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Characteristics of Executive Functioning in a Small Sample of Children with Tourette Syndrome

Applied Neuropsychology - Child

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### Abstract

Tourette Syndrome (TS) is a disorder that involves at least one vocal tic and two or more motor tics, however associated symptoms of Obsessive Compulsive Disorder (OCD) and Attention Deficit Disorder with or without hyperactivity (ADHD) are common. Many children with TS exhibit educational difficulties and one possible explanation may be deficits in executive functioning. The focus of this study was to look at the severity of symptoms often associated with TS (tics, OCS, and ADHD symptoms) and its potential relationship with the Behavior Rating Inventory of Executive Function (BRIEF) parent form in eleven children diagnosed with Tourette syndrome, ages 8-14. The BRIEF was completed by the parent of the child along with symptom measures evaluating tics, obsessive-compulsive behaviors and attention deficit symptoms. Despite relative low mean scores on the symptom measures and just a few children exhibiting clinically significant scores on the BRIEF indexes, at least half the children exhibited abnormal scores on the working memory, inhibit, and shift subscales on the BRIEF. Varying patterns of relationships were found on the BRIEF subscales for each symptom severity scales. Results suggest that the BRIEF may be useful in determining the specific areas of difficulty in a population with variable symptomatology.

Keywords: Tourette syndrome, Executive Function, BRIEF, ADHD, OCD

### Characteristics of Executive Functioning a Small Sample of Children with Tourette syndrome

Tourette Syndrome (TS) is a complex neuro-developmental disorder that is characterized by vocal and motor tics presenting before 18 years of age (American Psychiatric Association, 2013). Vocal and motor tics are involuntary vocalizations or movements. Examples of vocal tics are grunting, throat clearing, sniffing, screaming, screeching, repeating words, and barking. Examples of motor tics include eye blinking, facial grimacing, nose twitching, hand or foot twirling, head jerking, flexing, or rolling, jumping, and self-abusive behavior (Robertson, 1994).

Attentional deficits and obsessive-compulsive behaviors are other associated symptoms typically seen in individuals with TS. It is common for individuals with TS to carry a comorbid diagnosis of Attention Deficit Hyperactivity Disorder (ADHD), Obsessive-Compulsive Disorder (OCD) or both (Scahill, Bitsko, Visser, & Blumberg, 2009). Typical symptoms of ADHD, a neuro-developmental disorder, include attention difficulties with and without hyperactivity, along with features of executive dysfunction (Mahone, Cirino et al., 2002). Typical symptoms of OCD, an anxiety disorder, include recurrent, unwanted thoughts (obsessions) and/or repetitive behaviors (compulsions). Symptoms of OCD tend to overlap with tics whereby certain tics may appear to occur in a pattern or need to be done until the individual achieves the satisfaction that the tic has been performed “just right”. Some experts have also indicated that some repetitive thoughts may be classified as tics; however, they can also double as obsessive thoughts (Kompoliti, 2003). Diagnosis of TS typically occurs in children between the ages of 6-11, with a peak of tic symptoms between the ages of 10-12 and obsessive-compulsive symptoms peaking two years after the peak of the tics (Bloch, et. al, 2006). Symptoms resembling ADHD typically precede the emergence of tics (Cavanna & Shah, 2010).

Children with TS typically have an IQ range consistent with the general population, ranging from low average to above average, but due to the various symptoms associated with TS, they often exhibit educational difficulties (Kepley, Conners, Woods, Piacentini, & Walkup, 2007; Jovic, Milovanovic, & Knezevic, 1996). In an attempt to understand the etiology of the academic difficulties, researchers have studied a variety of neuropsychological variables such as visuomotor integration component processes and executive functioning including elements of inhibition, verbal fluency and recall, and elements of memory. In general researchers (e.g., Bornstein et al., 1991; Yeates & Bornstein, 1994, Rasmussen et al., 2009; Lin, Lai, & Gau, 2012; Eddy et al., 2012) have found that individuals with TS exhibit deficits in performance on various performance-based measures of executive function (such as Cambridge Neuropsychological Test Automated Battery (CANTAB®); Wisconsin Card Sorting Test, Behavior Assessment of Dysexecutive Syndrome for Children), however these results have been inconsistent between studies and measures. In addition, researchers have found a great deal of variability within the groups being studied (Bornstein, Baker, Bazylewich, & Douglas, 1991; Channon, Pratt, & Robertson, 2003; Eddy et al., 2012; Jovic, et al., 1996; Mahone, Koth, Cutting, Singer, & Denckla, 2001; Rasmussen et al., 2009; Lin et al., 2012; Schultz, Carter, Scahill, Leckman, & Cohen, 1999; Stebbins, et al., 1995; Yeates & Bornstein, 1994, Yeates & Bornstein, 1996). These inconsistencies have led some to believe that perhaps performance based tests may not be the most efficient way to assess executive functioning in the school environment (Peters, Algina, Smith & Daunic, 2012). Performance based measures have been criticized as not being “sufficient to capture more complex everyday executive problem solving” (Gioia, 2002, p. 250). Typical measures used as part of a neuropsychological battery attempt to isolate the components

of an interrelated executive system which then provides a short term snapshot which is unrealistic to the actual routine performance (Gioia, 2002).

Mahone, Koth, Cutting, Singer, and Denckla (2001) indicate that that the inconsistency found in the research of executive function (EF) with the TS and ADHD population may in part be due to the issue that performance based measures of EF are ineffective in being able to detect deficits in children with an IQ in the high average to above average range. In addition, Mahone, Hagelthorn, Cutting, Schuerholz, Pelletier et al.(2002) theorize that children with ADHD and/or TS who have high intelligence are able to use their “intellectual skills to compensate within the structured setting of laboratory measures, even when they may not be able to do so in the less structured reality of everyday life, (p. 53).” Mahone, Hagelthorn, et al., (2002) argue that in light of previous research, the effectiveness of performance-based measures of executive function may be restricted in this population.

Mahone, Hagelthorn, and colleagues (2002) examined the relationship between performance based measures of EF and IQ among children with ADHD compared to a control group. Performance based measures used included the Rey Osterrieth Complex Figure (ROCF; Osterrieth, 1944; & Rey, 1941), the Tests of Variables of Attention – Visual Test (TOVA-V) and the Letter Word Fluency test. The Full Scale IQ was a predictor for the ROCF-Copy, the TOVA-V, and the Letter Word Fluency. Even though a significant group difference between the control group and the ADHD group was not found there was a significant IQ x Group interaction. This indicated the ADHD group with an average IQ, did not perform as well as those with the high average or superior IQ. The authors concluded that performance based measures of EF, which are administered in a highly controlled setting, may not pose a great enough challenge on the executive functioning of children with ADHD, and other similar

developmental disorders such as TS. This concurs with reports that performance based measures of EF lack ecological validity because they are intended to be performed in a structured setting which eliminates the ordinary stresses that naturally occur during “routine use of EF such as motivation, emotion control and sustained attention in natural distractions.”(Shimoni, Engel-Yeger, & Tirosh, 2012, p. 859).

In an effort to investigate additional measures of EF that hold ecological validity, Mahone, Cirino, Cutting, Cerrone, Hagelthorn et al. (2002) explored the convergent and discriminant validity of the Behavioral Rating Inventory of Executive Function (BRIEF) in a study of 76 children (18 with ADHD, 21 with TS, 17 with TS+ADHD, and 20 controls). In addition to the parent form of the BRIEF (Working Memory, Inhibit, Metacognition Index, Behavioral Regulation Index, and the Global Composite Index), performance-based measures of EF were also administered (Controlled Oral Word Association Test; Tower of London; and the TOVA-V). In alignment with the notion that different symptom profiles will produce different outcomes, the authors found that the children with TS+ADHD and ADHD-only scored higher than the TS-only and control groups on all BRIEF scales and Index scores analyzed, while the TS-only group scored significantly higher than the control group on the working memory subscale. Of further interest, the relationships between the performance based measures of EF and the BRIEF scales were in the low to moderate range and were not significant.

In a more recent study, Shimoni et al., (2012) compared the Behavior Assessment of Dysexecutive Syndrome for Children (BADS-C), a performance based measure of executive function, to the Behavioral Rating Inventory of Executive Function (BRIEF) parent form in a group of 25 children with a diagnosis of ADHD with and without hyperactivity (ADD) and a group of 25 typical developing children. The children with ADD/ADHD displayed greater

executive deficits than the typical developing group on all but two subtests on the BADS-C and all of the subscales of the BRIEF with the exception of the Organization and Shift subscales. Significant correlations were found only between the BADS-C Total score and seven of the 11 indexes and scales on the BRIEF (Global Executive Composite and Metacognition Index, as well as the subscales of emotional control, working memory, planning, monitoring, and inhibition scores). The lack of significant relationships between each measure of the BADS-C with its corresponding subscales on the BRIEF provides additional evidence that the performance-based measures of EF are not reliable enough to be used as a sole source of EF in research or in school based assessments.

As noted in the above studies, some researchers have investigated the effectiveness of the BRIEF as a non-performance based measure to assess executive functioning. The BRIEF has been identified as a valid ecological assessment of executive function, providing “broader, molar aspects of complex, everyday problem-solving (Gioia, 2002, p. 250)”. The BRIEF (Gioia, Isquith, Guy, & Kenworthy, 2000) is a parent or teacher rating scale that measures executive functioning in children ages 5-18. There are eight clinical scales that have good internal consistency and test-retest reliability. The scale is then classified under two indexes, the Behavioral Regulation Index (BRI) which includes three of the sub-scales (Inhibit, Shift, and Emotional Control) and the Metacognition Index (MI) which includes five of the sub-scales (Initiate, Working Memory, Plan/Organize, Organization of Materials, and Monitor). The two indexes are then combined to form the Global Executive Composite (GEC).

Rasmussen and colleagues (2009) administered the BRIEF to parents and teachers of 38 children with TS and to an equal number of children with no history of neurological disorders. The children with TS scored higher, indicating greater impairment, on all subscales of the BRIEF



with the exception of the Plan/Organize subscale. When looking at TS plus comorbidities, there were no significant differences between the group of children with TS plus OCD and the children with TS without any comorbidities on any of the BRIEF indexes. Yet when looking at children with TS plus ADHD, they scored significantly higher on the BRIEF parent form than the children with TS without comorbidities in the areas of MI and GEC, indicating greater impairment for the children with TS plus ADHD.

### **Current Study**

Many have questioned the role that comorbidities play in executive dysfunction in TS but have not looked at the associated symptoms of TS separately. For instance, although attempts to control for comorbid diagnoses have been made, most of the studies do not rigorously analyze the impact of the symptom severity of tics, obsessive compulsive behaviors and symptoms of ADHD. It is also important to use continuous measures of ADHD and OCD because obsessive-compulsive and attention deficit symptoms are typical in patients with TS, despite not always being “severe enough to meet full diagnostic criteria for OCD or ADHD” (Baym, Corbett, Wright, and Bunge, 2008, p.172). As highlighted by Ozonoff et al., (1998), it is important to consider severity of all symptoms (i.e., tics, attentional issues, and obsessive-compulsive behaviors) when conducting research with individuals who have TS. To date, the BRIEF has been explored with TS, ADHD and TS+ADHD and suggestions have been made to look at the BRIEF in a population of children with Tourette Syndrome (TS) with Obsessive Compulsive Disorder (OCD), without comorbid ADD/ADHD (Gioia et al., 2002; Mahone, Cirino, et al., 2002). Prior research has also explored the BRIEF as a clinical measure in ADHD finding it to be a useful tool to identify characteristics that typically lead to difficulties in school but not in the

TS population (Mahone, Cirino et al., 2002, Jarratt, Riccio, & Siekierski, 2005, Peters et al., 2012).

Our approach in this pilot study was to assess the most often associated symptoms of TS (i.e., ADHD symptoms, OC symptoms, and Tic severity) opposed to just the comorbid diagnosis of ADHD and OCD. The rationale is that research indicates that the symptoms of ADHD and OCD are prevalent among individuals with TS but not always enough to meet the criteria for diagnosis. For this reason, it is important to explore the symptoms on a continuum rather than in an all or nothing grouping. By looking at all symptoms across all measures, it could potentially provide explanation to within group variability found in some previous studies and identify further areas of research. The specific research aims of the current study were to determine the characteristics of executive functioning in a small sample of children with TS and correlate the symptom measures to the BRIEF; in order to, determine the characteristic profile of executive functioning in children with TS. The analyses conducted on the data collected from this small sample of participants was intended to be viewed as a pilot study to provide a foundation for more in depth research in a particular area where deficits are found.

## **Method**

### **Participants**

Eleven children with TS participated in this study. The children were recruited from neurologists and TS support groups from the Northeast and Southeast. Only children ages 8-14 years were recruited for this study, due to the research showing that TS symptoms tend to peak during this time frame (Bloch, et al., 2006). The children with TS were required to have a previously confirmed diagnosis of TS from a qualified neurologist or psychiatrist with no other neurological disorders (i.e. seizures, traumatic brain injury, tumors, etc.). All children were

screened via a brief phone telephone interview with parents to exclude children with any history of specific learning disabilities, other neurological disorders, or traumatic head injuries.

## **Materials**

### **Demographics and School Performance**

**Demographic Questionnaire.** Demographic information including age, gender, race, education, primary language spoken in the home, and handedness were collected in a questionnaire completed by the parent. This questionnaire was developed and modeled after the Demographic Section of the Dimensional Yale-Brown Obsessive-Compulsive Scale (DY-BOCS). Information of school grades were also collected for current and prior year as well as whether the child was receiving any services or modifications in school. The demographic questionnaire can be found in Appendix A.

### **Intelligence Quotient**

**Kaufman Brief Intelligence Test 2 (K-BIT2).** The K-BIT2 was used to assess intelligence in all children by providing a Verbal IQ, Non-Verbal IQ and a Composite IQ score. There were two tasks measuring verbal IQ, including the vocabulary and riddles and one matrix task measuring non-verbal. The K-BIT2 was administered to establish the general IQ functioning of the group and to provide a foundation to rule out any chance that the results would be tied to intelligence.

### **Executive Functioning**

**Behavioral Rating Inventory of Executive Function (BRIEF) - Parent Form.** The parent form of the BRIEF was completed by the parent to get a parent report measure of the various components of executive function. The BRIEF (Gioia, Isquith, Guy, & Kenworthy, 2000) is a rating scale of 86 items that measures executive functioning in children ages 5-18. The

measure is made up of eight clinical scales and is divided into two indexes. The Behavioral Regulation Index (BRI): includes three sub-scales (Inhibit, Shift, and Emotional Control) and the Metacognition Index (MI) includes five sub-scales (Initiate, Working Memory, Plan/Organize, Organization of Materials, and Monitor). The two indexes are combined to form the Global Executive Composite (GEC). Scores in each area have a mean of 50 and standard deviation of 10 with the more elevated scores signaling to greater impairment. Abnormally elevated scores are at least 1.5 standard deviations above the mean and are indicated by *T* scores of 65 or greater. Test-retest reliability was high ranging from .76 to .85 across all scales and internal consistency ranged from .80-.98 (Gioia, Isquith, Retzlaff, & Espy, 2002).

### **Symptom Severity - Tics**

**Yale Global Tic Severity Scale (YGTSS).** The Yale Global Tic Severity Scale (YGTSS) was used to measure the presence and severity of vocal and motor tics, based on its common use in research to assess tic severity (Leckman, 1989). Storch, Murphy, Geffken, Sajid, Allen, Roberti, et al., (2005) found high internal consistency across two administrations for total motor tic score,  $\alpha=.92$  and .92, total vocal tic score,  $\alpha=.93$  and .93, and total tic score,  $\alpha=.93$  and .94. They also found good discriminant validity when compared with the Child Yale-Brown Obsessive Compulsive Scale, resulting in non-significant correlations between the two measures indicating the two scales measured different constructs. The YGTSS was administered via a semi-structured interview with both parent and child identifying the types of tics and then rating them on five dimensions including the number of tics, the frequency, intensity, complexity, along with interference of the vocal and motor tics. Additionally impairment was then rated on a scale of 0-50 with values in increments of 10, ranging from no impairment to severe impairment. Scoring for each dimension was on a scale of 0-5 and was broken down by a total motor tic

score, a total vocal tic score, as well as a total tic severity score comprised of the total motor + total vocal for a continuous score of 0-50. The impairment score was then added to the total for a Global Severity Score ranging from 0-100. The Motor tic, Vocal tic, and Global Severity Scores were recorded for analysis.

### **Symptom Severity: Inattention and Hyperactivity/Impulsivity**

**Swanson, Nolan and Pelham – Fourth Revision (SNAP-IV) Rating Scale.** To measure the presence and severity of ADHD Symptoms the SNAP-IV Parent Rating Scale (Swanson, 1992) was completed by the parent. The SNAP-IV consists of a series of subscales and a composite score. Bussing, Fernandez, Harwood, Hou, Garvan, Eyberg, et. al, (2008) found that internal consistency among items were high in three of the subdomains: Inattention ( $\alpha=.90$ ), hyperactivity/impulsive ( $\alpha=.79$ ), and oppositional defiance disorder ( $\alpha=.96$ ). There are a total of 90 items included in the measure; however, in the current study the subdomains of Inattention, Hyperactivity/impulsive, and ADHD combined were recorded and used in the analysis. Each item was scored by the parent on a rating scale ranging from 0 to 3 (0=not at all; 1=just a little; 2=quite a bit; 3=very much). Ratings were summed, then averaged per each subscale and are expressed as the Average Rating Per Item (ARPI). A tentative 5% cut off was determined by the test developers as a statistical cutoff for significance of clinical impairment. The higher the score, the higher the frequency of ADHD behaviors/symptoms reported.

### **Symptoms Severity: Obsessive Compulsive Symptom**

**Children Yale-Brown Obsessive Compulsive Scale, 6<sup>th</sup> Revision (CY-BOCS).** To measure the presence and severity of obsessive compulsive symptoms, the Children Yale-Brown Obsessive Compulsive Scale, 6<sup>th</sup> Revision (CY-BOCS) was administered (Scahill, et al, 1997). The CY-BOCS is a commonly used measure assessing the symptoms and severity of Obsessions

and Compulsions. Scahill and colleagues (1997) have reported studies supporting a high internal consistency across all 10 items with  $\alpha = .87$ ,  $N=65$  (1997). Inter-rater reliability across four raters for the two subscales and the total score ranged from good to excellent with intraclass correlation coefficients .91, .66, and .84 respectively. This measure was administered via a semi-structured interview to both the parent and the child together. An initial inventory of symptoms was first obtained through an outlined checklist for both obsessions and compulsions. Then there were five items assessing the time spent, interference, distress, resistance, and control for the identified obsessions and compulsions. Each item is rated on a scale of 0-4, with a subscore of the five items tallied for obsessions and for compulsions. The total 10 items make up the total CY-BOCS severity score on a continuous scale of 0-40.

### **Procedure**

The data used in this study was taken from a larger study that evaluated the relationship of symptom severity of Tourette Syndrome in children (tics, obsessive-compulsive symptoms, and inattention) with working memory. Each parent and child was fully consented prior to conducting any study procedures. Once the parental permission form and child assent that were approved by the Institutional Review Board were explained and signed, the initial screening information was reviewed including diagnosis of TS, any other diagnosed comorbidity and any medications that they were taking. The parent and child were then administered the YGTSS and the CY-BOCS to record the severity of tics and obsessive compulsive symptoms. The total time of the YGTSS and CY-BOCS interview lasted approximately one hour to complete.

Once the interview was completed, the parent or guardian was provided the Demographic and School functioning questionnaire, the BRIEF and the SNAP-IV Parent Rating Scale to complete while the child was accompanied to a separate room to be administered the K-BIT2.

The child was administered the K-BIT2 to establish an IQ score. Standardized instructions were read prior to the administration of each subtest, verbal, matrix, and riddles respectively.

## Results

### Descriptive: Demographics

The sample ( $N = 11$ ) was comprised of 10 boys and 1 girl, which is a higher rate of boys than the reported prevalence ratio of 3:1 in boys and girls with TS (Scahill, 2009). The ages of the children in the sample ranged from 11.3 to 14.2 years ( $M = 12.3$  years,  $SD = .97$ ).

Approximately 82% ( $n = 9$ ) of parents reported their child's race to be "White" with two parents reporting their child's race as "Other." All children were right handed, born in the United States and reported English as the primary language spoken in the home.

All but one child were taking some form of medication for at least one of the symptoms associated with TS (tics, ADHD, OCD, or anxiety). Of the 11 children, seven were taking medication to reduce tics. Seven of the children were reported to have comorbid OCD and of those seven children, five of the children were taking medication for anxiety or OCD symptoms. Four of the children were reported to have comorbid ADHD and only three of the children were reported to be taking medication for ADHD symptoms.

Of the 11 children, 18.2% ( $n = 2$ ) were being serviced with an Individualized Education Plan (IEP), both under the classification of "Other Health Impaired", while 54% ( $n = 6$ ) were currently receiving modifications under an IEP or 504 plan, which included modifications such as extended time, orally read tests, collaborative settings. None of the children had any reported comorbid learning disabilities. All parents reported that their children were making grades at B or above (GPA of 3.0 or greater) with 54.5% ( $n = 6$ ) of the children having an overall average between 80-89% and the other 45.5% ( $n = 5$ ) having an overall average at 90% or better.

The composite IQ scores for the group ranged from 95 to 123 ( $M = 109.18$ ;  $SD = 8.58$ ), placing 81.8% ( $n = 9$ ) in the average range while 18.2% ( $n = 2$ ) fell in the above average range. When evaluating the differences between the Verbal and Non-Verbal IQ scores, the group appeared stronger in their Non-Verbal IQs with 36.4% ( $n=4$ ) of the sample exhibiting scores above average ( $> 114$ ).

### **Descriptive: Symptom Severity Variables (YGTSS, CY-BOCS, and SNAP-IV)**

Tables 1 and 2 present the breakdown of all the scores in the YGTSS, the CY-BOCS and the SNAP-IV.

[Table 1 near here]

[Table 2 near here]

**Yale Global Tic Severity Scale (YGTSS).** As noted in Table 1, the mean Global Tic Severity Score on the YGTSS was 44.18 ( $SD = 24.51$ ), ranging from a score of 21 to 97 with approximately 64% ( $n = 7$ ) scoring under 39, which indicates the majority of the children with TS reported a low tic symptom severity. Only two children (18.2%) scored in the higher tic symptom severity range with a score greater than 80. The mean motor tic symptom severity score was slightly higher at 14 ( $SD = 4.60$ ), than the mean vocal tic severity score which was 12 ( $SD = 6.69$ ), which indicates the mean fell into the mild to moderate range for both motor and vocal tic severity.

**Child Yale-Brown Obsessive Compulsive Scale (CY-BOCS).** As seen in Table 1, the mean of the CY-BOCS total OCS severity score was 16.18 ( $SD = 8.00$ ), out of a possible score of 50 which was rather low however there was a great of variance with a range of scores from 6



to 34. The mean scores for compulsions ( $M = 7.73$ ,  $SD = 4.58$ ) was slightly lower than the mean score for obsessions ( $M = 8.46$ ,  $SD = 4.05$ ).

**Swanson, Nolan and Pelham – 4<sup>th</sup> Fourth Revision (SNAP-IV) ADHD Rating Scale.**

As seen in Table 2, the mean of the ADHD Combined score (Inattention and Impulsive/Hyperactive) was 1.32 ( $SD = .74$ ), which is below the 5% tentative cut off 1.67, which was established by the test developers as a statistical cutoff for significance for clinical significance on the parent form. This indicates that this sample as a whole did display moderate ADHD symptoms but still below the 5% tentative cut off. Since it is possible for a child to be classified as Inattentive or Impulsive/Hyperactive and not be in the combined group, these subscales were looked at independently. The mean Inattention score was 1.33 ( $SD = .73$ ), which is below the 5% tentative cut off of 1.78 and the mean Impulsive/Hyperactive score was 1.24 ( $SD = .74$ ), which is also below the 5% tentative cut off of 1.44. In looking at the individual scores, four of the children in the group (36.4%) scored above 1.78 on the Inattention subscale and only three children in the group (27.3%) scored above 1.44 on the Impulsive/Hyperactive subscale. Four children (36.4%) scored above 1.67 on the ADHD Combined scale, which included two children who were above the 5% cutoff on both subscales (Inattention and Impulsive/Hyperactive) and one child who was only above the 5% cutoff on the Inattention subscale and one child who was only above the 5% cutoff on the Impulsive/Hyperactive subscale for a total of 5 children falling into a clinically significant category on one or more of the ADD/ADHD symptom scales.

**Behavioral Rating Inventory of Executive Function (BRIEF).** As seen in Table 3, the scores from the BRIEF parent form, the indexes and subscales displayed considerable variability with 54.6% ( $n = 6$ ) scoring in the abnormally elevated range ( $> 65$ ) on the Behavioral Regulation

Index (BRI), 27.3% ( $n = 3$ ) scoring in the abnormally elevated range ( $> 65$ ) on the Metacognition Index (MI) and 36.4% ( $n = 4$ ) scoring in the abnormally elevated range ( $>65$ ) on the Global Executive Composite. At least one or more children scored in the abnormally elevated range ( $>65$ ) on each of the subscales with the highest number of abnormally elevated scores on the Working Memory subscale ( $n = 7$ ), the Shift subscale ( $n = 6$ ), and Inhibit subscale ( $n = 5$ ).

[Table 3 near here]

### Analysis

A bivariate correlation was completed between all variables. The IQ scores and age were not found to have any significant relationship with any of the variables, which establishes that for this sample, age and IQ are unlikely to potentially explain any relationship found between the symptom severity scores and the working memory performance scores.

**BRIEF Indexes/Subscales and Tics.** The BRI showed a significant positive relationship across motor  $r = .638, p < .05$ , YGTSS vocal  $r = .673, p < .05$ , and global severity scores;  $r = .604, p < .05$ . As can be seen in Table 4, no significant relationships were found between the MI and GEC with the YGTSS. When looking at the subscales, the Shift subscale was the only subscale that showed a significant positive relationship across motor  $r = .623, p < .05$ , vocal  $r = .676, p < .05$  and global tic severity scores  $r = .607, p < .05$ . The only other significant positive relationship for the motor tic severity score was the Plan/Organize subscale,  $r = .620, p < .05$ , which was also significant with the global tic severity score,  $r = .641, p < .05$ . The YGTSS vocal tic severity score also had a significant positive relationship with the Inhibit subscale,  $r = .629, p$

< .05, however the Inhibit subscale was not significant with the motor or the global tic severity scores.

**BRIEF and ADHD Symptoms.** The SNAP-IV, which measured ADHD symptoms, showed the greatest number of significant relationships with the BRIEF Indexes and the BRIEF subscales, shown in Table 4. The Inattention subscale on the SNAP-IV showed a strong positive relationship across all the indexes on the BRIEF, (BRI,  $r = .711$ ,  $p < .05$ ; MI,  $r = .730$ ,  $p < .05$ ; and GEC,  $r = .749$ ,  $p < .01$ ) as well as with four of the BRIEF subscales, (Inhibit,  $r = .770$ ,  $p < .01$ ; Shift,  $r = .665$ ,  $p < .05$ ; Working Memory,  $r = .772$ ,  $p < .01$ ; and Plan/Organize,  $r = .759$ ,  $p < .01$ ). The Impulsivity/Hyperactivity subscale on the SNAP-IV also showed significant relationships across all three indexes on the BRIEF, (BRI,  $r = .712$ ,  $p < .05$ ; MI,  $r = .622$ ,  $p < .05$ ; and GEC,  $r = .675$ ,  $p < .05$ ) and three of the BRIEF subscales, (Inhibit,  $r = .869$ ,  $p < .01$ ; Shift,  $r = .745$ ,  $p < .01$ ; and Working Memory,  $r = .688$ ,  $p < .05$ ). When looking at the ADHD-C scores on the SNAP-IV, which was a composite of the Inattention and Impulsivity/Hyperactivity, significant relationships were also seen across all BRIEF indexes, (BRI,  $r = .729$ ,  $p < .05$ ; MI,  $r = .695$ ,  $p < .05$ ; and GEC,  $r = .732$ ,  $p < .05$ ) as well as across the same four subscales on the BRIEF that were found to be significantly related to the Inattention subscale (Inhibit,  $r = .842$ ,  $p < .01$ ; Shift,  $r = .725$ ,  $p < .05$ ; Working Memory,  $r = .760$ ,  $p < .01$ ; and Plan/Organize,  $r = .692$ ,  $p < .05$ ).

**BRIEF and Obsessive-Compulsive Symptoms.** Interestingly, as seen in Table 4 when looking at the relationship between the scores on the CY-BOCS and the BRIEF, there were only two significant positive relationships found for the symptom Obsessions while there were seven significant positive relationships found for the symptom Compulsions and six significant positive relationships for the combined composite CY-BOCS score. Only the MI on the BRIEF ( $r =$

.639,  $p < .05$ ) and the subscale Emotional Control on the BRIEF ( $r = .613, p < .05$ ) were found to have a significant relationship with the symptom of Obsessions on the CY-BOCS. In contrast, the symptom of Compulsions were significantly related to all three indexes on the BRIEF, (BRI,  $r = .803, p < .01$ ; MI,  $r = .615, p < .05$ ; and GEC,  $r = .717, p < .05$ ) and four significant relationships with the subscales including Inhibit,  $r = .726, p < .05$ ; Shift,  $r = .737, p < .01$ ; Emotional Control,  $r = .637, p < .05$ ; and Plan/Organize,  $r = .627, p < .05$ . The combined composite score on the CY-BOCS was significantly related to the BRI,  $r = .784, p < .01$  and the GEC,  $r = .698, p < .05$ . The composite score on the CY-BOCS was related to the same subscales on the BRIEF as seen with the Compulsions subscale on the CY-BOCS, (Inhibit,  $r = .635, p < .05$ ; Shift,  $r = .718, p < .05$ ; Emotional Control,  $r = .677, p < .05$ ; and Plan/Organize,  $r = .631, p < .05$ ). Table 4 displays the pattern of the correlations between the BRIEF components and all the symptom measures.

The correlations among the three symptom severity scales showed that only the SNAP-IV Inattention subscale scores and the ADHD-C scores had positive significant relationships with the other symptom measures. Specifically, as seen in Table 5, the YGTSS Global Severity Scale was significantly related to the Inattention subscale,  $r = .638, p < .05$ , and the ADHD-C scores,  $r = .604, p < .05$ . The CY-BOCS Compulsion scores were also significantly related to the Inattention subscale,  $r = .783, p < .01$ , and the ADHD-C scores,  $r = .712, p < .05$ , and the CY-BOCS composite score was only significantly related to the Inattention subscale,  $r = .670, p < .05$ .

[Table 4 near here]

[Table 5 near here]

## Discussion

Executive function, an interrelated set of mental processes, is integral to many everyday tasks such as problem solving. The findings in this pilot study provide an initial framework of the symptoms most often associated with TS and their relationship with the multiple components of executive function. Recognizing that the symptom profiles can differ among individuals with TS both in degree of symptoms and severity, it is important to investigate how the severity of such symptoms are related to complex structures such as executive function. The BRIEF provides an ecologically valid tool to measure the everyday experiences of children with TS (Gioia, et al., 2002; Mahone, Cirino, et al., 2002).

Through the correlations in the current study between the symptom severity measures and the components of the BRIEF, some interesting patterns emerged. The SNAP-IV, which is the measure of ADHD symptoms, displayed the largest number of significant correlations. There has been some speculation that inhibition and not inattention is the core factor in executive function in individuals with ADHD (Mahone, Cirino, 2002) yet, the inattention subscale proved to have more positive correlations with the subscales than the Impulsive/Hyperactivity. Defined in the BRIEF manual, Inhibit is “the inability to inhibit, resist, or not act on impulse (Gioia et al., 2000, p. 17)” which describes the impulsivity symptom of ADHD. The subscales on the BRIEF found to be highly correlated with all three sub-types of ADHD symptoms (Inattentive, Impulsive/Hyperactive, and ADHD-C) were the Inhibit, Shift, and Working Memory subscales. In addition, both the Metacognition Index and the Behavioral Index along with the Global Executive Composite were also significantly correlated. The Inattention subtype also showed a significant correlation with Plan/Organize which also was shown to be significantly correlated among the YGTSS (Motor Tic Severity and Global Tic Severity) and the CY-BOCS

(Compulsions and OCS Composite), which calls into question if this area of executive function may cross symptom areas.

It was interesting to note that when looking at the Obsessions and Compulsion symptoms, the Compulsions far exceeded the number of significant relationships with the BRIEF subscales over the Obsessions. The Compulsion symptoms shared many of the same relationships as the SNAP-IV Inattention subtype (Inhibit, Shift, Plan/Organize, BRI, MI, and GEC) however the Compulsion subscale was also related to Emotional Control and was not related to Working Memory. The lack of relationship to working memory was surprising due to some studies that have found that the suppression of thoughts could impact working memory (Brewin & Smart, 2005). This could be due in part to the fact that the overall scores for obsessions were in the low to moderate range, restricting the range of symptom severity. Perhaps a more diverse symptom range would have shown a different relationship.

Interestingly, the correlations on the SNAP-IV were most consistent with the number of abnormally elevated scores on the Inhibit, Shift and Working Memory subscales and the BRI, with at least 50% scoring 1.5 standard deviations above the mean standard score of 50. When widening the margin and looking at those who scored one standard deviation above the mean standard score, the number of cases increases to at least 50% on Emotional Control, MI and the GEC. If one were to only look for the cut-off of those with abnormally elevated scores of 65 or higher on the Global Executive Composite score, only 4 cases would be found. The number of abnormally elevated subscale scores, as well as those just under the cut-off, point to the importance of looking at the individual subscales for guidance on determining the needs of children with TS in the school setting. By doing so, individualized intervention plans can be developed opposed to a one size fits all plan. Although the SNAP-IV showed the greatest

number of correlations, less than half scored in the clinically significant range for all three subtypes. This supports the importance of future research incorporating continuous measures versus categorizing groups on the basis of comorbid diagnosis.

In alignment with an argument that tics may not impact executive function, the YGTSS measure of tic symptom severity had the lowest number of relationships with the BRIEF functions, however some significant relationships were indeed found. Higher severity of motor tics were found to be related to Shift, Plan/Organize and the Behavioral Regulation Index while higher severity of vocal tics were found to be related to Inhibit, Shift, and the Behavioral Regulation Index. Working with such a small sample, where the majority of the sample was in the low to moderate range, could potentially explain the small number of correlations.

Although some symptoms showed a greater number of relationships with the components of executive function, all symptoms showed some form of relationship. Just as executive function is a complex interrelated set of mental processes, the results of this study support the complexity of TS in its symptomatology showing individuals with TS present with varying symptoms and severity. For this reason, all symptoms and their severity should be considered when assessing executive function. In addition, the mean IQ of the group was in the upper average range, with scores ranging from average to above average supporting that the diagnosis of TS does not impair intelligence. Since the IQ scores were not correlated with the BRIEF scores and the symptom scores were related to various aspects of executive functioning, it supports that further research is needed to look at the individual symptom profile in relation to the individual subscales of the BRIEF, to best evaluate the needs of a child with TS. To focus solely on the BRI, the MI, or the GEC may provide a misrepresentation of executive functioning in children with TS.

Parents reported that their children were doing well in school. However it is important to point out that despite the fact that all children were receiving A's and B's in school, eight of the children were receiving accommodations or modifications in instruction under an IEP or 504 plan. To qualify for special education services under an IEP under the "Other Health Impaired" category, there must be evidence that the student has "limited strength, vitality or alertness, including a heightened alertness to environmental stimuli, that results in limited alertness with respect to the educational environment, that - (i) Is due to chronic or acute health problems...; and (ii) Adversely affects a child's educational performance" (Grice, 2002, p. 1). Under the Section 504 of the Rehabilitation Act, any individual who has an impairment that substantially limits one or more life activities can qualify for a 504 plan, which allows for accommodations to provide equal access to education. Therefore, there had to be previous evidence supporting that the children were having difficulty in school in order to qualify for an IEP or 504 plan. This fact supports the importance of identifying the appropriate areas of weakness and providing individualized education plans so that children with TS can have the chance to achieve to their potential.

Due to the limited sample size the results of this study should only be viewed as suggestive for future research. Although the sample was diverse in terms of symptom severity profiles, the majority of tic severity scores were low on average and the OC symptoms also fell in the low to moderate range. This could also be due to the confounding factor that many of the children were on medication to treat the symptoms they exhibited, although there were some children not on medication for symptoms they exhibited as well. A larger sample of children who are medication-free may contribute to an adequate number of children exhibiting more severe symptoms, extending the range of symptom severity. Additionally, a larger sample



would provide more diversity with an opportunity to explore a cluster or factor analysis to determine a profile on the BRIEF in relation to symptom severity. Furthermore, it is unknown the potential effect the medication may have had on the everyday executive functioning of the participants as measured by the BRIEF. This confounding factor is yet another limitation in the current study. Future prospective studies should explore the role of medications on the relationships between symptoms and BRIEF profiles. In addition, another limitation of this pilot study is that sample consisted of primarily of Caucasian and male children. Future studies should attempt to obtain a more diverse sample in terms of race and gender in order to be able to generalize findings to the larger community.

The goal of this study was to explore how the severity of the most common symptoms found in individuals with TS related to the components measured by the BRIEF. It was expected that the various symptom measures would show a different pattern of relationships with the BRIEF. This was indeed seen with the symptom severity of the ADHD symptoms showing a large relationship with a greater number of the subscales followed by the OC symptoms, and lastly the tic symptoms. What was surprising is that certain subscales were anticipated to have a significant relationship with certain symptoms but did not, such as the obsession severity with working memory. Future studies should use the continuous measures to explore the severity of symptoms in TS as a potential predictor for the various working areas of executive function. Although there has been question about performance based measures of executive function, additional studies should be conducted using both the BRIEF and performance based measures in the assessment of symptom severity in children with TS.

**Appendix A***Questions from Demographic and School Functioning Questionnaire*

Sex: M F Date of birth: \_\_/\_\_/\_\_ Age: \_\_ years \_\_ months

Person completing this form: \_\_\_\_\_

Relationship to child: \_\_\_\_\_

Place of Birth:

What hand does the child write with? Left Right Both

Race: \_\_\_\_\_

1=White

2=African-American

3=Hispanic

4=Asian

5=Native-American

6=Pacific Islander

0=Other \_\_\_\_\_

Primary language spoken at home: \_\_\_\_\_

Secondary language: \_\_\_\_\_

**SCHOOL FUNCTIONING**

Current Grade for the following academic areas:

Math:

Reading:

Language Arts

Spelling

Science:

Social Studies:

Overall Grade since beginning of the school year:

Is your child currently being served through an IEP? Yes / No

If yes, what is your child's classification?

If your child has ever been served through an IEP please provide the date the IEP was implemented?

Is your child currently receiving modified instruction in the classroom? Yes / No

If yes, provide explanation:

Previous Year Grade for the following academic areas:

Math:

Reading:

Language Arts:

Spelling:

Science:

Social Studies:

Comments regarding your Child's academic functioning:

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Table 1

*Descriptive Statistics for Symptom Severity Variables (YGTSS and CY-BOCS)*

Variables	<i>M</i>	<i>SD</i>	<i>Min</i>	<i>Max</i>
YGTSS – Motor Tic Severity	14.00	4.60	7.00	23.00
YGTSS – Vocal Tic Severity	12.00	6.69	2.00	24.00
YGTSS - Global Tic Severity	44.18	24.51	21.00	97.00
CY-BOCS - Obsession Symptom	8.46	4.05	3.00	18.00
CY-BOCS - Compulsion Symptom	7.73	4.58	0.00	16.00
CY-BOCS - Total OCS Severity	16.18	8.00	6.00	34.00

*Note.* YGTSS = Yale Global Tic Severity Scale; CY-BOCS = Child Yale-Brown Obsessive Compulsive Scale

Table 2

*Descriptive Statistics for Symptom Severity Variables SNAP-IV Parent Form*

Variables	<i>M</i>	<i>SD</i>	<i>Min</i>	<i>Max</i>	5% <sup>a</sup>
SNAP-IV – Inattention	1.33	0.73	0.00	2.44	4
SNAP-IV – Impulsive/Hyperactive	1.24	0.74	0.00	2.44	3
SNAP-IV – Combined	1.32	0.74	0.00	2.44	4

*Note.* YGTSS = SNAP-IV = Swanson, Nolen and Pelham Questionnaire- 4<sup>th</sup> Rev; <sup>a</sup>5% Cut-off: Inattention  $\geq 1.78$ , 5% Cut-off: Impulsivity/Hyperactivity  $\geq 1.44$ , 5% Cut-off: ADHD Combined  $\geq 1.67$  indicates number clinically significant.

Table 3

*Descriptive Statistics for Behavioral Rating Inventory of Executive Function (BRIEF)*

Variables	<i>M</i>	<i>SD</i>	<i>Min</i>	<i>Max</i>	$\geq 1 SD$	$\geq 1.5 SD^a$
Inhibit	58.73	12.06	40	74	6	5
Shift	65.91	17.76	38	91	6	6
Emotional Control	62.63	17.83	45	100	6	3
Initiate	56.91	14.45	38	84	4	3
Working Memory	63.64	14.19	38	84	7	7
Plan/Organize	57.82	13.14	37	83	4	4
Organization of Materials	53.09	13.33	34	80	4	1
Monitor	55.64	12.84	33	75	4	3
Behavioral Regulation Index	63.91	15.87	42	87	6	6
Metacognition Index	59.09	12.79	35	83	6	3
Global Executive Composite	61.72	14.40	36	87	7	4

*Note.*  $N = 11$ ; Mean  $T$  score = 50, Clinically Significant Score  $\geq 1.5 SD$  ( $T$  scores  $\geq 65$ ). Scores above include number of participants with scores  $\geq 1 SD$  and  $\geq 1.5 SD$ .<sup>a</sup>Scores  $\geq 1 SD$  are include in the total number reported that scored  $1.5 SD$ .

Table 4

*Correlation between BRIEF components and Symptom Severity.*

		YGTSS			CY-BOCS			S
		Global Tic Severity	Vocal Tics Severity	Motor Tic Severity	Obsessions & Compulsions	Obsessions	Compulsions	ADHD Combined
BRI	Inhibit	.574	<b>.629*</b>	.566	<b>.635*</b>	.432	<b>.726*</b>	<b>.842**</b>
	Shift	<b>.607*</b>	<b>.676*</b>	<b>.623*</b>	<b>.718*</b>	.583	<b>.737**</b>	<b>.725*</b>
	Emotion Control	.415	.479	.487	<b>.677*</b>	<b>.613*</b>	<b>.637*</b>	.408
MI	Initiate	.600	.569	.553	.312	.337	.247	.397
	Working Memory	.388	.306	.302	.442	.265	.536	<b>.760**</b>
	Plan/Organize	<b>.641*</b>	.570	<b>.620*</b>	<b>.631*</b>	.536	<b>.627*</b>	<b>.692*</b>
	Org. of Materials	.101	.193	.059	.422	.232	.531	.390
	Monitor	.448	.273	.462	.504	.539	.402	.479
	BRI	<b>.604*</b>	<b>.673*</b>	<b>.638*</b>	<b>.784**</b>	<b>.639*</b>	<b>.803**</b>	<b>.729*</b>
	MI	.522	.466	.469	.590	.469	<b>.615*</b>	<b>.695*</b>
	GEC	.572	.560	.547	<b>.698*</b>	.565	<b>.717*</b>	<b>.732*</b>

*Note.* 2-tailed, \*\* $p < 0.01$  level. \* $p < 0.05$  level., BRI = Behavioral Regulation Index, MI = Metacognition Index, GEC = Global Executive Composites Index. Correlations are presented above according to the symptoms in relationship with the BRIEF components. Significant scores are bolded to highlight the patterns seen across the 3

**Table 5**  
*Correlation between Symptom Severity Measures.*

	SNAP-IV			YGTSS			CYBOCS		
	ADHD Inattention	ADHD Impulsivity	ADHD Combined	Motor Tic Severity	Vocal Tic Severity	Global Tic Severity	Obsessions	Compulsion	Composite
ADHD Inattention	1	<b>.849**</b>	<b>.962**</b>	.517	.541	<b>.638*</b>	.437	<b>.783**</b>	<b>.670*</b>
ADHD Impulsivity		1	<b>.961**</b>	.535	.491	.544	.246	.593	.465
ADHD Combined			1	.535	.524	<b>.604*</b>	.347	<b>.712*</b>	.584
Motor Tic Severity				1	<b>.883**</b>	<b>.934**</b>	.578	.422	.535
Vocal Tic Severity					1	<b>.896**</b>	.431	.502	.506
Global Tic Severity						1	.547	.443	.531
Obsessions							1	.711*	<b>.915**</b>
Compulsions								1	<b>.934**</b>
OCS Composite									1

Note. 2-tailed, \*\* $p < 0.01$  level. \* $p < 0.05$  level.