



Threat interpretation and parental influences for children with asthma and anxiety



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ABSTRACT

Anxiety disorders are highly prevalent in children with asthma yet very little is known about the cognitive and parent factors that may underpin this relationship. The present study investigated interpretation biases in children with asthma and anxiety and their parents, and whether parent-child discussions influenced children's interpretations. Eighty-nine parent-child dyads were included across four groups: children with asthma and anxiety, children with anxiety only, children with asthma only and healthy children (aged between 8 and 13 years old). Interpretation bias was assessed using ambiguous scenarios. Children with anxiety showed an interpretation bias in the general threat scenarios, whereas children with asthma showed an interpretation bias in the asthma threat scenarios. Parental predictions of their child's responses showed similar results. Parent-child discussions increased avoidance for children with anxiety and no asthma across all scenarios, but only for children with asthma and anxiety in the asthma threat scenarios. The results provide partial support for a cognitive theory of asthma and anxiety in children and suggest that parents play a role in influencing children's thinking styles. Treatment programs could thus aim to target and modify interpretation biases in children with anxiety, and include parents as part of treatment.

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Children with asthma are at three times the risk of developing anxiety disorders compared to children without asthma (Dudeney, Sharpe, Jaffe, Jones, & Hunt, 2016). The presence of anxiety disorders comorbid with asthma in children has marked effects on children's functioning and development, including reduced physical and emotional functioning (McCauley, Katon, Russo, Richardson, & Lozano, 2007), poorer control of their asthma symptoms (Lehrer, Feldman, Giardino, Song, & Schmalting, 2002) and greater utilization of health services (Brinke, Ouwerkerk, Bel, & Spinhoven, 2001). In addition, there appears to be reduced effectiveness of asthma treatments in children with comorbid asthma and anxiety (Miller & Wood, 1997), and children are at greater risk

of being a smoker as an adolescent (Bush et al., 2007). Given the profound negative impact that comorbid asthma and anxiety disorders have on a child's life, as well as its potential to interfere in healthy development in to adolescence (Katon, Richardson, Lozano, & McCauley, 2004) and family functioning, it is important to understand the factors that may lead to the co-occurrence of asthma and anxiety disorders in children.

It has been well documented that children with anxiety disorders frequently display interpretation biases when processing ambiguous or mildly negative situations (Barrett, Rapee, Dadds, & Ryan, 1996; Chorpita, Albano, & Barlow, 1996). Interpretation bias can be described as a tendency to interpret ambiguous or mildly threatening cues in a negative or catastrophic manner, and this bias may play a role in the onset, and/or maintenance of childhood anxiety disorders, which fits with cognitive models of child anxiety (Rapee, Schniering, & Hudson, 2009; Vasey & Dadds, 2001). A growing body of research suggests that children's interpretation

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bias may develop as a result of children's exposure to, and transmission of, the biases, values, beliefs, knowledge, and behaviours of their parents (Barrett et al., 1996; Chorpita et al., 1996; Creswell, O'Connor, & Brewin, 2006). Parents may inadvertently transfer their interpretation bias to their child via verbal communication, particularly if the parents are anxious themselves (Bell, Waters, & Zimmer-Gembeck, 2015; Creswell, Schniering, & Rapee, 2005; Muris, Steerneman, Merckelbach, & Meesters, 1996).

A seminal study conducted by Barrett et al. (1996) explored interpretation biases in children and how parent-child interactions influence these biases. Children aged 7–14 years and their parents were asked to interpret and decide on a behavioural response to a number of ambiguous scenarios. The results indicated that children with anxiety disorders made relatively high threat interpretations in response to the ambiguous situations, and chose more avoidant solutions, compared to the non-anxious groups. Furthermore, the results also showed that parents of children with anxiety disorders predicted that their child would make more threat-based interpretations, and more avoidant response plans, compared to children without anxiety disorders, and – after family discussions – anxious children became more avoidant. These results provided evidence for an interpretation bias in children with anxiety disorders, and provided the first evidence of family exacerbation of anxious cognitive styles in children.

Other studies have found similar results for the association between child anxiety disorders and interpretation bias using similar ambiguous scenario paradigms (Bogels & Zigterman, 2000; Bogels, van Dongen, & Muris, 2003; Chorpita et al., 1996; Creswell et al., 2005; Muris, Luermans, Merckelbach, & Mayer, 2000; Waters, Craske, Bergman, & Treanor, 2008) and for the role of the family or parents in the development and/or maintenance of those biases (Chorpita et al., 1996; Dadds, Marrett, & Rapee, 1996). A few studies have failed to find a relationship between child anxiety disorders and interpretation bias and avoidant responses (Bell et al., 2015; Cobham, Dadds, & Spence, 1999) or for the effect of family discussion on children's threat interpretation and avoidant responses (Bogels et al., 2003; Cobham et al., 1999; Shortt, Barrett, Dadds, & Fox, 2001). Furthermore, it appears that mothers who are anxious themselves are more likely to predict that their anxious child will choose an avoidant solution compared with low anxious mothers (Bell et al., 2015; Cobham et al., 1999).

Given the role of interpretation bias and family processes in the development and maintenance of child anxiety, it may be possible that these factors play a similar, albeit different, role in understanding anxiety disorders in children with asthma. A model developed by Park, Sawyer, and Glaun (1996) highlights the role of cognitive factors in the development of panic disorder in children with asthma. In this model, children with asthma may *misinterpret* or *confuse* sensations of breathlessness that are normal, and experience them as signifying imminent physical threat. Thus, children with asthma may *overestimate* threat in situations in which they experience asthma-like symptoms, and a vicious cycle may develop, in which children engage in avoidance (e.g. missing school) or safety behaviours (e.g. taking medication), which may exacerbate and/or maintain their anxiety and asthma symptoms. Of course, in some cases, avoidance or taking asthma medication in situations when real asthma-threat is present may be adaptive and warranted. However, it may be that higher levels of threat interpretation and subsequent avoidance in ambiguous situations which involve an asthma threat may actually be harmful to the child, through avoidance or the unnecessary use of medication.

If the cognitive model of comorbid asthma and anxiety holds, and the basis of children's anxiety is the asthma itself, we might expect that children with asthma and anxiety display higher levels of threat interpretation in ambiguous situations involving an

asthma threat compared to children with anxiety only and children with asthma only. In addition, we might also expect that children with asthma and anxiety display lower levels of threat interpretation in ambiguous scenarios related to general threat compared to children with anxiety only. The distinction between general and asthma threat interpretation is important because if the maintaining factors are different for children with asthma and anxiety to that of children with anxiety only, then cognitive-based interventions based on managing anxiety for healthy children could be targeting the wrong cognitive processes if delivered to children with asthma. This could explain the mixed outcomes associated with current psychological treatment of children with both anxiety and asthma (Marriage & Henderson, 2012; Papneja & Manassis, 2006).

Further, we might also expect that children with asthma experience a higher prevalence of panic disorder compared to children with anxiety only, given the overlap in symptoms. However, a recent meta-analysis (Dudeney et al., 2016) found that there is a spread of anxiety disorders experienced by youth with asthma, which is similar to what is seen in a healthy youth population. GAD and social phobia were three times higher for youth with asthma than for healthy youth, and separation anxiety disorder, panic disorder and agoraphobia, twice as high. Apart from Park et al. (1996) model which explains the relationship between asthma and panic disorder in children, we are yet to understand why children with asthma experience more anxiety disorders. It may be that experience of living with a chronic illness leads to anxiety (Goodwin, Bandiera, Steinberg, Ortega, & Feldman, 2012), perhaps as a result of a catastrophic thinking style or avoidance, such that the relationship is transdiagnostic in nature. Alternatively, a third factor may be influencing the relationship between asthma and anxiety disorders in children, such as parenting behaviours or parental psychopathology. Thus, understanding the specificity of interpretation biases in children with asthma and anxiety disorders may give further insight in to the nature of the relationship between asthma and anxiety and the specific cognitive factors that underlie the relationship.

Further, it is possible that parents play a role in the development and maintenance of cognitive styles in children with asthma and a comorbid anxiety disorder. It would be understandable if parents of children with asthma are more vigilant to cues of breathlessness compared to parents of children without asthma, and they may interpret their child's asthma-like symptoms as signifying an imminent asthma attack. Thus, parents may thus allow their child to engage in avoidance behaviours, such as keeping them home from school if the child has a mild cough, or they may encourage their child to use asthma medication when it is not necessary. Parents may thus inadvertently transfer their interpretation bias to their child via verbal communication, particularly if they think their child is experiencing asthma-like symptoms. Given that mothers of children with asthma are more likely to exhibit higher levels of anxious symptoms compared to mothers of children without asthma (Easter, Sharpe, & Hunt, 2015), the role of parents may be particularly important to understanding cognitive biases in children with asthma and anxiety.

To date, there are no studies that have investigated interpretation biases in children with asthma and comorbid anxiety, or any other chronic health condition comorbid with anxiety disorders. Studies which have investigated interpretation biases in adults with a chronic illness, however, have consistently demonstrated a cognitive bias towards threat information associated with their illness, such as pain (Khatibi, Sharpe, Jafari, Gholami, & Dehghani, 2015; Pincus, Pearce, & Perrott, 1996; Pincus, Pearce, McClelland, Farley, & Vogel, 1994), and congenital heart disease (Karsdorp, Kindt, Rietveld, Everaerd, & Mulder, 2008). One study has

investigated attentional bias in children with asthma and found that children with asthma demonstrated attentional biases towards asthma stimuli, but that biases that were not observed in children without asthma (Lowther, Newman, Sharp, & McMurray, 2016). However, there was no assessment of anxiety, and therefore no comparison of the attentional bias between children with comorbid asthma and anxiety disorders, and those with asthma or anxiety disorders alone. Further, this study did not measure interpretation bias in children with asthma, and the processes underlying attentional bias and interpretation bias, whilst related, are different. Therefore, a full account of interpretation bias underlying anxiety disorders in children with asthma is unknown.

The aims of the current study were: (1) to investigate interpretation bias and behavioural responses associated with ambiguous scenarios in children with asthma and a comorbid anxiety disorder. Specifically, the aim was to compare interpretation bias and responses across four groups of children and their parents: children with asthma and an anxiety disorder (asthma and anxiety), children with asthma only, children with anxiety disorders only (anxiety only), and healthy children (i.e. without asthma or an anxiety disorder); (2) to investigate the role of parents in children's biases, through the examination of parental predictions of, and the effect of parent-child discussion on, the children's responses; and (3) to investigate the relationship between parental anxiety and parental predictions of child's responses.

It was hypothesised that (1) children with anxiety would make more threat interpretations and provide more avoidant response plans compared to those without anxiety (a main effect for child anxiety status), and this would be higher in the general threat scenarios for children with anxiety only compared to children with asthma and anxiety (an interaction effect). It was predicted that parents of children with anxiety would also display a similar pattern of general threat interpretation bias and prediction of avoidance plans; (2) for asthma-specific threat scenarios, children with asthma would make more threat interpretations and more avoidant response plans compared to children without asthma (a main effect for child asthma status); however, children with asthma and anxiety would make more threat interpretations and avoidant response plans compared to children with either asthma only or children with anxiety only (an interaction effect). It was predicted that parents of children with asthma would display a similar pattern of asthma-specific threat interpretation bias and avoidance plans; (3) A similar pattern of results for both the general threat and asthma threat scenarios was expected for the effect of parent-child discussions on increasing children's avoidant responses; and (4) Finally, it was predicted that parental anxiety would be associated with parental predictions of their child's threat interpretations and avoidant responses.

1. Method

1.1. Participants

Children were included in the study if they were aged between 8 and 13 years old. The asthma groups consisted of children with a diagnosis of asthma from a respiratory paediatrician, their asthma was monitored by optimal and stable respiratory medications and they experienced no recent (i.e. less than one month) exacerbations in their asthma symptoms resulting in hospital admission. The anxiety groups consisted of children who had a primary diagnosis of an anxiety disorder. Children without a diagnosis of asthma or anxiety were included in the healthy control group. Children were excluded from the study if they had a severe intellectual or physical disability, were not fluent in English or had a primary diagnosis of post-traumatic stress disorder.

Children with asthma were recruited from the outpatient centre at the Sydney Children's Hospital ($n = 24$), the Children's Hospital at Westmead ($n = 9$) or from advertisements placed in community newsletters ($n = 11$). Children without asthma were recruited from advertisements in local newspapers, websites or school newsletters. The advertisement for children with anxiety offered free psychological treatment at the Psychology Clinic at the University of Sydney. The advertisement for children without anxiety requested individuals who had never sought treatment from a mental health professional.

1.2. Measures

1.2.1. Demographic information

Parents completed a demographic questionnaire prior to testing, which included questions regarding the child's age, gender, ethnicity, medical variables, parent's age, primary caregiver status, education level and occupation. The Hollingshead Four-Factor Index of Socioeconomic Status was used to assess SES (Hollingshead, 1975). A SES score between 8 and 66 was based on reported parental education level and occupation, with higher scores indicating higher SES.

1.2.2. Child anxiety

All children were assessed for an anxiety disorder by clinical psychology trainees, who had been trained to conduct diagnostic interviews, using the Anxiety Disorders Interview Schedule for DSM-IV: Child and Parent Version (ADIS: C/P; Silverman & Albano, 1996). The ADIS: C/P is a semi-structured clinical interview and is suitable for young people aged 6 years and above. Diagnoses and clinical severity ratings (CSRs; on a scale of 0–8) were assigned based on a composite parent and child report. A severity rating of 4 or above was indicative of clinically impairing symptoms. Twenty percent ($n = 19$) of the ADIS C/P interviews were audiotaped and coded by a clinical psychology trainee trained to conduct the ADIS. Interrater reliability was excellent ($\kappa = 1.0$ for the presence of an anxiety diagnosis; $= 0.95$ for the primary diagnosis). Disagreements were resolved by consensus.

Additional questionnaire measures were used to provide further support for the distinction between the anxious and non-anxious groups. To measure child anxiety symptoms, children and one parent completed the Spence Children's Anxiety Scale – Child and Parent Report (SCAS-P; Nauta et al., 2004) (SCAS-C; Spence, 1998). The SCAS and SCAS-P contain 38 anxiety items that all load on a single higher order scale (scores range from 0 to 114) and six subscales measuring panic/agoraphobia, social anxiety, separation anxiety, generalized anxiety, obsessions/compulsions and fear of physical injury. The scale has shown to significantly differentiate between clinically anxious and non-anxious children and has demonstrated good internal consistency and test-retest reliability (Nauta et al., 2004; Spence, 1998).

1.2.3. Parent anxiety

To measure symptoms of parental anxiety, the anxiety subscale of the Depression Anxiety Stress Scales – Short Form (DASS21; Lovibond & Lovibond, 1995) was used. The DASS 21 is a well-established 21-item self-report measure and has demonstrated good internal consistency and validity for each of the subscales (Antony, Bieling, Cox, Enns, & Swinson, 1998).

1.2.4. Ambiguous scenarios task

Parents and children completed an ambiguous scenarios task (AST) adapted from Barrett et al. (1996). Parents and children were individually presented with six scenarios; four of which were *general threat* scenarios (which included two social threat and two

physical threat scenarios), and two asthma-specific threat (“*asthma threat*”) scenarios. The general threat scenarios were in the original Barrett et al. (1996) study whereas the two asthma-specific threat scenarios were developed specifically for this study. An example of a general social threat scenario is, “You see a group of students from another class playing a great game. You walk over and want to join in and you hear them laughing”. An example of a general physical threat is: “You are walking to a friend’s house and a big dog comes up”. The two asthma threat scenarios were: (1) “You wake up in the morning and notice you have a cough”; and (2) “You are in the playground and you notice that you are puffing and out of breath”. The asthma threat scenarios were developed in consultation with a respiratory paediatrician (AJ) to ensure they were truly ambiguous, that is they could be interpreted as either a real asthma threat or as a neutral threat. The scenarios were verified by a respiratory clinical nurse consultant (AT). The scenarios were read in random order to parents and children separately and three questions were asked following each situation: (1) What do you think is happening? (free-choice interpretation) (2) Which of the following explanations do you think is most likely? (forced-choice interpretation; two threat and two neutral interpretations were read to the child and parent); and (3) What would you/your child do about it? (solution).

Children were asked to interpret each scenario and describe how they would respond. Parents were asked how their child would interpret and respond to each scenario. Three of the scenarios (one social threat, one physical threat and one asthma threat) were selected by the researchers to be the focus of brief family discussions. Subsequently, the parent and child discussed the three scenarios together and the parent was instructed to help their child with an appropriate response. At the end of these discussions the child was asked to provide a final solution to each of the three scenarios.

1.2.5. Scoring and data analysis of the AST

Two authors (GS and SL) blind to the child diagnoses independently coded the participants’ interpretations and responses to the ambiguous scenarios. Responses were coded as threat or non-threat interpretations, and avoidant or non-avoidant responses. An example of a threat interpretation to the asthma-specific scenario regarding a mild cough is “I will have an asthma attack”. An example of a non-threat interpretation to this scenario is “I have to clear my throat but it is nothing serious”. Responses were coded as avoidant if the solution involved avoidance or escape, a disproportionate response (e.g. calling an ambulance), safety behaviours (e.g. seeking reassurance from a teacher) or aggressive solutions (e.g. punching somebody). For the asthma threat scenarios specifically, responses were coded as avoidant if the solution was avoidant or not adaptive in the context of a benign asthma threat (e.g. taking medication, calling an ambulance, missing school or going to the doctor). The coding rules for the asthma threat responses were developed in consultation with a respiratory paediatrician (AJ). Inter-rater reliability was excellent $\kappa = 0.96$, and all disagreements were resolved through discussion to achieve 100 per cent consensus.

Threat interpretation and avoidant responses were coded as 1, and non-threat and non-avoidant responses were coded as 0. The *general threat score* was a summed threat interpretation score for the four general threat scenarios, leading to a score between 0 and 4 for each participant for both free-choice responses and forced-choice responses, where a higher score indicated greater threat interpretation. Similarly, the *general avoidance score* was a sum of the avoidant responses for the four general threat scenarios, leading to a score between 0 and 4 for each participant, where a higher score indicated greater avoidance. For the *asthma threat score*,

coded responses were summed across the two asthma-specific threat scenarios, leading to a threat score between 0 and 2 for each participant for both free-choice and forced-choice responses, and the *asthma avoidance score* was the summed avoidant responses, leading to an avoidance score between 0 and 2 for each participant, where a higher score indicated greater asthma threat or avoidance respectively. The measures derived were thus the mean number of threat interpretations (general and asthma) provided by children and their parents in each group, and the mean number of avoidant responses (general and asthma) provided by children and their parents in each group.

For the parent-child discussion procedure, the mean percentages of children in each group providing avoidant responses both before and after the discussions were calculated. The general threat percentage for each child was calculated by dividing the total general avoidance score divided by the total number of general threat scenarios discussed. The asthma threat percentage was calculated by dividing the total asthma avoidance score by the total number of asthma threat scenarios discussed. The mean percentages of parents in each group providing avoidant responses prior to the discussion was also calculated. The percentages were calculated in the same way as the children percentages except parent scores replaced the child scores. Thus three variables were derived for the mean percentage choosing avoidant responses in each group – pre-discussion child, pre-discussion parent and post-discussion child.

1.3. Procedure

Prior to the day of testing, participants completed the questionnaire measures and consent forms. After diagnostic interviews, children and their parents were interviewed separately regarding their interpretations and plans of response to the ambiguous scenarios. When interviewing the children the researcher instructed children: “I am going to tell you about some situations you might find yourself in and ask you what you would think and do about them. This is not an exam because there are no right or wrong answers. If you do not understand anything please feel free to ask”. Responses were written down by a researcher who was blind to the child’s diagnosis. When interviewing the parent, the researcher instructed parents: “I am going to read to you a number of hypothetical situations your child may find himself/herself in. For each situation I will ask you some questions about what you think your child might do if he/she were to experience those situations”. The parent and child were then brought together and asked to discuss three of the scenarios together. The parent was instructed to help their child with an appropriate response while the researcher left the room. At the end of the discussion the child was asked to provide a final solution. All responses were written down verbatim by the researcher for later coding. The procedures in the study formed part of a larger study examining asthma and anxiety in children that was approved by both the University of Sydney Human Ethics Committee and Sydney Children’s Hospital Human Ethics Committee.

1.4. Statistical analysis

All analyses were conducted with SPSS version 21.0. Differences between groups on demographic variables and questionnaire measures were assessed using two-way ANOVAs with child anxiety status (anxiety present or anxiety absent) and child asthma status (asthma present or asthma absent) as the two independent variables, or chi-squared analysis for categorical variables.

To analyse our main outcome variables, differences between groups on threat interpretation and avoidant responses were investigated using two-way analysis of variance (ANOVA), with

child anxiety status (present or anxiety absent) and child asthma status (present or asthma absent) as the independent variables. Results for the child and parent data are reported separately. Data for threat interpretation were analysed for both the free-responses and forced-choice threat interpretation; however, the results obtained were highly similar and thus only the results for the free-choice data are presented.

In order to investigate whether changes in children's avoidant solutions were statistically significant across groups, two-way ANOVAS were conducted with the positive mean change score (post-discussion score minus the pre-discussion score) as the dependent variable and child anxiety status and child asthma status as the independent variables.

We predicted that there would be a main effect for child anxiety status across all scenarios, indicating that children with anxiety show biases (for both threat interpretation and avoidance) towards threat stimuli compared to those without anxiety. We also expected an interaction effect between asthma and anxiety in the general threat scenarios, such that biases evident in children with anxiety would be greater for children with anxiety only compared to children with asthma and anxiety. We also expected that there would be a main effect for child asthma status on asthma threat scenarios, such that children with asthma showed biases that were absent in healthy children. Similarly, we predicted an interaction effect in the asthma threat scenarios, such that biases would be greater for children with asthma and a comorbid anxiety disorder compared to children with asthma only or children with anxiety only.

According to G*power, a total of 84 participants (21 participants in each group) were needed to detect a medium to large effect size based on 95% significance level and thus the final sample size was based on this.

2. Results

2.1. Participant characteristics

The sample consisted of 178 participants: 89 children and one of their parents ("dyads"). There were 29 dyads in which the child had asthma and anxiety, 15 dyads in which the child had asthma only, 21 dyads in which the child had anxiety only, and 24 dyads in which the child had neither asthma nor anxiety. Children were aged 8–13 years, with a mean age of 9.7 years ($SD = 1.5$ years).

There were no significant differences in child's age, gender, parent's age, ethnicity, family composition and SES between the four groups (see Table 1 for demographic information for all

participants). There were significant differences between the groups for the proportion of mothers reported as the primary caregiver, $\chi^2(3, N = 89) = 14.0, p = 0.003$, with a lower proportion of mothers in the healthy control groups compared to the other three groups. Excluding fathers from the main analyses resulted in no differences in our significant results and thus primary caregiver status was not controlled in the final analyses.

2.1.1. Descriptive measures

The primary diagnoses of the children in the anxious groups were: generalised anxiety disorder (GAD) 46% ($n = 23$) separation anxiety disorder 22% ($n = 11$), social phobia 18% ($n = 9$) and specific phobia 14%, ($n = 7$). Sixty-four percent ($n = 32$) met criteria for at least one additional anxiety disorder and no children met diagnostic criteria for a mood disorder.

The mean scores for the parent and child questionnaires are given in Table 2. There was a significant main effect of child anxiety status on anxiety symptoms as measured by the SCAS – child, $F(1, 85) = 34.3, p < 0.001$, and SCAS – parents $F(1, 85) = 61.5, p < 0.001$, supporting the diagnostic distinction between the anxious and non-anxious groups as assessed by the ADIS. There was no significant effect of child asthma status and no interaction effect, indicating that child asthma status was not associated with child anxiety symptoms. There was a significant main effect of child anxiety status on parental anxiety scores, $F(1, 85) = 4.3, p = 0.041$, indicating parents of children with anxiety were more anxious themselves. There was no significant effect of child asthma status and no interaction effect.

2.2. Ambiguous scenarios task

2.2.1. Comparisons between groups on threat interpretation and avoidance in general threat scenarios

Data are presented in Table 3. A significant main effect was found for child anxiety status on general avoidance scores reported by the child, $F(1, 85) = 8.7, p = 0.004$, but not for general threat scores, $F(1, 85) = 0.9, p = 0.334$. In other words, although children with anxiety did not interpret general threat scenarios as more threatening compared with children without anxiety, they made more avoidant solutions, which partially supported our predictions. There was no interaction effect on these measures respectively, $F(1, 85) = 0.1, p = 0.716$ and $F(1, 85) = 0.2, p = 0.638$, which did not support our predictions, as it showed similar levels of general threat interpretation and avoidance for children with anxiety only and children with comorbid asthma. As expected, there was no effect of child asthma status on child general threat scores, $F(1,$

Table 1
Demographic variables across groups.

	Asthma & Anxiety ($n = 29$)	Anxiety Only ($n = 21$)	Asthma Only ($n = 15$)	Healthy Control ($n = 24$)
Age in years M (SD)	10.0 (1.5)	9.2 (1.1)	10.1 (1.5)	9.5 (1.5)
Gender, Male % (n)	59 (17)	57 (12)	73 (11)	58 (14)
Ethnicity % (n)				
Australian/Oceanic	76 (22)	86 (18)	80 (12)	92 (22)
Asian	7 (2)	10 (2)	7 (1)	4 (1)
European	4 (1)	5 (1)	0 (0)	0 (0)
Other	14 (4)	0 (0)	13 (2)	4 (1)
Primary Caregiver				
% Mothers (n)	93 (27)	100 (21)	100 (15)	71 (17)
Age in years, M (SD)	43.3 (6.9)	41.9 (4.6)	42.0 (5.5)	44.2 (3.8)
Family composition % (n)				
Married	83 (24)	76 (16)	87 (13)	88 (21)
Single/divorced	17 (5)	14 (3)	13 (2)	8 (2)
Other	0 (0)	10 (2)	0 (0)	4 (1)
Family SES, M (SD)	42.9 (16.3)	53.5 (9.7)	48.0 (11.2)	54.9 (5.3)

Note. SES = family socioeconomic status score.

Table 2

Means and standard deviations (in parentheses) for questionnaire measures across groups.

	Asthma & Anxiety	Anxiety Only	Asthma Only	Healthy Control	F value	p
SCAS-C*	35.8 (15.6)	34.8 (15.1)	18.1 (8.4)	18.8 (7.7)	36.0	<0.001
SCAS-P*	29.5 (11.2)	25.0 (10.3)	12.2 (7.7)	10.7 (6.4)	61.8	<0.001
ATAQ	3.82 (2.44)	—	3.67 (2.94)	—		
DASS 21* (Anxiety subscale)	5.4 (7.9)	2.7 (4.3)	1.7 (3.4)	1.3 (3.3)	4.3	0.041

Note. SCAS-C = Spence Children's Anxiety Scale; SCAS-P = Spence Children's Anxiety Scale – Parent Report; ATAQ = Asthma Therapy Assessment Questionnaire; DASS 21 – Depression Anxiety Stress Scale – Short Form. * Significant difference between groups (anxiety versus no anxiety).

Table 3

Means and standard deviations (in parentheses) for threat and avoidant solutions across groups for general threat scenarios and asthma threat scenarios.

Measure	Asthma & Anxiety	Anxiety Only	Asthma Only	Healthy Control
General Threat				
Threat				
Child	2.0 (1.0)	2.1 (1.1)	1.7 (1.0)	2.0 (1.0)
Parent	2.6 (1.0)	2.3 (0.7)	1.6 (1.1)	1.4 (0.9)
Avoidance				
Child	1.9 (1.0)	1.8 (1.2)	1.1 (1.0)	1.2 (1.1)
Parent	1.8 (1.1)	1.4 (1.0)	1.1 (1.0)	0.8 (0.9)
Asthma Threat				
Threat				
Child	1.4 (0.7)	0.9 (0.7)	1.3 (0.7)	0.8 (0.7)
Parent	1.7 (0.6)	1.2 (0.6)	1.3 (0.8)	0.6 (0.5)
Avoidance				
Child	1.0 (0.7)	0.8 (0.7)	1.1 (0.5)	0.6 (0.8)
Parent	1.1 (0.8)	0.5 (0.6)	1.0 (0.8)	0.1 (0.3)

85) = 0.4, $p = 0.528$ and child avoidance scores, $F(1, 85) = 0.0$, $p = 0.910$. These results show that the child's asthma status did not influence child-reported threat interpretation or avoidant responses in the general threat scenarios.

The following analyses were conducted post-hoc. In order to investigate whether there was a relationship between type and severity of anxiety diagnosis and threat interpretation or avoidance for children with anxiety. Threat interpretation and avoidance was compared for children with GAD (the most common diagnosis in the current sample) versus children without GAD. Our results showed that there were no significant differences between children with GAD and those without GAD for threat interpretation, $F(1, 48) = 3.5$, $p = 0.065$, or avoidance, $F(1, 48) = 2.8$, $p = 0.101$. Further, we found no significant differences between children with high and low anxiety symptoms (using a median split on the SCAS-C and SCAS-P) on threat interpretation, $F(1, 48) = 3.6$, $p = 0.062$ and $F(1, 48) = 0.000$, $p = 0.998$ or avoidance, $F(1, 48) = 3.6$, $p = 0.062$ and $F(1, 48) = 0.000$, $p = 0.998$. Thus, child anxiety status appeared to be associated with avoidance but not threat interpretation in the general threat scenarios, regardless of type of anxiety diagnosis and anxiety severity.

For parental predictions a significant main effect was found for child anxiety status on general threat scores, $F(1, 85) = 20.0$, $p < 0.001$, and general avoidance scores, $F(1, 85) = 7.9$, $p = 0.006$, which was consistent with our hypotheses. Thus, parents of children with anxiety predicted their child would interpret general scenarios as more threatening and make more avoidant response plans. There was no interaction effect for general threat scores, $F(1, 85) = 0.1$, $p = 0.778$, or avoidance scores reported by parents, which was not consistent with our predictions. There was no effect of child asthma status on general threat scores and general avoidance scores reported by parents, $F(1, 85) = 1.4$, $p = 0.247$ and $F(1, 85) = 1.9$, $p = 0.169$ respectively, which we expected. Thus, a child's anxiety status, but not their asthma status, was associated with higher parental predictions of threat interpretation and avoidance scores in general threat scenarios.

2.2.2. Comparisons between groups on threat interpretation and avoidance in asthma threat scenarios

A significant main effect was found for child asthma status on asthma threat scores, $F(1, 85) = 10.9$, $p = 0.001$, and for asthma avoidance scores, $F(1, 85) = 6.8$, $p = 0.011$, reported by children (see Table 3), which was consistent with our hypotheses. However there were no interaction effects for asthma threat scores and avoidance scores reported by children, $F(1, 85) = 0.2$, $p = 0.681$, and $F(1, 85) = 0.6$, $p = 0.434$ respectively. This result partially supported our predictions. In other words, children with asthma interpreted asthma scenarios as more threatening compared with children without asthma, and were more likely to make avoidant response plans; however, threat interpretation and avoidant responses did not differ between children with a comorbid anxiety disorder compared to those without. There was no effect of child anxiety status on child-reported asthma threat scores, $F(1, 85) = 0.3$, $p = 0.6$ and asthma avoidance scores, $F(1, 85) = 0.0$, $p = 0.899$. In other words, a child's anxiety status did not influence threat interpretation or avoidance in ambiguous situations involving asthma threat for children's responses.

Consistent with children's responses, the results for parental predictions showed a significant main effect of child asthma status on asthma threat scores, $F(1, 85) = 19.3$, $p < 0.001$, and asthma avoidance scores, $F(1, 85) = 28.6$, $p < 0.001$, but there were no significant interaction effects for either measure $F(1, 85) = 1.6$, $p = 0.214$ and $F(1, 85) = 1.1$, $p = 0.293$ respectively. This result partially supported our predictions. It showed that parents of children with asthma predicted their child would interpret asthma threat scenarios as more threatening compared with parents of children without asthma, and that their child would make more avoidant response plans, however there were no differences between the two asthma groups for threat interpretation and avoidance. In contrast to the results for children's responses, there was also a significant main effect of child anxiety status on asthma threat scores reported by parents, $F(1, 85) = 13.5$, $p < 0.001$, which supported our predictions. This result demonstrated that parents of children with anxiety predicted their child would interpret asthma threat scenarios as more threatening compared to parents of children without anxiety. There was no effect of child anxiety status, $F(1, 85) = 4.1$, $p = 0.046$ on asthma avoidance scores reported by parents.

2.3. Differences between groups pre- and post- parent-child discussions

Mean percentages of children and parents in the asthma and anxiety, asthma only, anxiety only and healthy control groups choosing avoidant solutions before and after the parent-child discussions are shown in Table 4. Results showed that there were no main effects of anxiety status on the mean change score for the general threat scenarios, $F(1, 85) = 0.0$, $p = 0.987$, and no interaction effect, $F(1, 85) = 2.3$, $p = 0.136$, which was not consistent with our hypotheses. As expected, there was no significant main effect of asthma status on the mean change score for the general threat

Table 4
Mean percentages of children choosing avoidant solutions for the two general threat scenarios and one asthma threat scenario pre- and post- parent-child discussions (percentage).

	Asthma & Anxiety	Anxiety Only	Asthma Only	Healthy Control
General threat				
Pre-discussion – parent	48.3	30.9	20.0	23.0
Pre-discussion – child	55.1	54.8	30.0	35.4
Post-discussion – child	46.5	57.1	26.7	20.8
Asthma threat				
Pre-discussion – parent	51.7	42.9	40.0	8.3
Pre-discussion – child	44.8	57.1	73.3	45.8
Post-discussion – child	55.2	71.4	67.7	37.5

scenarios, $F(1, 85) = 0.6$ $p = 0.432$. These results show that neither child anxiety status nor child asthma status was associated with changes in children's avoidance solutions following the parent-child discussion.

For the asthma-threat scenarios, there was a significant main effect of child anxiety status on the mean change scores in the asthma-threat scenarios, $F(1, 85) = 4.4$ $p = .039$, as predicted. Thus, it appears that the parent-child discussion was associated with an increase in the percentage of children in the anxious groups choosing avoidant solutions in the asthma threat scenarios. There was no main effect of asthma status on mean change scores in the asthma-threat scenarios, and no interaction effect, $F(1, 85) = 0.0$ $p = 0.905$ and $F(1, 85) = 0.0$ $p = 0.768$ respectively, which was not consistent with our hypotheses. In other words, the child's asthma status was not associated with an increase in the percentage of children choosing avoidant solutions in the asthma threat scenarios following the parent-child discussion.

2.4. Relationship between parental anxiety and parental predictions of Children's threat interpretation and solutions

In order to investigate whether there was a relationship between parental anxiety and their predictions of their child's threat interpretations and solutions, a correlational analysis was conducted to assess relationships between the variables. Results showed that parental anxiety symptom scores were not statistically significantly associated with their predictions of their children's threat interpretations ($r = 0.24$, $n = 89$, $p = .024$) at the corrected critical alpha level ($p = 0.01$), and not significantly associated with their predictions of their child's solutions ($r = 0.19$, $n = 89$, $p = .076$).

3. Discussion

The current study investigated threat interpretation bias and behavioural responses associated with ambiguous scenarios in children with comorbid asthma and anxiety. Children with anxiety showed an interpretation bias in the general threat scenarios, whereas children with asthma showed an interpretation bias in the asthma threat scenarios. These results provide some evidence of a bias in the asthma and anxiety groups, which may be consistent with a cognitive explanation of comorbid asthma and anxiety in children.

As predicted, the results showed that children with anxiety made more avoidant response plans compared to the non-anxious groups in the general threat scenarios; however, contrary to our hypotheses, children with anxiety did not interpret general threat scenarios as more threatening. This result partially supports previous research. Our findings are consistent with findings of greater threat avoidance in children with anxiety compared to children without anxiety (Barrett et al., 1996; Chorpita et al., 1996; Creswell

et al., 2005; Dadds et al., 1996). However, our findings are inconsistent with findings of greater threat interpretation in these children. One reason for this discrepant finding may be children with anxiety were trying to “fake good” in order to present themselves in a socially desirable way (Kendall & Chansky, 1991; Silverman & Rabian, 1995). This corroborates with research showing comparable levels of threat interpretation between anxious and non-anxious children (Cobham et al., 1999). Alternatively, our results may reflect the use of only four threat scenarios to assess general threat, which may have reduced the range of threat scores we were able to capture, in comparison with other studies that used a greater number of threat scenarios to assess general threat interpretation (Barrett et al., 1996; Bogels et al., 2003; Dadds et al., 1996). We considered it possible that our result reflects the type of anxious sample in our study: nearly half of children with anxiety had a primary diagnosis of GAD and it may be that the ambiguous scenarios were too specific to social and physical fears, and did not capture the types of bias children with more generalised worry had. Although post hoc analyses showed that there were no significant differences on threat interpretation or avoidance between children with a primary diagnosis of GAD versus children with other primary anxiety disorders, it is likely that they are under-powered and, as such, it is possible that if we had a larger sample that this would have reached significance, particularly for threat interpretation. Hence, this should be a hypothesis for future research which is adequately powered to test the specificity of interpretation biases. Nevertheless, the results show that children with anxiety showed more avoidance compared to children without anxiety; thus, the behavioural response was more clearly demonstrated in children with anxiety.

The result for the general threat scenarios also showed that there were similar levels of threat interpretation and avoidant responses in general threat situations for children with anxiety only and children with asthma and anxiety, which is inconsistent with Park et al.'s cognitive model of asthma and anxiety. This suggests that children with asthma and anxiety interpret a range of similar ambiguous situations as threatening, which are not specifically related to their asthma status. This suggests that there are similar cognitive processes underlying children's anxiety disorders for children with asthma and healthy children, consistent with the idea that there are transdiagnostic factors which underpin the relationship between asthma and anxiety disorders in children (for example, catastrophizing or avoidance of situations).

The results for the asthma threat scenarios partially supported our predictions. As expected, there was evidence for a bias in the asthma groups compared to non-asthma groups for both threat interpretations and response plans; however children with anxiety did not show a bias towards asthma threat. This suggests that children with asthma interpret asthma-like information or symptoms as indicative of threat. The experience of living with a respiratory disease may be indicative of threat; which, in turn, may

provoke behavioural responses such as avoidance, or symptoms reduction measures, such as taking medication, which may be unnecessary or even harmful. Alternatively, it may be that these situations were interpreted as indicative of real threat, rather than ambiguous threat, in which case it may be an adaptive response for children with asthma to take medication or rest in order to reduce their asthma symptoms.

Our results did not show higher levels of threat interpretation and avoidance in children with asthma and anxiety compared to children with asthma and no anxiety, which is not wholly consistent with a cognitive model of asthma and anxiety developed by Park et al. (1996). The fact that children with asthma and no anxiety showed an interpretation bias is notable, and may indicate that the measures used in this study did not successfully assess ambiguous threat, but rather real threat, in which case responses such as taking medication or seeking medical help are adaptive and warranted. On the other hand, if we were successful in measuring ambiguous threat associated with asthma symptoms, our result may suggest that these children are vulnerable to developing anxiety as they may overestimate threat in situations in which they experience asthma-like symptoms. Alternatively, our result may reflect the age and nature of anxiety disorders of the sample; only one child met diagnostic criteria for panic disorder, which is more commonly associated with asthma in adolescent and adult populations (Katon et al., 2004). Panic disorder typically develops in older children as they are better able to understand the fatal nature of asthma symptoms, and children with panic disorder and asthma may show interpretation biases which are perhaps more closely aligned with a cognitive explanation of asthma and anxiety purported by Park et al. (1996). It is also possible that children with panic disorder were not included in the sample because they may be more likely to present to hospital with acute exacerbations related to their asthma, which was an exclusion criterion in the current study. Future studies could aim to measure interpretation bias and avoidance in older children with asthma and panic disorder, in comparison to those with asthma and other different anxiety disorders, preferably over time, to further ascertain the relationship between anxiety and interpretation bias in people with asthma.

Taken together, the results for both types of scenarios has important implications for understanding the relationship between asthma and comorbid anxiety disorders. The results show that children with asthma and anxiety show a range of biases – which are both asthma-specific and general – and suggests that there may be transdiagnostic factors underpinning the relationship. This does not necessarily mean that anxiety disorders in children with asthma are not related to their asthma, or the consequences of asthma. However, it appears that broader factors support the development and maintenance of anxiety, such as avoidance or catastrophising, which may have arisen as a result of living with asthma (Goodwin et al., 2012). This interpretation is consistent with research which shows that a range of anxiety disorders are comorbid with asthma (Dudeney et al., 2016), rather than panic disorder in particular. Alternatively, a third factor – particular to children – might be influencing the relationship between asthma and anxiety, such as parenting or parental psychopathology. Again, further research is needed to explore the exact nature of the relationship between asthma and anxiety disorders in children, and develop interventions that account for both general and asthma specific cognitive factors which may be maintaining the comorbidity.

The second aim of the study was to examine the role of family processes in children's biases. In line with our hypotheses, parents of children with anxiety predicted their children would interpret general threat scenarios as more threatening and make more avoidant response plans compared to parents of children without

anxiety, which supports and extends previous findings (Barrett et al., 1996; Chorpita et al., 1996; Dadds et al., 1996). In addition, it appears that parents of children with anxiety predicted their children would interpret asthma threat scenarios as more threatening compared to parents of children without anxiety. However, there were no differences between the two anxious groups for parental predictions in either types of scenarios. These results suggest that parents of children with anxiety do not distinguish between types of threat (general or asthma-specific); and as such, suggest that parental threat interpretations generalise across different types of scenarios.

In line with our findings for children with asthma, parents of children with asthma predicted their children would interpret asthma threat scenarios as more threatening and would make more avoidant responses plans compared to parents of children without asthma. However, there were no differences in parental predictions of threat interpretation and avoidance between the two asthma groups. Again, this result may reflect that the scenarios were interpreted as a real threat, rather than as an ambiguous threat, and thus parental predictions reflected an adaptive response to the presence of asthma-like symptoms.

The results of the effects of the parent-child discussions provide some evidence in regard to the influence of parents on anxious children's thinking styles. In line with the results for the parental predictions, children with anxiety only provided more avoidant solutions following discussion with their parents in both the general and asthma threat scenarios, which supports previous research on the FEAR effect in children with anxiety (Barrett et al., 1996; Dadds et al., 1996). However, contrary to our expectations and in contrast to the results for the parental predictions, parent-child discussions did not increase the proportion of avoidant solutions provided by children with asthma and anxiety in general threat scenarios, but did increase the proportion of avoidant responses in the asthma-specific scenarios. Thus, it appears that the *nature* of the threat, (here – an asthma specific threat rather than a general threat) and the possible relationship of the child's anxiety with their asthma, is pertinent for understanding the role of parents in enhancing their anxious child's avoidant response. Despite this finding, it should be noted that the increase in avoidant responses provided by anxious children with asthma was relatively small compared with both the anxiety only group and with other studies investigating the effect of family discussion on children's responses (e.g. Barrett et al., 1996), thus caution is required when interpreting these results.

In support of our predictions, we found that the proportion of avoidant solutions provided by children in asthma threat scenarios did not increase in the asthma only group compared to the asthma and anxiety groups following discussion with their parents. Parents of children with asthma who have not developed anxiety may thus serve to “buffer” against anxious coping styles in their children, and be one reason for the absence of anxiety in these children. Research investigating the content of parental-child discussions and their influence on the cognitions of children with asthma is recommended to examine this assertion further (e.g. Chorpita et al., 1996; Dadds et al., 1996).

Our study thus appears to provide support for the role that parents play in children's problem-solving strategies. Our results suggest that avoidance may be reinforced in families with anxious children across all types of ambiguous situations, but only in situations involving a possible asthma threat for children with comorbid anxiety and asthma. Conversely, parents also play a role in transmitting coping strategies in children without anxiety – both with and without asthma. These results suggest including parents in models of anxiety in children with asthma, and including them in treatment programs designed to reduce anxious symptoms in

children with asthma, may be worthwhile.

Finally, we investigated whether there was a relationship between parental anxiety and parental predictions of children's threat interpretation and avoidance. The results did not support the notion that parental anxiety is associated with parental predictions, which contrasts with research on healthy children with anxiety showing that parental anxiety is a factor influencing their predictions of their child's response (Bell et al., 2015; Cobham et al., 1999). If our finding is correct, it is consistent with longitudinal research suggesting that it is the child's anxiety that influences parental behaviours and responses, rather than the other way around (Jongerden & Bogels, 2015). However, there is likely to be a complex interplay between parental anxiety, parental cognitions and child cognitions in children with asthma and anxiety, and a more complex multivariate regression analysis with a larger sample is needed to investigate the relationships.

The existence of interpretative biases in children with asthma raises the questions of whether they can be modified, and whether modifying them would have therapeutic value either through a targeted cognitive bias modification for interpretation (CBM-I) program or through cognitive behavioural therapy (CBT). Both CBM-I and CBT has been shown to be effective for a wide range of disorders, including childhood anxiety (CBT: James, Cowdrey, Soler, & Choke, 2015; CBM-I: Lau, Pettit & Cresswell, 2013; Vassilopoulos, Banerjee, & Prantzalou, 2009) and for chronic health conditions, such as pain (Palermo, Eccleston, Lewandowski, de, & Morley, 2010), thus adapting CBT or CBM-I for children's asthma status and associated beliefs may be effective for treating and preventing anxiety and asthma symptoms in this population. The results also suggest that including parents in CBT would be worthwhile, as parental biases and beliefs about their children could be targeted in treatment, and parents could play an important role in modifying their child's interpretations and encouraging adaptive coping in their child with asthma. The inclusion of parents in treatment has been shown to improve treatment outcomes for healthy children with anxiety (Mendlowitz et al., 1999; Wood, McLeod, Piacentini, & Sigman, 2009; Wood, Piacentini, Southam-Gerow, Chu, & Sigman, 2006), as well as lower levels of internalising problems for children with chronic illnesses (Scholten et al., 2013, 2015).

Our research has some limitations and the results should be interpreted with these in mind. Firstly, the present research is cross-sectional, thus we are unable to draw conclusions about direction of the effects between interpretation bias and anxiety in parents and their children with asthma. Although the results of this study found the existence of interpretation bias in parents and children with asthma both with and without anxiety, the existence of an interpretation bias in itself cannot be said to be a causal or risk factor for anxiety. A longitudinal design measuring bias and anxiety symptoms in children with asthma would be needed to determine whether interpretation bias plays a causal role in later anxiety development. Causal pathways could also be explored by examining outcomes of CBM-I or CBT on interpretation bias, anxiety and asthma symptoms. Secondly, we used novel scenarios for the asthma-specific items. It is possible that these were not in fact ambiguous, but represented a real threat despite having been identified as ambiguous by two respiratory medicine experts. However, the fact that in the asthma and anxiety group, approximately half of the participants chose the avoidant behaviour, which is similar to the typical and well validated threat scenarios makes this interpretation unlikely. Further, the use of only two asthma threat scenarios versus four general threat scenarios limits the comparisons that can be made. Future research could aim to include more asthma threat scenarios to further examine the existence of interpretation bias for children with asthma. Thirdly, our sample for the asthma only group was small, which partly reflects

the high prevalence of anxiety in children with asthma. Low power may partially explain the findings for the non-significant findings between the two asthma groups as the sample size calculation required 21 participants in each group. In addition, there were a lack of fathers across three of the four groups, and therefore the extent to which the findings for parents generalise to fathers is unknown. Given that research has shown that having all family members in treatment leads to better outcomes for children with anxiety than the inclusion of one parent only (Podell & Kendall, 2011), it is important that future research includes fathers to further examine their role in influencing children's interpretation bias and adapt treatment accordingly. Fourthly, because we did not code the actual discussions of the parent-child interactions, we can only assume that the parents encouraged avoidance. Future research that coded the way in which changes in interpretation were encouraged by parents would be helpful. Finally, due to time restrictions, we did not measure or diagnose all comorbid medical or psychological conditions (apart from mood disorders), which may have confounded the results. Future studies should aim to include diagnostic measures of other childhood disorders and control for them if necessary.

In summary, the present study represents the first attempt to extend work in interpretation bias and parent-child processes to children with comorbid asthma and anxiety. The results provide partial support for cognitive and psychological theories of asthma and anxiety in children, and suggest parents may play a role in influencing interpretation biases in children with asthma and anxiety. Treatment programs should thus aim to target and modify interpretation biases in order to prevent, or decrease, anxiety in children with asthma, and include parents in treatment. Future studies should aim to measure interpretation bias in older and larger samples, preferably over time, in order to further explicate the role of interpretation bias in the development and maintenance of anxiety in children with asthma.

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