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Processing emotional facial expressions influences performance on a Go/NoGo task in pediatric anxiety and depression

Cecile D. Ladouceur,[1] Ronald E. Dahl,[1] Douglas E. Williamson,[1] Boris Birmaher,[1] David A. Axelson,[1] Neal D. Ryan,[1] and B.J. Casey[2]

[1]Department of Psychiatry, School of Medicine, Western Psychiatric Institute and Clinic, University of Pittsburgh, USA; [2]Sackler Institute for Developmental Psychobiology, Weill Medical College of Cornell University, New York, USA

Background: This study investigated whether processing emotionally salient information such as emotional facial expressions influences the performance on a cognitive control task in pediatric anxiety and depression. **Methods:** The sample included 68 participants between 8 and 16 years of age selected into three diagnostic groups: Anxiety Disorder (ANX, $n = 23$), Major Depressive Disorder (MDD, $n = 19$), and Low-Risk Normal Control (LRNC, $n = 26$). Participants completed an *Emotional Go/NoGo* task in which participants must either respond to (Go trials) or not respond to (NoGo trials) specific facial expressions (angry, fearful, sad, happy, neutral). In order to manipulate the level of cognitive control needed to perform the task, the probability of occurrence of the Go trials was varied across 3 probability conditions (low, moderate, high). **Results:** Analyses showed that the MDD group had significantly faster reaction times to sad face Go trials embedded in neutral face NoGo trials in the moderate probability condition and that the ANX group had significantly slower reaction times to neutral face Go trials embedded in angry face NoGo trials in the low probability condition. **Conclusions:** These data demonstrate that processing emotional facial expressions influences the performance on a cognitive control task in children and adolescents diagnosed with an anxiety disorder and major depression. **Keywords:** Children, adolescents, anxiety, depression, emotional processing, cognitive control. **Abbreviations:** ANX: Anxiety Disorder group; MDD: Major Depressive Disorder group; LRNC: Low-Risk Normal Control group; CBCL: Child Behavior Checklist; SCARED: Screen for Childhood Anxiety and Related Disorders; CDI: Children's Depression Inventory; BDI: Beck Depression Inventory.

Affective disorders are thought to reflect some maladaptive changes in emotion regulation. Information processing models have attempted to understand these maladaptive changes of emotion regulation in affective disorders by focusing primarily on the cognitive aspects of emotional processing (Beck, 1967; Beck, Emery, & Greenberg, 1985; Mogg & Bradley, 1998; Williams, Watts, MacLeod, & Mathews, 1997). Research studies on attention indicate that clinical anxiety or high trait anxiety is related to early attentional orienting toward threatening stimuli whereas depression is related to sustained attention toward depressogenic or sad emotional information (Williams et al., 1997). This tendency to focus attention toward threatening or sad information has been hypothesized by some to play a major role in the etiology and maintenance of these affective disorders (Beck, 1967; Bower, 1981; Bradley, Mogg, Falla, & Hamilton, 1998; Mathews & MacLeod, 1994; Vasey & MacLeod, 2001; Williams et al., 1997). It is only recently, however, that researchers have begun to examine the cognitive aspects of emotional information processing in pediatric affective disorders (Vasey & MacLeod, 2001).

Studies that have examined emotional information processing in pediatric affective disorders have shown that, like adults, anxious children selectively attend to threatening stimuli (Dalgleish, Moradi, Taghavi, Neshat-Doost, & Yule, 2001; Hadwin et al., 2003; Kindt, Brosschot, & Everaerd, 1997; Taghavi, Neshat-Doost, Moradi, Yule, & Dalgleish, 1999; Vasey, Daleiden, Williams, & Brown, 1995). The results related to depression, however, are rather unclear. Although a few studies have linked childhood depression with attention to threat, a larger number of studies have shown that depression is associated with an attentional bias toward negative or sad emotional information (Vasey & MacLeod, 2001).

Paradigms used to assess selective attention to threatening or sad stimuli typically have used emotional words in the context of modified dot-probe and Stroop tasks (Vasey & MacLeod, 2001). In the emotional Stroop task, for example, participants must name the color of the word and ignore the content of the word. The duration taken to name the color of emotional words compared to neutral words indicates the extent of the emotional bias. Using emotional words as stimuli, however, may not constitute very emotionally salient stimuli for children and may require a minimum reading level (Vasey, El-Hag, & Daleiden, 1996). Facial expressions are

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emotionally meaningful non-verbal stimuli for humans, especially for children (Herba & Phillips, 2004). The developmental literature on face processing has shown that the ability to discriminate among discrete facial expressions is relatively well developed in early childhood and becomes more sophisticated throughout childhood and adolescence (Kolb, Wilson, & Taylor, 1992; Taylor, McCarthy, Saliba, & Degiovanni, 1999). Yet very few studies of emotional information processing in pediatric affective disorders have included emotional facial expressions as emotional stimuli.

Another aspect that remains understudied with regard to the cognitive aspects of emotional information processing in pediatric affective disorders is the role of cognitive control processes. Cognitive control involves the coordination of cognitive subprocesses that facilitate the focus of attention on goal-relevant information while inhibiting goal-irrelevant information (Casey, Durston, & Fossella, 2001; Miller & Cohen, 2002; Norman & Shallice, 1986). Rothbart and colleagues (Fernandez-Duque, Baird, & Posner, 2000; Posner & Rothbart, 2000) have suggested that cognitive control plays an important role in the development of emotion regulation. For instance, research conducted on infants has shown that the development of cognitive control abilities, such as the ability to shift attention away from negative stimuli or toward positive stimuli, are related to better regulation of distress and anger in young children (Posner & Rothbart, 2000). As such, it is thought that cognitive control processes play an important role in emotion regulation by modulating the influence of emotional stimuli on behavior and that these processes may be impaired in individuals with affective disorders (Phillips, Drevets, Rauch, & Lane, 2003). Very few studies, however, have examined the role of cognitive control processes in emotional information processing in pediatric affective disorders.

In this study, we compared the performance of children and adolescents diagnosed with anxiety disorder (ANX), major depressive disorder (MDD), and low-risk normal controls (LRNC) on an *Emotional Go/NoGo* task (Hare, Tottenham, Davidson, Glover, & Casey, 2005), which is a modified version of the original Probability Go/NoGo task (Casey et al., 2001). In the original Go/NoGo task, participants were asked to respond to any letter (Go trials) but the letter 'X' (NoGo trials). In the *Emotional Go/NoGo* task, participants were asked to respond to a particular emotional facial expression (Go trials) and not respond (NoGo trials) to a neutral facial expression or vice versa.

Casey (Casey et al., 2001) and others (Durston, Thomas, Worden, Yang, & Casey, 2002; Jones, Cho, Nystrom, Cohen, & Braver, 2002) have shown that manipulating the frequency of the Go trials influences the need for cognitive control by increasing the stimulus and response demands of the task (Casey et al., 2001, 1997). In particular, when Go trials are frequent and NoGo trials are rare, subjects tend to have slower reaction times on Go trials reflecting recruitment of inhibitory processes to adjust for the tendency to respond to the Go trials and to successfully inhibit a response (Eigsti et al., submitted; Liston et al., in press).

In the current study, we manipulated the level of cognitive control needed to perform the task by varying the frequency of the Go trials in the *Emotional Go/NoGo* task according to three probability conditions: low (25%), moderate (75%), and high (100%). The low and moderate probability conditions require more cognitive control compared to the high probability condition, which involves simply responding to all of the Go trials. In particular, the moderate condition requires the most cognitive control as the subject must override the tendency to respond to a rare occurring NoGo trial. The low probability condition engages a moderate level of cognitive control as the subject must detect and respond to a rare occurring Go trial – thought to tap into processes related to vigilance.

Given that cognitive control processes play an important role in emotion regulation and that these processes may be perturbed in pediatric affective disorders, we predicted that the negative emotional faces would influence performance for the probability conditions requiring greater cognitive control – the low and moderate probability conditions – in the ANX and MDD groups but not in the LRNC group. More specifically, we predicted that the fear and angry facial expressions, which are considered to be ecologically valid and salient depictions of threat (Whalen et al., 2001), would influence the performance of the ANX group whereas the sad facial expressions, which have been used in adult studies and are thought to reflect depressogenic stimuli (Gotlib, Krasnoperova, Neubauer, & Joorman, 2004), would influence the performance of the MDD group.

Method

Participants

Participants consisted of children and adolescents aged 8 years 0 months to 16 years 11 months who were participating in a larger longitudinal program project on the neurobiology of pediatric affective disorders (Birmaher et al., 2000; Dahl et al., 2000). There were a total of 68 participants (32 girls and 36 boys). Overall mean age was 12.52 ($SD = 2.68$) years. Children in the ANX and MDD groups were recruited from inpatient and outpatient clinics at the Western Psychiatric Institute and Clinic, Pittsburgh, PA. Children in the LRNC group were recruited through advertisement in the local newspaper (see Table 1 for group demographics).

Children in the ANX group included children diagnosed with a current anxiety disorder (Generalized Anxiety Disorder ($n = 17$); Generalized Anxiety Disorder

Table 1 Demographic information and self-report measures

	Diagnostic groups								
	ANX ($n = 23$)			MDD ($n = 19$)			LRNC ($n = 26$)		
	M	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*	*n*
Participant characteristics									
Gender									
Girls	–	–	10	–	–	10	–	–	12
Boys	–	–	13	–	–	9	–	–	14
Age[a]	11.49	2.52	23	14.17	2.39	19	12.22	2.53	26
SES	41.93	14.30	21	43.50	14.56	18	45.10	12.77	24
Self-report measures									
CBCL – externalizing[b]	64.50	9.37	22	64.69	9.55	13	45.52	8.53	21
CBCL – internalizing[b]	70.86	8.03	22	69.23	5.02	13	42.90	6.83	21
CBCL – total[b]	70.09	8.95	22	70.23	7.00	13	42.67	8.38	21
SCARED – child form[b]	29.36	14.40	11	26.07	16.30	14	9.44	9.59	16
SCARED – parent form[b,c]	31.82	15.59	11	20.80	11.74	15	3.81	3.66	16
Z-score CDI/BDI[b]	.18	1.01	12	.52	1.01	14	–.85	.40	17

Note: *t*-scores are presented for the CBCL measures whereas total scores are presented for the SCARED; Z-scores are presented for the CDI, and BDI; [a]: ANX < MDD, $p < .05$; [b]: LRNC < ANX, MDD, $p < .01$; [c]: MDD < ANX, $p < .05$.

with Depression Not Otherwise Specified ($n = 2$); Separation Anxiety Disorder ($n = 3$); Social Phobia ($n = 1$)). Children in the MDD group included children in a current episode of major depressive disorder (Major Depressive Disorder ($n = 17$) and Major Depressive Disorder with Social Phobia ($n = 2$)). All clinical disorders were based on DSM-IV (American Psychiatric Association, 1994) criteria. Children in the clinical groups were asked to participate before commencing any type of medication treatment. Low-risk normal children ($n = 63$) were required to be free of any lifetime psychopathology. In addition, they were required to have no first-degree relatives with a lifetime episode of any mood or psychotic disorder; no second-degree relatives could have a lifetime history of childhood-onset, recurrent, psychotic, or bipolar depression or schizoaffective or schizophrenic disorder; and no more than 20% of their second-degree relatives could have a lifetime single episode of MDD (Ladouceur et al., 2005; Williamson, Birmaher, Axelson, Ryan, & Dahl, 2004).

The majority of the sample was Caucasian ($n = 59$), with 5 children (3 ANX, 2 MDD) that were of African-American origin and 4 children from other ethnic backgrounds (1 MDD Asian, 1 MDD Native American, 1 ANX Biracial, and 1 LRNC Biracial). Socio-economic status (SES) was measured with the Hollingshead Four-Factor Index (Hollingshead, 1975). Overall Mean for SES was 43.59 ($SD = 13.65$). No between-group differences were found for gender, race, and SES. There was, however, a significant between-group age effect $F(2, 67) = 6.34$, $p < .01$. Post hoc *t*-tests with Bonferroni adjustments indicated that children in the MDD group were significantly older than children in the ANX group, $p < .05$. Age was thus included as a covariate.

Measures

Diagnostic interview. Diagnosis was established using The Schedule for Affective Disorders and Schizophrenia for School Aged Children – Present and Lifetime Version (K-SADS-PL) (Kaufman et al., 1997). This interview provides assessments of present episode and lifetime history of psychiatric illness in children according to DSM-III-R and DSM-IV criteria.

Self-reports. Self-report measures were also used to establish diagnosis. Participants and their parents or guardians completed the following self-report measures: a) the Child Behavior Checklist – parent form (CBCL) (Achenbach & Edelbrock, 1983), b) the Screen for Childhood Anxiety and Related Disorders (SCARED) (Birmaher et al., 1999, 1997), c) the Children's Depression Inventory (CDI) (Kovacs, 1985) (children, 8–12 years old), and the Beck Depression Inventory (BDI) (Beck, Ward, Mendelson, Muck, & Erbaugh, 1961) (adolescents, 13–18 years old).

The Emotional Go/NoGo task. The *Emotional Go/NoGo* task (Hare et al., 2005) is a modified version of the Probability Go/NoGo task (Casey et al., 2001). It is an emotional cognitive control task designed to examine the role of cognitive control processes in emotional information processing (see Figure 1). In this task, participants must either respond to a particular emotional facial expression (angry, fearful, sad, happy) (Go trials) and not respond (NoGo trials) to a neutral facial expression or vice versa. The set of stimuli consisted of digitized black and white faces taken from the set of Ekman faces (Ekman & Friesen, 1976), which included emotional facial expressions (anger, fearful, sad, happy, neutral) from 10 individuals (5 males and 5 females). The faces were morphed to exclude the hair and cropped in a dark grey square. Pictures were presented sequentially in the middle of the screen on a white background. The task comprised 8 blocks of 30 trials each for a total of 240 trials. The following 8 blocks were presented: Angry Go/Neutral NoGo, Fear Go/Neutral NoGo, Sad Go/Neutral NoGo, Happy Go/Neutral NoGo, Neutral Go/Angry NoGo, Neutral Go/Fear NoGo, Neutral Go/Sad NoGo, and Neutral Go/Happy NoGo. The order of the 8 blocks was randomized across subjects and the order of the trials was randomized within each block. The frequency of occurrence of the Go trials varied within each block across three probability conditions

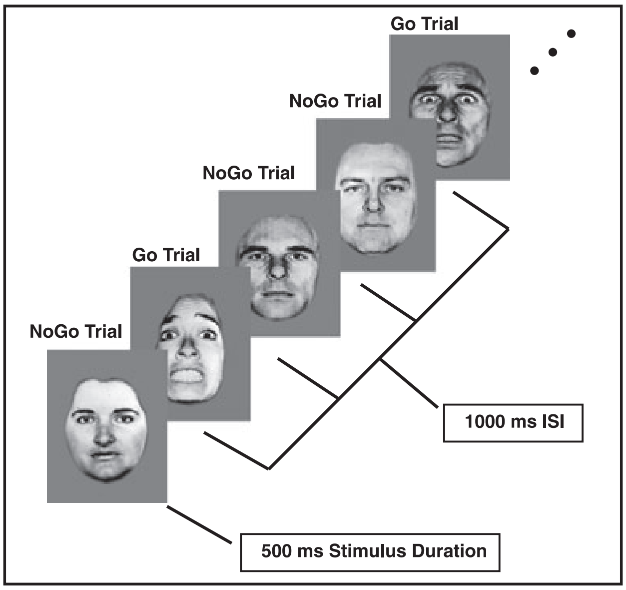

Figure 1 Illustration of the *Emotional Go/NoGo* task

of low (25%), moderate (75%), and high (100%). Stimulus duration was 500 ms and interstimulus interval was 1000 ms.

Procedure

The University of Pittsburgh Institutional Review Board approved the study. Parents signed informed consent forms, participants younger than 14 provided verbal assent, and participants older than 14 provided written consent. Upon entry into the study, participants were admitted to the Child and Adolescent Sleep and Neurobehavioral Laboratory at Western Psychiatric Institute and Clinic for a three-day assessment that included completing a series of computer tasks.

Diagnosis was established using a semi-structured interview and self-report questionnaires. The interview was administered independently with the child and one parent about the child by clinically experienced interviewers. Monthly reliability meetings were conducted under the supervision of a child psychiatrist to establish reliability of clinical diagnoses. Interrater reliabilities for diagnoses assessed during the course of this study were estimated to be $k \geq .70$. A best estimate procedure for diagnoses based upon all available information was employed to establish diagnosis (Leckman, Sholomskas, Thompson, Belanger, & Weissman, 1982).

For the *Emotional Go/NoGo* task, stimuli presentation and response acquisition were controlled by a Macintosh computer and PsyScope software (Cohen, MacWhinney, Flatt, & Provost, 1993). Subjects were tested individually. They sat in front of the computer screen at a distance of approximately 24 inches in a quiet room to perform the task. Before starting the task, an experimenter read with the participants written instructions presented on the computer screen. The instructions informed subjects that they were going to play a game and that in this game they were going to see a series of faces on the screen and that some of these faces would express an emotion while others would be neutral or 'plain'. Participants were also told that the game would be divided into blocks and they would receive instructions before each block specifying which face was a Go trial and which face was a NoGo trial (e.g., Happy Go/Neutral NoGo). They were instructed to respond by pressing the mouse button with their index finger to the face Go trials and not to press for any other facial expression. They were also told to respond as quickly and as accurately as possible. The duration of the task was approximately 10 minutes.

Statistical analyses

To examine whether the emotional saliency of the emotional facial expressions influenced performance on the *Emotional Go/NoGo* task we conducted two mixed multivariate analyses of covariance (MANCOVAs) model on the reaction time of correct Go trials. To examine the effects on performance when the emotional facial expressions were presented as Go trials, we conducted a 3 (Diagnosis: ANX, MDD, LRNC) × 4 (Emotional Facial Expressions: angry, fearful, sad, happy – with emotional facial expressions as Go trials and neutral facial expressions as NoGo trials) × 3 (Probability: low, moderate, high) MANCOVA. To examine the effects on performance when the emotional faces were presented as NoGo trials, we conducted a 3 (Diagnosis: ANX, MDD, LRNC) × 4 (Emotional Facial Expressions: angry, fearful, sad, happy – with neutral facial expressions as Go trials and emotional facial expressions as NoGo trials) × 3 (Probability: low, moderate, high) MANCOVA. Diagnosis was treated as a between-subject variable and emotional facial expressions and probability as repeated measures. Age was used as a covariate. The multivariate test statistic reported is Wilks' lambda. Greenhouse-Geisser and Bonferonni corrections were used where warranted. Univariate analyses and post hoc multiple comparisons were conducted to follow up main effects and interactions. Simple contrasts were used to follow up within-subject main effects. Outlying reaction time data points less than 100 ms or greater than 1000 ms were filtered out; this comprised less than 1% of the trials. The mean correct-trial reaction time was then calculated for each of the participants as a function of each of the factors in the design. Because of the limited number of errors in each of the cells, reaction time was the only dependent variable considered in this study. Preliminary analyses did not reveal any significant gender or ethnicity effects. Therefore, these variables were not considered further.

Results

Performance on the Emotional Go/NoGo task

Overall percentage of correct responses and false alarms. There were no significant diagnostic group effects on either the percentage of correct responses, $F(2, 64) = 1.78$, $p = .18$, or the percentage of false alarms (press the button to No go trials), $F(2, 64) = 1.39$, $p = .26$ (see Table 2).

Effects related to diagnosis. Results showed a significant diagnosis by emotional facial expressions by

Table 2 Mean (standard error) percentage of total correct responses and false alarms as a function of diagnostic groups

	Diagnostic groups		
Performance (%)	ANX ($n = 23$)	MDD ($n = 19$)	LRNC ($n = 26$)
Correct responses	83.20 (1.70)	85.93 (1.94)	87.52 (1.56)
False alarms	26.27 (2.53)	32.81 (2.87)	29.85 (2.32)

Note: There were no significant diagnostic group differences for any of the above variables.

probability interaction for mean reaction times on emotional facial expression Go trials (with neutral facial expression NoGo trials), multivariate $F(12, 116) = 1.93$, $p < .05$. Follow-up analyses examining the diagnosis by emotional facial expression interaction for each of the probability conditions revealed a significant effect for the moderate probability condition, $F(6, 124) = 2.93$, $p < .05$, but not for the low, $F(6, 122) = 1.93$, $p = .08$, or the high probability conditions, $F(6, 122) = 1.29$, $p = .27$. Univariate analyses indicated a significant effect for the Sad Go/Neutral NoGo block in the moderate probability condition, $F(2, 67) = 3.53$, $p < .05$. Post hoc comparisons indicated that relative to the LRNC group, the MDD group had significantly faster reaction times to the sad face Go trials embedded in neutral face NoGo trials in the moderate probability condition, $p < .05$ (see Figure 2).

In addition, results showed a significant diagnosis by emotional facial expressions by probability interaction for mean reaction times on neutral facial expression Go trials (with emotional facial expression NoGo trials), multivariate $F(12, 94) = 2.15$, $p < .05$. Follow-up analyses examining the diagnosis by emotional facial expression interaction for each of the probability conditions revealed a significant effect for the low probability condition, $F(6, 106) = 3.07$, $p < .01$, but not for the moderate, $F(6, 114) = .52$, $p = .80$, or the high probability conditions, $F(6, 118) = 1.23$, $p = .30$. Univariate analyses indicated a significant effect for the Neutral Go/Angry NoGo block in the low probability condition, $F(2, 62) = 3.98$, $p < .05$. Post hoc comparisons revealed that relative to the LRNC group, the ANX group had significantly slower reaction times to the neutral face Go trials embedded in angry face NoGo trials in the low probability condition, $p < .05$ (see Figure 3).

Main effects of emotional facial expressions. Results did not yield any significant main effect for mean reaction times with emotional facial expressions as Go trials (neutral facial expressions as NoGo trials), multivariate $F(3, 61) = 2.25$, $p = .09$. Results showed a significant main effect for mean reaction times with neutral facial expressions as Go trials (emotional facial expressions as NoGo trials), multivariate $F(2.48, 50) = 2.89$, $p < .05$, but post hoc contrasts were not significant.

Main effects of probability. Results did not yield any significant probability main effects for mean reaction times with emotional facial expressions as Go trials (neutral facial expressions as NoGo trials), multivariate $F(2, 62) = 1.86$, $p = .17$, or for mean reaction times with neutral facial expressions as Go trials (emotional facial expression as NoGo trials), multivariate $F(2, 51) = .68$, $p = .51$.

Self-report measures

Analyses of variance were performed on the subscales of the self-report measures in order to examine whether there were any overlapping symptoms of anxiety and depression across groups. Analyses for

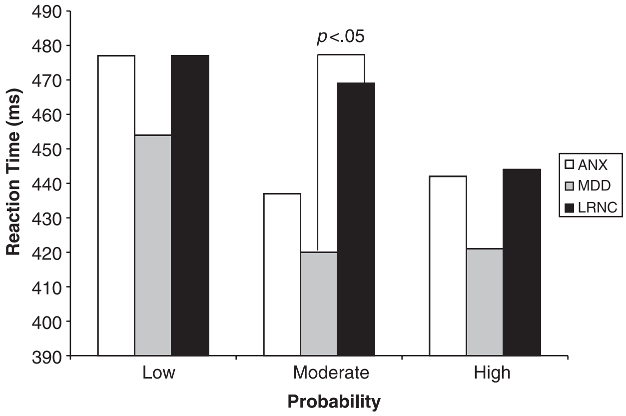

Figure 2 Mean reaction times on Sad Go/Neutral NoGo correct trials as a function of diagnostic groups and probability conditions

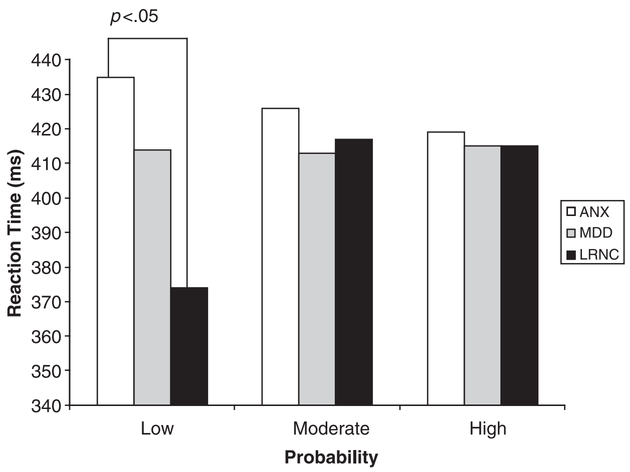

Figure 3 Mean reaction times on Neutral Go/Angry NoGo correct trials as a function of diagnostic groups and probability conditions

the SCARED-child, SCARED-parent, and *z*-score CDI/BDI included age as a covariate and gender as an independent factor. Results indicated a significant group effect for the CBCL – externalizing, $F(2, 56) = 28.71$, $p < .001$, CBCL – internalizing, $F(2, 56) = 100.82$, $p < .001$, CBCL – total, $F(2, 56) = 71.46$, $p < .01$, the SCARED-child, $F(2, 41) = 9.43$, $p < .01$, SCARED-parent, $F(2, 41) = 21.89$, $p < .001$, and the *z*-score CDI/BDI, $F(2, 43) = 17.69$, $p < .001$. Post hoc analyses (Tukey HSD, $p < .05$) indicated that for each of the scales, the LRNC group had significantly lower scores relative to ANX and MDD groups on each of the scales, $p < .01$. In addition, the ANX group had higher scores on the SCARED-parent scale compared to the MDD group, $p < .05$. Although the ANX group had a lower score on the *z*-score CDI/BDI, this difference did not reach statistical significance, $p = .41$ (see Table 1).

Discussion

Results of this study demonstrate that processing emotionally salient information, such as emotional facial expressions, influences the performance of children and adolescents diagnosed with an affective disorder on a task that engages cognitive control processes. Our predictions were supported partially in that the sad facial expressions influenced the performance of the MDD group in the moderate probability condition and the angry facial expressions influenced the performance of the ANX group in the low probability condition. Contrary to our predictions, however, the fear faces did not influence the performance of the ANX group and the effects were not observed across both the low and moderate probability conditions for both groups.

The significantly faster reaction times to the sad face Go trials in the MDD group supports findings from Murphy et al. (1999) showing that adult depressed patients were faster to respond to sad compared to happy words on an emotional-word Go/NoGo task (Murphy et al., 1999). These results also indicate that, like adults, children and adolescents diagnosed with depression appear to show an attention and/or response bias toward sad stimuli. Moreover, because the faster reaction times to the sad face Go trials were observed in the moderate probability condition, which involves a high level of cognitive control as indexed by slower reaction times to the Go trials, this suggests that such an attentional bias may be related to altered 'emotional cognitive control' processes. These results are consistent with a recent study by our group examining the role of cognitive control on emotional information processing in pediatric affective disorders (Ladouceur et al., 2005). In that study, we compared the performance of children and adolescents diagnosed with an anxiety disorder, major depression, and comordid anxiety and depression on an emotional *n*-back task and found that processing emotional information influenced the performance of subjects with major depression and comorbid anxiety and depression (Ladouceur et al., 2005). Together these results support findings from recent neuroimaging studies conducted in adults suggesting that depression may be associated with altered functioning of frontal-subcortical brain systems that support cognitive control processes involved in emotional information processing (Davidson, Pizzagalli, Nitschke, & Putnam, 2002; Gray, Braver, & Raichle, 2002). Given the paucity of research on emotional processing in childhood depression, more research is needed to better understand the mechanisms underlying these processes.

With regard to the ANX group, results showed that the ANX group had slower reaction times to neutral faces while inhibiting responses to angry faces in the low probability condition. The low probability condition (25%) requires a moderate level of cognitive control as subjects must detect rare target stimuli (Go trials) – which is thought to tap into processes related to vigilance. Our findings for the ANX group are, in part, contradictory with the existing literature of an attention bias toward threat in anxious children resulting in faster responses to threatening stimuli (Hadwin et al., 2003). The ANX group was not faster in detecting fear or angry facial expressions in the current study. Nevertheless, our results suggest an attentional bias toward threatening stimuli in that otherwise neutral faces, when embedded among angry faces, appeared to be interpreted as threatening by the ANX group relative to control group. A number of studies have shown that the context in which information is presented can affect the emotional interpretation of that information (Hare et al., 2005; Kim et al., 2005; Russell & Fehr, 1987). Russell and Fehr (1987) showed that the presence of fearful expressions could influence the interpretation of neutral facial expressions. More recently, imaging studies have shown that amygdala-related activity to facial expressions (e.g., fear, happy and neutral) is modulated by the emotional context (Hare et al., 2005; Kim et al., 2005). For example, amygdala activity has been shown to differ when viewing emotionally ambiguous surprised faces preceded by negatively valenced versus positively valenced contextual sentences, with negative context producing greater amygdala activation (Kim et al., 2005). The findings suggest that children in the ANX group may be particularly sensitive to threatening contexts when processing otherwise neutral stimuli.

Another way to interpret these results is by considering the ecological function of angry faces. Angry facial expressions signal the *presence* of threat (Whalen et al., 2001). Accordingly, it is possible that the ANX group may have had difficulty disengaging their attention from the frequently presented angry face NoGo trials which would have caused them to have slower reaction times when switching to respond to the neutral face Go trials. This difficulty to disengage attention from angry faces was observed recently in an electrophysiological study demonstrating that physically abused children had more difficulty disengaging attention to angry facial cues compared to age-matched controls (Pollak & Tolley-Schell, 2003). In this study results were interpreted as indicating that the angry faces served as salient cues to threat for these children because of their history of maltreatment and as such, processing these angry faces recruited a greater proportion of their attentional resources. Given the attentional bias toward threat in anxiety disorders and the fact that angry faces signal the actual presence of direct threat, the ANX group may have had a similar difficulty in disengaging attention from the frequently occurring angry face NoGo trials and as such had slower reaction times to the neutral face Go trials. This attentional bias toward angry faces was also observed in Hadwin et al.'s (2003) study, which showed that children with high self-report anxiety were faster when searching for angry faces, but not happy or neutral faces, on a visual search paradigm. An alternative interpretation of the results could be that the frequent angry face NoGo trials may have increased the emotional saliency of the angry faces and promoted a 'freezing' or inhibitory response tendency, which could also explain the slower reaction times to the rare neutral face Go trials.

Before considering the implications of our results, there are some methodological issues that merit discussion. First, use of neutral faces as Go trials or NoGo trials could represent a limitation, as children have more difficulty recognizing neutral facial expressions (Gross & Ballif, 1991). This is supported by a recent neuroimaging study showing that the expected differentiation in neural signal change between the fear and neutral faces observed in adults was not present in children (Thomas et al., 2001). Those results were interpreted as indicating that neutral faces are perceived negatively or require additional processing rather than signaling a neutral affective state. This may explain why the fear faces did not influence the performance of the ANX group as expected. Second, the fact that subjects had to identify or label the emotional facial expressions in order to decide whether to emit a 'go' or 'no go' response may have engaged cognitive processes involved in inhibiting the processing of emotionally salient information, thereby reducing the expected effects on reaction time. Recent research studies in adults have shown that labeling faces engages brain systems involved in inhibiting subcortical limbic circuitry associated with processing emotionally salient information (Hariri, Mattay, Tessitore, Fera, & Weinberger, 2003; Lange et al., 2003). Third, although we included age as a covariable, it is unclear how age may have influenced performance given the wide age range. An improved study would have included a larger number of subjects in each of the diagnostic groups and stratified age groups to address specific developmental questions more thoroughly such as the role of cognitive development and pubertal maturation. Finally, given that the depression scores of the ANX and MDD groups were not significantly different and that there were a couple of subjects in each group that had comorbid anxiety and depression, there is a possibility that these results do not fully speak to the issue of specificity. However, redoing analyses upon removal of these 'comorbid' subjects did not yield any significant changes in the pattern of results.

In summary, results of this study suggest that processing emotionally salient information, such as emotional facial expressions, influences the performance of children and adolescents diagnosed with an affective disorder on a task that engages cognitive control processes. These findings, along with those of a recent study demonstrating the influence of emotionally salient pictures on the performance of the *n*-back task (Ladouceur et al., 2005), suggest that the development of pediatric affective disorders may be related to impaired modulation of emotional information by cognitive control processes, which could be a contributing factor to the development of maladaptive changes in emotion regulation. However, more research is needed to investigate the role of cognitive control processes in emotional information processing specific to pediatric anxiety and depression. Examining the underlying neural circuitry is one avenue that will certainly help in this endeavor.

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Correspondence to

Cecile D. Ladouceur, Department of Psychiatry, School of Medicine, University of Pittsburgh, Western Psychiatric Institute and Clinic, 3811 O'Hara Street, Room E-701, Pittsburgh, PA 15213, USA; Email: ladouceurcd@upmc.edu

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