Brief Report: Cognitive Functioning in Children With Tourette’s Syndrome With and Without Comorbid ADHD

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Objective: To examine whether patients with Tourette’s syndrome (TS) with and without comorbid attention deficit and hyperactivity disorder (ADHD) differ in cognitive functioning and whether a higher level of cognitive functioning is associated with severity of TS symptoms and psychosocial functioning.

Methods: Cognitive functioning, symptom severity, and psychosocial functioning were examined in 40 patients (33 boys, 7 girls; age range 6–18 years) with TS, of whom 17 had the comorbid diagnosis of ADHD.

Results: Patients with a comorbid ADHD diagnosis evidenced poorer performance than those with TS alone with respect to severity of TS symptoms, psychosocial functioning, verbal and performance intelligence, and word fluency, but not on tests of cognitive flexibility. Psychosocial functioning was predicted by symptom severity, but not by intelligence or fluency.

Conclusions: Results confirm prior findings that comorbid ADHD is associated with more TS symptoms and worse psychosocial and cognitive functioning, and motivate whether cognitive flexibility plays a role in moderating the deleterious psychosocial effects of Tourette’s syndrome and ADHD.

Key words: Tourette’s syndrome; ADHD; cognitive flexibility; executive functions; children; adolescents.

Tourette’s syndrome (TS) is characterized by a chronic pattern of simple or complex motor and vocal tics occurring involuntarily. TS has a typical onset between 5 and 7 years of age. In about 50% of patients, there is comorbidity with attention-deficit hyperactivity disorder (ADHD) (Comings & Comings, 1988; Leckman et al., 1997). Self-regulation and adequate coping are important for well-being in people with TS.

Neurobiological hypotheses stress the involvement of the basal ganglia in TS. Connections of this region with other subcortical and frontal and pre-motor areas suggest that TS may be associated with deficits in executive functions (Ozonoff, Strayer, McMahon, & Filloux, 1998). However, Pennington and Ozonoff (1996) reported little evidence of executive dysfunctions in TS but more consistently so in ADHD.

Cognitive disturbances have frequently been reported in children with TS. Early studies suggested that patients with TS had subnormal IQs (Thompson, O’Quinn, & Logue, 1979) and that performance IQ (PIQ) was lower than verbal IQ (VIQ).
Recently it was suggested that comorbidity with ADHD exacerbates the outcome (Dykens et al., 1990; Ozonoff et al., 1998). Bornstein (1990) found that the cognitive performance of patients with TS was generally normal, although there were weaknesses in executive tasks such as concept formation and verbal fluency. Schuerholz, Baumgardner, Singer, Reiss, and Denckla (1996) compared patients with TS with non-TS comparison groups and with comorbid TS and ADHD patients. They found a poorer performance on verbal fluency in the TS-only group. Ozonoff et al. (1998), however, found failures to suppress unintended behavior (an executive function) only in the comorbid or severely disturbed patients. Channon, Flynn, and Robertson, (1992) found deficits on attentional measures such as a serial addition task, the Trail Making Test (TMT) and a vigilance test, in adult patients with TS compared to a comparison group.

Deficits in executive functions may impede psychosocial performance. In patients with TS, executive functions such as planning and attention may permit better coping with the tic behavior and potentially embarrassing situations. Patients with more cognitive flexibility may experience less distress and have a better psychosocial functioning and well-being. That is, these executive capabilities would diminish the influence of symptom severity. This suggestion is relevant in that cognitive flexibility may be trained on a behavioral level (Delahunty & Morice, 1996).

This study examines whether patients with TS only and patients with TS and comorbid ADHD differ in cognitive functioning, and whether cognitive flexibility moderates the effect of symptom severity on psychosocial functioning. We hypothesized that patients with a comorbid diagnosis perform worse in cognitive tests than those with TS alone and that psychosocial functioning is affected more by symptom severity in patients with low cognitive flexibility than in patients with high flexibility.

Method

Participants

In this retrospective case design, archival data were obtained from 40 Dutch outpatients involved in a treatment program in the Department of Child Psychiatry of the University Medical Center Utrecht. The department is a major outpatient clinic in the Netherlands, specializing in the diagnosis and treatment of TS and ADHD. The patients were assessed voluntarily. Assessments included a developmental history and a semi-structured parent interview, a psychiatric interview, a review of prior records, and information obtained from the teacher and psychological testing. In the interview with the parent, the diagnostic criteria of all relevant Axis-I conditions according to the DSM-IV (APA, 1994) were systematically reviewed, particularly those of disruptive conditions, anxiety disorders, obsessive compulsive disorders, depressive conditions, and tic disorders. The information about TS-related symptoms and features was organized according to a fixed format including measures of psychosocial functioning and severity of the disorder. The diagnosis of TS was confirmed by a psychiatrist specializing in the assessment and treatment of TS (JKB). Seventeen patients had a comorbid ADHD (all combined subtype characterized by attention deficit and hyperactivity). ADHD symptoms were assessed using the Diagnostic Interview Schedule for Children (Kasius, 1993).

Ages ranged between 6 and 18 years. The children in the TS-only group had a mean age of 11.7 years ($SD = 3.6$); in the comorbid group, this was 10.1 years ($SD = 2.5$). The difference in age was not significant. There were 33 boys (17 in the TS-only group) and 7 girls (6 in the TS-only group), which approximately equals the male/female ratio in the population. Distribution of type of medication in both groups was neuroleptic (10 in TS only/4 in comorbid group), clonidine (5/3), neuroleptic and clonidine combined (2/6), and no medication (6/4). Medication was aimed at the TS symptoms. No other medication was given.

Instruments

Instruments included the Tourette’s Syndrome Global Scale (TSGS; Harcherik, Leckman, Detlor, & Cohen, 1984). The TSGS provides a global score comprised of judgment of frequency and disruptive impact of the different types of tics and judgment of the child’s behavior, motor restlessness, and school or work problems. The scores may range between 0 and 100. To assess general psychosocial functioning the Dutch version of Endicott’s Kiddy GAS (Children-Global Assessment Scale) was used (Endicott, Spitzer, & Feiss, 1976). This scale yields a score from 1 (dangerous for self and others continuously) to 9 (functioning well in all areas). Verbal
and Performance IQ were measured with the Wechsler Intelligence Scale for Children (Pijl, De Bruyn, Haasen, Poortinga, & Lutje Spelberg, 1982) for children between the ages of 6 and 15 (32 children), and the Wechsler Adult Intelligence Scale (Stinissen, Willems, Coetsier, & Hulsman, 1970) for those older than 15 years (6 children). Three neuropsychological tests were administered. First was the Trail Making Test (TMT; Lezak, 1995). The TMT measures the ability to shift quickly between concepts (numbers and letters). As such, it is a measure of divided attention, or cognitive flexibility. This applies particularly to Form B, in which numbers and letters have to be traced alternately in ascending order. In these executive functions, the frontal lobes are believed to be involved. Second was the Stroop Color Word Interference Test. This test consists of three cards: (1) reading of color names (2) naming of colors, and (3) naming of the colors in which color names are printed. On card 3, the print color interferes with the color name. An interference measure is calculated, which is the time for card 3 minus the time for finishing card 2. This measure stands for the ability to attend to the physical features of the task while inhibiting the normal reading process, an ability also ascribed to frontal lobe mechanisms. The third test was for verbal fluency: within 1 minute, as many exemplars of a certain semantic category as possible must be mentioned. It is a measure of categorical long-term memory and word production. Two categories were included: “animals” and “professions.” The task has proven to be a sensitive indicator of brain dysfunction, especially in the frontal lobe area (Perret, 1974) and measuring aspects of mental flexibility (Lezak, 1995).

**Statistical Analysis**

Not all measures were available from each participant for unknown clinical reasons. See Table I for the number of participants for each variable. Analysis of variance was used to compare scores of symptom severity and psychosocial and cognitive functioning between patients with TS-only and patients with TS and ADHD. Regarding the multiple testing, the level of significance was set to the conservative Bonferroni criterion of $p = .005$, or the normal alpha of .05 divided by the number of measures (11). The scores of the TMT (A and B) and the Stroop Interference measure were combined into a measure called cognitive flexibility using z scores (correlations were between .50 and .79; Cronbach’s alpha was .83). The z scores were added and divided by the number of variables. The two fluency measures were averaged (correlation of .65; alpha .79) into a single word fluency measure. Multiple regression was used to examine the relationship between symptom severity and psychosocial functioning and the possible moderating role of intelligence, cognitive flexibility, and word fluency, according to the procedures proposed by Baron and Kenny (1986) and Holmbeck (1997). Twenty-one participants with complete data with respect to all variables (of these participants, 8 had the comorbid diagnosis, and 2 of the 21 were female) were included.

**Results**

Table I shows means and standard deviations of TSGS, Kiddy GAS, and the cognitive measures of the TS-only and the comorbid patients. The comorbid group had a significant higher mean score on the TSGS, $F(1, 33) = 11.9, p = .002$, and a lower score on the Kiddy GAS scale, $F(1, 27) = 10.6, p = .003$, than the TS-only group. The comorbid patients also had a lower verbal IQ, $F(1, 36) = 14.7, p < .001$, than the patients with TS alone. The same was true for performance IQ, although the difference just failed to reach the Bonferroni criterion, $F(1, 36) = 8.7, p = .006$. Differences between comorbid patients and patients with TS-only on the flexibility tests (Stroop and TMT) were not significant. Patients with comorbid diagnosis performed significantly worse in word fluency when compared to the patients with TS-only, $F(1, 29) = 11.03, p = .002$. In sum, the comorbid patients had significantly poorer scores than patients with TS-only on TSGS, Kiddy GAS, verbal IQ, and word fluency.

Table I also lists the effect sizes and associated estimation of power in each of the comparisons. The effect size is high with respect to the IQ measures and verbal fluency, but low to moderate with respect to the Stroop and TMT.

**Multiple Regression**

In an initial stepwise regression analysis, we examined whether the cognitive variables were predictive of individual differences in psychosocial functioning over and above variance explained by symptom severity. We found that intelligence and word flu-
ency were not predictive of psychosocial functioning. The predictive contribution of cognitive flexibility was stronger compared to these factors, although not statistically significant.

In a second analysis, the TSGS score (predictor) and cognitive flexibility (possible moderator) were both entered simultaneously, after being “centered” (Aiken & West, 1991; Holmbeck, 1997). This was followed by entering the interaction term. In this way, we examined whether cognitive functioning affected the relationship between symptom severity and psychosocial functioning.

Table II shows that the TSGS score was the major predictor (\( r^2 = .77 \); \( t = -7.23, p = .000 \)) reflecting higher symptom severity associated with worse psychosocial functioning. Cognitive flexibility was not significant in the prediction of psychosocial functioning. This was also true for the interaction between severity and flexibility. Explained variance (adj. \( R^2 \)) of the regression model was 80.7 %, \( F(1, 17) = 3.65, p = .07 \). Inclusion of diagnostic group (TS-only versus comorbid patients) in the regression model slightly changed the \( p \) values (.07 for flexibility and .09 for the interaction severity \( \times \) flexibility), suggesting that the differentiation between TS and comorbidity did not explain much variance over and beyond that of symptom severity. Finally, analyses using interactions of symptom severity with single cognitive variables (Stroop tasks, TMT-A, TMT-B, word fluency) showed that TMT-B (concept shifting) was the leading variable in the prediction of psychosocial functioning.

**Discussion**

Patients with TS and comorbid ADHD perform less well on cognitive tasks than patients with TS alone. Verbal and Performance IQs were normal for the patients with TS-only, as Bornstein (1990) reported, but were lower for the patients with a comorbid diagnosis. Dykens et al. (1990) reported that children with TS and ADHD had a lower IQ (especially performance IQ) than patients with TS without the attention deficit.

Pennington and Ozonoff (1996) concluded that executive dysfunctions are more likely in ADHD than in TS. We hypothesized that patients with a comorbid diagnosis would show a weaker performance on the tests of cognitive flexibility. This was in part confirmed. Verbal fluency was significantly impaired in the children with a comorbid diagnosis. Performance on the executive Stroop and Trail subtasks also was weaker in the comorbid condition in comparison to the Tourette’s group, albeit not statistically significant, possibly due to low power.

It was suggested that the impact of symptom severity on psychosocial functioning could depend on the degree of cognitive functioning. A nonsignificant contribution of cognitive flexibility in the regression analysis was found. Concept shifting (as measured with Form B of the TMT) is a measure of executive functioning (Lezak, 1995; Pennington & Ozonoff, 1996). In combination with other executive functions such as inhibition (Ozonoff et al., 1998), flexibility may be necessary for self-regulation.
The results are relevant clinically in that, for patients who are low on cognitive flexibility, treatment of symptoms could be the preferred way to psychosocial well-being. Delahunty and Morice (1996) suggested that cognitive flexibility may be trained. Some cognitive flexibility may thus play a role in coping with TS, and interventions that enhance cognitive flexibility may be helpful for children with TS.

The power of our study is low, and replication with larger samples is needed. We were not able to confirm the hypothesis, but the data are suggestive of the importance of the comorbidity factors in Tourette's syndrome. The possible role of mental flexibility as a buffer for the psychological impact of symptom severity in TS should be further investigated.

Table II. Results of Multiple Regression Analysis Predicting Psychosocial Functioning From Symptom Severity, Cognitive Flexibility, and the Interaction Between These

<table>
<thead>
<tr>
<th>Factors</th>
<th>β</th>
<th>t</th>
<th>p</th>
<th>ΔR²</th>
<th>F change</th>
<th>Adj. R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Symptom severity</td>
<td>-.77</td>
<td>7.23</td>
<td>.000</td>
<td>.772</td>
<td>64.34</td>
<td></td>
</tr>
<tr>
<td>Cognitive flexibility</td>
<td>-.22</td>
<td>2.04</td>
<td>.057</td>
<td>.028</td>
<td>2.56</td>
<td></td>
</tr>
<tr>
<td>Severity × flexibility</td>
<td>-.19</td>
<td>1.91</td>
<td>.073</td>
<td>.035</td>
<td>3.65</td>
<td>80.7%</td>
</tr>
</tbody>
</table>

and coping with the condition. Executive control operations are important in regulating behavior in coping with malfunctions and states of stress. Our data did not confirm the hypothesis that diminished cognitive flexibility may be important to explain the influence of symptom severity on psychosocial functioning.

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