Everyday Executive Function Predicts Adaptive and Internalizing Behavior among Children with and without Autism Spectrum Disorder

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Individuals with autism spectrum disorder (ASD) demonstrate challenges with executive function (EF), adaptive behavior, and mental health, all of which place long-term wellbeing at risk. In the current study we examined the relation between parent-rated EF and adaptive functioning and internalizing symptoms (anxiety, depression), as we expected that identifying the specific EF domains most closely related to these indices of functioning would illuminate opportunities for targeted intervention. Participants included 59 children and adolescents with ASD ($M = 10.1$ years) and 67 who were typically developing (TD) ($M = 9.4$ years) matched on age, IQ, mental age, and maternal education. Caregivers completed the Behavior Rating Inventory of EF (BRIEF) and Behavior Assessment System for Children, Second Edition (BASC-2). Parents rated children with ASD as demonstrating significantly more challenges across most of the examined BRIEF and BASC-2 indices and scales, with the exception of organization of materials (BRIEF) and anxiety (BASC-2). For both groups, metacognitive EF processes emerged as strongly associated with practical, conceptual, and social skills, though different BRIEF scales emerged as significant across the component subdomains. In terms of the relation with mental health, BRIEF index scores were unrelated to anxiety for both groups. Behavior regulation, however, was significantly associated with depression symptoms for children with and without ASD. The findings highlight the possibility that targeting particular EF domains among individuals with and without ASD may not only have direct benefit for behavior regulation and metacognitive abilities, but may also extend to other areas of life, including adaptive behavior and concomitant internalizing symptomatology. ***Autism Res*** *2018, 11: 284–295*. © 2017 International Society for Autism Research, Wiley Periodicals, Inc.

Lay Summary: We examined whether parents' ratings of their children's flexibility and ability to monitor their behavior predicted adaptive skills (e.g., ability to complete day-to-day personal tasks, communicate, and socialize) and symptoms of anxiety and depression among children with and without autism spectrum disorder. For both groups, children's abilities to manage and monitor their behavior were strongly related to adaptive skills. Children's flexibility and ability to inhibit inappropriate behavior and control their emotions was associated with depression symptoms for both groups.

Keywords: executive function; parent ratings; adaptive functioning; anxiety; depression; internalizing symptoms; autism spectrum disorder

Introduction

Executive functions (EF) refer to higher-level cognitive control processes involved in the conscious control of action and thought, and such skills may be integral to the child's ability to successfully demonstrate adaptive behaviour in various contexts (e.g., school, home, and community). EFs have traditionally been assessed through standardized psychometric measurements administered in controlled environments [Pennington & Ozonoff, 1996]. Although neuropsychological or performance-based measures provide good indicators of the fundamental cognitive components of EF at the level of individual constructs (e.g., working memory, inhibition, etc.), these traditional performance-based tests are not always predictive of real-world abilities [Burgess et al., 2006; Gardiner, Hutchison, Müller, Kerns, & Iarocci, 2017; Toplak, West, & Stanovich, 2013]. In contrast to performance-based EF tasks, in which children solve problems in highly structured settings where the demands are clear and distractions are limited, ratings of EF in real-life settings assess how well children are able to interpret competing social information, discern between information

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that is relevant and distracting, and flexibly shift from one activity to the next. Behavior rating scales therefore consider EF from a more ecological perspective, as they assess how multiple components of EF are applied across different contexts within the child's everyday activities [Kenworthy, Yerys, Anthony, & Wallace, 2008; Toplak et al., 2013]. It is within the context of such daily activities that the EF difficulties characteristic of ASD are most apparent [Blijd-Hoogewys, Bezemer, & van Geert, 2014; Chan et al., 2009; Granader et al., 2014; Rosenthal et al., 2013; Smithson et al., 2013; van den Bergh, Scheeren, Begeer, Koot, & Geurts, 2014] and are closely related to functional outcomes among individuals with ASD [Pugliese et al., 2015].

Adaptive functioning reflects one's ability to apply cognitive potential to real-world skills [(Sparrow, Balla, & Cicchetti, 1984]. Thus, adaptive behavior refers to "the performance of daily activities required for personal and social sufficiency" [Sparrow, Cicchetti, & Balla, 2005, p. 6], and is measured by the extent to which an individual is able to independently demonstrate developmentally appropriate conceptual (i.e., communication), practical (i.e., activities of daily living [ADL]), and social skills [Tassé et al., 2012]. As compared to typically developing (TD) individuals of the same age and intellectual ability, individuals with ASD experience challenges with various aspects of adaptive functioning [Klin et al., 2007]. Individuals with ASD struggle with daily living, communication, and particularly social skills [Kanne et al., 2011], and it is their adaptive rather than intellectual functioning that is most closely associated with long-term outcomes, including social adaptation and independent living (i.e., work status, residential situation, number and quality of friendships) [Farley et al., 2009].

The Behavior Rating Inventory of EF [(BRIEF; Gioia, Isquith, Guy, & Kenworthy, 2000] is the most commonly used parent-rating measure of EF for children (aged 5–18 years) with and without ASD. The BRIEF consists of eight scales (inhibit, shift, emotional control, initiate, working memory, plan/organize, organization of materials, monitor), which comprise two broad indices: *Behavioral Regulation*, profiling the ability to shift and modulate emotions and behavior via appropriate inhibitory control; and *Metacognition*, referring to the ability to cognitively self-manage tasks and monitor performance. Among children, adolescents, and adults with ASD without intellectual disability, metacognitive EF is consistently highlighted as most closely related to children's communication, daily living, and social skills [Gilotty, Kenworthy, Sirian, Black, & Wagner, 2002; McLean, Harrison, Zimak, Joseph, & Morrow, 2014, Peterson, Noggle, Thompson, & Davis, 2015; Pugliese et al., 2015, 2016; Wallace et al., 2016], though Pugliese et al. [2015] also found that behavior regulation significantly predicted socialization skills. Fewer studies have investigated the contribution of BRIEF scales comprising the summative indices. Pugliese et al. [2015] found that communication skills were predicted by initiation and working memory, daily living skills were predicted by these scales as well as organization of materials, and socialization abilities were predicted by initiation and shifting. This is largely consistent with Gillotty et al.'s (2002) correlational analysis. Examination of the scales that comprise 'everyday EF', as assessed with the BRIEF, represents an important contribution, as composite indices may mask variations within the component subscales, particularly for children with ASD, who often demonstrate uneven profiles of functioning [see Gardiner & Iarocci, 2015].

EF may also play an important role in the mental health of young people with ASD. Mental health represents a major concern for individuals on the autism spectrum, with reported prevalence rates as high as 84% for anxiety [White, Oswald, Ollendick, & Scahill, 2009] and 38% for depression [Magnuson & Constantino, 2011]. Such mental health concerns present significant risk to one's social competence [Johnston & Iarocci, 2017] and long-term adaptation [Kim, Szatmari, Bryson, Streiner, & Wilson, 2000]. Lawson et al. [2015] demonstrated that the association between ASD and symptoms of anxiety and depression was fully mediated by scores on the BRIEF shift scale among children and adolescents. Similarly, Wallace et al. [2016] reported that shifting was a significant predictor of anxiety among adults with ASD, whereas planning and organization abilities predicted depression. These research findings are consistent with those on performance-based EF, in which anxiety symptoms were negatively associated with performance on EF tasks assessing interference inhibition, cognitive set shifting, and attentional switching [Hollocks et al., 2014].

In the current study we examine the relation between EF and both adaptive functioning and mental health among children and adolescents with ASD. Given the long-term implications associated with disruptions in adaptive functioning and mental health, as well as the fact that ASD-characteristic deficits in adaptive and executive functioning become more pronounced during childhood [Kanne et al., 2011; Rosenthal et al., 2013], we suggest that the middle childhood years provide the optimal developmental period for assessment. Moreover, we aim to identify the specific domains of EF that are most closely related to adaptive functioning and mental health (i.e., BRIEF scales), which we suggest will provide insight into opportunities for early and targeted intervention. This is also the first study to include a TD control group matched on age, IQ, and mental age, with the goal of identifying how EF may differentially impact the adaptive functioning and internalizing symptoms of those with and without ASD. Such information has treatment implications in terms of whether interventions for school-aged children need to be targeted to children with ASD, for example, or can be delivered classroom-wide in

a non-specific way. Moreover, this methodological approach provides an advantage over previous research that compares individuals with ASD to the BRIEF normative sample, as differences in age and IQ can be controlled for. We predicted that children and adolescents with ASD would receive significantly lower scores on all EF domains, as assessed with the BRIEF, as compared to age-, IQ-, and mental age-matched TD peers. Further, we hypothesized that individuals with ASD would demonstrate significantly lower social skills, ADL, and communication, as well as more severe internalizing problems (anxiety, depression). With regard to the relation of EF to adaptive domains of functioning, we expected that metacognition would make the greatest contribution to our regression models, and emerge as a significant predictor for adaptive functioning and mental health. We did not have a priori expectations regarding which specific EF domains would most closely relate to adaptive functioning and mental health.

Methods

Participants

This study is based on archival data from 126 children and adolescents, aged 5–13 years, including 59 with ASD ($M = 10.1$ years, $SD = 2.1$) and 67 who were TD ($M = 9.4$ years, $SD = 1.7$). In order to be included in the current study, children had to have an IQ above 85, as assessed with the Wechsler Abbreviated Scale of Intelligence – Second edition [WASI-II; Wechsler, 2011], comprised of the Vocabulary and Matrices subtests. There were no significant differences across groups on age, IQ, mental age, or maternal education. Consistent with the gender distribution characteristic of the disorder [Centers for Disease Control and Prevention [CDC], 2014], there was a significantly higher proportion of males in the ASD group. Gender was not found to be significantly related to any of the examined adaptive functioning or mental health outcomes among either TD children or those with ASD. Consistent with expectation, children in the ASD group had a significantly higher level of autism symptoms, as assessed with the Social Responsiveness Scale [SRS; Constantino, 2002]. See Table 1 for participant demographic characteristics.

Diagnostic confirmation. All children in the ASD group received a standardized clinical diagnosis of ASD from a qualified pediatrician, psychologist, or psychiatrist associated with the provincial government-funded autism assessment network, or through a qualified private clinician. All diagnoses were based on the *Diagnostic and Statistical Manual of Mental Disorders* [*DSM-IV-TR*; APA, 2000] and confirmed using the Autism Diagnostic Interview–Revised [ADI-R; Rutter, Le Couteur, & Lord, 2008] and Autism Diagnostic Observation Schedule [ADOS; Lord, Rutter, DiLavore, & Risi, 1999], both of which are gold standard tools of ASD diagnostic assessment. The province of British Columbia (BC), where this study was conducted, has instituted standardized practices for a diagnosis of ASD as the diagnosis is tied directly to government funding. All individuals must be diagnosed by ADOS- and ADI-R-trained clinicians who use these tools and their clinical judgment to make the diagnosis. This policy extends to individuals who have been diagnosed in a different province or country, as they are required to be re-diagnosed upon their arrival to BC using these practices. The participants in this study were diagnosed in BC using these assessment standards.

Measures

Executive function. The BRIEF-Parent Form [Gioia et al., 2000] measures everyday EF abilities in children between the ages of 5 and 18 years. As noted, the BRIEF consists of eight scales, which comprise two broad indices: *Behavioral Regulation Index* (BRI) and *Metacognition Index* (MCI). Respondents rate the frequency of each listed behavior across a 3-point Likert-type scale that ranges from 'Never' to 'Often.' Results are reported as *t*-scores, with higher scores indicating greater difficulty [Gioia et al., 2000]. The measure demonstrates acceptable internal consistency (alpha = .82–.98) and 3-week test–retest reliability ($r = .72$–$.84$) [Gioia et al., 2000]. The validity of this instrument is supported by the correlations with other behavior rating measures [Mahone et al., 2002].

Adaptive functioning and mental health. The Behavior Assessment System for Children, Second Edition Parent Rating Scale [BASC-2; Reynolds & Kamphaus, 2004] provides indices of both adaptive functioning and mental health. Respondents rate the frequency of various problematic and adaptive behaviors across a 4-point Likert-type scale ranging from 'Never' to 'Almost Always', and results are reported as *t*-scores. In the current study, we examined the following scales: social skills, ADL, functional communication, anxiety, and depression. For the adaptive domains, higher scores are indicative of better functioning, whereas higher anxiety and depression scores reflect greater symptoms. The BASC-2 scales demonstrate acceptable internal consistency (alpha = .72–.88) and test-retest reliability ($r = .80$–$.84$).

Analysis

All data analyses were conducted using SPSS Statistics, Version 23. In order to compare BRIEF and BASC-2 scores across groups, a series of one-way analyses of

Table 1. Participant Demographic Characteristics

	TD ($n = 67$)	ASD ($n = 59$)	t-value/χ^2	P value
Chronological age (*years*)				
M (*SD*)	9.44 (1.73)	10.07 (2.09)	−1.82	.07
Range	6.86–13.40	5.92–13.74		
FSIQ-2				
M (*SD*)	111.37 (12.78)	107.47 (13.25)	1.68	.10
Range	87–142	87–144		
Mental age				
M (*SD*)	10.60 (2.67)	10.80 (2.64)	−.41	.69
Range	6.25–17.14	6.08–18.58		
Gender				
Male	33	51	19.52	<.001
Female	34	8		
SRS Score				
M (*SD*)	52.46 (10.49)	73.61 (10.95)	−11.07	<.001
Range	39–81	49–98		
Maternal education[a]				
M (*SD*)	4.03 (.89)	3.95 (.91)	.51	.61
Range	2–6	2–5		

[a]Maternal education was coded categorically, and ranged from 1 (less than high school) to 5 (graduate degree).
FSIQ-2 = Full Scale IQ Two-Subtest Form; SRS = Social Responsiveness Scale.

Table 2. BRIEF and BASC-2 Descriptive Statistics

	M (*SD*)			
Scales (*t*-scores)	TD ($n = 67$)	ASD ($n = 59$)	*F*	*p*
BRIEF BRI	51.36 (13.72)	70.66 (10.85)	75.35	<.001
Inhibit	51.88 (12.43)	66.64 (10.21)	52.18	<.001
Shift	51.34 (12.81)	72.15 (11.43)	91.54	<.001
Emotional control	51.01 (14.61)	65.81 (11.33)	39.57	<.001
BRIEF MCI	53.13 (12.85)	67.46 (9.30)	50.13	<.001
Initiate	52.78 (11.19)	66.92 (9.86)	55.91	<.001
Working memory	53.12 (13.14)	64.78 (9.64)	31.50	<.001
Plan/organize	53.61 (12.58)	67.80 (10.22)	47.42	<.001
Org of materials	54.22 (9.72)	59.19 (8.93)	8.82	.004
Monitor	50.12 (13.44)	64.37 (10.19)	44.03	<.001
BRIEF GEC	52.72 (13.24)	69.97 (9.31)	69.73	<.001
BASC-2 ADL	47.79 (9.59)	35.22 (9.25)	55.74	<.001
BASC-2 Func Comm	50.87 (10.73)	36.14 (8.08)	74.16	<.001
BASC-2 Social skills	49.58 (9.66)	37.27 (6.89)	66.19	<.001
BASC-2 Anxiety	51.09 (10.15)	55.64 (11.53)	5.56	.02
BASC-2 Depression	51.04 (10.58)	62.02 (14.57)	23.78	<.001

Note. ADL = Activities of Daily Living; ASD = Autism Spectrum Disorder; BASC-2 = Behavior Assessment System for Children, 2nd Edition; BRI = Behavioral Regulation Index; BRIEF = Behavior Rating Inventory of Executive Function; Func Comm = Functional Communication; GEC = Global Executive Composite; MCI = Metacognition Index; Org of Materials = Organization of Materials; TD = Typically Developing.

variances (ANOVAs) were conducted. In order to protect against inflated Type I error rates given the multiple comparisons, a Bonferroni correction was applied, and *P* values below .003 were considered significant. Hierarchical multiple regression analyses were then conducted separately for each group with BASC-2 adaptive functioning (ADL, functional communication, social skills) and mental health (anxiety, depression) scales as the dependent variables. Consistent with previous research, age and IQ were entered in the first block, followed by BRIEF composite indices (BRI, MCI). If the BRI or MCI significantly contributed to a model predicting adaptive functioning or mental health, a second set of regressions was then conducted including the subscales of the significant BRIEF index entered in step 2. All assumptions necessary for multiple regression analyses to be conducted and considered valid were met, and no outliers or influential points were detected.

Results

Table 2 presents the BRIEF and BASC-2 scale means and standard deviations across the ASD and TD groups. With the exception of organization of materials, children with ASD received significantly higher scores on all scales of the BRIEF, reflecting caregivers' perceptions of greater overall EF difficulty among this group. Similarly, children with ASD received significantly lower scores on the BASC-2 adaptive functioning scales (ADL, functional communication, social skills), and findings were unchanged when IQ was included as a covariate. With regard to mental health, children with ASD received significantly higher ratings (indicating greater symptoms) only on depression. No significant differences emerged across groups on the BASC-2 anxiety scale. As such, our first hypothesis was supported with the exception of anxiety symptoms.

Table 3. Hierarchical Multiple Regression Predicting Adaptive Skills from BRIEF – TD Children

	Activities of daily living			Communication			Social skills		
Predictor	β	t	P	β	t	P	β	t	P
BRIEF Index Analysis									
Step 1									
Age	−.14	−1.07	.29	−.19	−1.52	.13	−.19	−1.53	.13
FSIQ-2	.31	2.40	.02	.44	3.49	<.001	.47	3.84	<.001
Step 2									
Age	.03	.32	.75	−.03	−.28	.78	−.10	−.85	.40
FSIQ-2	.05	.57	.57	.20	2.13	.04	.32	2.79	.01
BRI	−.10	−.83	.41	−.28	−2.24	.03	−.01	−.08	.94
MCI	−.72	−6.34	<.001	−.47	−3.86	<.001	−.45	−2.92	.01
BRIEF Scale Analysis									
Step 2									
Age	.02	.20	.85	.01	.14	.89	−.06	−.53	.60
FSIQ-2	.06	.74	.46	.20	2.17	.04	.30	2.66	.01
Inhibit	-	-	-	.05	.27	.79	-	-	-
Shift	-	-	-	−.19	−1.27	.21	-	-	-
Emotional control	-	-	-	−.00	−.03	.98	-	-	-
Initiate	−.19	−1.44	.16	.02	.10	.93	−.31	−1.81	.08
Working memory	−.08	−.41	.69	−.37	−1.70	.09	.18	.73	.47
Plan/organize	.07	.39	.70	.26	1.31	.20	.27	1.15	.25
Org of materials	−.28	−2.55	.01	−.03	−.29	.78	−.08	−.54	.59
Monitor	−.43	−2.59	.01	−.52	−2.47	.02	−.62	−2.80	.01

Note. BRI = Behavioral Regulation Index; BRIEF = Behavior Rating Inventory of Executive Function; FSIQ-2 = Full Scale IQ Two-Subtest Form; MCI = Metacognition Index; Org of Materials = Organization of Materials; TD = Typically Developing.

EF and Adaptive Functioning

Activities of daily living. For TD children, the second model, which included both BRIEF index scores was statistically significant ($R^2 = .66$, $F(4, 62) = 29.74$, $P < .001$), and accounted for an additional 57.5% of the variance in ADL above age and IQ alone. Within this model, MCI was the only predictor to make a significant contribution to the model. When the MCI scales were included at Step 2 ($R^2 = .69$, $F(7, 59) = 19.03$, $P < .001$), both organization of materials and monitor emerged as significant, such that fewer EF difficulties in these domains were associated with better ADL skills (see Table 3).

For children with ASD, the second model was also significant ($R^2 = .56$, $F(4, 54) = 17.37$, $P < .001$), and accounted for an additional 52.7% of the variance above and beyond model 1. Both BRIEF indices, as well as age, emerged as significant predictors in the final model. When the individual BRIEF scales were included at Step 2 ($R^2 = .64$, $F(10, 48) = 8.67$, $P < .001$), older age, and better shifting and organization of materials abilities were significantly associated with better ADL scores (see Table 4).

Communication. For TD children, an additional 44.5% of the variance in functional communication skills was accounted for when BRIEF index scores were included at Step 2 of the regression model ($R^2 = .61$, $F(4, 62) = 23.71$, $P < .001$). Higher IQ, and fewer behavioral regulation and metacognitive challenges significantly predicted better communication skills. Interestingly, however, when all BRIEF scales were included at Step 2, only IQ and the BRIEF monitor scale made significant contributions to the model ($R^2 = .68$, $F(10, 56) = 11.78$, $P < .001$), such that higher IQ and better monitoring predicted better communication skills (see Table 3).

A different pattern emerged for children with ASD. Inclusion of the BRI and MCI at Step 2 resulted in 31.9% of additional explained variance ($R^2 = .43$, $F(4, 54) = 10.07$, $P < .001$). In the final model, higher IQ and better metacognition were significantly associated with better communication abilities. However, when the MCI scales were included at Step 2 ($R^2 = .50$, $F(7, 51) = 7.15$, $P < .001$), none of the predictors were significant at the .05 level, though the contribution of IQ, plan/organize, and monitor scores all approached significance ($P < .10$). Based on observed effects reported in past literature [Pugliese et al., 2015], post hoc power analyses indicated that there was not sufficient statistical power (Power = .32) to detect a small effect of MCI scales ($f^2 = .08$) at Step 2 with an alpha of .05 [Faul, Erdfelder, Buchner, & Lang, 2009] (see Table 4).

Social skills. For TD children, the second model, which included both BRIEF index scores was statistically significant ($R^2 = .38$, $F(4, 62) = 9.40$, $P < .001$), and accounted for an additional 19.1% of the variance in social skills above age and IQ alone. Within this model, IQ and MCI made significant contributions to the model. When the MCI scales were included at Step 2 ($R^2 = .46$, $F(7, 59) = 7.22$, $P < .001$), IQ and monitor emerged as significant, such that higher IQ and better monitoring abilities were associated with better social skills (see Table 3).

Table 4. Hierarchical Multiple Regression Predicting Adaptive Skills from BRIEF – Children with ASD

	Activities of daily living			Communication			Social skills		
Predictor	β	t	P	β	t	p	β	t	P
BRIEF Index Analysis									
Step 1									
Age	.17	1.32	.19	−.07	−.51	.61	.17	1.32	.19
FSIQ-2	−.06	−.43	.67	.32	2.50	.02	−.08	−.61	.55
Step 2									
Age	.33	3.31	.01	.02	.18	.86	.18	1.35	.18
FSIQ-2	−.11	−1.23	.22	.27	2.60	.01	−.12	−.96	.34
BRI	−.32	−2.81	.01	−.15	−1.14	.26	.04	.26	.80
MCI	−.54	−5.09	<.001	−.49	−4.04	<.001	−.44	−3.08	.00
BRIEF Scale Analysis									
Step 2									
Age	.23	2.21	.03	.06	.52	.60	.23	1.73	.09
FSIQ-2	−.12	−1.20	.24	.21	1.87	.07	−.13	−.97	.34
Inhibit	−.21	−1.82	.08	-	-	-	-	-	-
Shift	−.33	−2.59	.01	-	-	-	-	-	-
Emotional control	.19	1.32	.19	-	-	-	-	-	-
Initiate	−.11	−.81	.42	.06	.41	.69	−.25	−1.31	.20
Working memory	−.11	−.76	.45	−.28	−1.68	.10	.08	.40	.69
Plan/organize	−.21	−1.28	.21	−.34	−1.88	.07	−.30	−1.34	.19
Org of materials	−.26	−2.25	.03	.18	1.34	.19	.05	.29	.77
Monitor	−.03	−.18	.86	−.26	−1.75	.09	−.06	−.32	.75

Note. ASD = Autism Spectrum Disorder; BRI = Behavioral Regulation Index; BRIEF = Behavior Rating Inventory of Executive Function; FSIQ-2 = Full Scale IQ Two-Subtest Form; MCI = Metacognition Index; Org of Materials = Organization of Materials.

For children with ASD, the second model was also significant ($R^2 = .21$, $F(4, 54) = 3.62$, $P < .01$), and accounted for an additional 17.2% of the variance above and beyond model 1. Similar to TD children, the MCI emerged as a significant predictor in the final model. However, when the individual MCI scales were included at Step 2 ($R^2 = .25$, $F(7, 51) = 2.38$, $P < .05$), none of the predictors were significant at the .05 level, though the contribution of age approached significance ($P < .10$). Based on observed effects reported in past literature [Pugliese et al., 2015], post hoc power analyses confirmed that we had sufficient statistical power (Power = .75) to detect the effect of MCI scales ($f^2 = .22$) at Step 2 with an alpha of .05 (see Table 4).

EF and Mental Health

Anxiety. Neither the regression model including only age and IQ ($R^2 = .08$, $F(2, 64) = 2.77$, $P > .05$), nor that also including the BRIEF indices ($R^2 = .12$, $F(4, 64) = 2.20$, $P > .05$), were significant in predicting anxiety among our TD sample. This may be related to our sample size, as statistical power to detect a small effect ($f^2 = .02$) at the .05 level was .12 (see Table 5).

For children with ASD, the second model that included the BRI and MCI at Step 2 was significant ($R^2 = .26$, $F(4, 54) = 4.81$, $P < .01$), and accounted for an additional 6% of the variance in anxiety symptoms above age and IQ. However, in the final model, only age made a significant contribution, such that being older was associated with greater anxiety symptoms (see Table 6).

Depression. For TD children, the second model including both BRIEF index scores was statistically significant ($R^2 = .50$, $F(4, 62) = 15.66$, $P < .001$), and accounted for an additional 33.6% of the variance in depression above age and IQ alone. Within this model, age and BRI scores made significant contributions to the model. When the BRI scales were included at Step 2 ($R^2 = .57$, $F(5, 61) = 16.32$, $P < .001$), age and emotional control emerged as significant, such that being older and demonstrating poorer emotional control abilities were associated with more depressive symptoms (see Table 5).

For children with ASD, the second model was also significant ($R^2 = .38$, $F(4, 54) = 8.25$, $P < .001$), and accounted for an additional 28.6% of the variance above and beyond model 1. Similar to TD children, the BRI emerged as a significant predictor in the final model. When the individual BRI scales were included at Step 2 ($R^2 = .43$, $F(5, 53) = 8.07$, $P < .001$), both the shift and emotional control scales emerged as significant contributors. In both cases, poorer EF abilities were associated with more depressive symptoms (see Table 6).

Discussion

In the current study we examined the relative influence of everyday EF as indexed by parent report, at both the composite and subscale level, across a range of functional outcomes, including adaptive functioning and

Table 5. Hierarchical Multiple Regression Predicting Mental Health from BRIEF – TD Children

	Anxiety			Depression		
Predictor	β	t	P	β	t	P
BRIEF Index Analysis						
Step 1						
Age	.26	1.99	.05	.37	2.95	.00
FSIQ-2	−.26	−1.96	.06	−.38	−3.05	.00
Step 2						
Age	.21	1.56	.13	.21	2.08	.04
FSIQ-2	−.20	−1.49	.14	−.19	−1.83	.07
BRI	.30	1.64	.11	.62	4.48	<.001
MCI	−.13	−.71	.48	−.01	−.08	.94
BRIEF Scale Analysis						
Step 2						
Age	-	-	-	.29	2.93	.01
FSIQ-2	-	-	-	−.15	−1.58	.12
Inhibit	-	-	-	.01	.09	.93
Shift	-	-	-	.02	.13	.90
Emotional control	-	-	-	.65	4.48	<.001
Initiate	-	-	-	-	-	-
Working memory	-	-	-	-	-	-
Plan/organize	-	-	-	-	-	-
Org of materials	-	-	-	-	-	-
Monitor	-	-	-	-	-	-

Note. BRI = Behavioral Regulation Index; BRIEF = Behavior Rating Inventory of Executive Function; FSIQ-2 = Full Scale IQ Two-Subtest Form; MCI = Metacognition Index; Org of Materials = Organization of Materials; TD = Typically Developing.

Table 6. Hierarchical Multiple Regression Predicting Mental Health from BRIEF –Children with ASD

	Anxiety			Depression		
Predictor	β	t	P	β	t	P
BRIEF Index Analysis						
Step 1						
Age	.45	3.72	<.001	.29	2.26	.03
FSIQ-2	−.00	−.02	.99	.13	1.00	.32
Step 2						
Age	.36	2.73	.01	.07	.60	.55
FSIQ-2	.01	.09	.93	.15	1.37	.18
BRI	.22	1.48	.14	.53	3.90	<.001
MCI	.08	.59	.56	.09	.70	.48
BRIEF Scale Analysis						
Step 2						
Age	-	-	-	.02	.14	.89
FSIQ-2	-	-	-	.14	1.29	.20
Inhibit	-	-	-	−.04	−.30	.77
Shift	-	-	-	.35	2.35	.02
Emotional control	-	-	-	.37	2.28	.03
Initiate	-	-	-	-	-	-
Working memory	-	-	-	-	-	-
Plan/organize	-	-	-	-	-	-
Org of materials	-	-	-	-	-	-
Monitor	-	-	-	-	-	-

Note. ASD = Autism Spectrum Disorder; BRI = Behavioral Regulation Index; BRIEF = Behavior Rating Inventory of Executive Function; FSIQ-2 = Full Scale IQ Two-Subtest Form; MCI = Metacognition Index; Org of Materials = Organization of Materials.

mental health, among children with and without ASD. The parent-report measure is seen as an ecologically valid assessment of EF that identifies the specific areas in which children struggle when navigating through day-to-day routines and that may yield specific clinical targets for intervention.

As expected, children with ASD were rated as demonstrating significantly more EF difficulties when assessed with the BRIEF, across scales and summative indices, as compared to TD children matched on age, IQ, mental age, and maternal education. Interestingly, children with and without ASD were not significantly different on the organization of materials scale after applying a Bonferroni correction. In the current study, it was not actually the case that children with ASD were unimpaired on organization of materials, but instead that TD children also exhibited challenges in this domain. Indeed, a one-sample *t*-test confirmed that the difference between the mean *t*-score for our TD sample was significantly higher than that of the BRIEF normative sample ($t = 50$, $P < .01$). Huizinga and Smidts [2011] found that TD children aged 9–11 years were slightly worse in this domain as compared to 5–8 year olds, and this, may in part, explain our finding.

The observed BASC-2 ADL, functional communication, and social skills scores are consistent with evidence demonstrating that adaptive functioning is lower than cognitive abilities for individuals with ASD without intellectual disability [Klin et al., 2007], and significant group differences were observed across domains. In the current study, the 'typical' ASD adaptive profile, characterized by particular deficits in social skills [as assessed with the Vineland Adaptive Behavior Scales; Sparrow et al., 2005], was not observed, as among those with ASD, ADL received the lowest rating and social skills was in fact the highest. This profile, however, appears to vary depending on children's cognitive ability and whether standard or age equivalent scores are examined [Carter et al., 1998; Mouga, Almeida, Café, Duque, & Oliveira, 2015; Perry, Flanagan, Geier, & Freeman, 2009], and notably Volker et al. [2010] observed the same profile we did in this study using the BASC-2 among individuals with ASD of similar age ($M = 9.7$ years) and IQ ($M = 105.5$).

Although we hypothesized that children with ASD would demonstrate greater anxiety and depression than matched TD peers, this was only the case for the latter. Despite anxiety being a well-known comorbidity among those with ASD [Gillott, Furniss, & Walter, 2001; White et al., 2009], in the current study, the average anxiety score among those with ASD was in the average range. This is consistent with previous research [Goldin, Matson, Konst, & Adams, 2014; Mahan & Matson, 2011; Volker et al., 2010], and raises questions about the utility of the BASC-2 for measuring the expression of anxiety symptoms in this population. Others who also failed to find significant anxiety differences between children with and without ASD have suggested that this may be related to the scale's inclusion of items that rely on the child's ability to verbally communicate their worries (e.g., "says I'm afraid I will make a mistake") [Goldin et al., 2014; Mahan & Matson, 2011]. Such items, along with those that inquire about a child's concerns regarding others' perceptions of them (e.g., "Worries about what other children think"), may not reflect the specific kinds of anxieties experienced by individuals with ASD [Rieske et al., 2013; Wood & Gadow, 2010]. In contrast, significant differences emerged across groups on depression scores, which is consistent with previous research [Goldin et al., 2014; Johnston & Iarocci, 2017; Mahan & Matson, 2011; Volker et al., 2010].

For both children with and without ASD, inclusion of the BRIEF index scores at step 2 of our regression models resulted in significant additional explained variance for each domain of adaptive functioning, with the greatest amount of variance being accounted for ADL. Items within the ADL scale reflect independence around daily goal setting, safety awareness, routine following, and organization, all of which are skills that require metacognitive processes that govern how well a child is able to manage and monitor their behavior. Indeed, it was metacognitive processes that made the most significant contribution to ADL, as well as to communication and social skills. This was consistent with our expectations as well as with previous research [Gilotty et al., 2002; McLean et al., 2014; Pugliese et al., 2015].

Despite the consistent importance of metacognition at the composite level for adaptive functioning, different scales emerged as significant across the component subdomains for children with ASD. For ADL, organization of materials made a significant contribution to the model, as did shifting. The former inquires about how messy a child is and whether they can keep track of their belongings, and it is understandable that difficulties with these skills would contribute to challenges across personal, domestic, and community day-to-day functioning [Pugliese et al., 2015]. It was somewhat surprising that shifting was related to ADL, as this has not emerged within previous research, though this may relate to the inclusion of ADL items focused on organization and goal setting, as flexibility in problem solving and adaptability in the face of change would help one to plan more realistically. In contrast, none of the individual BRIEF scales significantly contributed to our models predicting functional communication or social skills among children with ASD, though for communication both the plan/organize and monitor scales approached significance. This is consistent with Wallace et al. [2016] who found plan/organize to be a significant predictor of conceptual skills, and with Pugliese et al. [2016], who identified that monitor significantly predicted communication scores. It may be that for both of these adaptive functioning domains, it is metacognitive abilities, collectively, that best translate into social and communicative competence, as opposed to proficiency within particular subdomains.

When the BRIEF scales were examined among our TD sample, monitor consistently emerged as a significant predictor across adaptive domains, highlighting that children's conscientiousness, as well as abilities to demonstrate insight into their strengths and weaknesses and to appreciate the effect their behavior may exert on those around them was predictive of practical, conceptual, and social capabilities. It is not surprising that these EF skills did not emerge for those with ASD, given the hallmark challenges such individuals experience with interpersonal insight and social nuance [Szatmari, 2011]. Organization of materials also emerged as significant for ADL, as was the case for those with ASD. It is difficult to compare these findings to previous research, as to our knowledge this is the first study to examine these associations with parent rating scales among TD children. Interestingly, for all outcomes the examined EF processes accounted for greater variance amongst TD children than was observed for those with ASD. There may be unique factors for children with ASD that were not accounted for in this research, such as symptom severity [McLean et al., 2014] and gender [White et al., 2017], that influence adaptive and internalizing behavior, that are not as relevant for children without the disorder.

The observed differences across groups suggest that there are potentially different executive mechanisms that are relied upon by children with and without ASD when negotiating the adaptive tasks associated with daily life, though metacognitive skills were highlighted as important for both. The results also indicate that children with and without ASD may benefit from different approaches to treatment. For example, TD children may require more targeted approaches, in which specific skills such as attentiveness and self-awareness are encouraged; whereas, for children with ASD, more generalized 'self-management' approaches that aim to improve goal-setting, organization, and problem solving, may be called for. We review interventions associated with improvements in the significant EF skills for both children with and without ASD later in the article.

When examining the relations between EF and mental health, our BRIEF indices were unrelated to anxiety. This is consistent with previous findings showing that neither the BRI nor MCI significantly predicted anxiety among young adults ($M = 21.6$ years) with ASD [Wallace et al., 2016], though it is inconsistent with the performance-based literature with ASD and TD samples that implicates the role of cognitive flexibility [Han et al., 2016; Hollocks et al., 2014]. In contrast, behavior regulation emerged as significantly associated with depression symptoms for children with and without ASD, with the emotional control scale emerging as significant across groups and shifting was significant only for those with ASD. There is limited prior work examining the relations between EF, particularly as assessed with behavior rating scales, and depression among children and adolescents [Hollocks et al., 2014]. The findings suggest that children who are best able to control their emotions and reactions are least likely to demonstrate depressive symptoms, but also underscore that depression may manifest as externalizing behavior. Clinicians supporting children who demonstrate angry outbursts, emotional lability, and who overreact should explore the association with internalizing problems such as depression, and look to treatment approaches that concurrently address both emotional control and depression symptoms.

Limitations and Future Directions

We note a few limitations in the current study. First, our measures of EF, adaptive functioning, and mental health were all completed by the same caregiver, and our findings may be influenced by some degree of shared method variance. The BRIEF and BASC-2 both have teacher report versions, and it would be interesting for future research to explore how ratings of behavior across different contexts (i.e., home and school) influence the observed associations. Second, the fact that we included only children with ASD with average or above average IQ mitigated concerns regarding the potential influence of co-morbid intellectual disability; however, it is possible that very different EF processes would have emerged had our inclusion criteria been broader and the current findings do not generalize beyond this group. ASD is a heterogeneous disorder, and future research that can extend their sampling methodology such that this variability is better represented will have greater clinical application and will better inform interventions for individuals across the spectrum. Finally, our sample size may have limited some of our analyses, particularly as related to anxiety (power = .12). An a priori power analysis revealed that a sample size of 602 would be required to detect a small size effect with a power of .80, and future research that includes larger samples will facilitate more fine-grained analyses.

Implications and Conclusions

The results of the current investigation illuminate the possibility that targeting particular EFs among children with and without ASD may not only have direct benefit for behavior regulation and metacognitive abilities, but also extend to other areas of life, including adaptive behavior and concomitant internalizing symptomatology, potentially protecting long-term functioning and well-being. We highlight some promising research that is emerging within the intervention literature, which reports improvements in the EF processes identified as relevant for adaptive functioning and mental health.

For those with ASD for example, Kenworthy et al. [2014] found that parents' and teachers' BRIEF shift and plan/organize ratings dropped significantly, such that children's scores were no longer in the clinically significant range after completing the Unstuck and On Target [Cannon, Kenworthy, Alexander, Werner, & Anthony, 2011] school-based cognitive behavioral intervention focused on flexibility, big picture thinking, and planning. Children also demonstrated significant improvements in their abilities to follow directions, transition easily, and to avoid getting stuck, as well as in social reciprocity, though this improvement also occurred for those in the control group. Similarly, Stichter, Herzog, Owens, and Malugen [2016] report positive outcomes associated with their school-based Social Competence Intervention for Adolescents (SCI-A) utilized with children with high-functioning autism and similar social challenges, including improved shifting, emotional control, working memory, planning and organization, and monitoring, as rated by teachers and parents, as well as improved social responsiveness. Finally, Hilton et al. [2014] describe a small-scale light and sound speed-based exergaming intervention, the Makota arena training intervention (Makoto USA, n.d.), which was associated with improvements in metacognition among children with ASD. In this program, participants strike lighted targets in response to tones, with signal speed increasing in .5-sec intervals.

Among TD children, there is support for computer-based training (e.g., CogMed), programs that combine computerized and interactive games, aerobic exercise, martial arts and mindfulness practice, and school curricula (e.g., Promoting Alternative Thinking Strategies [PATHS; Riggs, Greenberg, Kusché, & Pentz, 2006], Chicago School Readiness Project [CSRP; Raver et al., 2008; Raver et al., 2011]) [Diamond, 2012; Diamond & Lee, 2011]. We suggest that Flook et al.'s [2010] school-based mindfulness awareness program deserves particular attention, as it has been associated with improvements in shifting, initiation, planning and organizing, monitoring, emotional control, and working memory, as reported by parents and teachers. In this program, children complete developmentally appropriate exercises and games aimed at fostering self-awareness, regulation, and introspection, as well as awareness of others and of one's surrounding environment.

There is great potential for measures of everyday EF to guide targeted intervention among children with and without ASD [Iarocci & Gardiner, 2017; Isquith, Roth, Kenworthy, & Gioia, 2014]. The current literature in this area is small; however, the interventions that have been reviewed demonstrate promising results. To date, there is no available research on how EF interventions affect other areas of functioning, beyond social skills. The findings of the current study suggest that attention should also be paid to daily living skills, communication abilities, and internalizing symptoms. Future longitudinal work, in particular, would help to disentangle the long-term effects of early intervention, and determine whether such programs help strengthen protective developmental processes such as EF that may promote resilience both proximally and distally for individuals with and without ASD.

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Conflict of Interest

The authors declare that they have no conflict of interest.

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