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Memory and executive functions in adults with Gilles de la Tourette syndrome and chronic tic disorder

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Abstract

Introduction—The main aim of the current study was to assess whether adults with either Tourette syndrome (TS) or chronic tic disorder (CTD) show a similar neuropsychological profile. Neuropsychological investigations of tic disorders have been mostly focused on children, mainly because symptoms peak during that period. Little has been carried out on adults, even if a significant proportion of the tic population experience moderate or marked levels of tic frequency throughout adulthood. Still, it is not clear whether neuropsychological performances are affected to the same degree in adults with TS and CTD.

Method—Patients diagnosed with TS were compared with a CTD group and a control group free of psychiatric or neurological diagnosis, comparable in terms of age, gender, and intelligence. All participants completed two tests of memory (Rey-Osterreich Complex Figure, California Verbal Learning Test), one test of motor dexterity (Purdue pegboard), and four tasks of executive function (Stroop, Color Trail Test, Tower of London, Wisconsin Card Sorting Test).

Results—TS and CTD patients showed nonverbal memory impairments while verbal memory and executive functioning remained intact. Results also indicated that nonverbal memory performances decrease as a function of tic severity.

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Conclusion—Both TS and CTD patients present a specific nonverbal deficit whilst the executive and motor functions are relatively intact. The two tic disorder subgroups might be part of a spectrum implicating mainly nonverbal memory.

Tourette's syndrome (TS) is a disorder developing during childhood and characterised by the presence of multiple motor tics accompanied by at least one phonic tic (American Psychiatric Association, 2000). Tics are defined as repetitive and involuntary contractions of functionally related muscles and can be simple (e.g., eye blinking, coughing) or complex (e.g., nail biting, repeating sentences). Symptoms usually start around childhood (Leckman, 2002) and, for the majority, they fade at the end of adolescence (Bagheri, Kerbeshian, & Burd, 1999; Bruun & Budman, 1997). In the most severe cases, symptoms persist into adulthood and there is often more to TS than tic problems, as affected people often suffer from sleep troubles, learning disorders, behaviour problems, and anxiety (Leckman, 2002; Lin et al., 2002). Comorbidities such as attention deficit hyperactivity disorder (ADHD) or obsessive-compulsive disorders (OCD) are also prevalent among people with TS (Evidente, 2000; Marcus & Kurlan, 2001).

Neuropsychological studies have obtained results suggesting learning problems for mathematics and written language (Brookshire, Butler, Ewing-Cobbs, & Fletcher, 1994; Como, 2001), and specific deficits in verbal fluency (Bornstein, 1991; Brookshire et al., 1994), fine motor coordination and visuomotor integration abilities (Bornstein, Baker, Bazylewich, & Douglass, 1991; Bornstein, King, & Carroll, 1983; Brookshire et al., 1994; Como, 2001), and attention orienting, as well as vigilance (Bornstein et al., 1983; Channon, Flynn, & Robertson, 1992; Como, 2001; Georgiou, Bradshaw, & Phillips, 1998; Georgiou, Bradshaw, Phillips, Bradshaw, & Chiu, 1995).

However, some studies with TS children have observed normal performances on executive function tasks that evaluate abstract concepts (Bornstein, 1990; Bornstein & Baker, 1991; Harris et al., 1995; Randolph, Hyde, Gold, Goldberg, & Weinberger, 1993; Schuerholz, Baumgardner, Singer, Reiss, & Denckla, 1996; Yeates & Bornstein, 1994), planning and response inhibition (Ozonoff & Jensen, 1999), and verbal fluency (Mahone, Koth, Cutting, Singer, & Denckla, 2001; Randolph et al., 1993), while others concluded that executive functions are impaired in TS children (Baron-Cohen, Cross, Crowson, & Robertson, 1994; Bornstein et al., 1983; Brookshire et al., 1994; Schuerholz et al., 1996; Sutherland, Kolb, Schoel, Whishaw, & Davies, 1982).

Of all the different functions that have been targeted by neuropsychological studies in TS patients, memory functioning appears to be the least understood. Among those studies conducted with children, no particular deficit has been reported in verbal (Channon, Pratt, & Robertson, 2003) or nonverbal memory (Brookshire et al., 1994). However, several other studies have reported nonverbal memory difficulty in TS children during the copy of complex geometric designs such as the Rey-Osterrieth Complex Figure (ROCF), which also involve visuospatial integration (Harris et al., 1995; Schuerholz et al., 1996). Two other studies with TS adults point to a specific verbal memory deficit in working and procedural memory (Channon, Pratt, & Robertson, 2003; Stebbins et al., 1995).

This lack of consistency concerning memory dysfunction could be due to methodological problems considering that, in some cases, studies did not include a control group or did not control for the presence of comorbid disorders such as ADHD or OCD. The presence of ADHD or OCD in children often leads to poorer performance on neuropsychological tasks measuring integrity of executive functions (Bornstein, 1990; Harris et al., 1995). Considering that symptom severity is rarely reported, it is also possible that tic severity differed between groups and this could explain why some studies found impairments and others did not. CTD differ from TS by having motor or phonic tics, but not both, and CTD are thus viewed as a milder variant of TS (APA, 2000). For instance, it has been proposed that CTD could be part of the same continuum of symptoms with TS (Spencer, Biederman, Harding, Wilens, & Faraone, 1995). If this proposition is true, neuropsychological impairments should be more severe in TS than in CTD patients. However, so far such a profile, in CTD adults, has not been investigated, while most of the findings on the neuropsychological profiles of TS patients come from child studies. Approximately 11% of adults with tics remain with moderate or marked levels of tic severity (Leckman et al., 1998), but little work has been conducted with TS adults.

Considering the lack of information on memory, in TS adults particularly, our first aim was to profile memory performances in a TS adult sample. We hypothesised that patients with tic symptoms would show verbal memory problems, as previously reported, but also nonverbal memory problems. This last type of memory has rarely been studied with adults, but we hypothesised that the visuospatial and visuomotor impairments found in patients with tics would interfere with the recall performance of the ROCF. Given that CTD are often seen as a milder variant of TS, our second aim was to compare these two groups and examine the relationship between symptom severity and neuropsychological performances. Thus, we hypothesised that symptom severity and the presence of both motor and phonic tics would be linearly associated with impaired memory and, consequently, patients suffering from TS would perform more poorly on verbal and nonverbal memory tasks compared to the CTD.

METHOD

Participants

All participants were recruited through publicity in Montreal's main newspapers. They were recruited from the general population to minimise the potential clinical bias of a clinic-based sample, which is likely to be less functional and more distressed. Table 1 shows that 58 participants were divided in three groups consisting in 18 CTD, 18 TS, and 22 control participants, equivalent for nonverbal IQ (Raven), visual acuity (Snellen), gender, and lateral dominance (Edinburgh). The inclusion criteria were based on the DSM-IV-TR (APA, 2000) for the TS (307.23) and the CTD (307.22). The diagnosis was made by a certified psychiatrist (ES) and a clinical psychologist (supervised by KO). The diagnosis was based on the consensus between the evaluation of the psychiatrist and the psychologist. The Tourette Syndrome Global Scale (TSGS: Harcherik, Leckman, Detlor, & Cohen, 1984) was administered by the psychologist to assess tic severity. *Inclusion* criteria for the CTD group were the presence of at least one single motor *or* phonic tic, while those with at least one motor tic *and* at least one vocal tic were included in the TS group. *Exclusion* criteria were

the presence of diagnosis on *Axis I* such as: schizophrenia, mood, obsessive-compulsive, somatoform, dissociative, substance-related and disorders diagnosed during infancy, childhood, or adolescence; *Axis II*: the presence of personality disorders; *Axis III*: medical conditions such as neurological problems (e.g., Parkinson's, hemifacial spasms, Meige syndrome, cerebral sclerosis; Huntington's disease, Wilson's disease); *Axis IV*: any psychosocial stressors such as current behavioural, social, or family problems (e.g., marital rupture). Subjects currently receiving any treatment from a psychologist, acupuncturist, hypnotherapist, or massotherapist were also excluded. None of the participant was on medication before or during the neuropsychological testing.

Clinical evaluation and pretests

The TSGS has several subscales contributing to the global score. The first scale rates the tic type (i.e., motor or phonic) while the second scale rates the tic complexity (i.e., simple or complex). A third scale measures overall behavioural problems, learning problems, motor restlessness, and occupational problems. The Anxiety Disorders Interview Schedule for DSM-IV (ADIS-IV; Brown, DiNardo, & Barlow, 1994) was administered to assess the occurrence of anxiety disorders. A complementary assessment of clinical characteristics with regards to state and trait anxiety personality (Spielberger, 1983) as well as clinical anxiety with the Beck Anxiety Inventory (BAI; Beck, Epstein, Brown, & Steer, 1988), obsessive-compulsive symptoms with the self-administered Yale-Brown Obsessive-Compulsive Scale (Y-BOCS; Goodman, Price, Rasmussen, Mazure, Delgado, et al., 1989; Goodman, Price, Rasmussen, Mazure, Fleischmann, et al., 1989), overactive style in adults with the Style Of Planning questionnaire (STOP; O'Connor, 2005b), and depression with the Beck Depression Inventory (BDI; Beck, Ward, Mendelson, Mock, & Erbaugh, 1961; Bourque & Beaudette, 1982). Pretests were administered for visual acuity (Snellen test), colour vision (Ishihara test), laterality (Oldfield, 1971), and a nonverbal intelligence test (Raven, 1958).

Neuropsychological assessment

The following tests were administered during a single session that lasted approximately 2.5 hours. The Purdue pegboard test (PPT; Lafayette Instrument—Revised edition; Tiffin, 1999) mainly assesses *motor dexterity* (Tiffin & Asher, 1948). Three scores are generated by the number of pegs placed correctly in 30 s with each hand separately and with both hands. To assess *memory functioning*, two tests were administered, the Rey-Osterrieth Complex Figure (ROCF; Osterrieth, 1944) and the French version of the California Verbal Learning Test (CVLT; Delis, Kramer, Kaplan, & Ober, 1987). The ROCF evaluates visuospatial integration and nonverbal memory and includes a copy condition, an immediate recall (3 min after copy), and a 25-min delayed recall condition. Two independent raters blind to the participant's diagnosis scored the ROCF and the interrater reliability was excellent (alpha over .98 for all subscales). The CVLT was administered to evaluate the strategies involved in remembering verbal material with no contextual link. An interference list is followed by free and category-cued recall of the first list (immediate recall). After 20 min, free and cued recall of the first list is assessed (delayed recall). For the evaluation of *executive functions*, the Tower of London (ToL; Shallice, 1982), the Wisconsin Card Sorting Test (WCST-64-

CV2; Kongs, Thompson, Iverson, & Heaton, 2000), the Color Trail Test (CTT; D'Elia, Satz, Lyons-Uchiyama, & White, 1996), and the Stroop Test (Golden, 1978) were administered. The ToL is an instrument designed to evaluate higher order problem solving and planning abilities using two tower-structure boards and two sets of beads. The variables analysed were the number of correct items, time of initiation and execution, and the amount of rule violations. The computerised WCST was administered to assess the ability to form abstract concepts, to shift and maintain set, and to use feedback. The examinee is instructed to match each of the cards to one of the four key cards and is given feedback. The WCST variables were the number of categories completed and the sum of perseverations and errors. The CTT was administered to assess the ability to track numerical sequence (Color trail 1) and to divide attention between a number sequence and a colour sequence (Color trail 2). For both scores, the length of time to complete the trials was recorded. The Stroop Test (Golden, 1978; Stroop, 1935) was administered as an index of inhibition and consists of conditions requiring the reading of 100 randomised colour names (red, blue, and green), printed in conflicting colours, as fast as possible. The length of time to complete the interference condition was used.

Data analysis

Analyses were conducted using SPSS (version 13, SPSS Inc) with all types of data. First, the two clinical groups (TS vs. CTD) were compared with the TSGS tic subfactors including the tic complexity (two levels: simple vs. complex) and the tic type (two levels: motor vs. phonic) using a repeated-measures ANOVA. The behavioural scores of the TSGS were compared with a separate repeated-measure ANOVA (four levels: motor restlessness, behavioural, work, or learning problems). Clinical characteristics of hyperactivity, state-trait anxiety, depression, and anxiety (BAI) were compared using a one-way ANOVA. The demographic profile including age, schooling, and performances on the Raven nonverbal intelligence test were compared separately by means of a one-way ANOVA. A nonparametric Kruskall-Wallis test compared gender and laterality.

Secondly, performances on the nonverbal memory (ROCF) and verbal memory (CVLT) were analysed using a group by memory task (ROCF vs. CVLT) by recall (immediate vs. delayed recall) repeated-measures analysis of covariance within a MANCOVA design. The covariates included the Y-BOCS global score to control for obsession and compulsion symptoms and the STOP questionnaire to control for the presence of overactivity. Motor abilities (Purdue pegboard) and executive functions (Stroop, CTT, ToL, and WCST) were compared between groups using separate one-way ANOVAs. The Tukey post hoc test was used for multiple comparisons of group effects. Spearman correlation coefficients were calculated to examine the relationship between patients' clinical characteristics (i.e., TSGS, STOP, BAI, and Y-BOCS), memory, and executive function performances.

RESULTS

Analysis of tic disorder, anxiety, and depression symptoms

Clinical variables assessed by the STAI and the BDI didn't differ significantly across the three groups. However, the ADIS-IV revealed the occurrence of anxiety disorders in the

CTD (50%) as well as in the TS group (44%) with no significant difference between these two groups. Consistently, the STOP questionnaire showed significantly more symptoms of overactivity, $F(2, 55) = 8.08$, $p < .005$, in both clinical groups than in the control group with significant differences between the TS and control group ($p < .001$) and between the CTD and control group ($p < .001$). The Y-BOCS revealed significantly more obsessive-compulsive symptoms in the TS than in the CTD and the control group respectively, $F(2, 55) = 16.76$, $p < .001$, with significant differences between the TS and CTD group ($p < .001$) and between the TS and control group ($p < .001$). The BAI showed significantly more anxiety symptoms in the TS than in the CTD and the control group respectively, $F(2, 55) = 3.66$, $p < .05$, with significant differences between the TS and control group ($p < .05$). The analyses of the TSGS subfactors (i.e., complexity and type) showed a significant group main effect, $F(1, 34) = 11.63$, $p < .005$, and a Group × Tic type interaction, $F(1, 34) = 10.42$, $p < .005$, revealing that the TS group showed more phonic than motor tic scores compared to the CTD group. However, the complexity of the symptoms and behavioural problems were similar across both clinical groups.

Taken as a whole, these results revealed that both clinical groups are more anxious and overactive than the control group. The TS group also showed particularly more OCD symptoms than the CTD and the control groups (Table 1). Finally, the TSGS also confirms that the TS showed significantly more phonic tics than the CTD (Table 2).

Neuropsychological evaluation

Motor performances

The ANOVA comparisons failed to show group differences on motor dexterity as assessed by the PPT scores (Table 3). In addition, no correlation (all rs < .15) was found between any clinical measures and the PPT motor performances (Table 3).

Verbal and nonverbal memory

A Group × Memory task effect, $F(2, 55) = 4.94$, $p < .05$, and a tendency toward a Group × Memory task × Recall, $F(2, 55) = 2.78$, $p = .06$, interaction were present. The Group × Memory task interaction remained significant after covarying with OCD symptoms, anxiety, and overactivity, $F(2, 52) = 3.36$, $p < .05$. To investigate the nature of this interaction, we applied two separate one-way ANOVAs to each memory task (Table 3). A significant main group effect was found on immediate, $F(2, 55) = 3.18$, $p < .05$, and delayed, $F(2, 55) = 5.31$, $p < .01$, recall of the ROCF, while the CVLT showed no group effect. The post hoc tests applied to significant variables of the ROCF, revealed group differences between the TS and the control group on both immediate ($p < .05$) and delayed ($p < .01$) recall. Further significant differences between the CTD and the control group were also present for the delayed recall ($p < .05$). No difference was found between the CTD and the TS in both immediate and delayed recall, but control participants had higher scores compared to both TS and CTD groups (Table 3). Negative correlations were present between symptoms severity (TSGS global score) and the copy score, $rho = -29$, $p < .05$, immediate, $rho = -.26$, $p < .05$, and delayed recall, $rho = -.26$, $p < .05$. However, no correlation (all rs < .15) was found between other clinical measures and ROCF scores.

Executive functions

The ANOVA comparisons failed to show any group differences on tests of executive function (Table 3). In addition, no correlation (all *r*s < .15) was found between any clinical measures and tests of executive function.

DISCUSSION

Our first aim was to characterise memory performances in TS and CTD patients. In order to exclude other potential confounding effects, we also assessed motor performances and several types of executive functions. The main finding was a specific nonverbal memory impairment present in both TS and CTD patient groups correlated with symptom severity. Indeed, adults suffering from TS and CTD differed significantly from control participants on both immediate and delayed recall of the ROCF while they performed normally at the delayed and immediate recall of the CVLT. Thus, short- and long-term nonverbal memory could be considered at a relative disadvantage in both patient groups. Following earlier research, it could be argued that the nonverbal impairment seen in TS and CTD patients is due to right hemisphere anomaly (Bornstein et al., 1983; Sandyk, 1995). This is also convergent with studies showing that patients with right hemisphere dysfunction are more affected in delayed recall of the ROCF (Lacerda et al., 2003; Taylor, 1969). The right hemisphere effect on nonverbal function observed in the TS may be more subtle than the one observed in right hemisphere lesioned patients (Lanser, van Santen, Jennekens-Schinkel, & Roos, 1993). Nonetheless, it was suggested that TS patients suffer from anomalies of brain lateralisation due, in part, to striatal damage (Hyde et al., 1995). In an exhaustive review, Bradshaw and Sheppard (2000) proposed that TS children failed to show the normal pattern of priority of processing at a global level, which could be consistent with electrophysiological evidence suggesting a right-hemispheric specialisation for processing at a global level (Proverbio, Minniti, & Zani, 1998). Hence, the presence of altered right hemispheric asymmetry in TS could have affected global processing, which is also consistent with the integration necessary to fully recall the ROCF picture. From a cognitive perspective, it has been suggested that each score of the ROCF provides a different type of information (Chiulli, Haalaud, LaRue, & Garry, 1995; Kim et al., 2003). For instance, the copy condition reflects perceptual, visuospatial, and organisational skill, while the immediate recall condition reflects the amount of information that is encoded and the delayed recall condition reflects the amount of information that is stored and retrieved from memory. Because the copy condition was not significantly impaired across groups, it seemed that the difference observed on recall measures was not caused by a problem with visuospatial or organisational skills, but by a double deficit of nonverbal encoding and retrieval.

Results from the executive function assessment showed normal performance in all dimensions, so they have normal abstract planning, cognitive flexibility, and organisation abilities; three important parameters that could explain the poorer ROCF performance in TS. Performances on all scores of the CTT showed no significant group differences. This demonstrates that sustained visual attention involving perceptual tracking, sequencing, and the ability to divide attention are intact in both patient groups. Finally, the performance on

the Stroop interference, despite a small trend toward lower scores in the clinical groups, revealed normal ability to inhibit cognitive interference between two incongruent dimensions (i.e., colour and word), which is consistent with earlier studies with TS children (Channon, Pratt, & Robertson, 2003; Ozonoff & Jensen, 1999) and adults (Channon et al., 1992; Silverstein, Como, Palumbo, West, & Osborn, 1995).

In sum, no dysfunction in the executive function reflecting organisation, flexibility, attention, inhibition, and spatial tracking was detectable in adults with tic disorders. Even if the debate is still open concerning the presence of executive function impairment in the TS population, previous studies have obtained similar results to ours on the WCST (Bornstein, 1991; Channon, Crawford, Vakili, & Robertson, 2003; Harris et al., 1995; Ozonoff & Jensen, 1999), suggesting that there is no clear executive function impairment, at least in TS adults. In TS children, the presence of executive function deficit was noticeable (Schuerholz et al., 1996) but was more important when ADHD symptoms were comorbid with the TS (Harris et al., 1995).

One could also argue that our findings are explained, at least in part, by poor motor skills in the patient groups, which could affect in turn performances at the ROCF. For instance, earlier findings with small cohorts of TS adults showed problems in the finger tapping task and correlated with dysfunction of the supplementary motor area as documented by brain imaging (Biswal et al., 1998; Fattapposta et al., 2005). However, similar results from fine motor skills and dexterity obtained at the PPT in the current study are consistent with an earlier investigation with a comparable population (O'Connor, 2005a) and support the interpretation that the ability of the patient groups to reproduce a complex geometric figure, such as the ROCF, is probably not mediated by a fine motor dexterity problem.

Another confounding problem is the inclusion of patients having depression and OCD symptoms in earlier studies. Our patient groups also suffered from anxiety, hyperactivity, and additional OCD symptoms. These symptoms often appear concurrently and, as a result, it is possible that the accumulation of these symptoms accentuated nonverbal memory problems. Notwithstanding, we must underline that all the patients included in the current study had been diagnosed with tic disorder as the primary problem. Recent investigations using the ROCF with adult OCD patients found comparable group discrepancies to ours in immediate and delayed recall, with relatively normal performances on the copy score (Kim, Park, Shin, & Kwon, 2002; Kim et al., 2003; Roh et al., 2005). However, the specificity of this nonverbal memory deficit has not previously been clearly established when comparing OCD with other psychiatric population (Moritz et al., 2005). Another related argument is that the effect size (less than 1 SD) of the ROCF is relatively modest. As we excluded participants meeting the diagnosis of depression or OCD, a comorbid condition that occurs quite often in highly symptomatic TS, we are proposing that the small effect size at the ROCF could be related to the fact that both clinical groups were moderately symptomatic after controlling for comorbidity. For instance, the TS and CTD group had a global TSGS score of 24 and 17, respectively, with a possible maximum of 100. Perhaps, with a more symptomatic group, these differences could be more clinically significant since they were negatively correlated with tic symptoms. Nevertheless, our findings were quite robust and group differences remain significant even after covarying for OCD, hyperactivity, and

anxiety symptoms. So it is unlikely that a confounding comorbidity is responsible for modulating our results significantly. Moreover, the lack of correlation obtained, with our sample, between all comorbid symptoms and memory performances is consistent with past findings using a neuropsychological battery in a large TS patients sample (Bornstein, 1991; Bornstein, Stefl, & Hammond, 1990). Future neuropsychological research should perhaps focus on the comparison between “pure” TS with a “pure” OCD group and a third group meeting the dual diagnosis of TS and OCD or ADHD.

The second aim of the present investigation was to compare neuropsychological performances in TS and CTD patients. We hypothesised that the presence of both motor and phonic tics (i.e., TS) would affect memory and, consequently, patients suffering from TS would perform more poorly on verbal and nonverbal memory tasks compared to the CTD and control, respectively. Our results would suggest that TS and CTD adults constitute similar entities, since CTD patients resemble TS patients more closely than control participants, when we consider nonverbal memory performance. The correlation analysis indicated that nonverbal memory performances decrease linearly with the intensity of tic severity, as assessed by the TSGS, which is also consistent with previous neuropsychological findings obtained with children (Bornstein, 1990). This could further support the hypothesis that TS and CTD lie on a common symptom continuum (Spencer et al., 1995) characterised mainly by poorer nonverbal memory.

In sum, the current study demonstrated that GTS and CTD patients are affected in their nonverbal memory functioning and this deficit is linearly related to the symptom intensity even after controlling for the presence of anxiety, hyperactivity, OCD, and other confounding variables.

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TABLE 1

Means, standard deviations, and group comparison for demographic and clinical variables

	Tourette syndrome (n = 18)		***Chronic tic disorder (n = 18)***		***Control (n = 22)***		
	Mean	***σ***	***Mean***	***σ***	***Mean***	***σ***	***ANOVA (p)***
Demographic variables							
Age (years)	41	12	33	12	33	12	*ns*
Schooling (years)	16	3	16	3	15	2	*ns*
Raven intelligence (percentiles)	77	13	67	23	67	24	*ns*
Right-handers (%)	94	—	89	—	86	—	*ns*[a]
Sex (M/F ratio)	9/9	—	9/9	—	10/12	—	*ns*[a]
Visual acuity (Snellen)	1.3	0.4	1.3	0.3	1.4	0.3	*ns*
Colour perception (Ishihara)	10	2	10	0.5	11	0.5	*ns*
Clinical variables							
BDI	5	4	5	4	3	2	*ns*
BAI[b]	8	8	7	7	3	3	*
STAI-State[b]	35	8	36	7	31	8	*ns*
STAI-Trait[b]	39	9	39	11	37	10	*ns*
STOP over-activity	0.50	7	0.28	6	8	5	***
Y-BOCS –Global	11	10	2	4	0	0	***
Obsession	5	5	1	2	0	0	***
Compulsion	6	5	1	2	0	0	***

ns: nonsignificant;

[a]Kruskal-Wallis test;

[b]one missing data;

*$p < .05$,

***$p < .0005$.

BDI: Beck depression Inventory; BAI: Beck anxiety inventory; STAI : State-Trait Anxiety Inventory. STOP: Style of Planning Questionnaire. Y-BOCS: Yale-Brown Obsession Compulsion Scale.

Item at the STOP questionnaire can vary between a minimum of − 25 to a maximum of +25. Smaller negative numbers indicate higher level of overactivity.

TABLE 2

Mean and standard deviations in TS and CTD at each subfactor of the TSGS[b]

	Tourette syndrome (n = 18)		*Chronic tic disorder (n = 18)*			
	Mean	**σ**	***Mean***	**σ**	***t-tests***	***p***
TSGS (global score[c])	24	11	17	12	1.93	.06
Behavior score	13	8	11	10	0.83	*ns*
Motor restlessness (MR)	7	4	7	6	0.22	*ns*
Learning problems (LP)	1	2	1	2	0.44	*ns*
Work problems (WP)	5	6	3	7	0.95	*ns*
Behavior problems (BP)	7	5	5	6	1.09	*ns*
Tic score	11	5	6	4	3.41	**
Simple motor (SM)	7	4	5	4	1.31	*ns*
Complex motor (CM)	7	4	6	5	0.78	*ns*
Simple phonic (SP)	6	4	0.22	0	5.59	***
Complex phonic (CP)	1	2	0	0	2.26	*

[b] TSGS = Tourette Syndrome Global Scale.

[c] TSGS = ((SM+CM)/2)+((SP+CP)/2)+((BP+WP+LP+MR)×0.67).

* $p < .05$,

** $p < .005$,

*** $p < .0005$.

TABLE 3

Neuropsychological performance and multiple comparisons in TS, CTD, and control groups

	Tourette syndrome (n = 18) A		*Chronic tic disorder (n = 18) B*		*Control (n = 22) C*		*ANOVA*		*Tukey*	
	Mean	**σ**	***Mean***	**σ**	***Mean***	**σ**	***F***	***p***	***Comparison***	***p***
Motor										
Purdue pegboard										
Nondominant hand	15	2	15	2	14	2	0.86	*ns*		
Dominant hand	15	2	16	2	16	1	1.91	*ns*		
Both hands	12	1	12	2	12	1	0.09	*ns*		
Memory										
ROCF										
Copy	25	5	27	5	28	5	1.89	*ns*		
Immediate recall	13	5	15	7	18	6	3.19	*	A vs. C	**
Delayed recall	13	5	14	6	18	5	5.32	**	A vs. C; B vs. C	**
CVLT										
List A total (Trials 135)	57	17	63	8	61	7	1.72	*ns*		
Immediate. recall	13	3	14	3	13	3	0.05	*ns*		
Delayed recall	13	3	14	2	14	2	0.91	*ns*		
Executive										
ToL										
Correct items	4	2	5	3	4	2	0.23	*ns*		
Initiation time	62	32	65	38	67	37	0.11	*ns*		
Execution time	205	67	214	88	185	52	0.92	*ns*		
Rule violations[a]	0.34	0.96	0.06	0.23	0.27	0.63	0.93	*ns*		
Color Trail Making Test										
Color trail (1 s)	35	13	31	12	33	13	0.38	*ns*		
Color trail (2 s)	77	20	68	17	75	37	0.63	*ns*		
Interference score	1.36	0.64	1.32	0.66	1.29	0.51	0.06	*ns*		
Stroop test										
Interference score	100	23	104	20	111	21	1.31	*ns*		
WCST										

	Tourette syndrome (n = 18) A		*Chronic tic disorder (n = 18) B*		*Control (n = 22) C*		*ANOVA*		*Tukey*	
	Mean	**σ**	***Mean***	**σ**	***Mean***	**σ**	***F***	***p***	***Comparison***	***p***
Categories completed	3.42	1.20	3.90	0.88	3.16	1.46	0.56	*ns*		
Perseverations	8.00	4.70	7.20	3.08	9.12	5.72	0.49	*ns*		
Errors	16.50	8.10	13.10	2.88	16.64	8.85	0.71	*ns*		

* $p < .05$,

** $p < .01$.

ROCF = Rey-Osterrieth Complex Figure, CVLT = California Verbal Learning Test, ToL = Tower of London, WCST = Wisconsin Card Sorting Test.

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