Brief report

Anxious-depression in boys: an evaluation of executive functioning

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Abstract

The effects of anxiety and depression on frontal lobe functioning were tested in two groups of 9–11-year-old boys. Participants were screened for handedness, health, intelligence and classified as anxious-depressed or non-anxious, non-depressed based on scores from the A-State scale of the State-Trait Anxiety Inventory for Children and the Child Depression Inventory. Previous research in our laboratory has indicated that boys high in anxious-depression may have neuropsychological deficits [e.g., Emerson, C. S., Harrison, D. W., & Everhart, D. E. (1999). Investigation of receptive affective prosodic ability in school-aged boys with and without depression. Neuropsychiatry, Neuropsychology and Behavioral Neurology, 12(2), 102–109; Emerson, C. S., Harrison, D. W., Everhart, D. E., & Williamson, J. B. (2001). Grip-strength asymmetry in depressed boys. Neuropsychiatry, Neuropsychology, and Behavioral Neurology, 14(2), 130–134].

In order to assess the effects of anxious-depression on cerebral functioning performance on the Trail Making Test (Forms A and B) and on the Concept Formation subtest of the Woodcock Johnson was compared between groups. As predicted, anxious-depressed boys demonstrated deficits in sequencing, alternation, and problem-solving tasks as evidenced by longer completion times and significantly more errors on the tests. These results provide supportive evidence for deficits in frontal lobe functioning.

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Anxiety and depression are common disorders and are known to be associated with impairments in a number of functional cerebral systems (for reviews see Crews & Harrison, 1995;
Although each disorder makes a separate contribution to cerebral processing, the fact that anxiety and depression are commonly co-occurring makes it important to examine the co-morbid condition. Research on adult and child populations has revealed deficits in attention (Trichard et al., 1995), visual recognition (Thomas et al., 2001), motor functions (Crews, Harrison, Rhodes, & Demaree, 1995; Emerson, Harrison, Everhart, & Williamson, 2001), and reaction time (Dozois & Dobson, 2001) with anxiety and depression.

In adult research, neuropsychological investigations identify dysfunctional hemispheric activation in anxious-depression to explain deficits (i.e., increased reaction time, impaired motor functions) that are concurrent with the disorders. Electroencephalographic (EEG) and neuroimaging studies have shown asymmetrical activation of the frontal lobes or bilateral deactivation of the frontal lobes in mood disorders (Bruder et al., 1997; Davidson, Abercrombie, Nitschke, & Putnam, 1999). A widely accepted view is that anxious-depression produces deactivation of the left frontal lobe and increased activation of the right frontal lobe (Tucker et al., 1981; Henriques & Davidson, 1990, 1991). Recently we have proposed a functional cerebral systems model for mood disorders where the diagnosis of depression may result from dysfunction in either the left frontal, the right frontal, or in the right posterior quadrants (Shenal et al., 2003). Bruder et al. (1997) stated that anxiety concurrent with depression may act to heighten frontal asymmetries (Bruder et al., 1997).

In order to test this model in children, our laboratory has used behavioral measures that are reported to be sensitive to frontal lobe function. Prior research indicates that boys high in anxious-depression are impaired on verbal fluency measures (left frontal lobe) relative to non-anxious, non-depressed boys (Emerson, Harrison, & Everhart, 1999). On measures of grip strength, right-handed boys high in anxious-depression showed increased grip strength at the left hand (right frontal lobe), while non-anxious, non-depressed right-handed boys showed increased grip strength at the right hand (left frontal lobe) (Emerson et al., 2001). Data from neuroimaging investigations also indicate frontal lobe dysfunction in children and adolescence diagnosed with depression (see Stenigard, 2000 for a review). Stenigard et al. (1996) compared magnetic resonance imaging (MRI) scans of depressed children and adolescent to controls and found a significantly lower ratio for frontal lobe volume/cerebral volume in the depressed group.

The current experiment was designed to test the hypothesis that a population of school aged boys high in anxiety and depression as measured by the State-Trait Anxiety Inventory for Children and the Child Depression Inventory would display impairments on tasks that reportedly measure frontal functioning. Specifically, children high in anxiety and depression were predicted to have difficulties completing the Trail Making Test, Forms A and B, such that they would need increased time for completion and produce more errors. It was also hypothesized that boys high in anxious-depression would show deficits on the Concept Formation subtest of the Woodcock Johnson. The Trail Making Test and the Woodcock Johnson were chosen as measures because they have been associated with measuring frontal lobe functioning. Evidence from neuroimaging studies (Moll, de Oliveira-Souza, Moll, Bramati, & Andreuolo, 2002) and brain-damaged patients (Stuss et al., 2001) suggests that the Trail Making Test is a reliable measure of frontal lobe functioning.
1. Method

1.1. Participants

Thirty-eight boys, ages 9–11 (108–132 months) enrolled in grades four and five of a suburban Chicago public school were selected to participate in the present investigation, from a larger group of boys (n = 65), based on their scores on the Child Depression Inventory (CDI: Kovacs & Beck, 1977) and the Trait subscale of the State-Trait Anxiety Inventory for Children (STAIC: Spielberger, Edwards, Lushene, Montuori, & Platzek, 1973). Nineteen boys who scored at or above 12 on the CDI (mean = 40.21, S.D. = 5.98) and at or above 34 on the STAIC (mean = 40.21, S.D. = 4.48) were assigned to the anxious-depressed group. In this group, 13 boys were moderately depressed, with scores ranging from 12 to 18 (below the clinical cutoff score of 19 established by Kovacs, 1981). The other six boys were highly depressed with scores ranging from 20 to 32. Nineteen boys who scored at or below 5 on the CDI (mean = 2.95, S.D. = 1.96) and at or below 24 on the STAIC (mean = 28.42, S.D. = 2.65) were assigned to the non-anxious, non-depressed group. Additional selection criteria included right-handedness, normal hearing, normal corrected or uncorrected vision, and normal intelligence (80–120) as determined by the Wechsler Intelligence Scale for Children—Third Edition (Wechsler, 1991). Boys who were identified as having learning disabilities, Attention Deficit Hyperactivity Disorder (ADHD), or psychiatric disturbance (other than anxiety and depression, qualified within this project) were excluded. The experiment was approved by the Institutional Review Board (IRB) and informed consent was given by the participants and the participants’ parents prior to participation.

1.2. Materials

1.2.1. CDI

The CDI (Kovacs & Beck, 1977) is a 27 item self-report inventory designed to measure depression in children. It has been used in a large number of studies measuring cognitive, behavioral, and neurovegetative signs of depression in elementary and high school children. Initially, the cutoff score for identifying clinically severe depression in children was set at 19 or above by Kovacs (1981). However, more frequently investigators have used an upper cutoff score at the 67th percentile, and a lower cutoff score at the 33rd percentile (Bodiford, Eisenstadt, Johnson, & Bradlyn, 1988; Kazdin, 1989; Seligman & Peterson, 1986). Based on this previous research, the current experiment identified participants as “depressed” if their score was at or above 12 (the 67th percentile for the present sample) and as “non-depressed” if their score was at or below 5 (the 33rd percentile of the present sample).

1.2.2. STAIC

The STAIC (Spielberger et al., 1973) was developed as a research tool for the study of anxiety in elementary school children. It contains separate self-report scales for measuring two distinct anxiety concepts, State Anxiety (A-State scale) and Trait Anxiety (A-Trait scale). The A-State scale was used in this experiment. It consists of 20 items that require children to report how they generally feel. A median split was again used for group assignment. Scores
at or above 35 (67th percentile) were defined as high anxiety for this sample and scores at or below 30 (33rd percentile) were defined as low anxiety for this sample.

1.2.3. Trail Making Test
This test measures a participant’s ability to maintain attention and to shift mental set. It also requires visual-motor tracking and motor speed (Lezak, 1983). These capabilities are associated with frontal lobe functioning (Stuss & Benson, 1984). The test is administered in two parts and subjects are instructed to work as quickly as possible. First, participants are asked to connect numbered circles in consecutive order (Form A). On a subsequent worksheet, they are asked to alternate between numbered and lettered circles in sequence (Form B). Each form is scored separately. Scores consist of the number of seconds required for completion and sequencing errors are recorded as a measure of perseveration.

1.2.4. Concept Formation
Concept Formation is a subtest of the Woodcock Johnson Test of Cognitive Abilities (Woodcock & Johnson, 1989). This measure requires that a child conceptualize the solution to problems which increase in hierarchical complexity as the task proceeds. Problems are based on abstract rules of categorization, inclusion and exclusion, including color, shape and size. The measure yields a score based on total number correct.

Both the Concept Formation Test and the Trail Making Test were chosen as measures of frontal functioning because they are well-known, frequently used neuropsychological tasks which are normed for children in the age range under study.

1.3. Procedure
Pretesting for selection to groups was carried out in a general classroom setting during the school day. Boys who meet the scoring criteria completed the neuropsychological measures within a 2-week period of administration of the screening measures. The testing measures were completed individually in a quiet room, removed from any interference from school activities. The experiment began with each participant completing the Lateral Preference Test to establish handedness. Only right-handed participants were accepted for further participation. The participants were then administered the Trail Making Test (Forms A and B) followed by the Concept Formation Test. These tests were administered following standardized administration procedures. In all cases the experimenter was blind to the group the participant was assigned to.

2. Results
Data were analyzed to determine the significance of difference between groups on all measures, using a mixed design repeated measures analyses of variance (ANOVA). All results were determined significant at $P < .05$.

The Trail Making Test yielded two performance measures on each of Form A (sequencing) and Form B (sequential alternation): Completion Time and Perseverative Errors. The Concept Formation subtest yielded one performance variable: Accuracy of Performance.
Table 1

Means and standard deviations of the groups on each of the performance measures

<table>
<thead>
<tr>
<th></th>
<th>Anxious-depressed</th>
<th>Non-anxious, non-depressed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>S.D.</td>
</tr>
<tr>
<td>Trail Making Test, Form A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Completion Time</td>
<td>17.02</td>
<td>4.66</td>
</tr>
<tr>
<td>Perseverative Errors</td>
<td>.58</td>
<td>.69</td>
</tr>
<tr>
<td>Trail Making Test, Form B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Completion Time</td>
<td>38.13</td>
<td>19.34</td>
</tr>
<tr>
<td>Perseverative Errors</td>
<td>.79</td>
<td>.92</td>
</tr>
<tr>
<td>Concept Formation</td>
<td>22.94</td>
<td>4.09</td>
</tr>
</tbody>
</table>

2.1. Completion Time

The first variable, Completion Time on the Trail Making Test was analyzed using a two factor ANOVA with the fixed factor of Group (anxious-depressed and non-anxious, non-depressed) and the repeated measure of Condition (Form A or Form B). Analysis revealed a main effect for Condition, $F(1, 36) = 64.14, P < .001$. Significantly less time for both groups was required for completion of the Form A as compared to Form B. No significant differences in performance time between groups were found in the sequencing condition (see Table 1). Both groups required a greater length of time to perform Form B relative to Form A. However, a group by condition interaction, $F(1, 36) = 2.80, P < .051$, revealed that performance time for the anxious-depressed participants was significantly greater than the performance time for the non-anxious, non-depressed participants (see Table 1).

2.2. Perseverative Errors

The second variable, Perseverative Errors, was analyzed using a two factor mixed design ANOVA, with the fixed effect of Group (anxious-depressed and non-anxious, non-depressed) and the repeated measure of Condition (Form A or Form B). A main effect for Group was revealed, $F(1, 36) = 8.93, P < .003$. Anxious-depressed participants made significantly more errors in the sequencing condition (mean = .58, S.D. = .69) compared to the non-anxious, non-depressed participants (mean = .17, S.D. = .38). In the sequential alternation condition, anxious-depressed participants also committed significantly more errors (mean = .79, S.D. = .92) as compared to the non-anxious, non-depressed participants (mean = .33, S.D. = .49; see Table 1).

2.3. Concept Formation

A one-way ANOVA revealed a main effect of anxious-depression on concept formation scores, $F(1, 36) = 6.566, P < .015$. As hypothesized the non-anxious, non-depressed group
(mean = 26.61, S.D. = 4.35) was significantly more accurate on concept formation than the anxious-depressed group (mean = 22.94, S.D. = 4.09; see Table 1).

3. Discussion

The current experiment used the Trail Making Test (Forms A and B) and the Concept Formation Test of the Woodcock Johnson to measure the effects of anxious-depression in school aged boys. It was hypothesized that boys who are high in anxiety and depression as determined by the STAIC and the CDI would take more time to complete the Trail Making Test (Forms A and B), and would make more errors on both the Trail Making Test (Forms A and B) and the Concept Formation Test in comparison with boys who scored low on measures of anxiety and depression.

The only hypothesis not supported was completion time for Form A of the Trail Making Test. Completion time for Form A of the Trail Making Test was not significantly different between groups. This finding was not surprising considering the simplistic nature of Form A. Participants are only required to connect a single series of numbers. Prior research has indicated that Form A is easily performed by individuals without brain damage (Reitan & Wolfson, 1985). However, completion time for Form B of the Trail Making Test was significantly different between groups. Anxious-depressed participants demonstrated diminished speed in comparison to their non-anxious, non-depressed counterparts. This is consistent with research in adult depressives, where a significantly slower speed of cognitive processing has been found relative to control participants (Abrams & Taylor, 1987; Den Hartog, Derix, Van Remmel, Kremer, & Jolles, 2003). The performance of the anxious-depressed group on Form B may be due to general decreased neuropsychological functioning. Form B is generally sensitive to brain function in any of the cerebral hemispheres due to its content and requirements (Reitan & Wolfson, 2004). However, in combination with the rest of the results and previous investigations of the neurobiology of anxiety and depression (Steingard, 2000) and imaging data of participants performing the Trail Making Test (Moll et al., 2002), the current results provide supportive evidence for impaired frontal functioning in anxious-depression.

Anxious-depressed boys committed more perseverative errors on both Forms A and B. The increase in perseverative errors by the anxious-depressed boys may be due to motor perseveration and poor active perception, both of which are implicated in frontal lobe dysfunction (Taylor, Greenspan, & Abrams, 1979).

Performance by boys with anxious-depression on the Concept Formation subtest indicate impairments on set shifting, hypothesis testing, and categorical problem-solving. Taken together, the results from the current experiment suggest that anxiety and depression affect functions that are associated with frontal lobe functioning in adults, such that performance on behavioral measures of the frontal lobes is impaired in individuals with anxious-depression. However, both tasks used may measure functioning across a variety of cerebral systems. Given the lack of neuroradiological data in the current experiment it is difficult to identify specific areas, however, because boys with anxious-depression demonstrated impairments on both tasks, the present results make a case for the existence of frontal lobe deficits in mild to moderately high levels of anxiety.
References


