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BRIEF REPORT

Brief Report: Examining Executive and Social Functioning in Elementary-Aged Children with Autism

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Abstract There is a paucity of literature examining the relationship between executive and social functioning in children with autism spectrum disorder (ASD). Twenty-three school-aged children with ASD participated. Executive functioning was measured using the Developmental Neuropsychological Assessment, Second Edition and Differential Ability Scales, Second Edition, and the teacher-rated Behavior Rating of Inventory of Executive Function. Independent assessors observed children's social functioning on the playground while children with ASD and their peers completed a survey to measure peer friendships and rejections. Overall, poorer executive functioning was associated with increased playground isolation and less engagement with peers. This suggests that metacognitive skills such as initiation, working memory, and planning and organization are associated with children's social functioning.

Keywords Executive functioning · Autism spectrum disorder · Social skills

Introduction

Autism spectrum disorder (ASD) is characterized by impairments in social functioning and communication as well as repetitive, restrictive, or stereotyped interests (American Psychiatric Association 2013). Researchers have explored the executive functioning theory as one explanation for the symptoms of ASD. This theory posits that deficits in higher order cognitive skills underlie the functioning of individuals with ASD (Minshew et al. 2006). Although executive function (EF) deficits have been linked to the presence of restricted interests and repetitive behaviors (Lopez et al. 2005), there is less research on the association between EF and social functioning in children with ASD.

EF deficits in children with ASD have been widely documented. There is converging evidence to suggest that children with ASD have poor planning and flexibility (Ozonoff and Jensen 1999). However, behavioral regulation executive skills, such as inhibitory deficits, have been equivocal. Some studies have found no group differences on tasks of inhibition (Lemon et al. 2011; Ozonoff and Jensen 1999; Ozonoff and Strayer 1997), whereas others found that children with ASD struggled to inhibit dominant responses and shift sets (Ozonoff et al. 1994). Research on working memory is mixed; some research indicates that working memory skills remain intact (Ozonoff and Strayer 2001), while other studies have found impairments in verbal and spatial working memory (Schuh and Eigsti 2012).

Research on the association between EF and social functioning also is mixed. Measurement of EF and social skills may be one reason for this variability. Traditionally, both behavior regulation and metacognitive EF were based on observed performance of an individual during a task (performance-based measures). Rating scales of EF (parent- or teacher-rated) were developed to get a better sense of the application of EF in daily life. Similarly, social skills have often been measured using direct assessment of children's social understanding, whereas it is now also possible

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to observe and ask peers how that social understanding is applied.

Ozonoff and colleagues (2004) found no significant associations between performance-based EF and social skills (as measured by the Autism Diagnostic Observation Schedule; ADOS); however, planning, a metacognitive skill, was associated with adaptive communication skills. In contrast, Kenworthy and colleagues (2009) found performance-based measures of divided attention and verbal fluency were related to fewer social symptoms on the ADOS-2 and Autism Diagnostic Interview. Other research has supported the association between ratings-based measures of EF and social functioning, finding that metacognitive impairments, specifically in initiation and working memory, play a role in the adaptive social deficits, as measured by the Vineland Adaptive Behavior Scales (VABS; Gilotty et al. 2002). More recently, Pugliese and colleagues (2015) found ratings-based measures of initiation and cognitive flexibility were related to adaptive social skills on the VABS. Despite these findings, none of these studies used in vivo measures of social functioning in a naturalistic setting with peers. The current study builds upon this literature by adding direct observations of social functioning with peers in schools and examines the relationship between performance and ratings-based EF and social functioning.

Methods

Participants

All data were drawn from a larger randomized controlled trial. Children were included if they: (1) were referred by school administrators and had a confirmed classification of ASD on the ADOS from an independent assessor; (2) had an IQ of 65 or higher; and (3) were included in a general education classroom for at least 80% of the school day. Children were excluded if they: (1) were not expected to stay in the school or the classroom for the duration of the study; or (2) had a mental age-equivalent that was less than 4 years.

A total of 29 children who were fully included in a first through sixth grade general education classroom participated; however, six participants were excluded from this study due to a Differential Ability Scale – Second Edition (DAS-II) General Conceptual Ability (GCA) score below the cutoff of 65, leaving 23 participants (20 males and 3 females). Children were 73.9% white, 21.7% African American, and 4.3% multi-racial. The mean age was 8.6 years (SD = 1.8; range 5–12 years), with an average IQ of 91.5 (*SD* = 11.40). The average class size was 25.30 children (SD = 3.76; range17-30).

Measures

ADOS (Lord et al. 2000)

The ADOS is a semi-structured, standardized clinician administered observational measure of social interaction, communication skills and imaginative play that confirmed the ASD diagnosis of all participants. The ADOS has high inter-rater reliability and test retest reliability and validity (Lord et al. 2000).

DAS-II (Elliott 2007)

The DAS-II is a performance-based intellectual assessment (IQ test) for children ages 2 years 6 months through 17 years 11 months. Two diagnostic subtests (Recall of Digits Backwards and Recall of Sequential Order) were administered to gain a Working Memory composite score of metacognitive skills. This composite score is highly reliable with an internal consistency of 0.95, test/retest reliability of 0.83, and a standard error of measure of 3.53.

Developmental Neuropsychological Assessment, Second Edition (NEPSY-II; Korkman et al. 2007)

The NEPSY-II is a performance-based multidimensional assessment of neurocognitive abilities in children and adolescents ages 5–16 years old, with high internal and test–retest reliability. Two subtests, Animal Sorting, a measure of set-shifting and flexibility, and Inhibition, the ability to inhibit prepotent responses and switch depending on a set of rules, were used in this study.

Behavior Rating Inventory of Executive Function – Teacher Version (BRIEF; Gioia et al. 2000)

The BRIEF is an 86 item ratings-based survey, that yields eight clinical scales: (1) Inhibit (control impulsivity); (2) Shift (be flexible and move from one situation or activity to the next); (3) Emotional Control (control and modulate emotional responses); (4) Initiate (begin a task or activity, generate ideas and problem solve independently); (5) Working Memory (hold information in mind and manipulate that information as needed to complete a task); (6) Plan/Organize (anticipate future events, determine goals, and sequence steps); (7) Organization of Materials (put information into a meaningful order); and (8) Monitor (orient to tasks and self-monitor). The BRIEF has high internal consistency and test–retest reliability (Gioia et al. 2000). Higher scores on the BRIEF indicate more impairment. A score of 65 or over is considered clinically significant.

Social Functioning Measures

Playground Observation of Peer Engagement (POPE; Kasari et al. 2005)

The POPE is a timed-interval behavior coding system. Two independent observers rated children on the playground for at least 10 min during recess using 40 consecutive second observation intervals with 20 s of subsequent coding. Overall, percent agreement between raters was excellent (range 87–97%; mean = 92%). Playground engagement states were expressed as the percentage of intervals children spent in solitary engagement (i.e., unengaged with others) and joint engagement (i.e., playing a game, participating in a conversation or other joint activity).

Friendship Survey

Children were asked to list with whom they liked to hang out (friendships) and did not like to hang out (rejections) in their classroom. Friendship nominations and rejections were calculated as the number of times children said they liked and did not like to hang out with the child with ASD, respectively.

Procedure

Schools distributed recruitment materials to interested families. Once families provided consent, independent assessors administered the ADOS, DAS-II, and NEPSY-II in a quiet location at the child's school, which lasted approximately 1.5–2 h. Consent forms also were distributed to classmates of children with ASD for participation in the Friendship Survey. In order to provide an accurate assessment of the classroom social environment, a minimum of 40–50% of the classroom was needed (Cairns and Cairns 1994). Consented children also were assented and given an assent comprehension test to ensure they understood the procedures at the beginning of the study. Consented and assented children completed the Friendship Survey, while teachers were asked to complete the BRIEF about the child with ASD. Blind observers recorded children's peer engagement on the playground using the POPE.

Data Analysis

Descriptive analyses were conducted to examine the distribution of scores on each EF measure. As a result of significant correlations between age and GCA with EF, partial correlations controlling for age and GCA were used to explore the relationship between performance-based scores from the NEPSY-II subtests, Working Memory Index score from the DAS-II, and the ratings-based standard scores from the BRIEF clinical scales with received friendship nominations, rejections, and the proportion of time spent in solitary and joint engagement. We used an adjusted significant value of 0.025 (0.05/2) to account for the number of tests conducted since the outcomes are based within similar contexts (see Chang et al. 2012).

Results

Executive Functioning

Table 1 shows the mean and standard deviation of scores on the EF measures. Each standardized test was normed with a representative sample, and the functioning levels indicate the mean level of the current sample as compared to the test's norming sample. On the NEPSY-II subtests, the mean performance of participating students with ASD was below average for their age, indicating mild impairments in shifting, inhibition, and the switching component. Performance on measures of working memory as measured by the DAS-II was at the lower end of the average range. The results indicated elevated scores on ratings on the behavior regulation skill of Shifting, and the metacognitive skills of Initiation, Working Memory, and Monitor. The Emotional Control Scale was at the upper end of the typical range. Their scores on the remainder of scales were within normal limits. This indicates some level of impairment on both behavior regulation and metacognitive skills on both ratings- and performance-based assessments. Performance and ratings-based measures of shifting and working memory were significantly correlated; however, ratings of inhibition were not associated.

Executive Functioning and Social Functioning

There were significant correlations between children's age and the number of rejections received; GCA also was correlated with all performance-based measures of EF and ratings-based measures of Initiation and Planning and Organization. See Table 2. Thus, both age and GCA were controlled for in subsequent analyses. The only performance-based measure that was related to social skills was the inhibition-switching task, which requires both inhibition and cognitive flexibility. Children with better inhibition and cognitive flexibility skills spent more time in solitary play (see Table 3). Additional associations emerged between teacher ratings of EF on the BRIEF and social functioning. Poorer initiation and working memory skills were associated with more time spent in solitary play. Children with better planning and organizational skills spent more time jointly engaged on the playground.

Table 1 Mean scores and functioning level for executive functioning measures

Measure	Mean (SD)	Level Related to Normative Sample
NEPSY-II (Performance-Based)		
Animal Sorting (metacognitive) (n = 20)	6.35 (2.3)	Below Average
Inhibition (behavior regulation) (n = 23)	6.74 (3.5)	Below Average
Inhibition-Switching (behavior regulation) (n = 19)	7.21 (3.1)	Below Average
DAS-II (Performance-Based) (n = 22)		
Working Memory (metacognitive)	90.27 (16.1)	Average
BRIEF (Teacher Ratings) (n = 21)		
Inhibit (behavior regulation)	60.57 (13.7)	Within Normal Limits
Shift (behavior regulation)	66.24 (14.0)	Elevated
Emotional Control (behavior regulation)	64.43 (16.6)	Within Normal Limits
Initiation (metacognitive)	65.14 (11.0)	Elevated
Working Memory (metacognitive)	66.95 (11.5)	Elevated
Planning and Organization (metacognitive)	63.10 (10.4)	Within Normal Limits
Organization of Materials (metacognitive)	61.81 (13.0)	Within Normal Limits
Monitor (metacognitive)	64.57 (12.8)	(Mildly) Elevated

Table 2 Correlations between age, IQ, executive function and social measures

	Age	General Cognitive Ability
NEPSY-II		
Animal Sorting (n = 20)	−0.03	0.76**
Inhibition (n = 23)	0.08	0.49*
Inhibition Switching (n = 19)	−0.07	0.76**
DAS-II (n = 22)		
Working Memory	0.16	0.75**
BRIEF (n = 21)		
Inhibit	−0.21	−0.06
Shift	−0.09	−0.37
Emotional Control	0.10	−0.21
Initiation	−0.08	−0.54*
Working Memory	−0.26	−0.43
Planning and Organization	−0.36	−0.56**
Organization of Materials	−0.34	−0.24
Monitor	−0.18	−0.42
Social Functioning (n = 23)		
Friend nominations	0.02	−0.16
Rejections	−0.44*	−0.16
Solitary Play	0.39	−0.04
Joint Engagement	0.05	−0.12

*p ≥ .05 **p ≥ .01

Discussion

The purpose of this study was to examine: (1) impairments in EF; and (2) the relationship between EF and social functioning in elementary-aged children with ASD. Results indicated that children's EF were impaired relative to normative samples, and impairments were seen across both behavior regulation and metacognitive skills (with some skills intact and some impaired), as well as across measure type (performance or ratings based assessment).

Although scores were impaired, only one performance-based measure (inhibition-switching) was associated with social functioning (solitary play). Specifically, children with better inhibition and switching between rules spent more time in solitary play on the playground. If the child is hypervigilant, he/she may actually inhibit the initiation of social interaction and fail to join peers on the playground resulting in more time spent in solitary play. Previous studies have been inconsistent on the relationship between performance-based measures of inhibition and social skills (e.g. Ozonoff et al. 2004 and Landa and Golderberg 2005 did not find relationships, whereas; Kenworthy et al. 2009 did); however, these inconsistent findings are likely related to the variability in measures used to assess EF and social skills across studies. Given the small sample size in this study and inconsistency in previous literature, replication is needed to clarify this relationship.

Overall, ratings-based measures, relative to performance-based measures, appeared more indicative of the ability to apply EF in the real world setting. Teacher ratings of inhibition were within normal limits, while performance measures of inhibition were below average. This may reflect teachers' ability to judge student behavior over time relative to the brief test of inhibition for performance measures. Poor initiation, working memory, and planning and organizational skills ratings by teachers were related to more time engaged in solitary play. Children with poor initiation skills struggle to begin tasks independently; thus, they may spend more

Table 3 Partial correlation between executive function and social measures, controlling for age and IQ

	Friend Nominations	Rejection	Solitary Play	Joint Engagement
NEPSY-II				
Animal Sorting (n = 20)	−0.02	−0.04	−0.01	0.26
Inhibition (n = 23)	−0.07	0.18	0.41	0.01
Inhibition Switching (n = 19)	−0.48	0.28	0.65*	0.09
DAS-II (n = 22)				
Working Memory	0.43	−0.02	−0.05	0.38
BRIEF (n = 21)				
Inhibit	−0.09	−0.16	0.26	0.22
Shift	−0.26	−0.05	0.26	0.15
Emotional Control	−0.25	−0.02	0.35	0.11
Initiation	−0.54	0.38	0.79**	−0.56
Working Memory	−0.46	0.36	0.62*	−0.58
Planning and Organization	−0.32	0.29	0.46	−0.62*
Organization of Materials	−0.15	0.44	0.24	−0.46
Monitor	−0.27	0.11	0.55	−0.14

*p ≥ .25 **p ≥ .01

time in solitary play because they may not have the social skills to approach and engage their peers. With regards to working memory, the unstructured nature of the playground forces children to keep multiple pieces of information about social discourse in mind, constantly change and update that information, and act accordingly. This would place great demands on working memory. Children with poorer working memory skills also may struggle to maintain the swift social pace of their peers, resulting in more time in solitary play. Similarly, children with poorer planning and organizational skills may struggle to anticipate steps involved in social play and discourse, and struggle to plan steps to carry out a social goal, which may lead to less joint engagement with peers on the playground.

These findings are consistent with Gilotty and colleagues (2002), who found that metacognitive impairments, specifically initiation and working memory, were highly related to adaptive social functioning. Similarly, Pugliese and colleagues (2015) found a relationship between initiation and social skills; however, they also found a relationship with adaptive social skills and ratings-based measures of cognitive flexibility. The current study demonstrated that metacognitive impairments are not only related to reports of adaptive social functioning, but actual engagement on the playground. However, neither child nor peer reports of friendships were associated with performance-based or teacher reported EF.

Limitations

Limitations to the current study include the small variable sample size across measures, specific IQ requirements, multiple statistical comparisons, and lack of a typically developing comparison sample. This increases the chance of Type 1 error with underpowered analysis. Future studies should enroll a larger sample to allow for more sophisticated statistical analyses, children with various IQs to increase the generalizability of the data, and a typically developing matched sample for comparison.

Conclusions

Overall, this study has suggestive implications regarding the associations between EF and social functioning in children with ASD. Namely, metacognitive skills were related to social functioning. Metacognitive skills often are less apparent than more overt behavior regulation skills. For example, students who struggle to regulate their emotions or inhibit problematic behaviors often present challenges in general education classrooms; however, metacognitive impairments often are more difficult to distinguish. Given their association with other functional skills, however, this study highlights the importance of understanding metacognitive functioning in children with ASD, and how those skills can affect behavior with peers. In addition, current results reflect the importance of teacher ratings of EF as these were more related to functional social skills than performance-based ratings. Perhaps, teachers' ratings of EF also measure other behaviors more directly associated with social functioning. Further research is needed to better understand this relationship.

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Author's Contribution LMF generated the idea, was the primary writer of the manuscript, and approved all changes. JL is the principal investigator of the larger study in which these data were drawn. JL, ERF and DM provided input into the design of the study. All authors were involved in developing, editing, writing, reviewing, and providing feedback for this manuscript and have given approval of the final version to be published.

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Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent Informed consent was obtained from all individual participants included in the study.

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