were 2 years old. Based on temperament theories (see Chapter 10), adolescents who were inhibited at 2 years of age should exhibit greater threat-related interference compared with those who were uninhibited. This prediction was not supported and the results showed that colour-naming latencies were greater for threat and positive words relative to neutral words, but there were no significant differences between the two temperament groups. The authors did not measure concurrent anxiety, but these results seem to support Kindt *et al.*'s data showing a general processing bias for affective stimuli in all children. However, contrary to adult models, this bias was not affected by risk for anxiety.

Data from 'at-risk' populations may be limited because perhaps anxiety has to fully express itself before a processing bias is found. However, this possibility is unlikely because some studies using non-clinical samples do show processing biases using the emotional Stroop task (see the previous section). In addition, some studies using clinical samples have failed to replicate the expected processing biases to threat stimuli.

Freeman and Beck (2000) employed the emotional Stroop paradigm to examine cognitive interference for trauma-related stimuli in sexually abused adolescent girls (aged between 11 and 13 years old) with PTSD. Controlling for verbal IQ and reading achievement, their results indicated that sexually abused adolescent girls with PTSD showed more overall colour-naming interference for all word types presented (developmentally relevant general threat and abuse-related threat, positive and neutral) than non-clinical controls. In addition, interference of colour naming of abuse-related words was found in both abused and non-abused adolescents. The authors did, however, note that the abuse-related threat words (e.g. 'penis') might have caused interference for all adolescents, even controls, simply because all girls would have had less exposure to such taboo words. An alternative explanation is that non-abused adolescents showed cognitive interference for abuse-related words because they were at an age at which their sexuality was emotionally significant. This explanation fits well with Williams, Mathews and MacLeod's (1996) observation that 'relatedness to current concern is necessary to explain Stroop interference in non-clinical participants' (p. 19). Similarly, Dalgleish *et al.* (2003) failed to find a significant Stroop effect in children with GAD and PTSD for threat-related or depression words, but when using the dot-probe task found that GAD patients showed vigilance for threat words, and PTSD patients demonstrated an avoidance for depression words.

Kindt, Bögels and Morren (2003) used the emotional Stroop task to examine processing bias in clinically anxious children and adolescents aged between 7 and 18 years who were diagnosed as experiencing separation anxiety disorder (SAD), social phobia (SP) and/or GAD compared with normal controls. The aim of this study was to investigate whether clinically anxious children present a processing bias towards threat stimuli and also whether this bias was domain specific. To test for domain specificity, words tailored to each anxiety disorder were included: example words included 'lost' (SAD), 'bathroom' (neutral), 'silly' (SP), 'illness' (GAD). They found no significant evidence for either an anxiety-related processing bias towards threat or a domain-specificity effect. Their study contained a large age range (7–18 years), and although theoretically you would expect to find a processing bias in all children, the inclusion of younger children weakened the effect because of performance aspects of the task (see earlier): children of 7 years may have been unable to read or understand some of the words used. Unfortunately though, this hypothesis could not be tested by comparing age groups because the sample size was too small (especially within disorders).

Most recently, Benoit *et al.* (2007) did a picture adaptation of the emotional Stroop task in which children (7–12 years) and adolescents (13– 17 years) with a range of clinically diagnosed anxiety disorders named the colours of filters covering images of both adults and children depicting either a neutral expression or an emotional expression of anger, disgust or happiness (see also Hadwin *et al.*, 2009; Heim-Dreger *et al.*, 2006). They reported that the clinically anxious children, relative to controls, were slower to colour name in general. This finding suggests that social cues create greater interference in individuals with anxiety disorders. However, contrary to what was predicted, anxiety-disordered individuals were no slower than non-clinical controls at colour-naming filters covering threatening facial expressions (i.e. anger and disgust) relative to filters covering faces portraying happy or neutral expressions. This failure to find an interference effect towards threatening facial expressions could reflect the heterogeneity of the sample because the majority of participants had co-morbid diagnoses, and a range of anxiety disorders were included. However, in adults the extent of processing bias is comparable across anxiety disorders, and co-morbidity appears not to be a statistical moderator of processing bias effects (Bar-Haim *et al.*, 2007).

What conclusions can we draw about emotional Stroop effects in child populations?

In summary, findings from the Stroop task have shown a mixed set of results. In non-clinical and vulnerable samples at least there appears to be evidence that all children possess a processing bias for threat material. There are four studies that show some evidence for processing biases in clinical samples, but there are four studies that do not. Bar-Haim *et al.* (2007) conducted a meta-analysis on information processing biases in anxiety across many different paradigms. Their analysis, therefore, included data from the emotional Stroop task in both child and adult samples. Bar-Haim *et al.*'s meta-analysis revealed a significant effect of threat-related bias in anxious adults based on 81 studies ($d = .48$) and in anxious children, based on 11 studies ($d = .50$). The two groups were not significantly different from each other. Only two studies with children used picture stimuli, thus precluding a comparison between adults and children on this variable. For word stimuli, the bias was significant both for anxious adults ($k = 79$, $d = .43$) and for anxious children ($k = 9$, $d = .68$), with children showing a significantly larger effect size than adults ($Q = 3.78$, $p < .05$).

At face value then, this meta-analysis would suggest that interference effects found by the Stroop task in child samples are statistically equivalent (or stronger using word stimuli) to adults. However, studies were included as 'child' samples if the participants were 18 years or under and as we discussed earlier 18-year-old individuals are more or less adults and will have cognitions and cognitive abilities that are very different from those of a young child of 6 years (see Chapter 11). Many of the studies that have looked for Stroop effects have used very heterogeneous age groups (often by necessity when using clinical samples) and so it is impossible to know whether the apparent similarity between adult and child effect sizes in the Bar-Haim meta-analysis are being driven by the older children within the child studies. As such, although the comparisons between adult and child effects in the Bar-Haim *et al.* meta-analysis are the best we can do at present, they are not particularly useful in addressing the issue of the developmental trajectory of processing bias using the emotional Stroop. Bar-Haim *et al.* acknowledge this limitation by pointing out that there were not enough studies with children to allow a more sensitive breakdown of the data by age group.

There is also conflicting evidence about the validity of the emotional Stroop task from studies that have used different methodologies to measure anxiety-related processing biases. When performances on different tasks that measure processing biases do correlate weakly then it suggests one or more of the following: that the tasks measure distinct mechanisms, that one or both mechanisms lack validity or that one or both tasks lack validity. For example, Richards *et al.* (2007) used the emotional Stroop task in combination with a facial processing task (see above) and found that the interference index from the Stroop task correlated significantly with the number of 'anger' responses that children gave to less intense happy faces on the face processing task, $r = .38$. This finding suggests that the emotional Stroop task has convergent validity. However, Kindt, Bierman and Brosschot (1997) compared the card format of the Stroop task for spider words with the single-trial format and found a very low correspondence, $r = .13$. The card format seemed to produce stronger interference effects than the single-trial format. Furthermore, studies have found almost no correlation, $r = .003$ (Dalgleish *et al.*, 2003) and $r = -.04$ (Heim-Dreger *et al.*, 2006) between interference effects as indexed by the emotional Stroop task and the dot-probe task, suggesting that either the two measures are tap different cognitive processes or at least one of the measures is unreliable or invalid. Given that they did not find a significant interference effect using the emotional Stroop task, the strong implication is that it is the task that lacks validity. These are not the only studies to show generally poor correlations between different measures of cognitive biases in anxious youth. For example, processing biases using the dot-probe task correlate poorly when words and pictures are used, $r = -.13$; both formats of this task correlate poorly with memory bias, $rs = .14$ (word dot probe) and .06 (picture dot probe), and measures of cognitive errors, $rs = -.04$ (word dot probe) and .21 (picture dot probe); measures of cognitive errors and memory bias correlate poorly too, $r = .06$ (Watts and Weems, 2006). As such, there is generally a lack of convergent validity in tasks that might be expected to tap similar underlying processing mechanisms in anxious children.

Future research using the emotional Stroop task in anxious children

To explore whether there is a developmental course of processing bias as indexed by the emotional Stroop task as predicted by the inhibition and implied bias hypotheses, researchers will need to use large samples to allow a systematic analysis of trends across ages. Longitudinal designs would also allow researchers to assess causal relations between processing biases and the development of anxiety in childhood. Such research brings with it a unique set of problems because of the difficulty of constructing stimulus materials that are appropriate for both young children and adolescents. It is possible, for example, that the inconsistency in the research findings reflects the inadequacy of the emotional Stroop paradigm in child samples. For example, although there have been some studies that have made adjustments to the traditional version of the emotional Stroop task for use with children, for example, by using pictures rather than words, these adaptations do not systematically explain the success or failure of the task to demonstrate anxiety-related processing bias to threat (see Tables 3.1 and 3.2).

The use of an inhibitory task in children can also reflect cognitive development. For example, children of 3.5–4.5 years of age can find the day–night Stroop-like task challenging (Gerstadt, Hong and Diamond, 1994). When age and task performance is tracked over time, as age increases the task difficulty declines and by the age of 6–7 years, children find the task very easy (Diamond, Kirkham and Amso, 2002). These findings suggest that there is a sensitive phase of attentional control development at roughly 4 years of age tapped by this task. Future studies of processing bias in anxious children would benefit from establishing recognized norms on the emotional Stroop task (Bar-Haim *et al.*, 2007). There are also new inhibitory tasks that have been developed other than the Stroop that might prove useful in exploring processing biases to threat in children. For example, an emotional Go/No Go task has been developed (e.g. Hare *et al.*, 2005), which has been used in anxious children (Ladouceur *et al.*, 2006; Waters and Valvoi, 2009). In this task, participants respond to a particular emotional face on some trials (Go trials) and avoid responding to any other face on other trials (No Go trials). The participants' ability to suppress a behavioural response is indexed by the proportion of presses that they accidentally make on 'No Go' trials. In addition, when No Go trials are sparsely distributed within Go trials (e.g. 30% of trials are 'No Go'), response times tend to be slower on Go trials, reflecting the effect of self-regulatory processes, such as attentional control. However, like the Stroop task, effects from this task are less than clear-cut. For example, Waters and Valvoi (2009) showed that anxious girls were slower to respond to neutral face Go trials than when angry versus happy face No Go trials were present, whereas non-anxious girls were faster to respond. However, in boys there was no corresponding effect of anxiety. Also, anxiety status did not influence the general finding from adults that it is difficult to inhibit responding to happy versus angry faces. Finally, hyper-vigilance as predicted in adult models of anxiety would be shown by effects when emotional faces are the Go trials. However, this effect was not significant. As such, although other inhibition-based tasks might seem like a useful way to complement the research from the emotional Stroop task, it will probably be a long time before a clear picture emerges about the development of processing biases in anxious children.

Acknowledgements

Economic and Social Research Council grant number RES-062-23-0406 awarded to Andy Field and Sam Cartwright-Hatton enabled us to write this chapter.

References

Bar-Haim, Y., Lamy, D., Pergamin, L. *et al.* (2007) Threat-related attentional bias in anxious and nonanxious individuals: a meta-analytic study. *Psychological Bulletin*, **133** (1), 1–24.

Beck, A.T., Emery, G. and Greenberg, R.L. (1985) *Anxiety Disorders and Phobias: A Cognitive Perspective*. Basic Books, New York.

Benoit, K.E., McNally, R.J., Rapee, R.M. *et al.* (2007) Processing of emotional faces in children and adolescents with anxiety disorders. *Behaviour Change*, **24** (4), 183–194.

Bower, G.H. (1981) Mood and memory. *American Psychologist*, **36**, 129–148.

Bradley, B.P., Mogg, K., Millar, N. and White, J. (1995) Selective processing of negative information–effects of clinical anxiety, concurrent depression, and awareness. *Journal of Abnormal Psychology*, **104** (3), 532–536.

Cohen, J.D., Dunbar, K. and McClelland, J.L. (1990) On the control of automatic processes: a parallel distributed processing account of the Stroop effect. *Psychological Review*, **97**, 332–361.

Compton, R.J., Banich, M.T., Mohanty, A. *et al.* (2003) Paying attention to emotion: an fMRI investigation of cognitive and emotional Stroop tasks. *Cognitive, Affective, and Behavioral Neuroscience*, **3**, 81–96.

Dalgleish, T., (1995) Performance on the emotional Stroop task in groups of anxious, expert and control participants: a comparison of computer and card presentation formats. *Cognition and Emotion*, **9**, 341–362.

Dalgleish, T., Taghavi, R., Neshat-Doost, H. *et al.* (2003) Patterns of processing bias for emotional information across clinical disorders: a comparison of attention, memory, and prospective cognition in children and adolescents with depression, generalized anxiety, and posttraumatic stress disorder. *Journal of Clinical Child and Adolescent Psychology*, **32** (1), 10–21.

Dawkins, K. and Furnham, A. (1989) The color naming of emotional words. *British Journal of Psychology*, **80**, 383–389.

Diamond, A., Kirkham, N. and Amso, D. (2002) Conditions under which young children can hold two rules in mind and inhibit a prepotent response. *Developmental Psychology*, **38**, 352–362.

Dubner, A.E. and Motta, R.W. (1999) Sexually and physically abused foster care children and posttraumatic stress disorder. *Journal of Consulting and Clinical Psychology*, **67** (3), 367–373.

Field, A.P. (2006) Watch out for the beast: fear information and attentional bias in children. *Journal of Clinical Child and Adolescent Psychology*, **35** (3), 431–439.

Field, A.P. and Davey, G.C.L. (2001) Conditioning models of childhood anxiety, in *Anxiety Disorders in Children and Adolescents: Research, Assessment and Intervention* (eds W.K. Silverman and P.A. Treffers), Cambridge University Press, Cambridge, pp. 187–211.

Freeman, J.B. and Beck, J.G. (2000) Cognitive interference for trauma cues in sexually abused adolescent girls with posttraumatic stress disorder. *Journal of Clinical Child Psychology*, **29**, 245–256.

Gerstadt, C., Hong, Y. and Diamond, A. (1994) The relationship between cognition and action: performance of 31/2–7 year old children on a Stroop-like day-night test. *Cognition*, **53**, 129–153.

Hadwin, J.A., Donnelly, N., Richards, A. *et al.* (2009) Childhood anxiety and attention to emotion faces in a modified Stroop task. *British Journal of Developmental Psychology*, **27**, 487–494.

Hare, T.A., Tottenham, N., Davidson, M.C. *et al.* (2005) Contributions of amygdala and striatal activity in emotion regulation. *Biological Psychiatry*, **57** (6), 624–632.

Heim-Dreger, U., Kohlmann, C.W., Eschenbeck, H. and Burkhardt, U. (2006) Attentional biases for threatening faces in children: vigilant and avoidant processes. *Emotion*, **6** (2), 320–325.

Hock, M. and Krohne, H.W. (2004) Coping with threat and memory for ambiguous information: testing the repressive discontinuity hypothesis. *Emotion*, **4** (1), 65–86.

Holmes, D.S. (1974) Investigations of repression: differential recall of material experimentally or naturally associated with ego threat. *Psychological Bulletin*, **81**, 632–653.

Jones, G.V. (1984) Fragment and schema models of recall. *Memory and Cognition*, **12**, 250–263.

Jones, G.V. (1987) Independence and exclusivity among psychological processes: implications for the structure of recall. *Psychological Review*, **94**, 229–235.

Kindt, M., Bierman, D. and Brosschot, J.F. (1997) Cognitive bias in spider fear and control children: assessment of emotional interference by a card format and a single-trial format of the Stroop task. *Journal of Experimental Child Psychology*, **66** (2), 163–179.

Kindt, M., Bogels, S. and Morren, M. (2003) Processing bias in children with separation anxiety disorder, social phobia and generalised anxiety disorder. *Behaviour Change*, **20**, 143–150.

Kindt, M. and Brosschot, J.F. (1999) Cognitive bias in spider-phobic children: comparison of a pictorial and a linguistic spider Stroop. *Journal of Psychopathology and Behavioral Assessment*, **21**, 207–220.

Kindt, M., Brosschot, J.F. and Everaerd, W. (1997) Cognitive processing bias of children in a real life stress situation and a neutral situation. *Journal of Experimental Child Psychology*, **64** (1), 79–97.

Kindt, M. and van den Hout, M. (2001) Selective attention and anxiety: a perspective on developmental issues and the causal status. *Journal of Psychopathology and Behavioral Assessment*, **23** (3), 193–202.

Kindt, M., van den Hout, M., de Jong, P. and Hoekzema, B. (2000) Cognitive bias for pictorial and linguistic threat cues in children. *Journal of Psychopathology and Behavioral Assessment*, **22** (2), 201–219.

Ladouceur, C.D., Dahl, R.E., Williamson, D.E. *et al.* (2006) Processing emotional facial expressions influences performance on a Go/NoGo task in pediatric anxiety and depression. *Journal of Child Psychology and Psychiatry*, **47** (11), 1107–1115.

Lavy, E. and van den Hout, M. (1993) Selective attention evidenced by pictorial and linguistic Stroop tasks. *Behavior Therapy*, **24**, 645–657.

Lavy, E., van den Hout, M. and Arntz, A. (1993) Attentional bias and spider phobia: conceptual and clinical issues. *Behaviour Research and Therapy*, **31**, 17–24.

Lipp, O.V. and Derakshan, N. (2005) Attentional bias to pictures of fear-relevant animals in a dot probe task. *Emotion*, **5** (3), 365–369.

Logan, A.C. and Goetsch, V.L. (1993) Attention to external threat cues in anxiety states. *Clinical Psychology Review*, **13**, 541–559.

Lonigan, C.J., Vasey, M.W., Phillips, B.M. and Hazen, R.A. (2004) Temperament, anxiety, and the processing of threat-relevant stimuli. *Journal of Clinical Child and Adolescent Psychology*, **33** (1), 8–20.

MacLeod, C.M. (1991) Half a century of research on the Stroop effect: an integrative review. *Psychological Bulletin*, **109**, 163–203.

MacLeod, C.M. and Dunbar, K. (1988) Training and Stroop-like interference: evidence for a continuum of automaticity. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, **10**, 304–315.

Martin, J.M. and Cole, D.A. (2000) Using the personal Stroop to detect children's awareness of social rejection by peers. *Cognition and Emotion*, **14** (2), 241–260.

Martin, M., Horder, P. and Jones, G.V. (1992) Integral bias in naming of phobia-related words. *Cognition and Emotion*, **6**, 479–486.

Martin, M. and Jones, G.V. (1995) Integral bias in the cognitive processing of emotionally linked pictures. *British Journal of Psychology*, **86**, 419–435.

Mathews, A. and MacLeod, C. (1985) Selective processing of threat cues in anxiety-states. *Behaviour Research and Therapy*, **23** (5), 563–569.

Mathews, A. and Macleod, C. (1994) Cognitive approaches to emotion and emotional disorders. *Annual Review of Psychology*, **45**, 25–50.

Mathews, A. and MacLeod, C. (2005) Cognitive vulnerability to emotional disorders. *Annual Review of Clinical Psychology*, **1**, 167–195.

McKenna, F.P. and Sharma, D. (2004) Reversing the emotional Stroop effect reveals that it is not what it seems: the role of fast and slow components. *Journal of Experimental Psychology: Learning, Memory and Cognition*, **30**, 382–392.

McNally, R.J. (1995) Automaticity and the anxiety disorders. *Behaviour Research and Therapy*, **33** (7), 747–754.

Mogg, K., Bradley, B.P., Williams, R. and Mathews, A. (1993) Subliminal processing of emotional information in anxiety and depression. *Journal of Abnormal Psychology*, **102** (2), 304–311.
Mogg, K., Kentish, J. and Bradley, B.P. (1993) Effects of anxiety and awareness on color-identification latencies for emotional words. *Behaviour Research and Therapy*, **31** (6), 559–567.
Mogg, K., Mathews, A. and Weinman, J. (1989) Selective processing of threat cues in anxiety states: a replication. *Behaviour Research and Therapy*, **27** (4), 317–323.
Moradi, A.R., Neshat-Doost, H., Taghavi, R. *et al.* (1999a) Performance of children of adults with PTSD on the Stroop color-naming task. *Journal of Traumatic Stress*, **12**, 663–672.
Moradi, A.R., Taghavi, M.R., Neshat-Doost, H.T. *et al.* (1999b) Performance of children and adolescents with PTSD on the Stroop colour-naming task. *Psychological Medicine*, **29**, 415–419.
Morren, M., Kindt, M., van den Hout, M. and van Kasteren, H. (2003) Anxiety and the processing of threat in children: further examination of the cognitive inhibition hypothesis. *Behaviour Change*, **20** (3), 131–142.
Rapee, R.M. (2000) Group treatment of children with anxiety disorders: outcome and predictors of treatment response. *Australian Journal of Psychology*, **52**, 125–129.
Richards, A., French, C.C., Johnson, W. *et al.* (1992) Effects of mood manipulation and anxiety on performance of an emotional Stroop task. *British Journal of Psychology*, **83**, 479–491.
Richards, A., French, C.C., Nash, G. *et al.* (2007) A comparison of selective attention and facial processing biases in typically developing children who are high and low in self-reported trait anxiety. *Development and Psychopathology*, **19**, 481–495.
Richards, A., Richards, L.C. and McGeeney, A. (2000) Anxiety-related Stroop interference in adolescents. *Journal of General Psychology*, **127**, 327–333.
Riemann, B.C. and McNally, R.J. (1995) Cognitive processing of personally relevant information. *Cognition and Emotion*, **9** (4), 325–340.
Ruiter, C. and Brosschot, J.F. (1994) The emotional Stroop effect in anxiety: attentional bias or cognitive avoidance? *Behaviour Research and Therapy*, **32** (3), 315–319.
Schneider, S., Unnewehr, S., In-Albon, T. and Margraf, J. (2008) Attention bias in children of patients with panic disorder. *Psychopathology*, **41** (3), 179–186.
Schwartz, C.E., Snidman, N. and Kagan, J. (1996) Early temperamental predictors to Stroop interference to threatening information at adolescence. *Journal of Anxiety Disorders*, **10**, 89–96.
Segal, Z.V., Truchon, C., Horowitz, L.M. *et al.* (1995) A priming methodology for studying self-representation in major depressive disorder. *Journal of Abnormal Psychology*, **104**, 205–213.
Spielberger, C.D., Gorsuch, R.L., Lushene, P.R. *et al.* (1983) *Manual for the State-Trait Anxiety Inventory (Form Y)*, Consulting Psychologists Press, Inc, Palo Alto.
Stroop, J.R. (1935) Studies of interference in serial verbal reactions. *Journal of Experimental Psychology*, **18**, 643–662.

Taghavi, M.R., Dalgleish, T., Moradi, A.R. *et al.* (2003) Selective processing of negative emotional information in children and adolescents with generalized anxiety disorder. *British Journal of Clinical Psychology*, **42**, 221–230.
Thrasher, S.M., Dalgleish, T. and Yule, W. (1994) Information processing in PTSD. *Behavioural Research and Therapy*, **32**, 247–254.
van Strien, J.W. and Valstar, L.H. (2004) The lateralized emotional Stroop task: left visual-field interference in women. *Emotion*, **4**, 403–409.
Waters, A.M. and Valvoi, J.S. (2009) Attentional bias for emotional faces in paediatric anxiety disorders: an investigation using the emotional go/no go task. *Journal of Behavior Therapy and Experimental Psychiatry*, **40**, 306–316.
Watts, F.N., Mckenna, F.P., Sharrock, R. and Trezise, L. (1986) Color naming of phobia-related words. *British Journal of Psychology*, **77**, 97–108.
Watts, S.E. and Weems, C.F. (2006) Associations among selective attention, memory bias, cognitive errors and symptoms of anxiety in youth. *Journal of Abnormal Child Psychology*, **34** (6), 841–852.
Williams, J.M.G., Mathews, A. and MacLeod, C. (1996) The emotional Stroop task and psychopathology. *Psychological Bulletin*, **120** (1), 3–24.