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Real World Executive Control Impairments in Preschoolers with Autism Spectrum Disorders

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Abstract

This study examined executive control (EC) in preschoolers with and without autism spectrum disorders (ASD) using the Behavior Rating Inventory of Executive Functions-Preschool Version (BRIEF-P). ASD participants were a clinically referred sample of preschoolers; the typically developing control group was selected from the BRIEF-P standardization sample. The ASD group was rated significantly worse on all BRIEF-P scores, and these impairments did not correlate with ASD symptoms. These findings document impairments in real world EC in pre-schoolers with ASD, and have implications for assessing preschoolers suspected of having an ASD. Furthermore, the findings also converge with BRIEF studies of school-aged children with ASD.

Keywords

Executive control; Cognitive control; Autism; Flexibility; Preschool

Adults, adolescents and school-aged children with autism spectrum disorders (ASD) present with a cognitive profile that highlights impairments in executive control (EC) (Hill 2004; Kenworth et al. 2008; Pennington and Ozonoff 1996; Sergeant et al. 2002). EC refers to a collection of cognitive processes that contribute to the coordination and execution of future goals, as well as emotion regulation, proactive coping with stress, and attention maintenance. Cognitive processes such as cognitive flexibility, working memory, inhibition, planning, and action monitoring contribute to successful EC. Individuals with ASD demonstrate notable impairments in several components of EC, including cognitive flexibility/set-shifting, planning, and more recently inhibition (Geurts et al. 2009; Gioia et al. 2002; Maes et al. 2010; Ozonoff et al. 2004; Solomon et al. 2008; Yerys et al. 2009). Rigid behavior and a “need for sameness” have been observed clinically in ASD since Kanner’s (1943) initial observations, and a recent review postulated cognitive flexibility/set-shifting as a core EC impairment in ASD (Geurts et al. 2009). The notion of cognitive flexibility as a core impairment is supported by performance based measurement of EC profiles in the lab and by parent report (Gioia et al. 2002; Ozonoff and Jensen, 1999; but see Happé et al. 2006).

Findings of EC impairments that are unique to *preschool* age children with ASD relative to children with other developmental delays, or even in comparison to typically developing children matched on chronological age, are inconsistent (Dawson et al. 2002; Dawson et al. 1998; Griffith et al. 1999; McEvoy et al. 1993; Stahl and Pry 2002; Yerys et al. 2007); however prior investigations have not comprehensively assessed the full range of EC domains, nor have they reported on measures of real world EC in this age group. The first study of EC in preschoolers with ASD revealed group differences on the spatial reversal task (McEvoy et al. 1993); however, the research that followed failed to report group differences in spatial reversal or other early measures of EC (Dawson et al. 2002, 1998; Griffith et al. 1999; McEvoy et al. 1993; Stahl and Pry 2002; Yerys et al. 2007). These simplified EC tasks predominantly involve the hiding of food or toys, as in the classic ‘A-not-B’ task, delayed non-matching to sample, and the spatial reversal task. While these tasks have support from the primate literature for tapping into some of the brain regions that are relevant for EC (Petrides 2005), they suffer from a lack of norms across typical development, as well as little understanding about their relation to real world function.

An alternative measure that has standardized norms and captures real world function is the preschool version of the Behavior Rating Inventory of Executive Function (BRIEF-P; Gioia et al. 1996). This informant questionnaire-based approach is complementary to the performance-based measures used in previous studies, because it captures EC in the child’s natural environment through parent and teacher observations (Kenworthy et al. 2008; Meltzer 2007). It also allows for sampling across a wide range of behaviors that rely upon core EC components. The BRIEF-P has five scales (see Table 1 for description and example items) that form three indices, which compose the Global Executive Composite (GEC). The Inhibit and Self-Control Index (ISCI) is comprised of the Inhibit and Emotion Control scales. The Flexibility Index (FI) is comprised of the Shift and Emotional Control scales. The Emergent Metacognition Index (EMI) is comprised of the Working Memory and Plan/Organize scales. The BRIEF-P has previously identified real world EC impairments in preschoolers experiencing language delays and ADHD (Isquith et al. 2004; Mahone and Hoffman 2007).

The relationship between EC impairments and core autism symptoms is of interest; there is a burgeoning literature in children and adults with ASD demonstrating a positive relationship between EC impairments and core symptoms. In the domain of restricted, repetitive behaviors and interests symptoms, neuropsychological studies have documented a specific relationship with cognitive flexibility impairments (Reed et al. 2011; South et al. 2007;

Yerys et al. 2009). More general relationships between EC components and core symptoms have been established with both performance based and informant report measures (Kenworthy et al. 2009; Liss et al. 2001; Semrud-Clikeman et al. 2010; Solomon et al. 2008; Verté et al. 2006; but see Ozonoff et al. 2004). This relationship has not been explored in the preschool age range where core symptoms can be first observed.

The present study has a primary goal of examining whether preschoolers with ASD are reported to exhibit impairments in real world EC behaviors compared to typically developing children on a real world measure of EC, the BRIEF-P. This study tests the hypothesis that within the ASD group all BRIEF-P indices are elevated, but the Flexibility Index and Shift scale have the highest ratings (indicating more impairment and a peak in the EC profile). The Shift scale has been identified as the most sensitive to ASD-specific impairments in the school-age version of the BRIEF (Gioia et al. 2002) relative to other clinical groups (attention deficit hyperactivity disorder, reading disorder, and mild traumatic brain injury). The secondary goal of this study is to determine whether EC impairments relate to ASD symptoms. An extensive review outlined cognitive flexibility as a potential intermediate phenotype between the biology of ASD and the symptomatic repetitive, restricted behaviors and interests of ASD (Geurts et al. 2009). Even though multiple EC processes may relate to the repetitive, restricted behaviors and interests of ASD, the recent focus on cognitive flexibility impairments in ASD supports the present hypothesis that the Flexibility Index and Shift scale will relate to these core ASD symptoms. For completeness, we conducted exploratory correlation analyses on the remaining ASD symptoms. In review, our hypotheses include:

1. EC impairments will be identified in preschoolers with ASD relative to typically developing preschoolers.
2. The Shift scale from the BRIEF-P will yield the highest ratings of impairment in the ASD group.
3. EC impairments, particularly flexibility, will relate to restricted, repetitive behavior, and interest symptoms in the ASD group.

Method

Participants

Participants in the ASD group were a clinically referred sample of 44 children with an ASD who were culled from a larger sample of 67 children. The included sample was between the ages of 2.83–5.83 years of age ($M = 4.42 \pm 0.79$), and received an ASD diagnosis during a multidisciplinary or developmental evaluation in a hospital-based outpatient clinic. The 44 children selected for the ASD group had a clinical diagnosis made by trained and experienced autism professionals (autism ($n = 21$), Asperger syndrome ($n = 7$), and PDDNOS ($n = 16$)). Diagnosis was based on DSM-IV-TR criteria (American Psychiatric Association 2000), information obtained from a detailed history, general observation and performance on the Autism Diagnostic Observation Schedule (Lord et al. 2000). All children also met ASD criteria agreed upon by the National Institute of Child & Human Development/National Institute on Deafness and Other Communication Disorders Collaborative Programs for Excellence in Autism (Lainhart et al. 2006), based on their ADOS scores. Children were also excluded if they could not complete verbal cognitive testing ($n = 21$), or achieved a verbal ability score less than 70 ($n = 6$), or had missing scores on the BRIEF-P ($n = 1$). The verbal cognitive ability criterion was established to limit the potential confound of significant cognitive delay when assessing EC in very young children. The majority of children ($n = 32$) completed the Differential Ability Scale (Elliott 1990, 2007) and a minority ($n = 7$) completed the Wechsler Preschool and Primary Scales of

Intelligence (Wechsler 1989, 2002). A subset of children received different cognitive measures, because this ASD sample is culled from clinical practice, and not one recruited specifically for a research project. The sex ratio in the ASD group (34 males: 10 females) is consistent with recent ASD research indicating a 3.1:1 male to female prevalence ratio (Nicholas et al. 2008). This project was approved by the hospital Institutional Review Board, and all families who attended the clinic for services were informed that de-identified clinical data would be used for research purposes.

Participants in the typically developing (TD) group were 44 children selected from the BRIEF-P standardization sample. This group of children was identified as free from cognitive and or developmental delays based on parent report. The subset of children from the standardization sample was individually matched within ± 6 months of age and sex-ratio was matched, $\chi^2(N = 88) = 0.28, p = 0.60$. While there are no cognitive scores available for the TD group, we assume this randomly selected subset of children have average cognitive abilities. see Table 2 for sample characteristics.

Measures

Autism Diagnostic Observation Schedule (ADOS)—The ADOS (Lord et al. 2000) is a structured play and conversational interview that includes a series of social presses and other opportunities to elicit symptoms of an ASD. The ADOS contains four different modules that are separated based upon a child's language level. In the current study, Modules 1 (pre-verbal/single words), 2 (phrase speech), and 3 (fluent language) were administered as part of the clinical evaluations based on expert clinical opinion of the child's language function. see Table 2 for breakdown of the ASD sample by module. The communication, reciprocal social interaction, and stereotyped behavior composite scores from the ADOS were included as dependent variables for correlations with BRIEF scores.

Behavior Rating Inventory of Executive Functions-Preschool Version (BRIEF-P)—The BRIEF-P (Gioia et al. 1996) is a 63-item informant report of EC in real world situations comprised of five scales (Inhibit, Shift, Emotional Control, Working Memory, Planning/Organization) that are collapsed into three broad indices: Inhibitory Self-Control Index (ISCI), Flexibility Index (FI), and Emergent Metacognition Index (EMI). Inhibit and Emotional Control scales comprise the ISCI, the Shift and Emotional Control scales comprise the FI, and the Working Memory and Planning/Organization scales comprise the EMI. The five scales are then collapsed into a Global Executive Composite (GEC). The BRIEF-P asks parents to assign a rating of “Never”, “Sometimes”, or “Often” to each item, reflecting how much of a problem the behavior poses in their child. These ratings are then converted to a 1, 2, or 3 for statistical analyses. Results are reported as T-scores. Higher scores on scales indicate greater impairment; T-scores ≥ 65 (i.e., 1.5 Standard Deviations [SD] the mean) indicate clinically significant ratings (Gioia et al. 1996; Isquith et al. 2004). We use the means of raw scores for group comparisons, because the TD group was a subset from the normative sample and various scales and indices have different numbers of items (e.g., ISCI has 26 items, but the FI has 20 items). We converted scale and index scores to a mean score by dividing the sum of the scale or index by the total number of items in the scale or index. Therefore, all BRIEF-P scores vary from 1 to 3, with higher numbers indicating greater impairment.

Differential Ability Scale (DAS) and Differential Ability Scale-2nd Edition (DAS-II)—The DAS and DAS-II (Elliott 1990, 2007) are standardized cognitive assessments that separate cognitive abilities into verbal, nonverbal, and spatial clusters for children ages 2 years, 6 months to 17 years, 11 months. For the present study we included the Verbal Cluster (subtests: Naming Vocabulary and Verbal Comprehension), which uses standard

scores ($M = 100$; $SD = 15$). We also included Pattern Construction as a proxy for Nonverbal IQ, which uses a T-score ($M = 50$; $SD = 15$).

Wechsler Preschool and Primary Scale of Intelligence-Revised (WPPSI-R) and Wechsler Preschool and Primary Scale of Intelligence-Third Edition (WPPSI-III)—The WPPSI-III and WPPSI-R (Wechsler 1989, 2002) are standardized cognitive assessments that separate cognitive abilities into verbal and performance intelligence quotients (IQ) for children ages 2 years, 6 months to 7 years, 0 months. For the present study we included the Verbal IQ (subtests: Information, Vocabulary, and Word Reasoning), which uses standard scores ($M = 100$; $SD = 15$). We also included Block Design scaled scores ($M = 10$, $SD = 3$) as a proxy for Nonverbal IQ, which were converted to T-scores ($M = 50$; $SD = 15$) for the purposes of analysis with the DAS Pattern Construction T-scores described above.

Procedures

Two of the authors served as psychologists on multidisciplinary teams and conducted all of the cognitive/EC evaluations, and either administered or assisted with the ADOS evaluations. Speech and language therapists conducted or assisted with ADOS evaluations, a psychiatrist also assisted with ADOS evaluations. All disciplines contributed to diagnostic classification. Some children were assessed in single discipline developmental evaluations that included cognitive, EC, and diagnostic measures.

Data Analysis

Prior to any analyses, all raw data collected from the BRIEF-P were examined for outliers (scores more than 2.5 standard deviations from the mean), kurtosis, and skew. No outliers were detected. Nor did Verbal IQ, or ADOS data from the ASD group present with significant kurtosis or skew (all dependent variables < 1.01), and therefore parametric analyses were carried out for group comparisons. Mauchly's test of Sphericity was violated or trended towards violation for the repeated measures analysis of variance described below, thus a Greenhouse-Geisser correction was applied to the degrees of freedom.

To provide a broad overview of parent ratings on the EC, we present the mean T-scores relative to the entire BRIEF-P normative sample, as well as the percentage of children with ASD who have scores at or above 65 on any BRIEF-P measure, percentage of scores at or above 65 on any index, and then the percentage of scores at or above 65 on all three indices. In addition, to determine whether any scales or indices from the BRIEF-P were significantly elevated in the ASD group, mean raw scores from each scale were compared to the TD group ratings in two repeated measures analysis of variance (i.e., one for scales and one for indices), and a t test for GEC. Because the children comprising the TD group are a subset from the BRIEF-P standardization sample and contribute to the T-score, we cannot use standardized scores for group comparisons. Within the ASD group, a repeated-measures analysis of variance was conducted among the five scales to determine if Shift scale ratings were higher in children with ASD relative to the other scales. Measures of effect size (partial eta-squared for analyses of variance [ANOVA], Cohen's d for means, r^2 for correlations) are presented for the BRIEF-P. To examine the relationship between EC and ASD symptoms, Spearman's rho correlations were conducted between BRIEF-P indices and ADOS composite scores. Spearman's rho correlations are used because of the discontinuous nature of ADOS scores (Sears et al. 1999; Yerys et al. 2009). BRIEF-P indices (ISCI, FI, and EMI) were selected in order to reduce the number of comparisons, while retaining some form of specificity. With our a priori hypothesis regarding the Shift scale and FI, we set alpha to .05 for those correlations. For the remaining 12 exploratory correlations of the other BRIEF-P

indices with ASD symptoms, we controlled for Type I error with the False Discovery Rate correction method and set $q < 0.05$ (FDR; Benjamini and Hochberg 1995).

As part of a follow-up analysis, we compared the Verbal IQ and Nonverbal IQ proxy with a one-sample t test to the mean for the distribution (Verbal IQ $M = 100$; Nonverbal IQ proxy $M = 50$). As shown in Table 2, both scores differed significantly from their distribution mean even though the ASD group's mean is less than a standard deviation from the distribution mean. To address this difference in cognitive ability we conducted follow-up analyses with a subset of children ($n = 29$) that had Verbal IQs > 79 and Nonverbal IQ proxy > 36 (T-score), which led to means (Verbal IQ $M = 97.00$; Nonverbal IQ proxy $M = 51.00$) that did not differ from the distribution means (p 's $> .11$). The 15 excluded children either were missing Nonverbal IQ proxy scores ($n = 5$) or did not meet both the verbal and nonverbal criterion ($n = 10$). The pattern of results for group differences was the same within this subset of ASD children. We have reported the analysis on the complete sample of 88 children and the subsample of 58 children.

Results

Qualitative Overview of the BRIEF-P

As seen in Table 3, children with ASD have a mean of 60 or higher on every scale and index. The GEC, EMI, and the Working Memory scale are the only measures that have a mean at or above the clinically significant threshold of 65. When looking at percentage of children that score in the impaired range, every scale and index has at least 36 % of children with a T-score at or above 65; the Inhibit and Working Memory scales have the highest percentage (52 % each). Furthermore, 56 % of the ASD group had T-scores at or above 65 on at least one BRIEF Index score and 21 % on all 3 Index scores.

Group Comparisons on the BRIEF-P

Parent ratings on all five scales revealed a significant Group effect, $F(1, 86) = 49.94$, $p < 0.01$ partial Eta squared = 0.37, but not a significant interaction, $F(2.87, 246.75) = 1.97$, $p = 0.12$, partial Eta squared = 0.022 (see Fig. 1a for all BRIEF-P dependent measures on the full sample). Parent ratings on the three BRIEF indices yielded a significant Group effect, $F(1, 86) = 47.27$, $p < 0.01$ partial Eta squared = .36, and there was not a significant interaction, $F(1.75, 150.55) = 0.09$, $p = 0.90$ partial Eta Squared = 0.00. Parent ratings are higher for the ASD group compared to the TD group on the GEC, $t(86) = 7.35$, $p < 0.01$, Cohen's $d = 1.57$. We also found no differences between the five BRIEF-P scales within the ASD group, $F(4, 117.073) = 1.46$, $p = 0.23$ partial Eta squared = 0.03. In our follow-up analyses the group differences remained when the subset of children with ASD who were matched to the distribution means on Verbal IQ and the Nonverbal IQ Proxy were tested separately: Group effect on all five scales remained significant, $F(1, 56) = 26.94$, $p < 0.01$ partial Eta squared = 0.33, but no significant interaction was reported $F(2.71, 151.74) = 1.67$, $p = 0.18$ partial Eta squared = 0.03 (see Fig. 1b for all BRIEF dependent measures on the subset ASD and TD sample). Parent ratings on the three BRIEF indices yielded a significant Group effect, $F(1, 56) = 24.75$, $p < 0.01$ partial Eta squared = .31, and there was not a significant interaction, $F(1.76, 98.41) = 0.48$, $p = 0.60$ partial Eta Squared = 0.01. Parent ratings are higher for the ASD group compared to the TD group on the GEC, $t(56) = 5.52$, $p < 0.01$, Cohen's $d = 1.46$.

Correlating BRIEF-P Scores with ASD Symptoms

None of the indices or the Shift scale correlated significantly with ASD symptoms, which was indexed by the three ADOS composite scores (Communication, Social, and Stereotyped Behaviors; all p 's > 0.28).

Discussion

This study examined real world EC behaviors in pre-schoolers with ASD relative to a subset of the normative sample from the BRIEF-P, and correlated parent ratings of real world EC with ASD symptoms from the ADOS. Unlike many previous investigations of preschoolers with ASD, which failed to observe EC deficits on performance measures, we found pervasive EC deficits by parent report on a comprehensive, real world EC measure. Parents rated their children with ASD as having greater impairments in real world EC compared to an age and sex-matched subset from the BRIEF-P normative sample in the areas of inhibition, shifting, emotional control, working memory, and planning/organization. A majority of preschoolers (67 %) with ASD were rated by parents as having clinically significant EC impairments in one index from the BRIEF and a substantial minority (22 %) was elevated on all three index scores. There was no indication that preschoolers with ASD had relatively greater impairments in flexibility compared to other EC domains as hypothesized.

The current findings are complementary to the mixed findings observed in previous studies examining EC with performance-based tasks (e.g., A-not-B, delayed match-to-sample, or Spatial Reversal) in similar aged children with ASD (Dawson et al. 2002, 1998; Griffith et al. 1999; McEvoy et al. 1993; Pellicano 2007; Stahl and Pry, 2002; Yerys et al. 2007). A number of the previous studies included preschoolers with ASD and significant developmental delays, thus comparison groups included pre-schoolers with idiopathic or mixed developmental delays as the control groups (Dawson et al. 2002, 1998; Griffith et al. 1999; McEvoy et al. 1993; Yerys et al. 2007). The goal of most of these previous studies was to determine whether EC was a primary cause of ASD, and the mixed findings in this age range argued against this hypothesis. Our study is not intended to establish the primacy of EC impairments in ASD, but to investigate the presence of EC impairments as indexed in real world settings for preschool aged children. The advantage of including the BRIEF-P in future studies of preschoolers with ASD is its psychometric stability, which ameliorates concerns about performance based measures for this age range (Kenworthy et al. 2008), as well as its comprehensive coverage of a range of EC abilities. It has been used previously to identify real world EC impairments in preschoolers with ADHD or with language delays (Isquith et al. 2004; Mahone and Hoffman 2007), and now in a sizable sample of preschoolers identified with an ASD.

The school age version of the BRIEF is one of the more consistent measures in identifying real world EC impairments in children and adolescents with ASD (Chan et al. 2009; for a review of BRIEF in ASD see Kenworthy et al. 2008). Our finding of elevated parent ratings for pre-schoolers with ASD on the FI of the BRIEF-P provides a downward extension of this literature by showing sensitivity of real world EC impairments in the 2–5 year-old range. Similar to studies of childhood, our group of pre-schoolers with ASD were rated as having greater impairments in all domains of EC in real world settings. Our study did not find the Shift scale or the FI to be of greater impairment than other scales or indices. At first blush this may appear to conflict with previous findings of a ‘peak’ deficit in flexibility in school age children (Gioia et al. 2002), however the previous investigation demonstrated this peak relative to other clinical groups (mild traumatic brain injury, attention deficit hyperactivity disorder, and reading disorder), whereas the present study attempted to define flexibility as a peak among various impaired EC behaviors within ASD. Thus, the Shift and FI are not more impaired within the ASD group relative to other EC domain ratings on the BRIEF-P, but it remains to be seen if these measurements on the BRIEF-P would distinguish preschoolers with ASD from other developmentally delayed groups (e.g., attention deficit hyperactivity disorder, phonological disorder, idiopathic developmental delay, and known genetic disorders like 22q deletion syndrome or Angelman’s Syndrome).

This study failed to report significant correlations between EC problems on the BRIEF-P FI and restricted, repetitive behaviors and interest symptoms from the ADOS. This lack of a relationship between EC and any ASD symptom domain is consistent with prior studies in the preschool age range (Dawson et al. 1998). For school age and older individuals with ASD, significant correlations between EC and ASD symptoms have been reported (Kenworthy et al. 2009; Liss et al. 2001; Lopez et al. 2005; Semrud-Clikeman et al. 2010; South et al. 2007; Yerys et al. 2009). A recent longitudinal study of restricted, repetitive behavior and interest symptoms with the autism diagnostic interview-revised (ADI-R; Lord et al. 1994) suggests divergent developmental trajectories within this symptom domain (Richler et al. 2010), and this change over development may explain why some relationships are observed in older but not younger samples of individuals with ASD. Of note, the investigations in older samples have used the ADI-R (or another interview) alone or in combination with the ADOS. This difference in measures used to capture restricted, repetitive, behaviors and interests may also explain the divergent results, because the ADOS samples a 30 min time window, and is particularly limited in its capacity to document restricted, repetitive behaviors and interests, whereas the other interview measures capture real world behaviors as well as lifetime prevalence. Future studies could examine restricted, repetitive, behavior and interest symptoms and EC correlations with measures other than the ADOS.

The current study has limitations. This was not a random sample, but rather a sample of convenience from children seen in an ASD clinic combined with a subset of children recruited as part of the normative sample for the BRIEF-P. This raises the concern that: (1) the ASD children were evaluated at their most severe presentation and parent report may be biased; (2) children who were able to meet verbal cognitive testing criteria are a higher cognitive functioning subset of children with ASD in this age range; (3) the control group was not administered the same cognitive battery. While children may be presenting at their most severe during the evaluation, it is important to note that we did not observe significant kurtosis or skew in our data. Our exclusion criteria of preverbal children and children with verbal abilities less than 70 may limit the generalization of our findings to the wider population of children with ASD; however, this exclusion criterion should also have reduced our ability to detect group differences. Thus, the presence of differences observed in this study only strengthens the importance of examining real world EC for preschool aged children suspected of an ASD. The lack of cognitive information on the TD group limited our ability to confirm that the two groups were statistically matched on Verbal and Nonverbal cognitive abilities. It also limited our ability to conduct analysis of covariance statistics on the entire sample of 44 children. However, our follow-up with an ASD subgroup that did not differ in Verbal IQ and a Nonverbal IQ proxy from distribution means showed an identical pattern of results which reduces concern that cognitive ability alone explains the differences in BRIEF-P scores with the TD group.

Research investigating EC impairments in preschoolers with ASD has been marred by mixed findings, while older individuals tend to demonstrate EC impairments more consistently. This study provides a novel contribution by demonstrating the BRIEF-P is sensitive for detecting EC impairments in real world settings for preschoolers with ASD.

Future studies with young children on the autism spectrum should consider the BRIEF-P as a complementary method to performance based EC batteries. Future studies will use standard scores, which were not possible in our study because the TD group contributed to the BRIEF-P norms. The clinical implications of this study are also significant as components of EC are identified as a problem in two-thirds of the preschoolers in our sample. Inclusion of the BRIEF-P and performance-based assessments like the shape school

(Espy et al. 2006) may assist in identifying intervention targets for preschoolers suspected of an ASD.

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Fig. 1.

These bar graphs show the parent ratings of the entire sample (a) and the subset sample (b) of children for each scale, index and the global executive composite (GEC) from the preschool version of the BRIEF separated by group. There is a main effect of group in both graphs. The *error bars* represent one standard deviation above and below the mean score, providing an estimate of variation around the mean for each group. *ISCI* Inhibit and Self-Control, *FI* Flexibility Index, *EMI* Emergent Metacognition Index, *GEC* Global Executive Composite

Table 1

Description of BRIEF-P scales

Scale	No. of items	behavioral description	Example item
Inhibit	16	Control impulses; Ability to stop one's behavior at an appropriate time	54. Has trouble putting the brakes on his/her actions even after being asked
Shift	10	Ability to move freely from one situation to another; transitions; ability to see problems from different points of view	45. Resists change of routine, foods, places, etc.
Emotional control	10	Modulate or control emotions	36. Reacts more strongly to situations than other children
Working memory	17	Ability to hold information in mind; Sustain information to complete a task	59. Has trouble remembering something, even after a brief period of time
Plan/organize	10	Anticipate future events; communicate concepts in coherent order; set goals and achieve them	39. Gets caught up in the small details of a task or situation and misses the main idea

Table 2

Participant demographics by group

	ASD (n = 39)	TD (n = 39)	p value
Chronological age (years)			
Mean (SD)	4.38 (0.77)	4.40 (0.77)	–
Range	2.83–5.83	2.83–5.83	
Gender (male/female)	32/7	32/7	–
Verbal ability ^a			
Mean standard score (SD)	93.10 (12.98)	–	<0.05
Range	70–113		
Nonverbal ability ^b			
Mean T-score (SD)	45.31 (13.73)		0.05
Range	11–86		
ADOS module 1 (n = 2)			
Social + communication score ^c			
Mean (SD)	15.50 (0.71)	–	–
ADOS module 2 (n = 28)			
Social + communication score ^d			
Mean (SD)	14.07 (5.37)	–	–
ADOS module 3 (n = 9)			
Social + communication score ^c			
Mean (SD)	10.22 (4.92)	–	

^aGroup comparison was made to standard score distribution $M = 100$

^bGroup comparison was made to T-score $M = 50$; children receiving Wechsler Preschool and Primary Scales of Intelligence, third edition received block design and their scaled scores were converted to T-scores

^cThreshold for an Autism Spectrum Disorder = 7

^dThreshold for an Autism Spectrum Disorder = 8

ADOS Autism Diagnostic Observation Schedule, ASD Autism Spectrum Disorder, SD standard deviation, TD typically developing

Table 3

BRIEF-P index and scale score descriptive statistics in ASD sample (n = 39)

BRIEF-P	M	SD	No. of individuals scoring in clinically impaired range
Global Executive Composite (GEC)	65.31 ^a	12.55	51
Inhibit and Self-Control Index (ISCI)	62.28	14.11	49
Flexibility index (FI)	61.13	13.02	36
Emergent Metacognition Index (EMI)	66.18 ^a	12.23	44
Inhibit	61.97	12.84	49
Shift	61.10	10.93	36
Emotional control	59.05	15.33	33
Working memory	67.46 ^a	13.56	54
Plan/organize	61.10	11.84	39

T-scores (M = 50, SD = 10)

^aClinically impaired range is 1.5 SD above the mean (T-score = 65)