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Processing bias and anxiety in primary school children: A modified emotional Stroop colour-naming task using pictorial facial expressions

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Abstract

Three studies (Study I: $N = 92$, Study II: $N = 63$, Study III: $N = 225$) investigated the processing of threat-related information in non-clinical samples of young primary school children (aged 6 to 10 years) using a pictorial version of the modified emotional Stroop colour-naming task; the stimuli included threatening and happy facial expressions. The results of these experiments showed that for young children it seems promising to explore error data in addition to colour-naming times. With regard to the number of errors, in Study I, high trait anxious children selectively had the highest error rates on threatening stimuli. Similarly, in Study II, state anxiety (worry) was associated with a differential bias for threat-related error rates. Thereby, class level moderated the association between colour-naming times and error data (Study III). The results are discussed with respect to the literature on anxiety-linked Stroop interference in children.

Key words: cognitive bias, anxiety, emotional Stroop task, children

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Introduction

In recent years, there has been a large interest in exploring the cognitive processes that are assumed to cause or maintain emotional disorders. The general finding in the adult literature is that emotional states are associated with distinctive patterns in the processing of personally-relevant emotional information. Anxiety is associated with the selective processing of threat-related stimuli (Williams, Watts, MacLeod & Mathews, 1997). One of the most frequently used paradigms for the study of cognitive bias for threat is a modified version of the Stroop colour naming task (Stroop, 1935). Participants are required to name the colours in which either threat-related or neutral words are printed while trying to ignore the content of the word (Mathews & MacLeod, 1985). The time difference between colour-naming threatening and neutral words provides the relevant measure, called emotional Stroop interference. This index is an indicator of the degree to which attentional resources are captured by the word content.

Numerous studies have shown that anxiety in adults (particularly for clinically anxious patients) is associated with a cognitive bias towards threatening information (for a review see Williams, Mathews & MacLeod, 1996). High anxious participants show longer colour-naming times for words with threatening content than for non-threatening words. No differences in colour-naming latencies are shown for participants with low anxiety (e.g., Bradley, Mogg, Millar & White, 1995; Mathews & MacLeod, 1985; Mogg, Mathews & Weinman, 1989). Both trait anxiety (e.g., Mogg et al., 1989) and state anxiety (e.g., Mathews & MacLeod, 1985) were associated with emotional Stroop interference. Processing interference is most pronounced when emotional stimuli match personally relevant concerns (Williams et al., 1996). Results of studies using non-clinical samples are less consistent (e.g., Fox, 1993; MacLeod & Rutherford, 1992; Mogg & Marden, 1990; Mogg, Mathews, Bird & Macgregor-Morris, 1990; Richards & French, 1990).

In contrast to the large number of adult studies investigating anxiety-related cognitive bias with the emotional Stroop task, only few studies have addressed this topic in children (see Vasey & MacLeod, 2001, for a review). Moreover, based on extremely anxious or highly selected samples, most of this research has focused on children with fear of spiders. The first publication (Martin, Horder & Jones, 1992) showed that for all children (aged 6 to 13 years) colour-naming latencies were generally longer for spider-related words than for control words, particularly for spider-fearful children. The same anxiety-related bias for threat was found using a pictorial spider Stroop task in children aged 4 to 9 years (Martin & Jones, 1995). However, Kindt and colleagues (Kindt, Bierman & Brosschot, 1997; Kindt, Brosschot & Everaerd, 1997) have failed to find an anxiety-linked differential bias in children (aged 8 to 12 years) with spider and medical fear, respectively. Instead, all children were generally slower with threat than neutral words. In a following study (Kindt & Brosschot, 1999), pictorial and linguistic Stroop stimuli were administered to spider-phobic and control girls (aged 8 to 12 years). Again, for the linguistic Stroop task, all children showed elevated colour-naming interference on spider relative to neutral words. But spider-phobic girls displayed an anxiety-linked differential bias for threat-related words when target (colour) and distractor stimuli (word) were presented separately. However, no differential bias was found for spider pictures. In a more recent study (Kindt, van den Hout, de Jong & Hoekzema, 2000), the authors failed to replicate these findings in terms of an anxiety-linked differential bias: While all children aged 8 showed a bias for the spider words (experiment

2), this bias for threat words decreased with age from 8 to 11 in the non-fearful group but was stable in the spider fearful group (experiment 1). However, a further study with spider fearful children (aged 7 to 11 years) could not replicate this finding (Morren, Kindt, van den Hout & van Kasteren, 2003).

In summary, the results with regard to the emotional Stroop task as a paradigm for investigating anxiety-linked attentional bias in children are inconsistent. Kindt et al. (1997, 2000; see also Vasey & MacLeod, 2001) postulated that younger children may lack sufficient inhibition of the threat representation to prevent it from capturing attention. In younger age, all children (regardless of anxiety level) show increased interference effects on threat-related words. During development, non-anxious children in contrast to spider fearful children seem to learn to regulate the processing of threat-related information.

Based on the assumption that the balance between activation and inhibitory control processes determines the extent of an attentional bias (Mathews & Mackintosh, 1998), the aim of our studies was to extend on these findings and investigate within the non-clinical range of anxiety in young children (aged 7 to 10 years) whether both latencies and error data may provide potential indicators of inhibitory failure (Wood, Mathews & Dalgleish, 2001). Thereby, these indicators contribute to different forms of attentional control: latencies could be particularly influenced by reflective behaviour (inhibitory control processes), and error data by impulsive behaviour (activation). Accordingly, on the original Stroop Colour and Word Test it has been shown that dysfunctional impulsivity was associated with errors, and functional impulsivity was related to speed of information processing (Brunas-Wagstaff, Bergquist & Wagstaff, 1994). Alike, in adult males errors on the Stroop test were positively correlated with impulsivity (Boyden & Gilpin, 1978).

There is reason to doubt the assumption that in young primary school children reading skills are already automatised (Schiller, 1966). Therefore, schematic facial expressions instead of words were used. Moreover, several cognitive emotion researchers have resorted to the use of emotional facial expressions as ecologically valid stimuli (e.g., van Honk, Tuiten, de Haan, van den Hout & Stam, 2001). Facial stimuli represent a particularly important class of stimuli that high trait anxious individuals seem to worry about (Eysenck & van Berkum, 1992). Thus, within the adult literature, studies using an alternative selective attention paradigm, the dot-probe task (MacLeod, Mathews & Tata, 1986), have found that heightened trait anxiety is related to increased attentional bias towards angry faces (e.g., Bradley, Mogg, Falla & Hamilton, 1998; Mansell, Clark, Ehlers & Chen, 1999; Mogg & Bradley, 1999). Additionally, from early development facial expressions represent significant information for children (e.g., Slater, 1989) and therefore threatening faces might receive priority in processing (Öhman, 1993).

In sum, the aims of the first two studies were to investigate: (1) whether non-clinical highly anxious children show a general rather than a differential processing bias towards threat faces; (2) whether this attentional interference in children will be present for colour-naming times and error data. With regard to the anxiety measure, in the first experiment, teachers' reports of children's trait anxiety were used. In the second experiment, state anxiety was assessed using children's self-reports.

Study I

Method

Subjects

A total of 92 children aged between 7 and 8 years ($M = 7.59$, $SD = 0.50$) participated in the study: 40 girls and 52 boys, 38 first graders (21 girls, 17 boys) and 54 second graders (19 girls, 35 boys). Participants were recruited from a local primary school. An outline of the study was given to the children's parents prior to testing. Only children with written parental permission on the day of testing were included in the study.

Materials

Trait anxiety rating. Trait anxiety was measured by means of the Manifest Anxiety subscale of the Anxiety Questionnaire for Pupils (AFS; Wieczerkowski, Nickel, Janowski, Fittkau & Rauer, 1981). This anxiety scale is a German adaptation and modification of the Children's Manifest Anxiety Scale (CMAS; Castaneda, McCandless & Palermo, 1956) with adequate internal consistency (Cronbachs $\alpha > .70$) and test-retest reliability ($r_{tt} > .67$) for third to ninth-grade children. The questionnaire consists of a child self-report version and a short form for teachers with items that were adapted from the self-report form. Because of the young age of the children, we decided to obtain information concerning childhood anxiety from the version administered to class teachers. The Manifest Anxiety scale form for teachers consists of five statements which describe the presence of anxiety symptoms (e.g., "The child is anxious.", "The child worries about doing something wrong."). Teachers have to rate on a seven-point scale (range 1 = not at all, 7 = all the time) the extent to which the description is true for the child.

Emotional Stroop task. Children were administered an emotional Stroop task which consisted of pictorial stimuli (see Appendix). The Stroop task was presented on four cards (A4). Two cards contained drawings of happy faces (positive stimuli) and two cards contained drawings of angry faces (negative stimuli).[2] Each card consisted of 20 pictorial stimuli. There were four different variants of angry faces and four different variants of happy faces which were each presented five times in one of four colours (red, blue, yellow, and green). Stimuli were presented on the card in four rows of five pictures. The arrangement of colours was random with the constraint that there were no immediate repetitions of any colour in either row or column.

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[2] The eight pictorial stimuli (4 negative, 4 positive) were selected from a larger sample of drawn facial expressions compiled by our research group (in the style of stickers from Zweckform, e.g., Article Number 55270). This larger sample was shown to a group of 72 first and second graders (who did not take part in the main experiment). In order to assess whether the pictorial stimuli were threat-related or not, children were asked to rate the pictorial stimuli on a 3-point scale ranging from "not at all threatening" to "very threatening". Four stimuli which were rated most threatening and four rated not at all threatening were selected for this experiment. We chose positive stimuli instead of commonly used neutral stimuli because "neutral" facial expressions have often been rated ambiguous (see Ekman & Friesen, 1978).

Procedure

Two weeks after the class teachers had completed the trait anxiety ratings, each child was tested individually in a quiet room outside the classroom.[3] Children were instructed to name aloud as fast as possible the colour of the ink in which each picture was printed, while ignoring the drawing. Colour-naming times and number of errors were taken. Timing with a stopwatch started when the first colour was named and stopped when the last colour was named. All children started with a practice card (containing ambiguous facial expressions) for which data were not collected. This practice card served also as assessment for colour-blindness. When it was clear that the children understood the task, the four experimental Stroop cards (two positive, two negative) were presented. The order of presentation was a fixed random order with always one positive and one negative stimulus card as test halves (e.g., positive card 1, negative card 1, positive card 2, negative card 2; interference time index first test half = negative card 1 – positive card 1, interference time index second test half = negative card 2 – positive card 2).

Results

Anxiety Scores

Children were given a mean trait anxiety score on the basis of the teachers' ratings (ranging from 1 "not at all" to 7 "all the time"; $M = 3.30$, $SD = 1.80$). We tried to obtain three anxiety groups with approximately 25% participants, 50% and 25%, respectively. With regard to the distribution, children were assigned to the low trait anxiety group with a score of 1 ($n = 25$; 7 girls, 18 boys), the medium trait anxiety group with a score between 2 and 4 ($n = 51$; 24 girls, 27 boys; $M = 3.59$, $SD = 0.75$), and the high trait anxiety group with a score between 5 and 7 ($n = 16$; 9 girls, 7 boys; $M = 6.00$, $SD = 0.97$). There was no significant association between anxiety group and gender, $\chi^2(2, N = 92) = 3.77, p > .15$.

Emotional Stroop Data

Analyses of variance (ANOVAs) with repeated measures were carried out separately for colour-naming times and number of errors with group (low, medium, high trait anxiety) as between-subject factor and stimulus set (positive, negative) as within-subject factor. Table I shows the mean colour-naming times in seconds and number of errors for the two stimulus sets (positive, negative) for children with low, medium, and high trait anxiety. Analysis of the mean colour-naming times[4] revealed a main effect of stimulus set, $F(1, 89) = 60.77, p < .001$, with mean latencies larger for negative ($M = 46.55$ s, $SD = 12.36$) than for positive stimuli ($M = 41.12$ s, $SD = 8.41$). There was no main effect of group, and there was no interaction between group and stimulus set.

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[3] The experimenter was blind with regard to the children's anxiety score.

[4] In order to assess the stability of the Stroop data, Pearson correlations were calculated between the colour-naming scores of the first and second test-half. The test-retest reliability was high for positive stimuli ($r = .86, p < .01$), and for negative stimuli ($r = .90, p < .01$), indicating convergence with respect to the assessment of reaction speed. More interestingly, there was moderate convergence between the first and second test halves of time indices of emotional Stroop interference ($r = .43, p < .01$). The association between interference time index and interference error index was $r = .37, p < .01$.

Table 1:
Means and Standard Deviations for Colour-Naming Times (s) and Number of Errors for Low, Medium and High Trait Anxious Children (Study I)

	Group*		
	Low Anxiety ($n = 25$)	Medium Anxiety ($n = 51$)	High Anxiety ($n = 16$)
Colour-naming times (s)			
Positive	38.56 (6.33)	42.49 (9.71)	40.75 (5.78)
Negative	43.00 (8.41)	47.75 (13.99)	48.31 (11.51)
Interference Time Index	4.44 (5.55)	5.26 (5.79)	7.56 (8.79)
Number of errors			
Positive	0.64 (0.91)	0.75 (0.89)	0.88 (0.89)
Negative	1.76 (1.79)	1.96 (1.43)	2.94 (1.53)
Interference Error Index	1.12 (1.42)	1.22 (1.10)	2.06 (1.48)

*Note: N = 92. *based on teachers' ratings (Wieczerkowski et al., 1981).*

Analysis of the number of errors produced a significant main effect of stimulus set, $F(1, 89) = 99.15$, $p < .001$. Mean error rates were higher for negative ($M = 2.08$, $SD = 1.58$) than for positive stimuli ($M = 0.74$, $SD = 0.89$). More importantly, there was a significant interaction effect between anxiety group and stimulus set, $F(2, 89) = 3.24$, $p < .05$. Highly anxious children differed from those of both medium and low anxiety in their cognitive biases for negative stimuli: They showed the highest error rate for the negative stimuli. Further analyses were performed to examine the role of gender on the emotional Stroop data. ANOVAs with repeated measures were conducted with group (low, medium, high trait anxiety) and gender as between subject factors and stimulus set (positive, negative) as within-subject factor. With regard to colour-naming times (Fs < 2.2, ps > .14) and number of errors (Fs < 1.8, ps > .18), there were no effects of gender.[5]

Discussion

All children (regardless of their trait anxiety levels) were slower in colour-naming threat-related relative to non-threatening facial expressions. However, the results of the first study showed that besides colour-naming times, error rates provide a worthwhile measure of processing bias. With regard to error rates, an anxiety-linked differential processing bias was observed. All children produced more errors on negative relative to positive material. Most important, children high in trait anxiety had the highest error rates on negative stimuli. For the emotional Stroop task, it is not common to find a Stroop effect based on error data. An exception is a study by Duka, Townshend, Collier and Stephens (2002): high alcoholic inpatients had more errors in the emotional Stroop task for negative words than low alcoholic

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[5] Additional analyses showed that the interference error index correlated significantly with trait anxiety ($r = .22$, $p < .05$). There was no significant association between the interference time index and trait anxiety ($r = .15$, *ns.*).

inpatients. Therefore, we planned a second experiment to investigate whether the finding of Study I concerning a differential threat-related processing bias for error rates in children could be replicated. In addition, the study sought to apply an improved instrument for the assessment of childhood anxiety and used children's self-reports of state anxiety.

Study II

Method

Subjects

Sixty three children (37 girls, 26 boys) aged between 7 and 10 years (M = 8.02, SD = 0.66) took part in this study.[6] Participants were recruited from three classes of year two from a local primary school. Again, an outline of the study was given to the parents of the children prior to testing. Only children with written parental permission on the day of testing were included in the study.

Materials

State anxiety rating. State anxiety during the task was measured with a short (four-point; 1 = not at all, 4 = very much so) scale containing nine items adapted from the Worry-Emotionality Questionnaire (WEQ; Morris, Davis & Hutchings, 1981). The Worry subscale consisted of six items which reflect negative preoccupation with performance (e.g., "I was afraid to make a mistake." or "I thought: I am too slow."), the Emotionality subscale contained three items which involve specific physiological and somatic reactions (e.g., "I was nervous." or "I felt my heart beating fast.").

Emotional Stroop task. The same stimulus pictures were used as in Experiment I.

Procedure

The experimental procedure was similar to the procedure of Experiment I, with one major exception. Instead of children's trait anxiety ratings by the teachers used in Study I, children's self-reports of state anxiety were obtained. The modified WEQ was administered immediately following the emotional Stroop task.

Results

Anxiety Scores

Psychometric properties of the state anxiety measure were the following: Worry subscale (6 items), M = 12.14, SD = 4.14, Cronbach's α = .73, Emotionality subscale (3 items), M = 6.52, SD = 2.30, Cronbach's α = .62. Comparable with Study I, we tried to obtain three anxiety groups (separately for the worry subscale and the emotionality subscale) with approximately 25% participants, 50% and 25%, respectively. There was no effect of gender on state anxiety scores, Fs(1, 62) < 1.69, ps > .20.

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[6] The reported data consist of a class-level-matched sub-sample of Study I of Heim-Dreger, Kohlmann, Eschenbeck & Burkhardt (2005).

Emotional Stroop Data

Descriptive statistics for mean colour-naming times and mean number of errors were the following: positive cards (time: $M = 39.80$ s, $SD = 8.99$; errors: $M = 1.02$, $SD = 1.37$), negative cards (time: $M = 39.98$ s, $SD = 8.98$; errors: $M = 1.24$, $SD = 1.83$).[7]

For colour-naming times, the only significant effect was a main effect of anxiety group (only in respect to emotionality), $F(2, 60) = 3.88$, $p < .05$, with mean latencies larger for children with high emotionality ($n = 15$, $M = 44.23$ s, $SD = 9.08$) than for children with medium ($n = 36$, $M = 39.46$ s, $SD = 7.78$) or low emotionality ($n = 12$, $M = 35.72$ s, $SD = 7.23$). There was no main effect of stimulus set, and there was no interaction between group and stimulus set. For colour-naming times there were no effects with regard to the worry subscale.

Analysis of the number of errors produced a significant main effect of anxiety group (only in respect to worry), $F(2, 60) = 3.31$, $p < .05$. Mean error rates were higher for children with high worry ($n = 17$, $M = 1.82$, $SD = 1.68$) than for children with medium ($n = 34$, $M = 0.93$, $SD = 1.24$) or low worry ($n = 12$, $M = 0.71$, $SD = 0.99$). More importantly, there was a significant interaction effect between anxiety group and stimulus set, $F(2, 60) = 3.04$, $p = .055$. Children with high worry showed more errors for negative stimuli than for positive stimuli. No differences were found for children with medium or low worry (see Figure 1). Regarding colour-naming times (Fs < 1.01, ps $> .37$) and number of errors (Fs < 2.35, ps $> .10$), there were no effects of gender.[8]

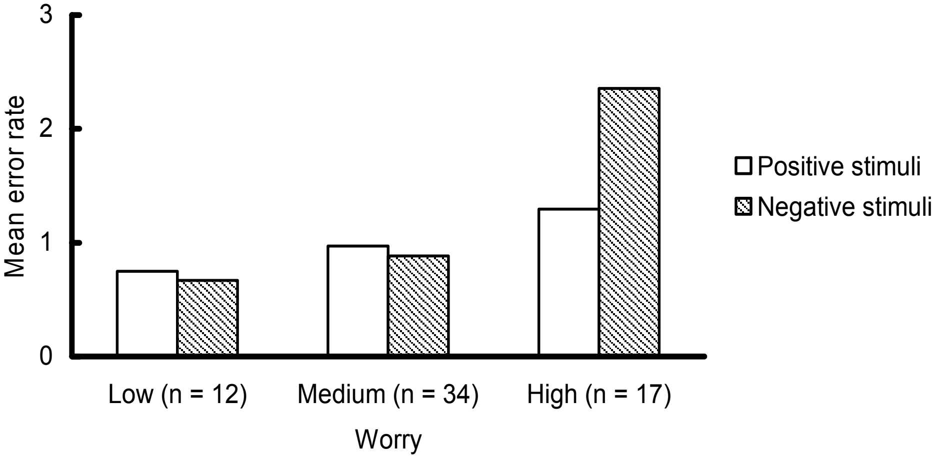

Figure 1:
Mean error rates as a function of stimulus type and self-reported worry (Study II).

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[7] The correlation between interference time index and interference error index was $r = .45$, $p < .01$.

[8] Pearson correlation coefficients computed between the state anxiety subscales and the emotional Stroop interference indices indicated that for worry positive associations could be traced with the interference error index ($r = .25$, $p < .05$) and the interference time index ($r = .29$, $p < .05$), respectively. The corresponding correlations with emotionality were insignificant (rs $< .22$, *ns.*).

Discussion

The main finding of Study II was that with regard to error rates, an anxiety-linked differential processing bias has been observed. Although children with high worry generally produced more errors in colour-naming all pictorial stimuli used, the error rate was particularly high for threat-related stimuli. This result of a differential bias for error data clearly parallels the finding of Study I. For colour-naming times, neither a general (i.e. longer naming times for negative relative to positive stimuli regardless of anxiety level) nor a differential processing bias (i.e. longer naming times for negative relative to positive stimuli in high anxious participants) was present. In general, children with high emotionality performed more poorly than children with medium or low emotionality; they were slower in colour-naming the pictorial stimuli independent of stimulus type.

The results of the present experiments indicate that with regard to the emotional Stroop task for young children, besides colour-naming times, error rates provide a worthwhile measure of processing bias. Thus, an anxiety-linked differential processing bias was apparent in both experiments when error data were analysed: non-clinical highly anxious children selectively had the highest error rates on negative stimuli. Moreover, this pattern occurred for trait anxiety and the worry component of state anxiety. For the emotional Stroop task, it is not common to systematically analyse error rates as a dependent variable (for an exception see Duka et al., 2002). Hence, in adult studies, number of errors is negligible. In contrast, studying processing bias in young children, it seems promising to explore error data in addition to latencies.

With regard to the colour-naming times, the results indicate that children experiencing high emotionality were slower overall on colour-naming performance. This effect has been interpreted as a general effect of anxiety on cognitive processing (see Williams et al., 1996). In Study II, neither a differential nor a general processing bias was present for colour-naming times (see also Morren et al., 2003). However, in Study I all children (regardless of their trait anxiety levels) were slower in colour-naming threat-related relative to non-threatening facial expressions. This result concerning a general attentional bias parallels several former Stroop studies in children with fear of spiders or medical fear (e.g., Kindt, Bierman et al., 1997; Kindt, Brosschot et al., 1997; Kindt & Brosschot, 1999). The appearance of a general processing bias in Study I but not in Study II may have been due to differences in the studied samples, with first graders only in Study I. However, first graders may have experienced higher levels of anxiety during the task or they particularly might lack the ability to inhibit the processing of threat-related information because of lower cognitive capacity (Kindt et al., 2000).

It would seem advisable for future work to learn more about underlying processes that drive children's responses in the emotional Stroop task (e.g., Kindt et al., 2000; Vasey & MacLeod, 2001). How do children distribute their processing capacity among the two Stroop task demands "to be fast" and "to be accurate"? Could both colour-naming latencies and number of errors be seen as two different albeit related indicators of processing bias in children (r = .37 in Study I, r = .45 in Study II) which involve activation or impulsive behaviour as well as inhibitory control processes as underlying cognitive processes? Which factors influence the relationship between naming times and error data? Hence, Study III was designed to examine in more detail the association between interference time index and interference error index using moderated regression analyses. Does the relationship depend on the children's age?

Study III

Method

Subjects

Two hundred twenty five children (116 girls, 109 boys) aged between 6 and 10 years ($M = 7.72$, $SD = 0.62$) took part in this study: 92 children of Study I, 63 children of Study II and an additional sample of 70 children (39 girls, 31 boys, 21 first graders, 49 second graders). Participants were recruited from local primary schools.

Emotional Stroop task and procedure

The same material was used as in Experiments I and II. The experimental procedure for the additional sample was the same as for Experiments I and II.

Results

Descriptive statistics for mean colour-naming times and mean number of errors were the following: positive cards (time: $M = 40.44$ s, $SD = 8.64$; errors: $M = 1.21$, $SD = 1.40$), negative cards (time: $M = 43.80$ s, $SD = 11.47$; errors: $M = 2.10$, $SD = 1.98$). The correlation between interference time index and interference error index was $r = .52$, $p < .001$ (see Figure 2).

To analyse moderating effects of this association, we computed a stepwise multiple regression analysis with interference error index as dependent variable. In a first step interference time index was entered as predictor. As could be expected from the zero-order correlation, the regression showed that interference error index was predicted by interference time index, $R^2 = .27$, $F(1,223) = 81.37$, $p < .001$. In step two, class level as moderator variable was included into the equation, in step three the interaction term (cross product) of interference time index and class level. There was a significant increment in explained variance from step 1 to step 2, $\Delta R^2 = .02$, $F(1,222) = 5.76$, $p < .05$, and also from step 2 to step 3, $\Delta R^2 = .02$, $F(1,221) = 5.38$, $p < .05$. The final regression equation (step 3) with interference time index ($\beta = 02$, *n.s.*), class level ($\beta = -.22$, $p < .001$) and the interaction term time index × class level ($\beta = .49$, $p < .05$) was significant, $R^2 = .30$, $F(3,221) = 32.0$, $p < .001$. Thus, the relationship between interference error index and interference time index varies over levels of the moderator variable class level. The association is stronger in second graders ($r = .56$) than in first graders ($r = .35$).

Discussion

Comparable with Studies I and II, Study III provides evidence for a positive association between interference time index and interference error index. This correlation clearly depends on children's class level: compared to second graders, in first graders interference time index is less strongly related to interference error index. Thus, at least in young children both colour-naming times as well as error data may provide different indicators of processing bias. At this point, it seems possible to characterize error data as potential indicators of impaired inhibitory processing (see Wood et al., 2001) or cognitive impulsive processes (see Brunas-Wagstaff et al., 1994) which must be confirmed by future research.

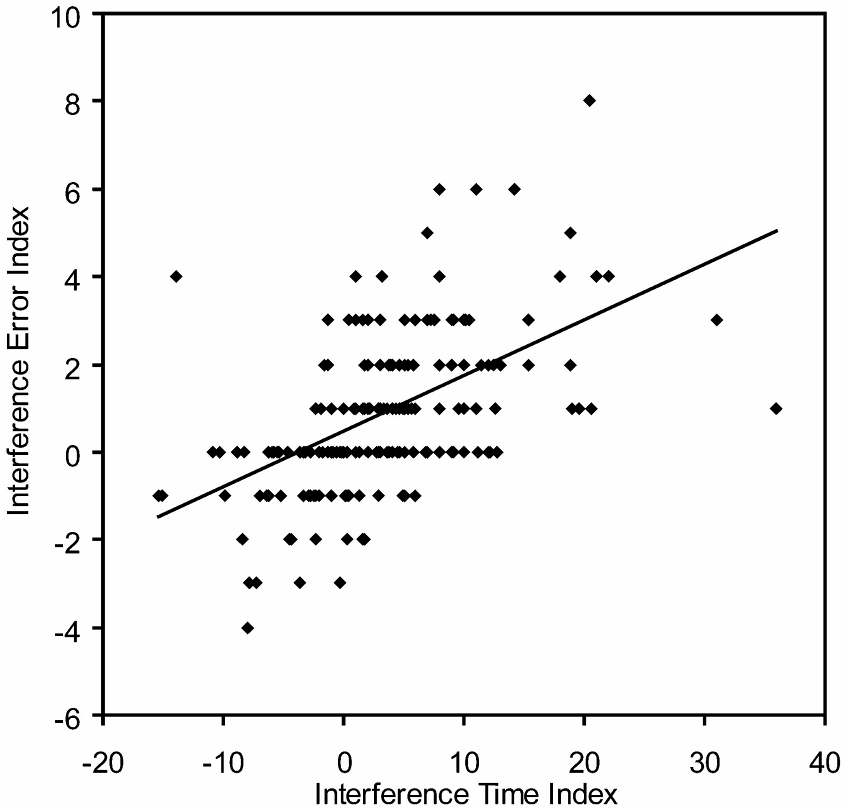

Figure 2:
Interference error index as a function of interference time index
(y = 0.465 + 0.127 interference time index; Study III, *N* = 225).

General discussion

The studies described here provide considerable evidence for the usefulness of exploring error data in addition to colour-naming times as dependent variables in the emotional Stroop colour-naming task. In Study I, high trait anxious children selectively had the highest error rates on threatening stimuli. Alike, in Study II, state anxiety (worry) was associated with a differential bias for threat-related error rates. Both colour-naming times and error data share substantial common variance (Study III). Nevertheless, to some extent, both indices may have different underlying cognitive processes such as reflective behaviour and inhibitory control or impulsive processes. Thereby, this association varies over different class levels probably reflecting a different development status. Future research might explore further moderator variables (e.g., cognitive capacity) of the association between interference time index and interference error index.

As proposed by Williams et al. (1997) emotional Stroop interference is best accounted for by an interaction of trait and state anxiety: for individuals high in trait anxiety, state anxiety and Stroop interference are positively correlated (see Egloff & Hock, 2001). Since we either included a trait measure or a state measure in our studies, it is not possible to further examine this hypothesis. In future studies, both trait and state measures of childhood anxiety could be used. Additionally, general trait anxiety as well as more specific social anxiety could be assessed by asking multiple reporters (e.g., child, teachers, and parents).

Although preliminary, the results of the present experiments clearly support the use of pictorial stimuli when studying information processing bias in children. This view fits well with findings in adults (Kindt & Brosschot, 1997; Lavy & van den Hout, 1993). In contrast, in children two former emotional Stroop studies have failed to demonstrate any effects with regard to anxiety (Kindt & Brosschot, 1999; Kindt et al., 2000). One possible explanation for the observed difference is that from early development, faces (unlike pictures of spiders used in earlier Stroop studies) represent significant information for children (e.g., Slater, 1989) and when associated with threat might receive processing priority (Williams et al., 1996). Future studies could further optimise the pictorial stimuli to be as ecologically valid as possible (e.g., using photographs of faces, Eschenbeck, 2003). It should be noted that in the present experiments positive stimuli instead of neutral stimuli were used. Emotional Stroop effects can be attributed to the match with the individual's current emotional concerns. Therefore, interference effects can occur with positive as well as with negative material (e.g., Mathews & Klug, 1993; Riemann & McNally, 1995). The results of the present studies indicate that the threat content of the negative facial expressions was able to produce Stroop interference. However, future studies could further explore attentional bias in children adding a third stimulus category with neutral material which is unrelated to perceived threat or current concerns.

It is interesting to note that anxiety scores did not differ with regard to gender. Moreover, both girls and boys showed similar attentional processing biases. In children only few studies have considered gender differences in cognitive bias, and they obtained mixed results. Kindt, Brosschot et al. (1997) found that girls, as opposed to boys, showed threat-related attentional biases. But this pattern could only be revealed in the neutral situation. However, similar to the present studies, three studies found no evidence of gender differences in cognitive bias (Kindt, Bierman et al., 1997; Kindt, Brosschot et al., 1997; Martin & Jones, 1995).

Following Vasey and Lonigan (2000), it seems worthwhile to improve the utility of performance-based measures (e.g., measures of information-processing biases) to enhance the assessment of childhood anxiety. Before trying to establish the emotional Stroop task as a diagnostic instrument for assessing individual interference as an individual's anxiety status, it is absolutely essential to evaluate the psychometric properties of the emotional Stroop interference score itself. Future research could further explore potential methodological influences on the Stroop task (e.g., different versions of the Stroop task, see Kindt et al., 1996; Kindt, Bierman et al., 1997; differences with regard to the stimuli, see Eschenbeck, 2003; Kindt & Brosschot, 1999; Kindt et al., 2000) in non-clinical samples of children.

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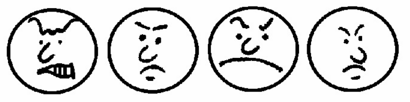
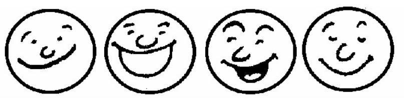
Appendix

Stimuli used in the Stroop colour-naming task: Negative and positive facial expressions





Note: The diameter of the stimuli was 3.5 cm. Each stimulus was presented five times in one of four colours (red, blue, yellow, and green).