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The purpose of this study was to test whether children and adolescents with anxiety disorders exhibit selective processing of threatening facial expressions in a pictorial version of the emotional Stroop paradigm. Participants named the colours of filters covering images of adults and children displaying either a neutral facial expression or one displaying the emotions of anger, disgust, or happiness. A delay in naming the colour of a filter implies attentional capture by the facial expression. Anxious participants, relative to control participants, exhibited slower colour naming overall, implying greater proneness to distraction by social cues. Children exhibited longer colour-naming latencies as compared to adolescents, perhaps because young children have a limited ability to inhibit attention to distracting stimuli. Adult faces were associated with slower colour naming than were child faces, irrespective of facial expressions in both groups, possibly because adults provide especially salient cues for children and adolescents. Inconsistent with prediction, participants with anxiety disorders were not slower than healthy controls at naming the colours of filters covering threatening expressions (i.e., anger and disgust) relative to filters covering faces depicting happy or neutral expressions.

Because attentional capacity is limited, a person can attend to only a subset of stimuli at any given time. A bias for selectively attending to threatening cues should increase a person's likelihood of experiencing anxiety and perhaps developing anxiety disorders. Confirming this intuition, cognitive psychology experiments have shown that adults with anxiety disorders are characterised by an attentional bias for processing threatening information (For a review, see Harvey, Watkins, Mansell, & Shafran, 2004, pp. 25–70). For example, in the emotional Stroop task (Williams, Mathews, & MacLeod, 1996), participants are shown words of varying emotional significance, and are asked to name the colours in which the words appear while ignoring the meanings of the words. Delays in colour-naming occur when the meaning of

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the word captures the participant's attention despite his or her effort to attend to the colour of the word. Most experiments have shown that adults with anxiety disorders take longer to name the colours of words related to their threat-related concerns than to name the colours of other emotional or neutral words, and take longer to name the colours of threat words than do psychiatrically healthy control participants (Williams et al., 1996). Although debate continues about the mechanisms driving the emotional Stroop effect, it remains among the most robust cognitive bias effects in the adult anxiety disorders field.

Emotional Stroop studies involving anxious children have revealed mixed results. Relative to control participants, spider-fearful children have taken longer to name the colours of spider words (Martin, Horder, & Jones, 1992) and the colours of line drawings of spiders (Martin & Jones 1995). Adolescent survivors of a shipwreck who developed posttraumatic stress disorder (PTSD) exhibited delayed colour naming of trauma-related words (Thrasher, Dalgleish, & Yule, 1994), as did children who developed PTSD after being either physically or sexually abused (Dubner & Motta, 1999). Relative to control participants, children and adolescents (aged 9–17 years) with PTSD following either road traffic accidents or exposure to violence exhibited slower colour naming for trauma words than for neutral words (Moradi, Taghavi, Neshat-Doost, Yule, & Dalgleish, 1999).

Children and adolescents with generalised anxiety disorder (GAD) exhibit slower colour naming of negative words, especially threat-related ones, than of positive or neutral words (Taghavi, Dalgleish, Moradi, Neshat-Doost, & Yule, 2003).

However, several researchers have failed to replicate the anxiety-linked Stroop effect in children. For example, nonanxious children have exhibited just as much of an effect for threat words as have anxious children in some experiments (Kindt, Bierman, & Brosschot, 1997; Kindt, Brosschot, & Everaerd, 1997). A pictorial version of the spider Stroop (naming colours of backgrounds against which spider pictures appeared) did not reveal a fear-related effect in children aged 8–11 (Kindt, van den Hout, de Jong, & Hoekzema, 2000).

More recent studies concerning the dot probe task have also failed to reveal an attentional bias toward threat in anxious children and adolescents. Adolescents with generalised anxiety disorder showed a greater attentional bias away from angry faces than did controls (Monk et al., 2006), and children who had been physically or sexually abused and/or neglected demonstrated an attentional bias away from threatening faces (Pine et al., 2005).

The purpose of the present experiment was to test whether children and adolescents with anxiety disorders, relative to healthy control participants, exhibit delayed colour naming of threat-related faces of children and adults in a variant of the pictorial emotional Stroop paradigm. Modifying our previous version of the pictorial Stroop (Constantine, McNally, & Hornig, 2001), we asked participants to name the colours of filters covering pictures of adults and children displaying either an emotionally neutral facial expression or an expression depicting anger, disgust, or happiness. Psychologists have increasingly utilised facial expressions of emotion as ecologically valid stimuli having potential evolutionary significance in attentional bias research on adults (e.g., Mansell, Clark, Ehlers, & Chen, 1999). Moreover, although researchers have increasingly utilised facial expressions of emotion in attentional bias studies involving adults (e.g., Mogg, Philippot, & Bradley, 2004), they have only recently begun to use these cues with children. Pollack and Tolley-Schell (2003) found that physically abused children, aged 8 to 11 years, exhibited delayed attentional disengagement from angry facial expressions in a selective attention paradigm. Likewise, Hadwin et al. (2003) found that trait anxiety in children aged 7 to 10 years was related to attentional bias for schematic angry faces in a visual search paradigm. Although emotional Stroop studies in children have produced conflicting results, facial expressions of emotion may possess greater ecological validity than relatively abstract lexical threat cues.

Accordingly, we predicted that relative to control participants, those with anxiety disorders would exhibit slower colour naming of threatening faces (anger and disgust) relative to happy and neutral faces. Facial expressions of anger convey threat, whereas expressions of disgust convey contempt and rejection. We chose not to include fearful faces as they convey only indirect threat to the observer, whereas anger and disgust faces more directly communicate social threat.

Method

Participants

Patients were recruited from among those scheduled for assessment at the Child and Adolescent Anxiety Clinic at Macquarie University, Sydney, Australia.

The clinical group (n = 52) consisted of 37 children aged 7 to 12 years (M = 9.8, *SD* = 1.6) and 15 adolescents aged 13 to 17 years (M = 14.6, *SD* = 1.4). Twenty-two of the children were female, whereas seven of the adolescents were female. All participants met criteria for an anxiety disorder, according to the Anxiety Disorders Interview Schedule for Children and the Anxiety Disorders Interview Schedule for Parents (ADIS-C and ADIS-P; Silverman & Nelles, 1988). Many qualified for more than one anxiety disorder, other disorders, or both. The numbers of patients meeting criteria were as follows: generalised anxiety disorder (n = 47), social phobia (n = 32), specific phobia (n = 27), separation anxiety disorder (n = 22), panic disorder (n = 3), obsessive–compulsive disorder (n = 3), anxiety disorder not otherwise specified (n = 2), and posttraumatic stress disorder (n = 1). Other comorbid diagnoses included attention deficit hyperactivity disorder (n = 9), oppositional defiant disorder (n = 7), dysthymia (n = 7), [major] depression (n = 6), enuresis (n = 2), conduct disorder (n = 1), and selective mutism (n = 1).

The control group (n = 46) consisted of 27 children aged 7 to 12 years (M = 10.3, *SD* = 1.5) and 19 adolescents aged 13 to 15 years (M = 14.0, *SD* = 0.88). Thirteen of the children were female, whereas 12 of the adolescents were female. Participants were recruited through school newsletters and community newspapers. None qualified for a current mental disorder, according to the ADIS-C and ADIS-P. Among the children, the control group (M = 10.3, *SD* = 1.5) and the clinical group (M = 9.8, *SD* = 1.6) did not differ in age, $t(62) = 1.14$, $p = .26$. For the adolescents, there was also no difference in age, $t(22) = 1.45$, $p = .16$, between the control group (M = 14.0, *SD* = .88) and the clinical group (M = 14.6, *SD* = 1.4). The child control and patient groups did not differ with respect to sex ratio, $\chi^2(1) = .81$, $p = .37$, and neither did the adolescent groups, $\chi^2(1) = .93$, $p = .34$.

Participants completed the Spence Children's Anxiety Scale (SCAS; Spence, 1997, 1998) and the Strengths and Difficulties Questionnaire (SDQ; Goodman, 1997), which assesses externalising problems such as hyperactivity, inattention, conduct problems, and difficulties with peers. Parents of participants, usually mothers, completed the parent-report version of these questionnaires (SCAS-P; Nauta, Scoling, Rapee, Abbott, & Spence, 2004; SDQ-P; Goodman, 1997). The child and parent versions of each test were highly correlated (SCAS and

TABLE 1

Means and Standard Deviations for Psychometric Measures

Measure	Clinical Group		Control Group		*t*	*p*
	M	*SD*	*M*	*SD*		
SCAS	36.1	19.3	11.8	8.1	7.89	.001
SCAS-P	34.1	17.0	8.5	5.6	9.65	.001
SDQ	14.3	7.2	7.2	5.4	5.49	.001
SDQ-P	15.4	7.3	4.4	3.8	9.16	.001

Note: SCAS = Spence Children's Anxiety Scale (possible range of scores: 0–114); SCAS-P = Spence Children's Anxiety Scale — Parent Version (possible range of scores: 0–114); SDQ = Strengths and Difficulties Questionnaire (possible range of scores: 0 –40); SDQ-P = Strengths and Difficulties Questionnaire-Parent Version (possible range of scores: 0–40). Because of missing data, *df*s were 98 for the SCAS and SDQ, and 96 for the SCAS-P and SDQ-P.

MSCAS: $r = .85$, $p < .001$; SDQ and MSDQ: $r = .75$, $p < .001$). As evident from Table 1, the clinical group was more symptomatic than the control group on all four measures.

Apparatus and Materials

Adult faces depicting emotions were from Matsumoto and Ekman's (1989) set, whereas child faces were from Mazurski and Bond (1993). Following Constantine et al.'s (2001) procedure, we first created grayscale images by removing colour from the original picture, and then created integrated Stroop stimuli by placing a colour filter over the grayscale image. We used Adobe Photoshop 4.0 to create the Stroop stimuli, SuperLab to present the stimuli, and PsyScript to present the child faces for the postexperimental validation of valence (see below). Stimuli appeared on a 40 cm (16 inch) Macintosh computer approximately 60 cm (24 inches) from the participant. Stroop colour-naming latencies were detected by a microphone positioned between the participant and the screen, and recorded in milliseconds by voice recognition software.

On every trial, participants saw 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. Each model/expression combination appeared four times, once per colour: blue, red, green, and yellow. Accordingly, there were a total of 64 trials involving adult faces, 32 female and 32 male. Four female and three male child models displayed the four expressions (some models displayed more than one expression). Each model/expression combination appeared four times, once per colour: blue, red, green, and yellow. There were a total of 48 trials involving child faces, 24 female and 24 male. Therefore, participants were exposed to 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.). We chose a block design rather than random presentation because the former is more potent and sensitive to psychopathology than is the latter (Bar-Haim, Lamy, Pergamin, Bakersman-Kranenburg, & van IJzendoorn, 2007; Holle, Neely, & Heimberg, 1997;). Stimuli within each block appeared in a single, fixed random order except that neither a face nor a colour could appear more than twice in succession. The blocks themselves appeared in a different random order for each participant.

Unlike the adult emotional faces validated by Matsumoto and Ekman (1989), the child faces of Mazurski and Bond (1993) have received less validation. Accordingly, after the Stroop task was completed, we asked participants to rate each of the child emotional faces on a seven-point scale ranging from 1 ('very, very mean') to 7 ('very, very nice'). For adolescents, we replaced the low anchor with 'very, very threatening'. For the clinical group, the mean ratings were 2.5 for anger, 2.8 for disgust, 4.0 for neutral, and 6.2 for happy. For the control group, the mean ratings were 2.9 for anger, 3.3 for disgust, 4.0 for neutral, and 5.9 for happy. Relative to the control group, the clinical group rated the anger faces as marginally more negative (p = .072) and the disgust faces as significantly more negative (p = .015). The ratings support the validity of the facial expressions of emotion in children and may suggest a bias in anxious participants for amplifying threat. The ratings also validate our decision to use disgust rather than fearful faces, as anxious individuals clearly find these faces either 'mean' or 'threatening'. Although no data were collected regarding social desirability, these ratings may have resulted from children and adolescents giving answers that they thought would be 'correct'.

Procedure

Participants were told to name the colour of each picture as accurately and as quickly as possible while ignoring the content of the picture. Participants received 20 practice trials naming the colours of filters covering pictures of chairs. These trials enabled the experimenter to adjust the sensitivity of the microphone to ensure detection of the child's vocal response. Participants initiated each trial by pressing the space bar. The purpose of self-pacing of stimulus presentation was to counteract fatigue. After the Stroop task, the children rated the valence of the child facial expressions. The Stroop task plus the ratings took approximately 20 minutes.

Results

Prior to data analysis, we excluded outliers, defined as response latencies less than 300 ms or more than 3000 ms. This resulted in the exclusion of only 5.6% of all trials. Children in the control (M = 5.9, *SD* = 6.3) and clinical (M = 6.8, *SD* = 6.6) groups did not differ in their average total number of outliers, $t(62)$= .56, p = .58. Adolescents in the control group (M = 4.5, *SD* = 6.2) also did not differ in this regard to adolescents in the clinical group (M = 6.1, *SD* = 6.7), $t(32)$ = .75, p = .46.

Mean response latencies as a function of status (clinical versus control), age group (child versus adolescent), model (adult versus child), and emotion (anger, disgust, neutral, happy) are shown in Tables 2 and 3. These data were submitted to a 2 (status) × 2 (age group) × 2 (model) × 4 (emotion) analysis of variance (ANOVA) with repeated measurement on the second, third, and fourth variables.

The clinical group exhibited longer colour-naming latencies than did the control group, $F(1, 94)$ = 10.53, p = .002, children exhibited longer colour-naming latencies as compared to adolescents, F (1, 94) = 8.94, p = .004, and adult models provoked longer latencies than did child models, $F(1, 94)$ = 192.06, p < .001.

There was also a 2-way interaction for model × emotion, F (1, 94) = 3.79, p = .01, which proved to be a cubic contrast, F (1, 94) = 7.04, p = .009. Paired sample t-tests showed that participants were slower on adult anger faces as compared to adult disgust faces, $t(95)$ = 2.04, p = .044. For child models, happy faces provoked less

TABLE 2

Mean Response Latencies as a Function of Status, Model, and Emotion in Children

	Clinical		Control	
Stimulus	*M*	*SD*	*M*	*SD*
Adult model				
Anger	982	231	826	174
Disgust	932	225	785	159
Happy	977	228	791	141
Neutral	970	204	805	135
Child model				
Anger	855	303	656	192
Disgust	823	237	690	194
Happy	786	240	615	179
Neutral	819	263	682	201

Note: Data are in milliseconds.

colour-naming delay than did either angry, $t(95) = 2.7$, $p = .008$, disgust, $t(1, 94) = 2.60$, $p = .01$, or neutral faces, $t(95) = 3.0$, $p = .003$.

The 4-way interaction for model × emotion × status × age group closely approached significance, $F(1, 94) = 2.53$, $p = .06$, and further investigation revealed a linear contrast in this interaction, $F\ (1, 94) = 7.45$, $p = .008$. Given the difficulty in interpreting 4-way interactions, we decided to perform two separate 2 (status) × 2 (model) × 4 (emotion) ANOVAs, one for children and one for adolescents. We found that similar to our first analysis, clinical children had slower responses than control children, $F(1, 62) = 12.34$, $p < .001$, and children were slower on adult faces as com-

TABLE 3

Mean Response Latencies as a Function of Status, Model, and Emotion in Adolescents

	Clinical		Control	
Stimulus	*M*	*SD*	*M*	*SD*
Adult model				
Anger	835	184	735	137
Disgust	843	164	735	99
Happy	823	159	757	117
Neutral	791	203	732	122
Child model				
Anger	609	181	615	151
Disgust	679	229	601	138
Happy	615	163	578	155
Neutral	728	230	588	183

Note: Data are in milliseconds.

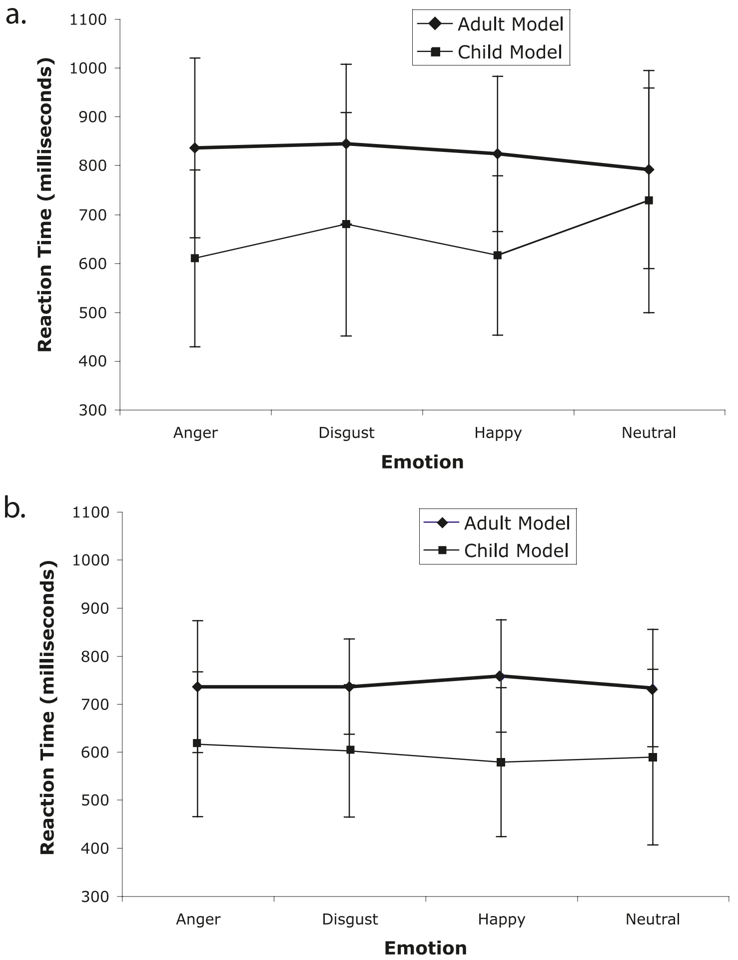

FIGURE 1

Adolescent reaction time means and standard deviations by model and emotion for (a) patients and (b) control participants.

pared to child faces, $F(1, 62) = 103.3$, $p < .001$. Two other results approached significance: emotion, $F(1, 62) = 2.31$, $p = .08$ and model × emotion, $F(1, 62) = 2.42$, $p = .07$.

In the 2 × 2 × 4 ANOVA with adolescents, we again found a slower response to adult faces as compared to child faces, $F(1, 32) = 142.01$, $p < .001$. Unlike the child analysis, however, we also found significant model × emotion, $F(1, 32) = 3.8$, $p = .013$ and model × emotion × status, $F(1, 32) = 3.72$, $p = .014$, interactions (see Figure 1). A model × emotion cubic contrast was again revealed, $F(1, 32) = 4.99$, $p = .033$, which paired sample t tests suggested was due to adolescents having a longer colour-naming latency with child neutral faces as compared to child happy faces, $t(33) = 2.42$, $p = .02$.

To elucidate the 3-way interaction in this group of adolescents, we ran a series of 2 × 2 × 2 interactions involving each possible pair of emotions. We found significant three-way interactions with two pairs: angry/neutral, $F(1, 32) = 9.32$, $p = .005$, and happy/neutral, $F(1, 32) = 5.43$, $p = .03$. Paired sample t tests showed that clinical adolescents, unlike control adolescents, were slowed by neutral child faces as compared to angry child faces $t(33) = 2.60$, $p = .02$, and as compared to happy child faces, $t(33) = 2.83$, $p = .013$.

Discussion

Several conclusions emerged from our study. First, like adults with anxiety disorders (Williams et al., 1996), anxious children and adolescents exhibited slower colour-naming latencies overall relative to healthy control participants. This finding suggests that young patients with anxiety disorders are more easily distracted by task-irrelevant stimuli than are their healthy peers. This finding is consistent with other studies showing general processing deficits in anxious children (Kindt et al., 2000; Kusche, Cook, & Greenberg, 1993; Morren, Kindt, van den Hout, & van Kasteren, 2003). Alternatively, this finding may indicate that anxious individuals are especially hesitant about responding. Such a cautious response style would slow responding to all stimuli, irrespective of emotional valence.

Second, children exhibited longer colour-naming latencies as compared to adolescents. As noted by Vasey and MacLeod (2001), young children have a limited ability to inhibit attention to distracting stimuli, and tasks such as the present one, which involve integrated stimuli, may especially tax this capacity.

Third, both anxious and control children and adolescents exhibited longer colour-naming latencies for adult faces than for child ones. This suggests that adults are especially salient cues for children and adolescents in general. Perhaps it is more difficult for youth to identify emotions on adult faces than on those of their peers.

Fourth, both groups exhibited shorter colour-naming latencies for adults displaying disgust faces as compared to anger faces. They were also faster when children displayed happy expressions relative to neutral, disgust, or angry expressions. That is, neutral expressions were functionally indistinguishable from faces expressing disgust or anger in children.

When children and adolescents were analysed separately, we failed to confirm that anxious children are characterised by disproportionately long colour-naming latencies for threat faces — those expressing either disgust or anger. This runs counter to most published research on anxious adults (Williams et al., 1996), but it is in accordance with Vasey and MacLeod's (2001) assertion that younger children do not often show an attentional bias for threatening information.

Anxious adolescents similarly did not show an attentional bias for anger and disgust faces, but they did take significantly more time to colour-name child neutral faces as compared to child anger and happy faces. Some researchers have found that anxious individuals exhibit an attentional bias *away* from faces depicting anger, sadness, disgust, or fear (Mansell et al., 1999; Monk et al., 2006; Pine et al., 2005) and this is what we have seen with the adolescent group and child anger faces. The fact that anxious adolescents also exhibited a bias away from happy child faces is surprising and merits future attention.

According to Vasey and MacLeod (2001), anxious children may display a bias toward negative interpretations of ambiguous stimuli. Although participants did not disproportionately rate child neutral faces as negative, perhaps anxious adolescents interpreted them as being negative in the course of the colour-naming task, and that was why child neutral faces produced significantly more interference than child anger and happy faces. Also, anxious adolescents may be slower to respond in the face of ambiguity.

It is important to note the significance of developmental factors in the present study. Although attentional biases did not occur in the anxious child group, they did in the anxious adolescent group. This accords with research showing that developmental issues are critical in assessing attentional biases in children and adolescents (Bar-Haim et al., 2007; Vasey & MacLeod, 2001).

Why did expressions of anger and disgust fail to slow colour naming, especially among children and adolescents with anxiety disorders? Indeed, although the emotional Stroop sometimes fails to distinguish nonclinically anxious individuals from nonanxious ones, our anxious participants had sufficiently severe anxiety disorders as to warrant treatment. Accordingly, insufficient severity of anxiety seems an unlikely explanation for the absence of the predicted disorder-linked emotional Stroop effect.

Further, although our sample size was only sufficient to detect a moderate effect of size difference between groups (d = .28) with reasonable power (i.e., .80; Erdfelder, Faul, & Buchner, 1996), the study group was considerably larger than in most studies showing an emotional Stroop effect in adults.

Despite their seeming ecological relevance, facial expressions of disgust and anger may have failed as potent threat stimuli. On the other hand, anxious participants did interpret these faces as threatening on the rating task, but only in child models, as adult faces were not rated.

Some studies suggest that facial expressions of fear may be especially potent cues for activating the amygdala (e.g., Whalen, 1998). Perhaps a heightened emotional Stroop effect in the anxiety group would have occurred had we utilised faces of fear rather than anger and disgust. On the other hand, anger and disgust faces convey direct social threat, whereas fear faces communicate indirect threat.

Also, we followed researchers who have utilised dot-probe studies involving facial expressions of anger with anxious adults, and these have often resulted in the predicted attentional bias effects (e.g., Mogg et al., 2004). Because anxiety-disordered children and adolescents have exhibited an attentional bias towards threatening words (Taghavi et al. 1999; Vasey, Daleiden, Williams, & Brown, 1995) but away from threatening faces (Monk et al., 2006, Pine et al., 2005), further elucidation of the mechanisms at work in both the Stroop and the dot probe task are needed.

The self-pacing of the Stroop task may also have affected our ability to differentiate anxious from nonanxious individuals. Although we did not collect data on how these groups may have differed in their pacing of the task, anxious individuals may have slowed down the presentation of threat faces, thus diminishing their concurrent anxiety, and thereby concealing between-group effects.

Finally, the heterogeneity of our sample could be considered a further limitation. Most participants presented with comorbid diagnoses and a range of anxiety disorders were represented. On the other hand, Bar-Haim et al. (2007) found that the magnitude of threat-related bias was similar across the anxiety disorders, and comorbidity mattered little.

Debate continues regarding the mechanisms underlying the emotional Stroop effect in anxious adults (Algom, Chajut, & Lev, 2004; Chajut, Lev, & Algom, 2005; Dalgleish, 2005; Williams et al., 1996). Whether it reflects attentional capture by threat cues, difficulty disengaging from threat, heightened accessibility of threat-related concepts, emotion-provoked response competition, atypical functioning in neural substrates (Bar-Haim et al., 2007), or some combination thereof, remains uncertain. Regardless of the mechanism, if the effect reliably correlates with anxiety disorder status, then the emotional Stroop has value.

Unfortunately, matters remain even more complicated in the child anxiety disorders field. In addition to the effect being less reliably apparent in young patients, recent data suggest that anxiety-linked biases on the emotional Stroop are not necessarily related to similar biases on other tasks. For example, Dalgleish et al. (2003) found no correlation between attentional bias on the emotional Stroop task and attentional bias on the dot probe detection task among anxiety-disordered children and adolescents. This study implies that these tasks measure different cognitive correlates of anxiety disorders.

In summary, two overriding goals confront clinical scientists working on cognitive aspects of anxiety disorders in children. They need to identify reliable measures of selective processing of threat cues, and to elucidate the mechanisms underlying these effects.

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