Published in final edited form as:

J Child Psychol Psychiatry. 2009 December ; 50(12): 1550–1558. doi:10.1111/j.1469-7610.2009.02121.x.

Inhibitory Control in anxious and healthy adolescents is modulated by incentive and incidental affective stimuli

Michael G. Hardin¹, Darcy Mandell¹, Sven C. Mueller¹, Ronald E. Dahl², Daniel S. Pine¹, and Monique Ernst¹

¹Emotional Development and Affective Neuroscience Branch, Mood and Anxiety Disorders Program, National Institute of Mental Health, NIH/DHHS

²Departments of Psychiatry and Pediatrics, University of Pittsburgh Medical Center

Abstract

Background—Anxiety disorders are characterized by elevated, sustained responses to threat, that manifest as threat attention biases. Recent evidence also suggests exaggerated responses to incentives. How these characteristics influence cognitive control is under debate and is the focus of the present study.

Methods—Twenty-five healthy adolescents and 25 adolescents meeting DSM-IV diagnostic criteria for an anxiety disorder were compared on a task of response inhibition. Inhibitory control was assayed with an antisaccade task that included both incentive (monetary reward) and incidental emotion (facial expression) cues presented prior to the execution of inhibitory behavior.

Results—Inhibitory control was enhanced following exposure to threat cues (fear faces) only in adolescent patients, and following exposure to positive cues (happy faces) only in healthy adolescents. Results also revealed a robust performance improvement associated with monetary incentives. This incentive effect did not differ by group. No interaction between incentives and emotional cues was detected.

Conclusions—These findings suggest that biased processing of threat in anxious adolescents affects inhibitory control, perhaps by raising arousal prior to behavioral performance. The absence of normalization of performance in anxious adolescents following exposure to positive emotional cues is a novel finding and will require additional exploration. Future studies will need to more specifically examine how perturbations in positive emotion processes contribute to the symptomatology and the pathogenesis of anxiety disorders.

Keywords

emotion; motivation; cognitive control; affective context; anxiety disorders; facial expressions

Introduction

Anxiety disorders are among the most prevalent psychiatric diagnoses in the pediatric population and carry a huge individual and societal burden (Costello, Mustillo, Erkanli, Keeler, & Angold, 2003). Over the past 20 years, research has focused on the role of cognition in the development and maintenance of these disorders (Beck & Clark, 1997; Ehrenreich & Gross, 2002; Eysenck, 1992; Eysenck, Derakshan, Santos, & Calvo, 2007).

Please address correspondence to: Michael G. Hardin, Emotional Development and Affective Neuroscience (EDAN) Branch, Mood and Anxiety Disorders Program, NIMH/NIH/DHHS, 15K North Drive, Bethesda, MD 20892, Tel: 301.594.1257, Fax: 301.402.2010, hardinm@mail.nih.gov.

Much of this research has targeted selective attention to threat-related information. Because of this specific focus on threat processing in anxiety, less work has been devoted to questions that concern the processing of positively valenced stimuli, such as rewards or cues signaling positive emotion. Even less work examines the influence of these emotional stimuli on cognitive control in pediatric anxiety. The present work was designed to examine these issues.

Recent investigations of reward systems and incentive processing provide some insights into adolescent anxiety. Although very few studies have been conducted, early findings suggest the occurrence of hypersensitivity to incentives in pediatric anxiety disorders. For example, behavioral research conducted with exceptionally shy and anxious college students has indicated they respond faster to potential rewards compared to their demographically matched peers during a monetary incentive delay (MID) task (Hardin et al., 2006). This report has been further supported by two parallel functional neuroimaging studies. Using the same MID task, additional studies examined the neural response to potential rewards in adolescents with an anxiety disorder (Guyer et al., in prep), and adolescents at high risk for an anxiety disorder by virtue of a behaviorally inhibited temperament (Guyer et al., 2006). Both anxious and behaviorally inhibited adolescents in these studies showed greater reward system (i.e., ventral striatum) engagement in response to incentives compared to age- and sex-matched typical adolescents. Finally, recent evidence also suggests incentives modulate cognitive control performance in both anxious and healthy adolescents (Hardin, Schroth, Pine, & Ernst, 2007; Jazbec, McClure, Hardin, Pine, & Ernst, 2005), though it remains unclear whether differences occur in the effect of incentives on cognitive control in anxious relative to healthy adolescents.

Whereas hypersensitivity to incentives engages neural mechanisms involving striatal circuits, responses to affective cues typically recruit a different neural network. The typical network recruited by affective stimuli also involves the amygdala, and thus modulates cognitive performance via a different neural path than incentives (Davis & Whalen, 2001; Vuilleumier, 2005). While striatum and amygdala centered networks appear to have a dominant role related to distinct processes involving incentives and affect, respectively, other processes do simultaneously recruit both networks. For example, amygdala recruitment is sometimes reported in reward-processing studies (see Holland & Gallagher, 2004; Murray, 2007), while striatal involvement occurs during the coding of negative emotional events (see Delgado, Li, Schiller, & Phelps, 2008).

Theories of anxiety suggest that threat-related affective cues raise states of arousal disproportionately to the level of actual danger (see Beck & Clark, 1997; Ehrenreich & Gross, 2002; Mogg & Bradley, 1998). When threat cues precede behavioral responses, elevated levels of arousal and vigilance are associated with facilitated attention and orienting responses (i.e., Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJzendoorn, 2007; Dalgleish et al., 2003; Ehrenreich & Gross, 2002; Mogg & Bradley, 1998) that include cognitive control processes (see Corbetta & Shulman, 2002; Miller & Cohen, 2001). In contrast, when threat cues occur during or simultaneously to performance responses, the behavior becomes negatively impacted. Indeed, co-occurring threat cues can produce interference with cognitive processes and lead to performance decrements (i.e., Bishop, 2008; Williams, Mathews, & MacLeod, 1996). Much less is known about the influence of positive emotional cues in anxiety. Data in healthy subjects suggest that positive emotion cues enhance cognitive processes (Rowe, Hirsh, & Anderson, 2007). Whether positive emotion modulates cognitive function differentially in anxious individuals is not clear.

The current study was concerned with the influence of incentive and affective stimuli presented *prior* (and not simultaneously) to behavioral responses. For this reason highly

salient stimuli were expected to facilitate responses. Evidence from non-human primate studies examining cognitive control (response inhibition) indicate that increased neural arousal (i.e. increased cell firing) during a “preparatory period”, prior to a required behavioral response, facilitates successful inhibitory control (see Munoz & Everling, 2004). Likewise, presentation of salient stimuli during the preparatory period correspond with increased neural arousal and performance (see Hikosaka, 2007). Given the neural arousal observed during the processing of salient stimuli in human neuroimaging studies (i.e., Davis & Whalen, 2001; Knutson, Adams, Fong, & Hommer, 2001; Knutson & Cooper, 2005; Vuilleumier, 2005), presentation of salient stimuli during the response preparation period in the current study was expected correspond with increased cognitive control and corresponding performance.

Taken together, evidence of incentive hypersensitivity and of affective processing biases in anxiety raises the question of how these two unique motivational/affective processes interact to influence cognitive function and subsequent behavior. The goal of the present study was to address this question. This study examined how incentive cues and incidental, task-irrelevant, affective cues influence the performance of anxious and healthy adolescents on an inhibitory control task. Of note, and important to the generation of hypotheses, both incentive and emotion cues in this task were presented prior to cognitive performance, rather than simultaneously with cues requiring execution of a response. Based on enhanced reward responses (Hardin et al., 2007; Jazbec et al., 2005) and emotion biases reported in anxious individuals (Bar-Haim et al., 2007), the following patterns of inhibitory performance were predicted: (1) *incentive*-related improvements for both anxious and control adolescents, with relatively greater improvements in anxious compared to control adolescents; (2) relatively greater improvements related to incidental *threat* cues for anxious adolescents compared to control adolescents; and (3) improvements related to incidental *positive emotion* cues in both anxious and control adolescents.

Methods

Participants

Participants were 25 (13 female) adolescents diagnosed with an anxiety disorder ($M=12.65$ years, $SD=2.35$ years), and 25 (12 female) age-matched healthy, typically developing adolescents ($M=13.21$ years, $SD=2.39$ years). All participants were medication free at the time of the study. Of the anxious adolescents, 13 had a primary diagnosis of Social Phobia, and 12 Generalized Anxiety Disorder (GAD). Two adolescents with GAD had a co-morbid diagnosis of Major Depressive Disorder. Participants were recruited through local newspaper advertisements and word of mouth. The study was approved by the National Institute of Mental Health Institutional Review Board. The parents of all participants gave informed consent, and adolescent participants provided informed assent.

Inclusion criteria for healthy adolescents included: (1) age between 9-17 years; (2) absence of acute or chronic medical problems; and (3) absence of current or past psychiatric disorders. Inclusion criteria for anxious adolescents included: (1) primary diagnosis of an anxiety disorder based on a semi-structured diagnostic interview (K-SADS) (Kaufman et al., 1997); (2) Children's Global Assessment Scale's score < 60 (CGAS) (Shaffer et al., 1983); (3) Pediatric Anxiety Rating Scale score > 9 (RUPP, 2001); (4) desire for outpatient treatment; and (5) age between 9-17 years. Exclusion criteria for all participants included: (1) current use of any psychoactive substance; (2) current Tourette's syndrome, obsessive-compulsive disorder, PTSD, conduct disorder, exposure to extreme trauma, or suicidal ideation; (3) lifetime history of mania, psychosis, or pervasive developmental disorder; or (4) $IQ < 70$. All adolescent diagnoses were based on semi-structured interviews using the K-SADS. Interviews were conducted by experienced clinicians who demonstrated excellent

inter-rater reliability ($\kappa > 0.75$). Additional self report anxiety measures were collected with the State Trait Anxiety Inventory (STAI) (Spielberger, 1983), and self report depression measures were collected with the Children's depression Inventory (CDI) (Helsel & Matson, 1984; Kovacs, 1982).

Incentive Emotion Antisaccade Task (Figure 1)

The Incentive Emotion Antisaccade Task (IEAT) was designed to assess inhibitory cognitive control of antisaccade eye movements in two explicitly presented Incentive conditions (Reward, No Reward). Each incentive condition was paired with three face Emotion conditions (Happy, Fear, Neutral). This design permitted us to examine how cognitive control was modulated by incentives, by incidental affective cues, and by the interaction of both incentives and affective cues in anxious and healthy adolescents.

Task trials were comprised of three phases (Figure 1): (1) the cue phase (1250-1750ms) informed participants of the Incentive condition; (2) the target antisaccade response phase (1850ms); and (3) the feedback phase (1000ms). Participants were instructed to fixate the Incentive condition cue during the cue phase, to respond with an antisaccade eye movement during the response phase, and to fixate the performance feedback symbol during the feedback phase. A relatively long duration of the cue phase (average 1500ms) was chosen to maximize incentive and affective stimulus exposure during the response preparation period. The relative long duration of the antisaccade response phase was chosen to maximize this paradigm for future neuroimaging studies. Despite the long duration of the response phase, analyses were restricted to saccade responses that occurred less than 500ms after target onset.

Each task trial began with the presentation of one of two possible Incentive cues. Each of these Incentive cues was superimposed on an Emotion condition face. The Emotion face was centered on a black computer screen and subtended 2.5° horizontal and 4° vertical. The Incentive cue was located at the center horizontal and 1° above the vertical center of the computer screen. This location placed the Incentive cue approximately on the center forehead of the Emotion face images. Participants were instructed to fixate the Incentive cue. Incentive cues subtended 1°. Potential monetary Reward was cued by a "\$" in black font, while No Reward was cued by a "O" in black font.

Emotion faces appeared concurrently with the Incentive cues, but transferred no task-related information to the participant (i.e., task-irrelevant). The Emotion faces consisted of black and white portraits of actors from the NimStim set of Facial Expressions (<http://www.macbrain.org/resources.htm>). Facial emotion included happy, fearful, and neutral emotion expressions from 24 different actors (12 female, 12 male).

Following a variable period of 1250-1750ms, the Incentive cue and simultaneously occurring Emotion face were replaced by a lateral target stimulus that remained on the screen for 1850ms. The target was a "*" presented in white font and subtending .5°. The target appeared at the vertical center and 6° from center to the left or right horizon. The participant was required to fixate for 100ms minimum in an area of 1° radius around the correct target location to succeed on a trial.

The target was replaced by a feedback signal in the correct response location. In the Reward condition feedback was "\$1.00" presented in green font for a correct response, and "-\$1.00" presented in red font for an incorrect response. Feedback in the No Reward condition was "\$0.00" presented in green font for a correct response and red font for an incorrect response. The IEAT task consisted of 144 trials total (24 per condition), and was presented in four runs of 36 trials. All conditions were randomly presented. Participants were trained on the

tasks prior to study participation, and were instructed that they would receive the dollar amount won during the task.

Eye Movement Recording

Eye movements were recorded with an ASL Model 504 eye tracking system (Applied Science Laboratories, Boston, MA) at 240Hz temporal resolution and 0.25° spatial resolution. A magnetic head tracker and auto focusing lens were used to minimize head movement artifact. Raw eye movement data was analyzed off-line with ILAB software (Gitelman, 2002). Saccades were defined as movements greater than 30°/second that lasted for a minimum duration of 25ms. When determining correct and incorrect movements, only the first saccade following onset of the target stimulus was considered. Saccade accuracy was indexed as the percent of saccades directed to the correct location (opposite periphery of the target). Saccade latency was the time elapsed between target onset and the start of a saccade. To ensure task-relevant saccades were analyzed, analyses were restricted to saccades occurring 80-500ms after target onset.

Data Analyses

Analyses were conducted to assess Group (healthy adolescents; anxious adolescents), Incentive condition (Reward, No Reward), and Emotion condition (Happy, Fear, Neutral) effects on inhibitory control during the IEAT. Inhibitory control was operationally defined by the percent of correct antisaccades (saccade accuracy) and reaction time for correct antisaccades (saccade latency). Accuracy was considered a metric of *effectiveness*, providing an index of the overall quality of task performance (Eysenck et al., 2007). Latency was considered a metric of the *efficiency* of performance, providing an index of how correct responses were made. The mapping of these variables onto the constructs of effectiveness and efficiency has been validated in previous studies employing antisaccade tasks (Ansari, Derakshan, & Richards, 2008; Derakshan, Ansari, Hansard, Shoker, & Eysenck, 2009). A 3-way (Group $\times$ Emotion $\times$ Incentive) repeated-measures ANOVA was conducted for each of these two dependent variables. All *post hoc* comparisons were Bonferroni corrected and a two-tailed alpha level of .05 was used for all significance tests.

Results

Accuracy (index of performance effectiveness)

The 3-way ANOVA conducted on accuracy scores revealed no Group differences. Across Incentive and Emotion conditions, healthy and anxious adolescents did not differ on percent of correct antisaccades (healthy adolescents: $M = 85.8\%$, $SE = 2.1\%$; anxious adolescents: $M = 81.0\%$, $SE = 2.1\%$), $F(1,48) = 2.51$, $p = .12$).

However, a main effect of Incentive emerged. All adolescents were more accurate in the Reward condition ($M = 84.8\%$, $SE = 1.5\%$) than the No Reward condition ($M = 79.89\%$, $SE = 1.5\%$), $F(1,48) = 18.80$, $p < .001$ (Figure 2). No accuracy differences emerged among Emotion conditions.

To summarize the accuracy findings, neither the status of anxiety nor the presence of incidental emotion stimuli modulated task accuracy. However, as expected from previous work, inhibitory performance improved with incentive for both adolescent groups.

Latency (index of performance efficiency)

The three-way ANOVA conducted on latency to correct antisaccades revealed a Group by Emotion interaction, $F(2,96) = 3.67$, $p < .05$ (Figure 3). This interaction was the result of anxious adolescents performing most efficiently in the Fearful emotion condition, in contrast

to healthy adolescents, who performed most efficiently in the Happy emotion condition. Anxious adolescents presented a shorter latency in the Fear condition ($M = 283.88$) compared to the Neutral ($M = 324.42$) or Happy ($M = 322.92$) conditions. In contrast, healthy adolescents presented a shorter latency in the Happy ($M = 279.65$) condition compared to the Neutral ($M = 310.89$) or Fear ($M = 301.97$) conditions (see Table 2). To more clearly illustrate this interaction, Figure 4 presents these latencies as a ratio of the neutral condition to the Happy and Fear conditions. In this figure, a ratio equal to 1 represents latency equivalence between the neutral condition and the emotion condition. Ratio values greater than 1 represent higher response efficiency (relative to the neutral condition), while values less than 1 represent lower response efficiency. As apparent in this figure, the greatest increase in antisaccade efficiency for healthy adolescents occurred during the Happy face condition, and for anxious adolescents during the Fear face condition.

Similar to the accuracy results, a main effect of Incentive was also present, $F(1,48) = 5.62$, $p < .05$. Performance in both groups was more efficient, as latency during the Reward condition ($M = 292.44$, $SE = 15.89$) was significantly shorter than in the No Reward condition ($M = 315.48$, $SE = 14.68$). This facilitation by Incentive was independent of the Emotion condition (no significant Incentive by Emotion interaction). No additional main or interaction effects were present in latencies.

To summarize the latency findings, anxiety status was associated with a distinct sensitivity to incidental emotion cues. Specifically, efficiency of inhibition was facilitated by threat cues in anxious adolescents, and by positive emotion cues in healthy adolescents. Additionally, reward cues facilitated inhibitory control for both anxious and healthy adolescents.

Discussion

Anxiety disorders are associated with threat attention biases (Bar-Haim et al., 2007; Roy et al., 2008; Williams et al., 1996) and an exaggerated response to incentives (Hardin et al., 2007; Jazbec et al., 2005). How these perturbations interact with cognitive control, particularly inhibitory control, can be of critical importance not only for understanding the pathogenesis of anxiety disorders, but also to provide rational therapeutic interventions. The present study was designed to address questions concerning the influence of emotion and incentive stimuli on inhibitory control. For this purpose, the current study examined the performance of anxious and healthy adolescents on an antisaccade eye movement task that was paired with monetary incentives and emotion cues.

Two primary findings resulted from this study. First, incidental emotional cues, that were presented prior to inhibitory performance in each task trial, influenced cognitive control differentially as a function of diagnosis. Inhibitory performance following positive emotion stimuli (happy faces) was improved only for healthy adolescents. Contrary to expectations, anxious adolescents failed to show this pattern of improved performance following positive stimuli. Anxious adolescents, however, did show improved performance after the presentation of threat stimuli (fearful faces), whereas healthy adolescents did not show this threat-related pattern. Second, in line with predictions and previous findings, incentives enhanced inhibitory control in both anxious and healthy adolescents. However, contrary to hypotheses this cognitive enhancement by incentives did not differ between groups.

In this study, we were particularly interested in the influence that affective and incentive cues have on inhibitory control when presented *prior* to response execution (i.e., during response preparation). This approach differs from previous studies, which focused on the interfering effect of salient stimuli, and presented salient stimuli *during* response execution.

Contrary to these previous studies, which predicted impaired cognitive and behavioral responses based on interference effects, the current study predicted an enhanced response based on arousal effects. Indeed, we predicted performance enhancement secondary to increased stimulus-driven arousal that occurs when salient stimuli are presented during the response preparation period.

The current findings revealed that healthy adolescents showed the predicted improvement in inhibitory performance following presentation of happy faces. However, this normative effect of positive emotional stimuli was absent in anxious adolescents. This finding has strong theoretical implications as it may reflect a deficiency for anxious adolescents in the processing of facial displays of positive emotion. Recent work conducted with anxious individuals provides additional support for this possibility. For example, anxious young adults lack the bias seen in healthy young adults to judge facial displays of moderate happiness as more positive than they are in actuality (Frenkel, Lamy, Algom, & Bar-Haim, 2008). Instead, these anxious young adults judge displays of moderate happiness as being much “less happy” (Frenkel et al., 2008). Similarly, whereas healthy adults overestimate the prediction for positive outcomes following exposure to happy faces, adults with social anxiety show a deficit in this positive bias (Garner, Mogg, & Bradley, 2006). Overall, these findings suggest that happy emotion faces may not hold the same level of salience for anxious individuals as they do for non-anxious individuals.

While the literature on emotion processing in anxiety has traditionally focused on threat, the current findings suggest additional deficits exist in processing positive emotional stimuli. Likewise, it appears that models based solely on threat processing biases only provide a partial account of the processes underlying anxiety. Future work will be required to better characterize positive-affect-related deficits in anxious adolescents. It will be particularly important to evaluate this deficit with both social and non-social affective stimuli, as well as in various subtypes of anxiety (social anxiety for example). Likewise, it is currently unclear whether the deficits displayed by anxious adolescents results from perceptual processing deficiencies or from deficiencies in the amount of arousal generated by positive emotional stimuli. It will be important for future models of anxiety-related processes to integrate findings of deficient positive emotion processing.

The current findings are consistent with our initial proposition that anxious adolescents would show facilitated performance following threat cues. When looking at within-group difference in response latency, anxious adolescents showed significantly more efficient inhibitory control following threat cues relative to neutral or happy face cues. A similar threat-related effect was not observed in the healthy adolescents. As a caveat, however, groups did not differ in the absolute effect of threat cues. When taken together these within-group and between-group differences indicate that the facilitation of inhibitory efficiency by threat cues in anxious adolescents aid them in overcoming an initial efficiency deficit, and raises inhibitory efficiency to the level of healthy adolescents.

The beneficial effect of incentives was significant for both accuracy and latency measures. This finding is consistent with previous work employing similar antisaccade paradigms (i.e., Hardin et al., 2007; Jazbec et al., 2005), and may be mediated by a facilitating influence of motivational arousal on inhibitory control processes. The underlying neural mechanisms are suggested to involve bottom-up (stimulus-driven) modulation, by which incentives activate meso-striatal cortical loops (Cardinal, Parkinson, Hall, & Everitt, 2002; Schultz, 2006), which in turn enhance the signal-to-noise ratio in inhibitory circuits and result in enhanced inhibitory performance. Performance improvements were observed in both the effectiveness (accuracy) and efficiency (latency) measures, arguing for a robust effect (Ansari et al., 2008; Derakshan et al., 2009). The failure to detect a stronger effect of incentives in anxious

relative to healthy adolescents could be related to the structure of the paradigm. Indeed, compared to previous antisaccade tasks that have examined the influence of incentives only, the present task included the additional manipulation of incidental emotional stimuli. This change might have mitigated a diagnosis effect, and will require further examination.

While the findings concerning incentive-related enhancement of inhibitory control have focused on the rewarding aspect of the incentive condition, an influence by the punishing aspect of the incentive condition cannot be ruled out. The bivalent nature of the incentive condition in this study was based on previous behavioral findings that implicated improved performance following cues signaling either winning or not winning, and cues signaling either losing or not losing (i.e., Hardin et al., 2007). The current finding raises the interesting possibility that the incentive-related findings were driven by the “fear of losing” rather than the lure of a gain.

This study should be considered in light of the following limitations. First, the heterogeneity of anxiety disorders precludes any conclusions about diagnostic specificity. For completeness, a comparison between the patients with a primary diagnosis of social anxiety (n=13) and those with a primary diagnosis of generalized anxiety disorder (n=12) failed to reveal significant group differences, either as a main effect or in interaction with incentives or emotion cues. This negative finding may reflect the fact that, collectively, anxiety disorders represent a distinct diathesis, which is characterized by unique deficits, in threat bias and responses to positive stimuli. However, how each disorder manifests these deficits in specific ways remains an important question to examine in future work. Second, our relatively small sample size did not permit us to examine age or sex effects with sufficient statistical power. Third, the significance of the findings as primary or secondary manifestations of anxiety cannot be determined in this work. Studies of at-risk populations could help in this respect.

In summary, findings from the current work indicate that response inhibition in both anxious and healthy adolescents is modulated by monetary incentives. Additionally, incidentally presented affective stimuli differentially modulate response inhibition in anxious and healthy adolescents. Anxious adolescents appear to be deficient compared to healthy adolescents in the influence of positive emotion faces on inhibitory control. Additionally, anxious adolescents show abnormally high efficiency of response inhibition following negative affective stimuli. These findings need to be further explored via functional neuroimaging methods.

- Anxiety disorders are characterized by biased responses to threat stimuli, and recent evidence of enhanced responses to incentive-related stimuli.
- Despite involvement of cognitive control processes in emotion and incentive-related responses, little is known about the influence of these stimuli on cognitive control processes.
- The current study suggests an anxiety-related deficit in the normal enhancement of cognitive control by positive emotional stimuli.
- Anxiety-related enhancement of cognitive control following threat stimuli also occurs and may result from increased threat-related arousal.
- Like non-anxious adolescents, anxious adolescents show enhanced cognitive control with incentive stimuli.

- Understanding the interaction between processing salient stimuli and regulatory cognitive control processes can provide insight into the onset and maintenance of anxiety disorders, and guide future behavioral treatment

Acknowledgments

This research was supported by the Intramural Research Program of the National Institutes of Health. We would like to thank Harvey Iwamoto for his programming insistence.

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Figure 1.

Schematic representation of the Incentive Emotion Antisaccade Task (IEAT). During the Cue phase, participants viewed an incentive cue (signaling the prospect of either winning or losing an incentive, or no-incentive) that was superimposed on a task-irrelevant emotion face). In the Anti-saccade Response phase a peripheral target appeared and the participant responded by looking to the opposite side (antisaccade) as the target. During the Feedback phase, the participants received the outcome of their response (won or lost money for incentive condition; won or lost no money for no-incentive condition).

Figure 2.
Mean (*SE*) percent of correct antisaccades during Reward and No Reward conditions in healthy and anxious adolescents.

Figure 3. Mean (*SE*) latency for correct antisaccades during incidental Neutral, Happy, and Fear face conditions in healthy and anxious adolescents.

Figure 4. Mean (SE) latency for Happy face and Fear face conditions when normalized to the Neutral condition. In this figure, a latency difference greater than one represents an efficiency increase relative to the Neutral condition.

Table 1Mean (*SD*) demographic information for Healthy and Anxious adolescent groups

	Healthy	Anxiety
Age	13.21 (2.39)	12.62(2.35)
Sex	12F/13M	13F/12M
Tanner Stage	2.32 (1.20)	2.42 (1.34)
IQ	117.42 (8.99)	111.57 (12.76)
CDI	42.22 (5.78)	49.75 (7.02)
STAI*	26.56 (5.16)	37.80 (5.91)

* significant group difference, $p < .05$

Table 2

Mean (*SD*) percentage of correct antisaccades, and mean (*SD*) latency (ms) of correct antisaccades in Reward and No Reward conditions by Neutral, Happy, and Fear face conditions

	Reward			No Reward		
	Neutral	Happy	Fear	Neutral	Happy	Fear
Accuracy %						
Healthy	86.12 (10.72)	89.17 (9.84)	86.17 (11.45)	83.50 (11.37)	84.67 (10.73)	85.00 (11.53)
Anxious	82.33 (13.78)	83.14 (12.42)	81.67 (11.02)	81.58 (12.40)	80.06 (13.32)	77.47 (12.07)
Latency						
Healthy	302.05 (129.70)	280.61 (129.09)	277.47 (109.50)	319.73 (124.26)	278.69 (123.41)	326.46 (119.35)
Anxious	310.40 (131.88)	323.70 (163.40)	260.36 (78.85)	338.43 (140.72)	322.13 (120.86)	307.40 (143.75)