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Pediatric anxiety associated with altered facial emotion recognition

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Abstract

Multiple psychiatric disorders are associated with difficulties in facial emotion recognition. However, generalized anxiety disorder may be associated with *more accurate* recognition of others' emotional expressions, particularly expressions of happiness and fear, which index safety and threat. Children aged 9-14 from a community sample (N=601) completed a facial emotion labeling task. Children's symptoms of depressive and anxiety syndromes were assessed by self-

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and parent-report. Elevated symptoms of generalized anxiety disorder were associated with more accurate facial emotion recognition (β=0.16, *p*=0.007), specifically recognition of happiness (β=0.17, *p*=0.002) and fear (β=0.15, *p*=0.006). Elevated depressive symptoms were associated with less accurate facial emotion recognition (β=−0.12, *p*=0.018), specifically happiness (β=−0.15, *p*=0.002). Elevated symptoms of separation anxiety disorder were also associated with less accurate facial emotion recognition (β=−0.16, *p*=0.003), specifically happiness (β=−0.15, *p*=0.006) and fear (β=−0.15, *p*=0.005), which highlights the importance of distinguishing between anxiety syndromes. Results held when adjusting for child age and sex. Evidence that symptoms of generalized anxiety disorder are associated with more accurate recognition of happiness and fear is consistent with theories of heightened social vigilance and support a transdiagnostic role of facial emotion recognition that may inform the psychosocial development of youth with anxiety and depressive symptoms.

Keywords

anxiety; depression; emotion recognition; facial emotion recognition

1. Introduction

Social cues are critical to social communication and development. The importance of identifying others' facial expressions of emotions, called facial emotion recognition, is illustrated by cross-cultural similarities (Ekman et al., 1987) and associations with development (Trentacosta & Fine, 2010). Indeed, a tendency to misidentify the emotion expressed by another person has been linked to major depressive disorder (Dalili et al., 2015), bipolar disorder (Brotman et al., 2008), externalizing disorders (Moore et al., in press), and irritability (Guyer et al., 2007; Rappaport et al., 2018) in youth. Lower overall accuracy in recognizing emotions may occur in multiple disorders (Collin et al., 2013); however, lower accuracy for specific emotional expressions may occur in specific syndromes. Despite consistent evidence implicating lower overall accuracy in many disorders, inconsistencies exist in research on anxiety disorders.

Anxiety disorders provide a unique case to evaluate specificity in the association of facial emotion recognition with psychopathology. Recent hierarchical models of psychopathology distinguish anxiety syndromes related to acute fear, such as separation anxiety disorder, from anxiety syndromes related to distress, such as generalized anxiety disorder (Kotov et al. 2021). Research on face-emotion identification extends such models to the realm of social cognition. Facial emotion recognition is an aspect of social cognition (Pinkham et al., 2014) that provides critical information related to interpersonal interaction (Ekman et al., 1987). Others' expressions of happiness may signal safety whereas expressions of fear may signal danger. Multiple theories link generalized anxiety or social anxiety disorders to hypersensitivity to safety or threat cues (e.g., Eysenck et al., 2007; Goodwin et al., 2017; Hirsch & Mathews, 2012; Puliafico & Kendall, 2006), including such cues expressed by faces (Roy et al., 2008). Youth who report elevated symptoms of generalized anxiety disorder may become attuned to others' expressions of happiness or fear as social indicators of safety or threat in the present environment (Costello et al., 2005b).

Alternatively, youth with symptoms of social anxiety disorder may also interpret ambiguous social cues as threatening (Rapee & Heimberg, 1997), leading to lower thresholds to identify others' expressions of anger or increased accuracy in recognition of anger (Maoz et al., 2016). Hence, cognitive conceptualizations of anxiety disorders make differing predictions regarding the association of generalized anxiety disorder or social anxiety disorder severity with one's ability to recognize others' emotional expressions.

Interpersonal problems occur among individuals with myriad psychopathological conditions (e.g., Horowitz et al., 1988; McEvoy et al., 2013), including anxiety disorders (Kachin et al., 2001; Przeworski et al., 2011). Research into the association of anxiety disorders with social cognitive processes, such as emotion recognition, may clarify characteristics of anxiety disorders that lead to interpersonal problems (e.g., Conway et al., 2012). Heightened sensitivity to expressions of happiness may lead one to respond acutely to another's decreased happiness (e.g., Strong et al., 1988), which might partially explain elevated quarrelsome behavior among individuals with elevated anxiety (Rappaport et al., 2014). Similarly, heightened sensitivity to expressions of fear may render one frequently alert, anxious, or 'on edge' to potential danger, such as is described in the diagnostic criteria for generalized anxiety disorder (American Psychiatric Association, 2013). Therefore, increased or decreased accuracy in recognizing others' emotional expressions may inform the maintenance and social implications of anxiety disorders.

Similar to competing theoretical perspectives, empirical research on the association of anxiety disorders with facial emotion recognition is also mixed. Anxiety has previously been: i) associated with *impaired* (i.e., less accurate) recognition of the emotion that another person expressed (e.g., in a static image; Berg et al., 2016; Simonian et al., 2001; Walker, 1981), ii) associated with *elevated* (i.e., more accurate) recognition of the emotion expressed (Ale et al., 2010; Richards et al., 2002; Surcinelli et al., 2006), iii) not associated with altered (i.e., more or less accurate) recognition (Cooper et al., 2008; McClure et al., 2003), or iv) associated with impaired (Battaglia et al., 2004; Maoz et al., 2016) or elevated recognition of only *specific* emotions (Short et al., 2016). Prior results on the association of anxiety disorders with facial emotion recognition are mixed in both child (Ale et al., 2010; Battaglia et al., 2004) and adult samples (Berg et al., 2016; Richards et al., 2002) and when collapsing across anxiety disorders or when examining specific anxiety disorders (Maoz et al., 2016). Mixed results may be due to inconsistent adjustment for concurrent psychopathology. For example, failure to parse anxiety and depression may obscure specific associations of anxiety and depressive disorders with facial emotion recognition (Dalili et al., 2015; Rappaport et al., 2018).

Most research on face-emotion processing examined individual anxiety disorders (Maoz et al., 2016) or anxiety as a broad trait (Cooper et al., 2008). Such studies (Richards et al., 2002) rarely adjust for concurrent anxiety and depressive symptoms. In a meta-analysis of emotion recognition and related social cognitive correlates of anxiety disorders, Plana and colleagues (2014) assert that there is a paucity of research examining multiple anxiety disorders. For example, evidence suggests that generalized anxiety disorder, but not other anxiety or depressive disorders, is associated with increased accuracy of facial emotion recognition. This may relate to heightened sensitivity to social indicators of general threat

(Eysenck et al., 2007; Goodwin et al., 2017; Hirsch & Mathews, 2012). Plana and colleagues (2014) further suggest the importance of considering comorbidity. The present study addressed this challenge through dimensional assessment of syndrome severity in a large community sample (e.g., Hudziak et al., 2007; Kotov et al., 2017).

Two notable studies suggest syndrome-specificity in relations between anxiety and facial emotion recognition. Lee and colleagues (2013) report impaired facial emotion recognition among children with separation anxiety disorder, which was not evident when the authors compared children with any anxiety disorder to children without an anxiety disorder. Children with separation anxiety disorder identified the emotion displayed by an animated female teenage character less accurately than did children with generalized anxiety disorder, social anxiety disorder, or children with no psychiatric diagnosis. Similarly, Reeb-Sutherland and colleagues (2015) report an elevated tendency to identify fearful facial expressions among adolescents with social anxiety disorder that was not present when the authors examined the presence of another anxiety disorder. However, Hezel and McNally (2014) suggest that adults with social anxiety disorder made more errors when attempting to identify negatively valanced emotions than did a community comparison group. Overall, both youth studies suggest the need for more work in this area.

1.1 The Present Study

Prior evidence suggests an association of impaired facial emotion recognition with various disorders. To further examine syndrome-specific associations, the present study examined the association of anxiety symptom severity and type with facial emotion recognition while adjusting for the concurrent severity of depressive symptoms. Cognitive theories make differing predictions. On one hand, elevated symptoms of generalized anxiety disorder may be associated with attunement to and elevated (i.e., more accurate) recognition of others' emotional expressions, specifically expressions indicative of safety (e.g., happiness) or threat (e.g., fear). On the other hand, elevated symptoms of social anxiety disorder may be associated with impaired recognition of anger due to an elevated tendency among individuals with social anxiety disorder to interpret subtle, partially ambiguous cues for other emotions (e.g., surprise) as indicative of anger in others.

The present study leveraged a large community sample of pre-adolescent children to clarify the association of anxiety severity and type with facial emotion recognition in a sample considerably larger than the majority of prior research. We adjusted for concurrent depressive severity and known associations of facial emotion recognition with age and participant sex (McClure, 2000). Based on multiple cognitive theories (e.g., Goodwin et al., 2017; Hirsch & Mathews, 2012), we hypothesized that children who reported more severe symptoms of generalized anxiety disorder would demonstrate more accurate facial emotion recognition, specifically more accurate recognition of happiness and fear, which serve as cues of safety and threat. However, given competing theories relevant to social anxiety disorder (e.g., Rapee & Heimberg, 1997), in lieu of specific hypotheses, we hoped to clarify the association of social anxiety disorder with facial emotion recognition. Additionally, based on work by Lee et al. (2013), we hypothesized that elevated symptoms of separation anxiety disorder would be associated with lower accuracy facial emotion recognition.

Symptoms of panic/somatization, which are hypothesized to be unrelated to facial emotion recognition, were included to examine a range of anxiety syndromes in youth (Birmaher et al., 1997).

2. Material and methods

2.1 Participants

Participants were drawn from the Juvenile Anxiety Study, a community twin sample of pre-adolescent twin children (N=796 children [398 families]) aged 9 to 14 (M = 11.25, SD = 1.44) from the mid-Atlantic region of the United States (i.e., Maryland, Virginia, North Carolina) (Carney et al., 2016). Participants were recruited from the Mid-Atlantic Twin Registry (Lilley et al., 2019), of which children of non-Hispanic European descent comprise 76.09%. Therefore, given budgetary constraints, the Juvenile Anxiety Study was designed to recruit 450 families of twins of non-Hispanic European descent to enhance power for planned, primary genomic research by minimizing genetic heterogeneity due to population stratification (e.g., Price et al., 2010). To minimize risk to participants and potential confounding factors, participants were excluded from the Juvenile Anxiety Study if they: i) had a prior diagnosis of intellectual disability or autism spectrum disorder, ii) experienced a past or current psychotic episode, iii) were currently using anxiolytic or antidepressant medications, or iv) had been diagnosed with any medical condition that might have adversely affected their safety or ability to complete the study (e.g., unexplained seizures) including aspects of the study not described here. Only participants (N = 664 children) who completed the face-emotion labeling task (FELT) (Marsh & Blair, 2008) and self-reported on symptoms of depressive and anxiety syndromes were included in the present analyses. Compared to participants who did not complete the task, participants who completed the face-emotion labeling task reported higher symptoms of panic disorder, $t(218.22)=-4.06$, $p=0.00007$, generalized anxiety disorder, $t(212.79)=-3.64$, $p=0.0003$, separation anxiety disorder, $t(206.11)=-2.56$, $p=0.01$, and social anxiety disorder, $t(211.06)=-2.94$, $p=0.004$, but were of similar age, depressive symptom severity, and proportion of male or female children, $ps > 0.08$. Severity of all four anxiety syndromes were retained in all subsequent analyses.

Prior research from the present sample has not examined the association of facial emotion recognition with anxiety syndromes but identified, in children, i) the test-retest reliability of the face-emotion labeling task (Cecilione et al., 2017); ii) genetic and environmental contributions to the etiology of facial emotion recognition (Rappaport et al., 2018); iii) genetic contributions to facial emotion recognition deficits in externalizing syndromes (Moore et al., in press); and iv) genetic and environmental contributions to the etiology of anxiety syndromes in children (Rappaport et al., in press). Post hoc power analysis of the resulting structural equation model using a Monte Carlo approach with 5000 simulations at $\alpha=0.05$ demonstrates that the effective sample (N=601; see section 2.3.3) provides at least 80% statistical power to detect a small, standardized association of an anxiety or depressive syndrome with improved or reduced accuracy in facial emotion recognition (i.e., $\beta=0.125$).

A study psychiatrist or clinical psychologist assessed past or current psychiatric diagnoses of each child based on parent interview using the K-SADS (Kaufman et al., 1997). Diagnostic

rates, based on DSM-IV criteria, indicate that the sample generally represents children in this age range regarding internalizing disorders. Lifetime prevalence rates of any depressive (2.27%) or anxiety disorder (27.4%) in the Juvenile Anxiety Study (Rappaport et al., 2017) are consistent with, or slightly higher than, rates reported elsewhere (Costello et al., 2005a, 2005b). Specifically, 60 (8.01 %) children met lifetime criteria for generalized anxiety disorder, 7 (0.93%) for panic disorder, 126 (16.82%) for a specific phobia, 59 (7.88%) for separation anxiety disorder, 37 (4.94%) for social anxiety disorder, and 17 (2.27%) for major depressive disorder. However, the lifetime prevalence of specific anxiety disorders was too low to provide sufficient statistical power for analyses based on the diagnosis of each anxiety disorder, which may also fail to capture distress associated with sub-threshold symptoms detected by dimensional assessment (Hudziak et al., 2007).

2.2 Design & Procedure

Children completed the FELT and self-reported on the severity of anxiety and depressive syndromes in the context of a larger study (Carney et al., 2016). A parent or legal guardian provided informed consent; children provided assent. Participating families were assessed during a single session at the geographically closer of two sites: The Virginia Institute for Psychiatric and Behavioral Genetics at Virginia Commonwealth University (Richmond, VA) or the National Institute for Mental Health (Bethesda, MD). The study, including all procedures, was approved by the Institutional Review Board of Virginia Commonwealth University.

2.3 Materials & Measures

2.3.1 Anxiety symptom severity.—

Child participants completed the Screen for Child Anxiety Related Emotional Disorders (SCARED) to assess symptoms of five anxiety syndromes over the past 3 months: generalized anxiety disorder, separation anxiety disorder, social anxiety disorder, panic/somatization, and school avoidance (Birmaher et al., 1997). An accompanying parent or legal guardian also completed the SCARED about each child. Reliability and validity of the SCARED among child samples is supported in the Juvenile Anxiety Study (Carney et al., 2016) and in prior research (e.g., Birmaher et al., 1999), which documents moderate-to-high internal consistency, test-retest reliability, and validity including putative thresholds with high sensitivity and specificity to anxiety disorder diagnoses in childhood (Birmaher et al., 1997). As suggested by prior research, only the first four subscales were used in the present study (e.g., Birmaher et al., 1997; Rappaport et al., in press).

2.3.2 Depressive symptom severity.—

Child participants reported depressive symptoms on the Short Mood and Feelings Questionnaire (SMFQ) (Angold et al., 1995), modified to reference the past 3 months consistent with the assessment of anxiety syndromes. Reliability and validity of the SMFQ among child samples is supported in prior research (Klein et al., 2005) and in the Juvenile Anxiety Study (Carney et al., 2016). An accompanying parent or legal guardian also completed the SMFQ about each child.

2.3.3 Face-Emotion Labeling Task (FELT).—

To assess their ability to detect others' facial expressions of emotion, participants attempted to identify the emotion expressed in

photos of White adult faces (50% female). Each face depicted one emotion drawn from the well-validated Pictures of Facial Affect Series (Ekman & Friesen, 1976). Multiple faces were included depicting all six prototypical emotions (i.e., sadness, fear, happiness, anger, disgust, surprise). The task was based on prior neuropsychological correlates of facial emotion processing (Guyer et al., 2007; Lau et al., 2009). Prior research documented high validity of the face-emotion labeling task including associations with psychopathology (e.g., Dalili et al., 2015), heritability of facial emotion recognition (e.g., Rappaport et al., 2018), and distinct neural correlates of facial emotion recognition (Wiggins et al., 2016). Two prior studies demonstrate test-retest reliability of the task in adult (T. Adams et al., 2016) and child samples including in the Juvenile Anxiety Study (Cecilione et al., 2017). The task took approximately 15 minutes to complete.

To mirror naturalistic ambiguity in others' facial expressions of emotions, each image was morphed with a static photo of the same person depicting a neutral expression to form 10 gradient clarity steps. Each image was presented 6 times (i.e., 6 trials) as depicted by different adults. Thus, participants attempted to identify the emotion expressed on 360 trials (6 emotions depicted X 10 clarity steps X 6 trials). Trial order was randomized, but consistent across participants. At each image presentation, participants viewed a fixation cross for 250ms before viewing the target image for 500ms. Participants then pressed one of six buttons corresponding to the six possible answers to identify the emotion expressed.

Prior research on this task identified that participants can achieve high or perfect raw accuracy (i.e., correct identification of the presented emotion) by endorsing one emotion on all tasks (Wagner, 1993). One could achieve perfect raw accuracy for happiness by endorsing happiness on all 360 trials. To adjust for this impact of response tendency, task performance for each emotion at each clarity step was computed as the product of raw accuracy and differential accuracy (i.e., correct identification when an emotion is not depicted). Regarding the prior example, endorsing happiness on all trials would produce perfect raw accuracy but low differential accuracy. Finally, task performance was adjusted for guessing by subtracting 1/6 and arcsine transformed to improve distributional normality (Wagner, 1993). Data from 63 individuals (9.49% of the sample) were removed due to suspected poor compliance with the task instructions (e.g., pressing the same button throughout the task without looking at the screen) or reported distress (e.g., headache) that impeded a participant's ability to engage with the task. Research assistants who noted poor compliance were unaware of other study data. Children whose data were removed were younger (10.59 years vs. 11.26 years of age), $t(73.24)=4.19$, $p=0.00008$, more likely to be female, $\chi^2(1)=4.84$, $p=0.028$, and reported higher depressive symptoms ($M=6.84$) than those whose data could be retained ($M=5.14$), $t(64.07)=-2.65$, $p=0.01$, though the two groups reported comparable severity of anxiety syndromes ($ps > 0.24$).

2.4 Data Analysis

Each emotion was presented on the same number of trials at the same number of clarity steps. Mean recognition of each emotion was computed across clarity steps. To adjust for the well-documented comorbidity of anxiety and depressive disorders (Costello et al., 2005b), an *a priori* data analytic design planned to regress mean recognition of each

emotion on the severity of depressive and anxiety symptoms assessed via the SCARED (i.e., panic/somatization, generalized anxiety disorder, separation anxiety disorder, and social anxiety disorder). To adjust for well-documented improvements in facial emotion recognition in girls and older children, age and sex were included as covariates in all analyses (McClure, 2000). There is a well-documented discrepancy between child- and parent-report, particularly for internalizing syndromes (e.g., Cantwell et al., 1997). Recent work on the subject suggests novel, clinically impactful solutions, such as the extraction of a latent trait through factor analysis or principal components analysis (e.g., Makol et al., 2020; Martel et al., 2017). However, these techniques, derived from structural equation modeling, require at least three indicators of the latent trait (e.g., report from the child, parent, and another informant). Without at least three indicators, loadings of the latent factor on child- and parent-report must be constrained to equality to avoid factor indeterminacy, which effectively averages child- and parent-report. Therefore, primary analyses examined the average of child- and parent-report, while supplementary analyses examined solely child-report of anxiety and depressive syndrome severity to evaluate the robustness of primary results. In the present sample, agreement between child- and parent-report was evident but weak to moderate (see Table 1) such that the average of child- and parent-report may integrate diverse perspectives on the child's well-being, particularly where results are further confirmed by analysis of child-report.

Structural equation modeling was used to model a latent general facial emotion recognition ability indexed by accurate recognition of all six emotions (Tomarken & Waller, 2005). To distinguish clinical correlates of participants' ability to recognize each emotion, recognition of each emotion was analyzed in separate multivariate regression models. Structural equation models were run with robust full information maximum likelihood (FIML) estimation with a sandwich estimator to adjust for possible deviations from multivariate normality and nonindependence due to the nesting of participants within families (Muthén & Asparouhov, 2002). Initial regression analyses used multivariate regression to produce standardized regression estimates to support the interpretability of empirical results. Residuals were checked for normality and influential outliers; no influential outliers were identified based on Cook's distance. Regression models were checked for multicollinearity. VIF estimates were between 1.04 and 1.91; tolerance estimates were between 0.52 and 0.96. However, participants were recruited in families and are not fully independent. Secondary analyses used multilevel, mixed-effects models to adjust for statistical nonindependence due to nesting within families. Data processing, multivariate regression, and multilevel regression were completed in R version 3.6.0 (R Core Team, 2018) using the psych (Revelle, 2015) and plyr (Wickham et al., 2018) packages for data processing; ggplot2 for figure generation (Wickham, 2009); and the nlme package for multilevel modeling (Pinheiro et al., 2016). Structural equation modeling was completed in Mplus version 8.3 (Muthén & Muthén, 1998). Multilevel and structural equation models used FIML estimation, which is robust to data missing at random conditional on covariates included in the model (Little et al., 2014) and recommended by prior simulation studies (e.g., von Hippel, 2016) including for multilevel data (e.g., Larsen, 2011). Analyses used two-tailed null-hypothesis significance tests. Consistent with statistical recommendations (e.g., Vasilopoulos et al.,

2016), empirical, 'raw' p-values are presented; interpretation of results considered the number of tests conducted among correlated outcomes (e.g., recognition of each emotion).

3. Results

3.1 Association of Anxiety and Depressive Symptoms with Latent Overall Facial Emotion Recognition

A structural equation model was fit to estimate latent general facial emotion recognition and regress it onto the severity of depressive and anxiety syndromes (see Figure 1). The model evidenced acceptable/good fit to the data (χ^2[44]=79.44, p=0.0008, CFI=0.974, RMSEA=0.037, 95%CI[0.023,0.049]). Standardized loadings indicated that latent overall facial emotion recognition was indexed significantly by accurate recognition of all six emotions. As hypothesized, elevated symptoms of generalized anxiety disorder were associated with, overall, more accurate facial emotion recognition (β=0.16, 95% CI [0.04, 0.27], p=0.007), whereas elevated symptoms of separation anxiety disorder (β=−0.16, 95% CI [−0.26, −0.06], p=0.003) and depression (β=−0.12, 95%CI[−0.22,−0.02], p=0.018) were associated with less accurate facial emotion recognition. Contrary to study hypotheses, symptoms of social anxiety disorder (β<0.001, 95%CI[−0.09,0.09], p=0.995), and panic/somatization symptoms (β=−0.014, 95% CI [−0.13, 0.10], p=0.804), were unrelated to facial emotion recognition. As expected based on previous work (e.g., McClure, 2000), female (β=0.16, 95% CI [0.07, 0.25], p<0.001) and older children (β=0.31, 95% CI [0.22, 0.40], p<0.001), demonstrated more accurate overall facial emotion recognition. Similar results were obtained for symptoms based only on child-report (see Supplement and Supplemental Figure S1).

3.2 Association of Anxiety and Depressive Symptoms with Emotion-Specific Recognition

As hypothesized, symptoms of generalized anxiety disorder were associated specifically with more accurate recognition of happiness and fear (see Table 2 and Figure 2). Elevated depressive symptoms were associated with impaired (i.e., less accurate) recognition of happiness, sadness, and disgust, though associations with recognition of sadness and disgust were not robust to adjustment for multiple testing. Even after adjustment for participant sex and age, symptoms of separation anxiety disorder were associated with less accurate recognition of happiness, fear, surprise, and disgust, though associations with recognition of surprise and disgust were not robust to adjustment for multiple testing.

By disaggregating child- from family-level variance in child-reported anxiety and depressive syndromes, multilevel models support initial results and indicate the importance of family-level influences on facial emotion recognition in childhood (see Table 3). Multilevel models clarify that families (i.e., pairs of twins) in which both twins report elevated symptoms of generalized anxiety disorder and separation anxiety disorder demonstrate, respectively, more and less accurate recognition of happiness, fear, and surprise. Elevated child-specific symptoms of generalized anxiety disorder, which index cases where one child reported symptoms higher than their twin, were associated only with more accurate recognition of happiness compared to one's twin. Conversely, both family- and child-level variation in depressive symptom severity were associated with less accurate recognition of happiness

and sadness. Finally, family-level variation in social anxiety disorder severity may be associated with more accurate recognition of anger. However, caution is warranted as this association is only evident when disaggregating child- from family-level variation in anxiety symptoms.

4. Discussion

The present study leveraged a large sample to examine the association of childhood anxiety with facial emotion recognition. Consistent with social cognitive theories (e.g., Goodwin et al., 2017; Puliafico & Kendall, 2006), elevated symptoms of generalized anxiety disorder were associated with increased overall accuracy and increased accuracy specifically in recognizing others' expressions of fear and happiness, which may index social cues of threat or safety, respectively. Generalized anxiety disorder and worry, broadly, have been associated with increased vigilance towards social threat or safety (Bar-Haim et al., 2007; Zainal & Newman, 2018). However, prior research on facial emotion recognition has not compared associations across anxiety syndrome domains in a large sample of children (Plana et al., 2014). The present study documents that, consistent with increased attentional bias towards cues of social safety or threat, children with elevated generalized anxiety disorder symptoms may show increased sensitivity to others' social safety or threat cues.

The present results highlight the importance of distinguishing between types of anxiety disorders in youth. Consistent with one prior study (Lee et al., 2013), elevated symptoms of separation anxiety disorder were associated with less accurate recognition of happiness and fear. Separation anxiety disorder reflects anxiety specific to separation from a caregiver. Therefore, though speculative, while generalized anxiety disorder may be associated with broad heightened vigilance, individuals with elevated symptoms of separation anxiety disorder may demonstrate less accurate facial emotion recognition as social cognitive resources are devoted instead to ascertain the presence or absence of caregivers. Also, consistent with prior research (Dalili et al., 2015; Rappaport et al., 2018), elevated depressive symptoms were associated with less accurate overall facial emotion recognition, specifically recognition of happiness. Results were largely similar when anxiety and depressive symptoms were assessed using the average of child- and parent-report or by child-report only, with the caveat that several associations (e.g., of depressive symptoms with recognition of sadness) survived adjustment for multiple testing only when based on child-report (see Supplemental Table S1).

Symptoms of social anxiety disorder did not relate to facial emotion recognition. We note that alternative processes, such as the interpretation of ambiguous facial expressions as threat cues, may also impair the accuracy of facial emotion recognition in individuals with social anxiety disorder (Rapee & Heimberg, 1997). For example, Maoz and colleagues (2016) report a lower threshold to identify anger among children with social anxiety disorder. Similarly, Reeb-Sutherland and colleagues (2015) identify a lower threshold to discriminate fear from anger among children with both social anxiety disorder and elevated behavioral inhibition relative to both i) children without social anxiety disorder and ii) children with social anxiety disorder and low behavioral inhibition. However, others implicate social anxiety disorder in lower accuracy emotion recognition (Hezel & McNally,

2014). The present study examined a normative, community sample of children, which informs developmental models but may miss increased or decreased accuracy in children with clinical levels of social anxiety disorder.

Evident associations of depressive symptoms with both lower overall accuracy and lower accuracy for specific emotions are consistent with substantial prior studies in various conditions. However, the present study also addresses aspects of specificity in both symptoms and face-processing not examined in prior studies (Dalili et al., 2015). Broadly, the present results are consistent with prior indications that some syndromes are characterized by broad deficits in facial emotion recognition whereas other syndromes may impact accuracy in the recognition of only specific emotions (e.g., Guyer et al., 2007). Where syndromes are characterized by distinct increases or decreases in the recognition of specific emotions, the specific pattern of altered recognition may clarify psychosocial and neural correlates important to the development and/or maintenance of each syndrome (e.g., Harms et al., 2010; Wiggins et al., 2016). For example, broad deficits in facial emotion recognition accuracy may indicate distinct neurodevelopmental alterations different from those that affect the recognition of only specific emotions (e.g., happiness). Understanding the distinct impact of each syndrome on the recognition of different emotional expressions may inform clinical assessment and novel psychological treatments focused on improving youth emotion recognition (S. Adams et al., 2013).

Evidence of lower accuracy of facial emotion recognition in multiple psychiatric and psychological conditions implicates facial emotion recognition as a putative transdiagnostic process. However, to validate facial emotion recognition as a transdiagnostic process, it is critical to evaluate whether lower accuracy in facial emotion recognition informs the characterization of specific disorders or may simply index higher order psychiatric distress reflected in myriad syndromes. The present results are consistent with models of nosology that allow for common and distinct correlates of depressive and anxiety disorders (e.g., Clark & Watson, 1991). Specifically, the present results suggest that symptoms of generalized anxiety disorder, separation anxiety disorder, and major depressive disorder show distinct associations with facial emotion recognition. Consistent with recent dimensional models of psychopathology (e.g., Kotov et al., 2017), evidence of distinct psychosocial correlates in childhood highlights the importance of distinguishing between concurrent anxiety and depressive disorders in youth development.

Mixed results from prior research further illustrate the importance of adjusting for concurrent depressive disorders, which are often comorbid with anxiety disorders (Costello et al., 2005a) and consistently associated with lower accuracy in facial emotion recognition (Dalili et al., 2015). Similarly, the present results are consistent with emerging research to indicate the importance of considering anxiety disorder subtype (Lee et al., 2013; Reeb-Sutherland et al., 2015). Collapsing across anxiety disorders or combining anxiety with depressive disorders risks obfuscating distinct associations of generalized anxiety disorder, separation anxiety disorder, and major depressive disorder symptoms with facial emotion recognition. The present results also demonstrate the utility of dimensional clinical assessment to parse comorbidity in developmental research and inform clinical assessment. Categorical clinical diagnoses may limit the statistical information available to adjust for

concurrent conditions (Hudziak et al., 2007). For example, when treated categorically, statistical adjustment for a comorbid depressive episode estimates the association of an anxiety disorder with facial emotion recognition only in participants who do not report a depressive episode.

Psychosocial correlates of dimensional assessment may also more readily generalize to comorbidity in clinical settings where one child with comorbid generalized anxiety disorder and major depressive disorder may present with pronounced anxiety severity while another with both conditions may present with pronounced depressive severity. Through dimensional assessment, the present study adjusted for concurrent depressive symptoms and symptoms of generalized anxiety disorder to indicate that elevated symptoms of generalized anxiety disorder may correlate with increased accuracy in recognizing others' expressions of happiness and fear; depressive symptoms with lower accuracy in recognizing others' expressions of happiness. Research is needed on a larger sample of children to evaluate potential interactions of concurrent depressive symptoms with symptoms of generalized anxiety disorder; the present sample was underpowered to examine statistical interactions. Among children who report very high symptoms of both depressive and generalized anxiety disorders, it would be consistent with the present data to anticipate increased accuracy in recognizing others' expressions of fear, though it is unclear whether one might anticipate increased or decreased accuracy in recognizing others' expressions of happiness. Moreover, given evidence that anxiety and depressive symptoms fluctuate over time (e.g., Ben-Zeev & Young, 2010; Fisher et al., 2017), research is needed to leverage intensive repeated measure designs (e.g., ecological momentary assessment) to evaluate how facial emotion recognition changes in situ as a function of temporal changes in the severity of depressive and anxiety symptoms. For example, Zainal and Newman (2018) report that individuals with generalized anxiety disorder demonstrate amplified theory-of-mind reasoning for negatively valanced social stimuli when acutely worried.

4.1 Limitations and Future Directions

Despite the insights provided on the association of facial emotion recognition with pediatric anxiety disorders, the present results should be considered in light of several limitations. First, participants were recruited from the community. Community samples reflect a normative range of symptom severity (see Carney et al., 2016 for descriptive statistics from the larger Juvenile Anxiety Study) and inform psychosocial mechanisms in the development of psychopathology (Hudziak et al., 2007). However, caution is warranted before generalizing the present results to treatment-seeking child populations. The present study also required exclusion criteria to ensure the reliability and validity of study measures including measures from the larger Juvenile Anxiety Study (Carney et al., 2016). For example, anxiolytic and antidepressant medications may impact cognitive processing, which could obfuscate the association of depressive and anxiety syndromes with increased or decreased accuracy of facial emotion recognition (Harmer & Cowen, 2013). Similarly, given well-documented social deficits in people with autism spectrum disorders (Harms et al., 2010) and psychotic disorders (e.g., Mandal et al., 1998), the present study focused on examining the association of depressive and anxiety syndromes with facial emotion recognition in children without an autism spectrum or psychotic disorder. The sample was

also composed of twins, which may affect the generalizability of results. For example, it may be possible that the experience of growing up as a twin uniquely influences one's facial emotion recognition or the association of facial emotion recognition with anxiety syndromes. However, we are not aware of evidence to suggest that, as compared to non-twin children, twin children demonstrate increased or decreased accuracy in recognizing others' facial expressions of emotion. Ultimately, future research is needed to replicate the present findings in large community and clinically referred samples of children.

Second, prior research validated the present facial emotion recognition task to assess accuracy in recognizing others' facial expressions of emotion in child and adolescent samples (T. Adams et al., 2016; Cecilione et al., 2017). However, future research is needed to extend these results to other social cues that youth may use to interpret others' emotional expressions. For example, Morningstar and colleagues pioneered a vocal analogue of the facial emotion recognition paradigm to assess youths' recognition of vocal expressions of emotion (Morningstar et al., 2017, 2018, 2019). Similarly, unmeasured third variables, such as aspects of executive functioning, may affect both anxiety disorders and facial emotion recognition in a manner that could produce the associations evident here. If so, the present associations may index how other altered cognitive processes impact this core aspect of social functioning in children and youth, namely recognition of others' facial expressions of emotion (Trentacosta & Fine, 2010).

Third, the present study used a large sample of children to clarify mixed prior results on the association of anxiety disorders with facial emotion recognition. However, the cross-sectional nature of the study limits causal inference. Recent genetically-informed research implicates low facial emotion recognition accuracy in the etiology of depression and irritability (Rappaport et al., 2018). However, future research is needed to evaluate the temporal association of anxiety syndromes with facial emotion recognition. For example, longitudinal research is needed to clarify whether increased recognition of fear contributes to the development of generalized anxiety disorder or is produced by it. Finally, to maximize statistical power for unrelated genetic aims, the Juvenile Anxiety Study was limited to families of non-Hispanic European descent. This represents the largest genetically similar subpopulation in the catchment area of the Mid-Atlantic Twin Registry. However, future research is critically needed to broaden the present findings to children of diverse racial and ethnic backgrounds.

Future research is also needed to evaluate potential clinical implications of evidence that generalized anxiety disorder symptoms are associated with heightened sensitivity to others' facial expressions of emotion, specifically happiness and fear. Heightened sensitivity may partially explain an avenue through which individuals with generalized anxiety disorder are at elevated risk for interpersonal problems (e.g., Conway et al., 2012; Newman & Erickson, 2010). For example, heightened sensitivity to another's expression of happiness may render one sensitive to decreases in others' expressions of happiness and provoke increased anxiety or quarrelsome behavior when happiness decreases, which prior research documents among individuals who report elevated anxiety symptoms (Rappaport et al., 2014). If so, psychotherapeutic interventions might incorporate discussion of heightened

sensitivity to others' emotional expressions to help mitigate risk for interpersonal problems (e.g., Newman et al., 2011).

5. Conclusions

Overall, the present study indicates that elevated generalized anxiety disorder symptoms are associated with increased accuracy in recognizing others' facial expressions of emotion, particularly others' expressions of happiness and fear, which may reflect heightened sensitivity to social cues of safety or threat, respectively. Evidence of increased accuracy in facial emotion recognition among children who report elevated symptoms of generalized anxiety disorder indicates that facial emotion recognition may be a transdiagnostic characteristic of multiple syndromes rather than a broad correlate of psychological or psychiatric distress. In contrast, consistent with prior research, the present study demonstrates that symptoms of depression and separation anxiety disorder are associated with lower accuracy in recognizing others' facial expressions of emotion. Overall, the present results suggest a nuanced contribution of facial emotion recognition to multiple clinical syndromes that may distinguish between comorbid conditions, inform the psychosocial development of children with elevated anxiety, and guide psychosocial interventions for pediatric anxiety.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Highlights

- Pediatric symptoms of GAD are linked to improved recognition of others' emotions.
- GAD symptoms are linked to improved recognition of others' happiness and fear.
- Pediatric depressive symptoms are linked to impaired recognition of others' happiness.

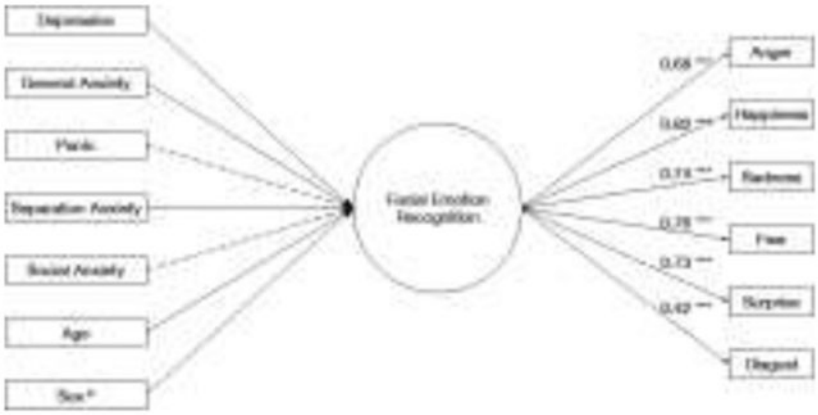

Figure 1.

Structural Equation Model of Overall Facial Emotion Recognition Accuracy

Note. [a] Sex is dummy coded such that the reference group is male. Depressive, general anxiety, panic, separation anxiety, and social anxiety refer to dimensional symptom severity for each syndrome listed. Residual variances for 6 endogenous variables (i.e., in the right-hand column) and intercorrelation of all 7 exogenous variables (i.e., in the left-hand column) were specified but omitted from the figure for clarity. Dashed lines indicate paths not significantly different from 0 at $\alpha = 0.05$. *** $p < 0.001$.

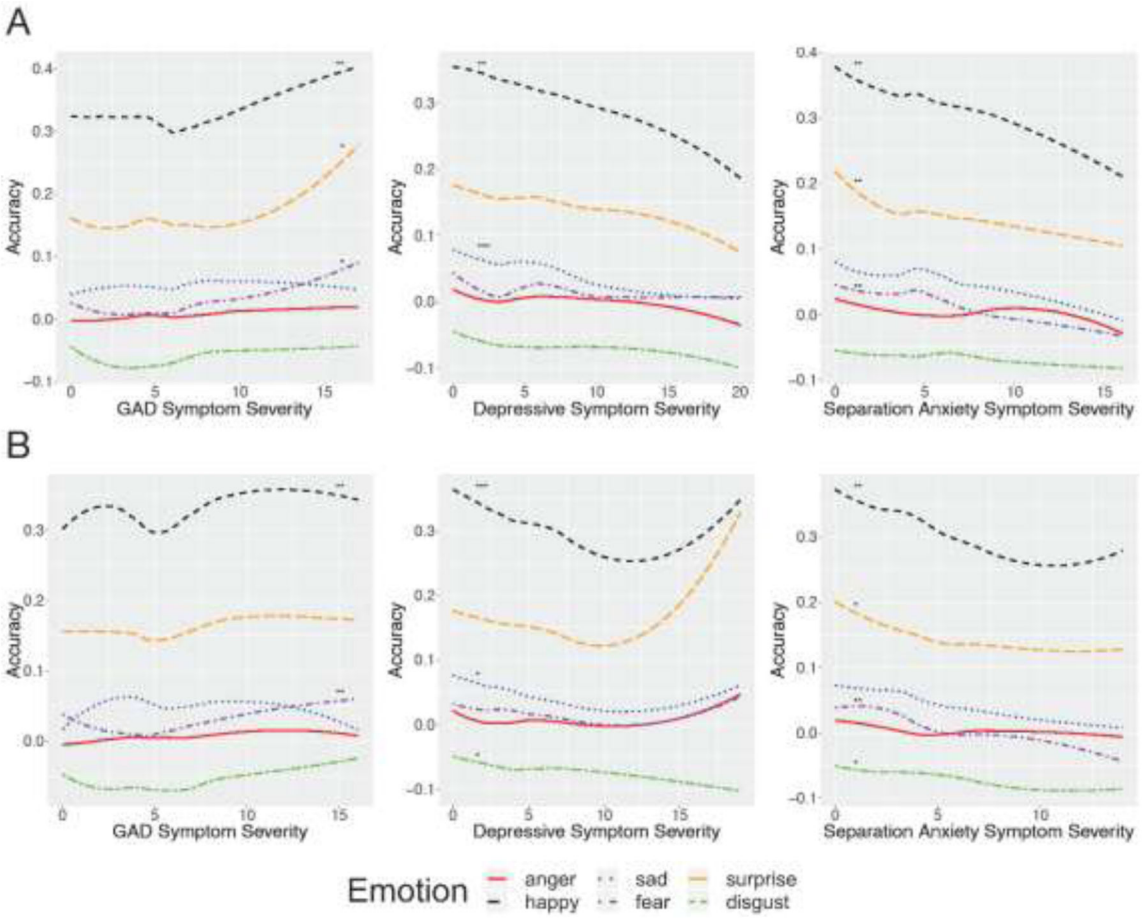

Figure 2.

Association of Facial Emotion Recognition Accuracy with Anxiety and Depressive Symptom Severity assessed by Child-Report (A) or Child- and Parent-Report (B)

Note. A reflects symptom severity assessed only by child-report; B reflects symptom severity assessed as the average of child- and parent-report. Please see Supplemental Table S1 for results of analyses based only on child-report symptom severity GAD = generalized anxiety disorder. Happy indicates happiness; sad indicates sadness. * $p \leq 0.05$, ** $p \leq 0.01$, *** $p \leq 0.001$.

Table 1.

Descriptive Information and Agreement Between Child- and Parent-Report

Variable	Child Report M (SD)	Parent Report M (SD)	Correlation of Child with Parent Report r (95% CI)	Correlation Matrix				
				Depressive Symptoms	Panic/Somatization Symptoms	General Anxiety Symptoms	Separation Anxiety Symptoms	Social Anxiety Symptoms
Depressive Symptoms	5.32 (4.09)	1.94 (2.97)	0.23 (0.14, 0.30)	--	0.21 (0.13, 0.29)	0.46 (0.38, 0.53)	0.25 (0.15, 0.35)	0.16 (0.07, 0.25)
Panic/Somatization Symptoms	5.41 (3.84)	1.43 (2.52)	0.10 (0.03, 0.19)	0.46 (0.37, 0.52)	--	0.60 (0.53, 0.66)	0.57 (0.49, 0.64)	0.40 (0.32, 0.48)
General Anxiety Symptoms	6.21 (.371)	3.97 (3.69)	0.19 (0.10, 0.27)	0.44 (0.37, 0.51)	0.48 (0.40, 0.54)	--	0.60 (0.53, 0.66)	0.48 (0.40, 0.55)
Separation Anxiety Symptoms	5.38 (3.44)	2.18 (2.74)	0.28 (0.21, 0.36)	0.38 (0.30, 0.47)	0.48 (0.42, 0.54)	0.41 (0.35, 0.46)	--	0.36 (0.28, 0.45)
Social Anxiety Symptoms	6.22 (3.25)	4.00 (3.54)	0.28 (0.21, 0.36)	0.24 (0.15, 0.32)	0.35 (0.28, 0.41)	0.37 (0.28, 0.45)	0.43 (0.35, 0.50)	--

Note. Correlations below the diagonal reference child report; correlations above the diagonal reference parent report.

Table 2.

Multivariate Associations of Depressive and Anxiety Symptom Severity with Facial Emotion Recognition Accuracy (β [95% CI])

	Emotion		
Term	**Anger**	**Happiness**	**Sadness**
Sex [a]	0.140 (0.129, 0.151) +	0.135 (0.108, 0.163) ***	0.1 (0.083, 0.116) *
Age	0.238 (0.234, 0.242) +	0.219 (0.209, 0.229) +	0.25 (0.244, 0.256) +
Depressive [b]	−0.057 (−0.059, −0.055)	−0.146 (−0.152, −0.141) ***	−0.11 (−0.113, −0.107) *
Panic/Somatization [b]	−0.005 (−0.008, −0.002)	−0.014 (−0.02, −0.007)	−0.016 (−0.02, −0.012)
General Anxiety [b]	0.075 (0.073, 0.078)	0.168 (0.162, 0.174) **	0.069 (0.065, 0.073)
Separation Anxiety [b]	−0.042 (−0.045, −0.04)	−0.146 (−0.152, −0.139) **	−0.093 (−0.097, −0.089)
Social Anxiety [b]	0.028 (0.026, 0.03)	−0.022 (−0.027, −0.016)	0.035 (0.032, 0.039)
	Emotion		
Term	**Fear**	**Surprise**	**Disgust**
Sex [a]	0.071 (0.052, 0.089)	0.136 (0.113, 0.16) **	0.103 (0.091, 0.115) *
Age	0.235 (0.228, 0.241) +	0.201 (0.192, 0.209) +	0.266 (0.261, 0.27) +
Depressive [b]	−0.034 (−0.038, −0.03)	−0.068 (−0.072, −0.063)	−0.101 (−0.103, −0.098) *
Panic/Somatization [b]	−0.024 (−0.029, −0.02)	0.019 (0.013, 0.024)	0.047 (0.044, 0.05)
General Anxiety [b]	0.153 (0.149, 0.158) **	0.105 (0.1, 0.11)	0.107 (0.104, 0.11)
Separation Anxiety [b]	−0.149 (−0.54, −0.144) **	−0.115 (−0.12, −0.109) *	−0.107 (−0.11, −0.104) *
Social Anxiety [b]	−0.014 (−0.017, −0.01)	−0.048 (−0.052, -0.043)	0.034 (0.031, 0.036)

Notes.

[a] Sex is dummy coded such that the reference group is male.

[b] indicates dimensional symptom severity for each syndrome listed.

* $p \leq 0.05$

** $p \leq 0.01$

*** $p \leq 0.001$

+ $p \leq 0.0001$.

Table 3.

Multilevel Associations of Child- and Family-Level Depressive and Anxiety Symptom Severity with Facial Emotion Recognition Accuracy (B [95% CI])

	Emotion		
Term	**Anger**	**Happiness**	**Sadness**
Child Level			
Sex [a]	0.019 (0.008, 0.031) ***	0.048 (0.02, 0.076) ***	0.021 (0.004, 0.037) *
Depressive [b]	0 (−0.003, 0.003)	−0.009 (−0.015, −0.003) **	−0.006 (−0.01, −0.002) **
Panic/Somatization [b]	0.001 (−0.002, 0.004)	0.002 (−0.004, 0.009)	0.004 (0, 0.008)
General Anxiety [b]	0.001 (−0.002, 0.004)	0.008 (0.002, 0.015) *	0.001 (−0.003, 0.005)
Separation Anxiety [b]	0.001 (−0.002, 0.004)	−0.005 (−0.013, 0.002)	−0.004 (−0.008, 0)
Social Anxiety [b]	−0.002 (−0.005, 0.001)	−0.007 (−0.013, 0)	−0.001 (−0.005, 0.003)
Family Level			
Age	0.011 (0.006, 0.015) +	0.025 (0.013, 0.037) +	0.017 (0.01, 0.024) +
Depressive [b]	−0.001(−0.003, 0.001)	−0.005 (−0.011, 0) *	−0.003 (−0.006, 0) *
Panic/Somatization [b]	−0.001 (−0.003, 0.002)	−0.001 (−0.007, 0.005)	−0.001 (−0.005, 0.002)
General Anxiety [b]	0.001 (−0.002, 0.003)	0.006 (0, 0.013) *	0.002 (−0.002, 0.006)
Separation Anxiety [b]	−0.001 (−0.004, 0.002)	−0.008 (−0.015, −0.001) *	−0.003 (−0.007, 0.001)
Social Anxiety [b]	0.003 (0.001, 0.006) **	0.006 (−0.001, 0.012)	0.004 (0, 0.008) *
	Emotion		
Term	**Fear**	**Surprise**	**Disgust**
Child Level			
Sex [a]	0.014 (−0.004, 0.033)	0.036 (0.012, 0.06) **	0.014 (0.002, 0.027) *
Depressive [b]	−0.001 (−0.005, 0.004)	−0.005 (−0.011, 0)	0 (−0.003, 0.003)
Panic/Somatization [b]	0.001 (−0.004, 0.005)	−0.001 (−0.006, 0.005)	0 (−0.003, 0.003)
General Anxiety [b]	0.004 (−0.001, 0.009)	0.004 (−0.002, 0.01)	0.003 (−0.001, 0.006)
Separation Anxiety [b]	−0.001 (−0.006, 0.004)	−0.003 (−0.01, 0.003)	−0.002 (−0.005, 0.002)
Social Anxiety [b]	−0.005 (−0.009, 0) *	−0.005 (−0.011, 0.001)	0 (−0.003, 0.003)
Family Level			
Age	0.016 (0.009, 0.024) +	0.016 (0.007, 0.026) ***	0.016 (0.01, 0.021) +
Depressive [b]	−0.001 (−0.004, 0.003)	−0.002 (−0.006, 0.002)	−0.002 (−0.005, 0) *
Panic/Somatization [b]	0 (−0.004, 0.004)	0 (−0.005, 0.005)	0.001 (−0.001, 0.004)
General Anxiety [b]	0.004 (0, 0.009) *	0.006 (0.001, 0.011) *	0 (−0.003, 0.002)
Separation Anxiety [b]	−0.007 (−0.012, −0.003) **	−0.008 (−0.013, −0.002) **	0 (−0.003, 0.003)
Social Anxiety [b]	0.004 (0, 0.008)	0.005 (−0.001, 0.01)	0.003 (0, 0.006)

Notes.

[a] Sex is dummy coded such that the reference group is male.

[b] indicates dimensional symptom severity for each syndrome listed.

* $p \leq 0.05$

** $p \leq 0.01$

*** $p \leq 0.001$

+ $p \leq 0.0001$.