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Inter-relations and prediction of behavior

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Biases in attention, interpretation, memory, and associations in children with varying levels of spider fear: Inter-relations and prediction of behavior

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ABSTRACT

Background and Objectives: Cognitive theories suggest that cognitive biases may be related and together influence the anxiety response. However, little is known about the interrelations of cognitive bias tasks and whether they allow for an improved prediction of fear-related behavior in addition to self-reports. This study simultaneously addressed several types of cognitive biases in children, to investigate attention bias, interpretation bias, memory bias and fear-related associations, their interrelations and the prediction of behavior.
Methods: Eighty-one children varying in their levels of spider fear completed the Spider Anxiety and Disgust Screening for Children and performed two Emotional Stroop tasks, a Free Recall task, an interpretation task including size and distance indication, an Affective Priming Task, and a Behavioral Assessment Test.
Results: We found an attention bias, interpretation bias, and fear-related associations, but no evidence for a memory bias. The biases showed little overlap. Attention bias, interpretation bias, and fear-related associations predicted unique variance in avoidance of spiders. Interpretation bias and fear-related associations remained significant predictors, even when self-reported fear was included as a predictor.
Limitations: Children were not seeking help for their spider fear and were not tested on clinical levels of spider phobia.
Conclusions: This is the first study to find evidence that different cognitive biases each predict unique variance in avoidance behavior. Furthermore, it is also the first study in which we found evidence for a relation between fear of spiders and size and distance indication. We showed that this bias is distinct from other cognitive biases.

Cognitive theories of fear and anxiety emphasize the importance of cognitive processes in the onset and maintenance of anxiety disorders. According to these theories, fearful adults and children have anxiety-related associations and schemata that direct processing resources towards threat-relevant information, resulting in cognitive biases in attention, interpretation, and memory (e.g., Daleiden & Vasey, 1997; Muris & Field, 2008; Williams, Watts, MacLeod, & Mathews, 1997; for a schema-based theory of childhood anxiety, see; Kendall & Ronan, 1990). These fear-related associations, attention, interpretation and memory processes are believed to be related to each other (Williams et al., 1997), and some theoretical models suggest that they also influence each other in order to elicit an anxiety response (e.g., Daleiden & Vasey, 1997; Hirsch, Clark, & Mathews, 2006; Muris & Field, 2008; Weems & Watts, 2005).

Research with fearful children has indeed provided evidence of biases in attention and interpretation in childhood anxiety, but the evidence for memory biases and fear-related associations in childhood anxiety is mixed (for an overview see, Hadwin & Field, 2010). Most studies report that children with higher levels of fear

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have the tendency to quickly focus attention on stimuli that are associated with fear and threat, and that they find it difficult to disengage attention from these stimuli (attention bias; for a meta-analysis see Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van Ijzendoorn, 2007). Studies regarding interpretation biases often find that fearful children interpret ambiguous situations more negatively than non-fearful children (interpretation bias; Muris, 2010). The findings concerning memory biases show a rather mixed picture; some studies find evidence that fearful children remember more negative stimuli than non-fearful children (e.g., Watts & Weems, 2006), but other studies find no differences between fearful and non-fearful children (Dalgleish et al., 2003). Finally, there are only a few studies that have explored differences in associations between fearful and non-fearful children. Almost all studies found no evidence for the existence of fear-related associations (Huijding, Wiers, & Field, 2010). The only study that did find a difference between fearful-and non-fearful children unexpectedly found that fearful children showed fewer fear-related associations (Klein et al., 2012).

Even though there are many studies that have examined cognitive biases in children using different tasks, there are only few studies that addressed different biases simultaneously in children, and the evidence for significant overlap is rather weak and inconsistent (e.g., Broeren, Muris, Bouwmeester, Field, & Voerman, 2011; Klein et al., 2014,2012; Richards, French, Nash, Hadwin, & Donnelly, 2007; Weems, Costa, Watts, Taylor, & Cannon, 2007; Watts & Weems, 2006). Furthermore, none of these studies included attention, interpretation, memory *and* fear-related associations in a single trial. Finally, some of these studies found some evidence for the ability of the different cognitive biases to predict unique variance in fear, indicating that the different biases might measure separate aspects of fear (e.g., Klein et al., 2014,2012; Watts & Weems, 2006). Several authors have expressed the need for more research on the relation between cognitive biases (e.g., Hirsch et al., 2006; Muris & Field, 2008; Weems & Watts, 2005). Knowing more about how cognitive biases persist and interact with each other could have important implications for the identification, prevention, and treatment of anxiety in children.

Therefore, the main goal of this study was to investigate attention, interpretation and memory biases and fear-related associations, their relation, and their ability to uniquely predict spider fear in a sample of children with varying levels of spider fear. We chose to study fear of spiders for several reasons. First, specific fears such as fear of spiders are highly prevalent in children (Strauss & Last, 1993). Second, normative fears such as fear of spiders are often used as a model for studying the development of other fears, because several studies suggest that the underlying processes of fear are similar (Williams et al., 1997). Third, unlike other fears and anxieties, there are good behavioral tasks designed to measure behavior related to fear of spiders. Finally, we wanted this study to be comparable to the studies by Klein, Becker, and Rinck (2011), Klein et al. (2012) for the purposes of replication. Both studies (Klein et al., 2011,2012) explored attention bias in children with varying levels of spider fear, and Klein et al. (2012) also included an Affective Priming Task (APT) to study fear-related associations. Both studies found evidence for an attention bias, and Klein et al. (2012) also found differences between fearful and non-fearful children on the APT. Furthermore, the indirect measures used in both studies were able to explain unique variance in fear-related behavior.

Based on theoretical conceptualizations (Williams et al., 1997) and previous findings (for an overview, see Hadwin & Field, 2010), we hypothesized that children with high levels of spider fear on the self-report and behavioral measures would display biases in attention and interpretation. We had no definite hypothesis for either the relation between spider fear, memory bias and fear-related associations or the interrelations between the different measures, because of the few studies showing mixed results (see Hadwin & Field, 2010). However, we did expect that two tasks that measure the same construct should correlate with each other. Finally, based on previous results from our own laboratory (Klein et al., 2014,2012) and from Weems and Watts (2005), we expected that the different cognitive biases would not only predict unique variance in spider fear-related behavior but would also predict variance above and beyond self-reported spider fear.

1. Methods

1.1. Participants

The current study was part of a large community-based project on childhood anxiety. After parental consent had been granted, a total of 718 children were screened on anxiety in their regular classroom environment. Approximately two months after initial screening, 95 children were invited to participate in this study. The children who participated in this study also participated in another study about social anxiety and were therefore pre-selected on levels of social anxiety. The data of 14 participants were excluded from the dataset, due to technical problems with the recording of the responses on the different tasks. As a result, the data of 81 children (26 boys; 32%) between the ages of 8 and 13 ($M = 10.2$, $SD = 1.1$) were used in the analyses.

An ANOVA with a homogeneity test revealed that this selection did not influence the variance in levels of spider fear as measured with the SADS-C, $F(1{,}703) = 1.34$, *n.s.* Children who participated in this study had slightly, but significantly higher scores on the SADS-C than the children in the screening, $F(1{,}703) = 7.37$, $p = .007$, $eta^2 = .01$ (this study: $M = 2.70$, $SD = 1.30$; Screening: $M = 2.36$, $SD = 1.19$). Correlations between the SCARED social anxiety subscale (Bodden, Bögels, & Muris, 2009) and the SADS-C were comparable for the 718 children in the screening ($r = .25$, $p < .001$) and the 81 children of this study ($r = .21$, $p = .066$). The current sample partly overlapped with the sample in the study to validate the Auditory Interpretation Task (Klein, Bakens et al., 2016), and a study on the specificity of interpretation biases (Klein, Flokstra et al., 2016). The Ethical Committee of the Behavioural Science Institute of Radboud University Nijmegen, the Netherlands, approved this study.

1.2. Instruments

1.2.1. Emotional Stroop Task (EST)

The EST was used as a measure of distraction: We were interested in how the meaning of the stimuli catches attention and slows down performance in the color-naming task (for a discussion of the EST, see Nightingale, Field, & Kindt, 2010). Two different versions of the EST were used in this study; a pictorial version and a word version. The pictorial version was identical to the task used by Klein et al. (2011) and consisted of three different categories; shapes of spiders, butterflies or wheels. The word version consisted of four different categories with each category including four words related to spiders (e.g. hairy), social situations (e.g. shame), happiness (e.g. happy), or general fear (e.g. worry). Both tasks were presented in a 'card format', so that identical shapes (EST-picture) or words (EST-word) of each category were presented at once on a computer screen. In Total, each 'card' consisted of 24 stimuli presented in the four different colors (green, blue, red, yellow). Following a practice card, the experimental 'cards' were shown in random order. For each 'card', the children were instructed to name the different colors as quickly as possible without making errors. As soon as the child named all colors, the experimenter pushed the space bar again and the card disappeared. During the task, the experimenter recorded all color naming mistakes, while the time between appearance and disappearance of each card was measured automatically and served as the dependent variable.

1.2.2. Affective priming task (APT)

We used the APT as a measure of fear-related associations. Despite the few studies that are reported in children, and the fact that is a reaction-time-based paradigm, Huijding et al. (2010) concluded that the APT is a task that promises to provide a good indirect measure of fear-related associations in children. The APT used in this study was very similar to the APT used by Klein et al. (2012). The APT is a task in which associations between prime stimuli and target stimuli are examined. The target stimuli were pictures of six faces of children (three boys, three girls) who looked either happy or fearful. These pictures had to be evaluated as either positive or negative as quickly as possible by pressing either the happy key (marked with a smile symbol) or the fearful key (marked with a fearful symbol). The key positions were counterbalanced across the sample and the pictures of the faces were shown in random order. Before each target stimulus, a prime stimulus word was presented. The prime words (three per category) were related to four different categories: negative feelings, happiness, spiders, and general fear words. Two sets of words were created, and each child was assigned to one of the sets (see Appendix 1 for all stimulus words). The prime words were presented for 1000 ms, after which the target faces were presented until the children reacted by pressing a key. The time between the presentation of the target face and the reaction was measured. The children were instructed to first look at a cross that was presented in the middle of the screen, because this would be the place where the prime appeared. When the prime appeared on the screen, the children were asked to look at the prime, but to ignore this prime when categorizing the subsequent target stimulus into negative or positive. All four prime categories were fully combined with the two target categories, yielding 8 combinations, each of which was presented 18 times. In total, the children categorized 144 faces, which were divided into three blocks of 48 trials each. The children took self-paced breaks between the blocks. Internal consistency for the different categories in this study ranged between alpha .57 and .82. Test-retest reliability for the Reaction Times between the three blocks was good (block 1 versus block 2: $r = .77$, $p < .001$; block 1 versus block 3: $r = .76$, $p < .001$; block 2 versus block 3: $r = .90$, $p < .001$). Test-retest reliability for the priming scores were near zero and non-significant ($rs = -.10$ to .19). Directly following the 144 trials, the children were asked to recall as many prime words as they could remember. The total number of correctly recalled words related to spiders versus the happiness related words was used as an indication of *memory bias*.

1.2.3. Spider Anxiety and Disgust Screening for Children (SADS-C)

The SADS-C is a self-report questionnaire that measures responses to four spider-related statements on a 5-point scale (Klein, van Niekerk, Baartmans, Rinck, & Becker, in press). The four statements address fear of spiders, physical reactions, avoidance, and disgust. Internal consistency and test-retest reliability are strong ($\alpha = .88$, $r = .91$; Klein et al., in press). In this study, internal consistency was excellent ($\alpha = .90$).

1.2.4. Behavioral avoidance test (BAT)

This task was used to assess the children's avoidance behavior when confronted with a tarantula skin, which children believed to be a real, living spider. The task was identical to the BAT described by Klein et al. (2011). BAT performance was scored on a scale ranging from zero (no approach) to 8 (touching the spider skin). Right before the child was asked to approach the spider, the child was asked to indicate the size of the spider and the distance towards the spider as an indication of perceptual bias. As this task includes perception of something that the participant does not know precisely, this estimation might be affected by their interpretation of the situation. This task could therefore be seen as an indirect measure of *interpretation bias*, which assesses interpretation in a more indirect way than the most commonly used scenarios task (see also Vasey et al., 2012). Interpretation bias is often measured by means of a questionnaire or an ambiguous scenarios paradigm (see Muris, 2010). Disadvantages of these measurements are that they are sensitive to experimenter demand and social desirability, and that they are sometimes time consuming. We therefore decided to follow a new procedure used by Vasey et al. (2012), in which they simply asked spider phobic adults to indicate the size of the spider from the tips of its front legs to the tips of its back legs. The children in this study were asked to point the estimated size on a ruler of 30 cm. The spider skin itself was approximately 12 cm long. Additionally, we also asked the child to estimate the distance between themselves and the spider with the means of a white cord with small red tapes for every 50 cm and a big red tap for every meter. The child was of course unaware of the fact that he/she was exactly three meters away from the spider. The experimenter was unaware of the child's level of spider fear during administration of the BAT.

1.3. Procedure

The testing was divided into two sessions. In the first session, the children performed the word version of the EST followed by the APT and the spider BAT individually, accompanied by a trained research assistant. In the second session, the children performed the pictorial version of the EST followed by the SADS-C individually, again accompanied by the trained research assistant. We chose this order because of the necessity to measure reliable reaction times during the EST and the APT, given a limited attention span in children. The children were free to refuse the tasks and could stop at any time. The children received a certificate for participating.

2. Results

2.1. Descriptives

2.1.1. Emotional Stroop tasks (EST)

The overall number of mistakes was low, for both the EST-picture (0.8%) and the EST-word (0.5%). From the EST-picture card RTs and the EST-word card RTs, two relative scores related to spiders were computed; that is, the EST-picture score (RT-Spider minus RT-Neutral) and the EST-word score (RT-Spider minus RT-Neutral). Higher scores indicate larger distraction by the spider category. Two one-sample *t*-tests revealed that children did not show significant distraction specifically related to spiders in the word version, $t\,(80) = 1.7$, $p > .1$, or the pictorial version, although the latter approached significance, $t\,(80) = 1.9$, $p = .064$. There were no significant correlations between age and Stroop scores (EST-picture: $r = .04$, $p > .1$; EST-word: $r = -.14$, $p > .1$), nor were there effects of gender (EST-picture: $F\,(1,79) < 0.1$, $p > .1$; EST-word: $F\,(1,79) = 0.35$, $p > .1$).

2.1.2. Size and distance estimation

The mean estimated size of the spider was 10.4 cm ($SD = 3.4$; min = 3.0 cm, max = 21 cm). The mean estimated distance from the spider was 2.9 m ($SD = 0.75$; min = 1.8 m, max = 5.0 m). Bivariate correlations indicated that there was neither a significant correlation between age and estimated spider size ($r = .07$, $p > .1$) nor was there a significant correlation between age and estimated distance ($r = .06$, $p > .1$). There was a significant gender difference for the estimated spider size, $F(1,79) = 4.79$, $p = .032$, girls ($M = 10.9$; $SD = 3.4$) estimated the spider as being larger than boys did ($M = 9.2$; $SD = 3.2$). There was no gender difference for the estimated distance from the spider, $F(1,79) = 0.95$, $p > .1$.

2.1.3. Memory task

From the number of remembered items, a relative memory score related to spiders was calculated for each child: the mean number of remembered spider-related words was subtracted from the mean positive-related remembered words. A one-sample *t*-test revealed that children did remember significantly more spider-related words than positive-related words, $t(80) = 3.42$, $p = .001$. There was neither a significant correlation between age and the number of remembered items ($r = -.01$, $p > .1$), nor was there an effect of gender, $F(1,79) = 1.24$, $p > .1$.

2.1.4. Affective priming task (APT)

The average number of mistakes was 4.2%. From the RTs, a relative priming score related to spiders was calculated for each child: The mean negative target RT was subtracted from the mean positive target RT. Positive scores indicate that the spider primes pre-activate fearful faces more than smiling faces, and vice versa for negative scores. A one-sample *t*-test revealed that the spider priming score did not differ significantly from 0, $t(80) = 1.18$, $p > .1$. Thus, on average, the children did not show negative associations related to spider words. There was neither a significant correlation between age and the priming score (r = −.0,1 $p > .1$), nor was there an effect of gender, $F(1,79) = 2.66$, $p > .1$.

2.1.5. SADS-C questionnaire

The mean score on the SADS-C was 2.5 ($SD = 1.1$; min = 1, max = 4.4). There was neither a significant correlation between age and self-reported spider fear ($r = .07$, $p > .1$), nor was there an effect of gender, $F(1,79) < 0.1$, $p > .1$.

2.1.6. Behavioral Assessment Test (BAT)

The children's mean BAT score was 5.6 ($SD = 2.1$; min = 0, max = 8). There was neither a significant correlation between age and BAT score ($r = .15$, $p > .1$), nor was there an effect of gender, $F(1,79) < 0.1$, $p > .1$.

2.2. Correlations

As expected, children who reported more fear of spiders approached the spider less closely $r = -.45$ ($p < .001$). We also found an *attention bias*; both the EST-picture score and the EST-word score correlated significantly with self-reported fear of spiders (EST-picture: $r = .24$, $p = .015$; EST-word $r = .31$, $p = .003$) and with the BAT (EST-picture: $r = -.23$, $p = .021$; EST-word $r = -.26$, $p = .012$). We also found evidence for an *interpretation bias*; children who estimated the spider as being larger reported higher levels of spider fear ($r = .38$, $p < .001$), but they did not approach the spider less closely ($r = -.07$, $p > .1$) than children who estimated the spider as being smaller. On the other hand, children who estimated the spider as being closer, avoided the spider more on the BAT ($r = .30$, $p = .004$), but these children did not report more fear of spiders ($r = .005$, $p > .1$). There was no evidence for a *memory bias*; the number of relative recalled items related to spiders was unrelated to SADS-C scores ($r = .12$, $p > .1$) or BAT scores ($r = -.05$, $p > .1$). Finally, children with stronger *fear-related spider associations* avoided the spider significantly more ($r = -.28$, $p = .006$), but they did not report more fear of spiders ($r = .13$, $p > .1$) than children with more positive spider-associations (see Table 1).

Table 1
Correlations between SADS-C, BAT, and bias measures, controlled for gender ($n = 81$).

	SADS-C	BAT	EST-pic	EST-word	Size	Distance	APT
SADS-C							
BAT	-.45**						
EST-pic	.24*	-.23*					
EST-word	.31*	-.26*	.46**				
Size	.38**	-.07	-.07	.26*			
Distance	.005	.30*	-.11	-.18[a]	.04		
APT	.13	-.28*	.34*	.01	.09	-.09	
Memory	.12	-.05	.12	.10	.13	-.004	.07

[a] $p < .01$ one-tailed, *$p < .05$ one-tailed, **$p < .001$ one-tailed.

Next, we correlated all bias scores with each other. As expected, children with a high spider distraction score on the EST-picture also had a higher score on the EST-word, $r = .46$ ($p < .001$). The EST-picture also correlated significantly with fear-related associations, $r = .34$ ($p = .001$), indicating that children with more distraction on the pictorial version of the Stroop also displayed more fear-related associations on the APT. Furthermore, the EST-word correlated significantly with the spider-size estimation $r = .26$ ($p = .011$), meaning that children with an attention bias, also estimated the spider as being larger. Finally, the word version of the Stroop also correlated marginally significant with spider-distance estimation, $r = -.18$ ($p = .050$), suggesting that children who displayed an attention bias had the tendency to estimate the spider as being closer by. All other scores were unrelated to each other (see Table 1).

2.3. Regression analysis

To test whether the different cognitive biases explained unique variance in fear-related behavior measured by the BAT, we performed a regression analysis with BAT scores as the criterion. The bias scores were entered as predictors; APT spider priming scores, size estimations, distance estimations and recall scores. Furthermore, we also included a weighted *z*-score based on the EST-picture score and the EST-word score to avoid collinearity. As expected, the model was significant, and explained 19% of the variance in BAT behavior, $F(5,75) = 3.52$, $p = .007$. APT spider priming scores, spider attention bias scores, and spider distance scores were significant predictors. Thus, fear-related spider associations, attention bias, and interpretation bias (distance estimation) predicted unique variance in fear-related behavior on the BAT (see Table 2).

Next, we repeated this analysis, but we now included SADS-C scores in the first step, before entering all bias scores in the second step. After the first step, the model was significant $F(1,79) = 19.60$, $p < .001$, and explained 20% of the variance in BAT behavior. After the second step $F(6,74) = 6.56$, $p < .001$, the model also reached significance, and explained 35% of the variance in BAT behavior. This second model was also significantly better than the first model $F(5,74) = 3.36$, $p = .009$. For this second model, SADS-C scores, APT spider priming scores, and spider distance estimates were significant predictors. Thus, fear-related spider-associations and interpretation bias (distance estimation) each predicted unique variance in fear-related behavior on the BAT, above and beyond self-reported fear (see Table 2).

3. Discussion

This study is the first to combine attention bias, interpretation bias, memory bias, and fear-related associations, to examine their inter-relations and to test the independent ability of these biases to predict avoidance of spiders in children. The first goal of this study

Table 2
Hierarchical regression analyses predicting BAT scores ($n = 81$).

Regression 1 with bias measures only			
Criterion variable	R^2	Predictor	β
BAT-score			
	.19*		
		EST	-.20*
		Size	-.02
		Distance	.25*
		APT	-.21*
		Memory	.007

Regression 2 with self-reported fear and bias measures					
Criterion variable	Step	R^2	R^2 change	Predictor	β
BAT-score					
	1	.20**			
				SADS-C	-.45**
	2	.35**	.15*		
				SADS-C	-.45**
				EST	-.07
				Size	.14
				Distance	.28*
				APT	-.19*
				Memory	.01

*$p < .05$ one-tailed, **$p < .001$ one-tailed, standardized β coefficients are reported.

was to replicate the findings of the current study to earlier studies by Klein et al. (2011, 2012). Consistent with our earlier results, we found that spider-fearful children displayed both attention bias and fear-related associations and that these biases predicted unique variance in behavioral avoidance of spiders. Furthermore, in line with findings from the broader childhood anxiety literature, spider-fearful children, just like children with other anxieties, show an interpretation bias for threatening information (e.g., Muris, 2010). These findings support the importance of attention biases, interpretation biases and fear-related associations in anxiety (for an overview see, Hadwin & Field, 2010). To our knowledge, this is the first study in which we found evidence for a relation between fear of spiders and size and distance estimation; spider fearful children indicated the spider as being larger and closer by than non-fearful children. Furthermore, we also showed that this bias is distinct from other cognitive processes. Spider distance estimation predicted unique variance in behavioral avoidance above and beyond the variance predicted by other cognitive bias measures and self-reported fear. This suggests that this variation of measuring interpretation bias, which is also referred to as a (visual) perceptual bias, is a unique bias in explaining fearful behavior. Furthermore, it also suggests that more indirect measures of interpretation bias correlate significantly with spider fear measures. This result is in line with the findings in adult anxiety (Vasey et al., 2012), namely that spider-fearful adults have a tendency to overestimate the size of a spider. The children in this study also underestimated their distance from the spider, which is in line with results found in height phobia where a link between overestimation of heights and fear of heights was observed (e.g., Teachman, Stefanucci, Clerkin, Cody, & Proffitt, 2008). Aside from finding attention, interpretation, and association biases, we did not find support for a memory bias. We found that *all* children remembered more spider-related words compared to positive-related words and this memory effect was not related to spider fear. This non-significant correlation between memory bias and fear is in line with most studies (see, Coles & Heimberg, 2002), although there are also a few studies that have found evidence for a memory bias (e.g., Klein et al., 2014).

The second goal of this study was to explore relations between different biases and to explore the ability of these biases to predict spider fear behavior, above and beyond self-reported fear. The results showed that the different biases correlated only weakly with each other, but that attention, interpretation and fear-related associations predicted unique variance in fear-related behavior in the BAT. These results indicate that, despite their minimal overlap, attention and interpretation biases and fear-related associations are all important processes in explaining fearful behavior. Furthermore, when we included self-reported fear as a predictor in the regression model, both interpretation bias and fear-related associations remained significant predictors of avoidance behavior. These results are in line with our hypotheses and with previous studies of child and adult anxiety (Klein et al., 2012, 2011; Rinck & Becker, 2007; Watts & Weems, 2006) and supports cognitive models of childhood anxiety (Muris & Field, 2008; Weems & Watts, 2005). Our finding suggests that both these cognitive biases are useful for predicting fear-related behavior in children, independently of each other, and over and above the predictive power achieved by self-reports. The findings underline the importance of automatic processes in fear-related behavior and support the use of indirect measures in research settings.

Interestingly, we did not find significant correlations between some of the indirect measures and self-reported fear in the SADS-C or with behavioral avoidance in the BAT. For example, priming effects in the Affective Priming Task correlated significantly with behavioral avoidance, but not with self-reported fear. Correlations between direct and indirect measures have indeed been found in previous (adult) research (e.g., Teachman & Woody, 2003), but results similar to ours have also been reported (e.g., Egloff & Schmukle, 2002; Klein et al., 2012). These results are in line with several dual-process models (e.g., Beck & Clark, 1997; Strack & Deutsch, 2004): They indicate that self-reports and indirect tasks may measure different processes, which are not necessarily closely related to each other (see also Huijding & de Jong, 2006; Klein et al., 2011). Self-reports may reflect more controlled processes while many cognitive processes are more automatic and not open to introspection and self-report (see also Bijttebier, Vasey, & Braet, 2003). The lack of relation between direct and indirect measures may also explain why some earlier studies did not find stronger fear-related associations in children with high levels of self-reported fear (see also Huijding & de Jong, 2006; Klein et al., 2011).

Another finding that needs clarification is the fact that some of the indirect measures did and some of the measures did not correlate significantly with each other. For example, fear-related associations in the word-based Affective Priming Task correlated significantly with attention bias in the picture-version of the Emotional Stroop Task, but not in the word-version, although the latter employed partly the same words as the Affective Priming Task. We could not find a specific pattern in the correlations of the different measures, except for the significant correlation between the pictorial version and the word version of the Emotional Stroop Task, which are similar tasks measuring the same construct. Although the different tasks supposedly tap distinct automatic processes, these processes are thought to interact at certain points. It is therefore expected that the measures will not correlate highly with each other, but should show some overlap. This null finding is in line with several other studies that failed to find significant correlations between different cognitive biases (Klein et al., 2014,2012; Watts & Weems, 2006). There are also several studies in adult anxiety that only found limited evidence for the overlap of different cognitive biases (e.g., Van Bockstaele et al., 2011). The lack of correlations between indirect measures might be explained by insufficient reliability of these measures (Bosson, Swann, & Pennebaker, 2000; Brown et al., 2014). Furthermore, different task characteristics of the Affective Priming Task, the Emotional Stroop Task, and the interpretation task may also be a reason why the tasks did not correlate with each other (e.g., words versus pictures and reaction times versus free responses; see also De Houwer, 2003). Perhaps if the processing biases had been assessed with the same task (e.g., where participants have to make sense of a particular situation), biases in attention, interpretation, and memory, and the activated associations might be more strongly correlated. For example, Everaert, Duyck, and Koster (2014) studied multiple cognitive biases in adult depression and found that attention bias during a scrambled-sentences task predicted interpretation bias in the task, and later memory bias for the meaning of the sentences. Unfortunately, as yet, there are virtually no tasks that are designed to capture multiple biases in children. Cleary more studies are needed that include a task that is able to capture several processes simultaneously. Alternatively, one might speculate that fear-related associations, threat distraction and biased perception are simply not as closely related to each other as one might expect (see also Van Bockstaele et al., 2011; Watts & Weems, 2006). Clearly new theory and research on this topic is needed, using more reliable tasks, and different samples including children with different fears and anxieties.

Regarding the relation between fear-related associations and fear-related behavior, in the present study we found the expected priming effect: The more children avoided the spider during the BAT, the more quickly they responded to fear-congruent compared to fear-incongruent trials of the Affective Priming Task. This result is in line with adult studies (e.g., Reinecke, Becker, & Rinck, 2010) but contrasts with the only other study that has found fear-related associations in children with the Affective Priming Task, because that study found a reversed priming effect, that is, the more children avoided the during the BAT, the more quickly they responded to fear-incongruent than to fear-congruent trials (Klein et al., 2012). There are various theoretical models explaining priming effects (Fazio, Sanbonmatsu, Powell, & Kardes, 1986; Hermans, De Houwer, & Eelen, 2001), but also models explaining reversed priming effects (Glaser & Banaji, 1999; Hermans, Spruyt, De Houwer, & Eelen, 2003; Maier, Berner, & Pekrun, 2003; Wentura & Rothermund, 2003). These differences might be due to low reliability of the priming scores of the APT in this study, which is often found in reaction time paradigms in children (see also Brown et al., 2014). However, the fact that we found a significant relation between the APT and behavioral avoidance speaks against this argument. Clearly, more research is needed to further explore the reliability of the Affective Priming Task in child samples and the interaction between priming effects, anxiety, and avoidant behavior in children.

The current study has several limitations. First, the 95 children in the current sample were preselected from 718 children. Even though this subgroup of 95 children was comparable to the original 718 children, many more children were invited to participate in this first screening. We did not register how many children were originally invited, and a response bias could thus have influenced the composition of the sample. Additionally, we did not collect demographic data. Furthermore, due to a relatively low number of children, we only had enough power to test our hypotheses for the stimuli that were specifically related to spiders. As a result, it is not clear whether the results are specific to spider fear or reflect a more general negative bias. Finally, even though we found evidence for several cognitive biases, we did not include a clinical sample in our study. In future research, we recommend larger samples and inclusion of clinical participants, to be able to compare spider-specific stimuli to general stimuli in the different tasks, and to see whether the results generalize to children with an anxiety diagnosis.

Based on our findings, we recommend using both direct and indirect measures in research settings, because they seem to tap into distinct processes which complement each other in the prediction of fearful behavior. Moreover, both types of measures have specific advantages and disadvantages. Direct measures are usually fast, easy and reliable, but also more sensitive to experimenter demand, social desirability, and limited self-awareness (e.g., Bijttebier et al., 2003). Indirect measures may provide a clearer picture of the underlying cognitive processes, but they are frequently less reliable than direct measures because they usually require the measurement of reaction times. This measurement may be especially difficult in child samples because young children are generally more easily distracted and have relatively short attention spans, which may render the measurement of reaction times less reliable (Huijding et al., 2010). This is one of the reasons for our choice of "card" versions of the Emotional Stroop Task, rather than a version in which latencies of reactions to single stimuli are measured (see also Klein et al., 2011). We further recommend the simultaneous use of different indirect measures, as it seems that fearful children differ from other children with respect to several cognitive processes (see also Watts & Weems, 2006; Weems & Watts, 2005). Here, we found evidence of differences in attention, interpretation and associations. This study was limited to fear of spiders, and we recommend the study of other types of fears and anxieties as well.

In summation, we found that the current versions of the Emotional Stroop Task (attention bias), the estimation of distance from a spider (interpretation bias), and the Affective Priming Task (fear-related associations) were able to independently predict fear-related behavior. The current version of the distance estimation task and the Affective Priming Task were even able to independently predict fear-related behavior, over and above the variance explained by self-reported fear. Therefore, using these tasks in addition to self-reports allowed an improved prediction of fear-related avoidance. These results are theoretically supported by dual process models (e.g., Beck & Clark, 1997; Strack & Deutsch, 2004). To the best of our knowledge, this is the first study to find evidence that attention bias, interpretation bias, and fear-related association each predict unique variance in spider fear-related behavior. This unique insight can be used to further conceptualize theoretical models of childhood anxiety.

4. Author note

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Appendix 1. English translations of the Dutch prime words used in the Affective Priming Task.

	Version 1	Version 2
negative feelings	abuse	shame
	embarrassed	bullying
	softy	stupid
happiness	fantastic	happy
	nice	pleasant
	fun	cheerful
spiders	tarantula	spider
	cobweb	cross spider
	spiders	spider web
general fear	anxious	anxious
	afraid	afraid
	horror	horror

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