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Longitudinal Examination of Adaptive Behavior in Autism Spectrum Disorders: Influence of Executive Function

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Abstract

This study characterizes longitudinal change in adaptive behavior in 64 children and adolescents with autism spectrum disorder (ASD) without intellectual disability (ID) evaluated on multiple occasions, and examines whether prior estimate of executive function (EF) problems predicts future adaptive behavior scores. Compared to standardized estimates for their developmental stage, adaptive behavior in most participants was impaired and did not improve over time. Prior EF predicted later adaptive behavior in daily living skills and socialization domains after controlling for age and IQ. Self-monitoring behaviors robustly predicted later adaptive behavior in all domains (d = 0.60-0.94). Results support targeting treatment of adaptive skills in ASD, as well as the importance of assessing for EF problems that may contribute to adaptive behavior difficulties.

Keywords

autism spectrum disorder; adaptive behavior; executive function; cognitive ability; longitudinal

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Of the increasing number of children identified with an Autism Spectrum Disorder, the fastest growing sub-group is those without co-occurring intellectual disability (ID; Baio, 2014). There is an expectation of positive outcome for these individuals, based on higher IQ, however the extant data does not support this optimism. Increased emphasis has been placed on understanding real world adaptive behaviors in adolescence and adulthood as it relates to functional outcome. Adaptive behavior is a term used to indicate a person's ability to function independently in his or her environment. Given that independent living status is more dependent on adaptive behavior than cognitive ability or autism spectrum disorder (ASD) symptomatology (Farley et al., 2009; Kanne et al., 2011) understanding the development of adaptive skills, as well as factors that contribute them, is critical to helping

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youth with ASD achieve optimal outcomes. Many of the findings on adaptive behavior related to autism have stemmed from studies utilizing heterogeneous samples, with far fewer studies focusing on individuals with ASD without ID (Lopata et al., 2013).

Adaptive behavior is strongly associated with IQ in typically developing individuals, but for individuals with ASD, even when typical levels of intelligence (IQ≥70) are present, ratings of adaptive behavior fall one to two standard deviations below the population mean (Lee & Park, 2007; Liss et al., 2001). There is some evidence that the discrepancy between adaptive behavior and IQ may increase with age (Bolte & Poustka, 2002; Pugliese et al., 2015), suggesting that cognitively able individuals with ASD fail to acquire adaptive skills at rates corresponding with gains in IQ.

The most commonly used measure of adaptive behavior is the Vineland Adaptive Behavior Scales (Sparrow, Balla, & Cicchetti, 1984; Sparrow, Cicchetti, & Balla, 2005), which emphasizes three adaptive domains in children over 6 years: Communication, Socialization, and Daily Living Skills. Individuals with ASD who do not have ID demonstrate greatest weakness in adaptive socialization skills, while adaptive communication skills, though still impaired, are a relative strength (Kenworthy, Case, Harms, Martin, & Wallace, 2010; Liss et al., 2001). Many of the ASD-related adaptive behavior findings have come from studies that either include individuals with ID (Lopata et al., 2013) or only contain cross-sectional information. It is important to determine the impact of individual factors on developmental course of adaptive behavior in order to identify candidates for intervention and predictors for optimal outcomes.

With one exception, studies that have examined within-person change in adaptive behavior skills in ASD have focused on early childhood, investigated isolated domains of adaptive behavior, or included youth with a wide range of cognitive abilities within the sample. Green and Carter (2014) assessed Vineland Adaptive Behavior Scales (VABS) Daily Living Skills in a large sample of toddlers (17-38 months) with ASD across diverse levels of IQ over a 3-year period and reported an increase in daily living skills (i.e., an increase in raw scores), though the rate of gain was slower than found among typically developing children (i.e., a decrease in standard scores over time). Thus, the gap in daily living skills between children with ASD and typically developing children increased across early childhood. Lower IQ scores and higher levels of ASD symptoms were associated with slower adaptive gains. Freeman and colleagues (1999) investigated a mixed sample of ASD children and young adults with and without ID and found that those without ID showed greater gains in adaptive behavior over time than those with ID. A recent study by Smith and colleagues (Smith, Maenner, & Seltzer, 2012) examined longitudinal change in adolescents and adults (aged 10-52 years at first assessment) with ASD with a wide range of cognitive abilities. Using the Waisman Activities of Daily Living Scale administered over a decade at four different time points, latent growth curve modeling analyses indicated that daily living skills (raw scores) improved for individuals with ASD during adolescence and their early 20s, plateaued during their late 20s, and declined in their early 30s. Notably, 70% of the sample was diagnosed with ID, which was associated with lower initial skill levels and a slower rate of change over time but a similar trajectory to those with ASD without ID. These findings stood in stark contrast to a comparison group of individuals with Down Syndrome, who continued to gain skills throughout adulthood.

To date, only one study has examined longitudinal change in VABS scores in a sample comprised exclusively of children with ASD without ID. Szatmari and colleagues (2009) investigated developmental trajectories of children with ASD from early childhood to adolescence, though their aim was to determine whether the presence of structural language impairment differentiated autism from Asperger syndrome. Children were assessed at five different time points between the ages of 2 and 19 years. Hierarchical linear modeling (HLM) analyses indicated that VABS Communication, Socialization, and Daily Living skills standardized scores tended to increase across development and then flatten by approximately 17 years of age in both groups. Thus, there is evidence that children with ASD may reach a plateau in their level of adaptive skills across development. Taken together, these longitudinal studies suggest that daily living skills in youth with ASD improve during early childhood and into adolescence, although the rate of change slows over time, and that the presence of (ID) further slows the rate of growth.

Several cross-sectional studies have reported age-related declines in standardized adaptive behavior scores, (Duncan & Bishop, 2015) but they have also either included individuals with ID in their samples (Kanne et al., 2011; Klin et al., 2007) or only examined the relationship between age and daily living skills (Duncan & Bishop, 2015). Klin and colleagues (2007) reported strong negative correlations between age and adaptive behaviors in the areas of (standardized) Communication and Socialization skills in a sample of children and adolescents aged 7-18. In a large sample of 1,089 children between the ages of 4 and 17, Kanne and colleagues (2011) indicated 37% of the variability in total adaptive scores was predicted by age. In an examination of adaptive behavior in a sample exclusively of ASD children, adolescents, and young adults aged 4-23 years without ID, Pugliese and colleagues (2015) found age related differences in Communication, Daily Living Skills, and Socialization (standardized) scores. In their sample, age was found to be a negative predictor of these domain scores, accounting for between 6 and 28% of the variance in scores. These cross-sectional findings are important given how few longitudinal studies have been conducted and highlight the need for further investigation of how adaptive skills change over time for individuals with ASD without ID. It is particularly important to determine factors that are associated with improvements in these skills so that they can be targeted for intervention.

Common correlates of adaptive behavior such as IQ, sex, and ASD symptoms have generally been found to have small effects on adaptive behavior in ASD without ID, though recent research suggests that executive functioning (EF) may have greater effects on the development of adaptive behavior skills than these other factors (Pugliese et al., 2015). Given age-related increases in parent reported EF problems in ASD compared to typically developing populations (Rosenthal et al., 2013), it is important to account for EF when predicting adaptive abilities across development. EF problems are frequently documented in ASD and play a role in the observed social and cognitive deficits in this population (Hill, 2004; Kenworthy, Yerys, Anthony, & Wallace, 2008). Behavioral manifestation of EF difficulties has been linked to difficulty with adaptive behavior (Gilotty, Kenworthy, Sirian, Black, & Wagner, 2002) above and beyond IQ and ASD symptom severity. Pugliese and colleagues (2015) reported that fewer EF problems were associated with better adaptive behavior in youth with ASD without ID. Specifically, EF behaviors accounted for between 5-17% of the variance in Communication, Daily Living Skills, and Socialization skills, above and beyond age and IQ. McLean and colleagues (2014) reported similar findings in their cross-sectional sample of youth with ASD. Parent-reported EF deficits were related to profound age-related decreases in standardized adaptive behavior scores, even after controlling for age, IQ, and severity of ASD symptoms. Importantly, the association between EF and adaptive behavior is also found when using laboratory measures of EF skills. Using a “flexible thinking” factor derived from EF tasks (e.g., Tower of Hanoi, Wisconsin Card Sorting Test, etc.), Williams and colleagues (2014) found that flexible thinking scores significantly correlated with VABS adaptive behavior composite scores in children and adults with ASD without ID.

Present Study

The primary aim of the present study was to characterize longitudinal change in adaptive behavior skills from childhood to young adulthood in a sample of individuals with ASD without ID. A secondary aim was to determine whether EF is predictive of the development of adaptive behavior skills. Hypotheses were aligned with cross-sectional findings given large sample sizes that utilized standard scores compared to longitudinal studies. Specifically, it was hypothesized that:

1) Standardized adaptive behavior scores will decrease or stagnate with age.

2) IQ will demonstrate a (significant but small) relationship to adaptive behavior.

3) Greater prior EF skills would predict higher levels of subsequent adaptive behavior.

Method

Procedure

This project used archival data in compliance with the institution’s IRB. Participants were previously evaluated for clinical and/or research purposes in the autism center of a children’s hospital. Informed assent and consent were obtained when appropriate. Participants were evaluated on multiple occasions (M = 2.63 occasions, SD = 0.80, range 2-5 times) separated by at least 6 months (M = 3.40 years, SD = 5.41, range 0.5-9.3) resulting in a total of 170 adaptive behavior observations. Participants had a prior assessment of EF for 92 subsequent adaptive behavior evaluations.

Participants

Participants were 64 children and adolescents (13 females) between the ages of 3 and 14 at their first VABS evaluation (M = 8.12 years, SD = 2.59). Participants ranged in age from 7 to 23 at their last VABS administration (M = 12.88 years, SD = 3.46). Trained and experienced clinicians diagnosed all participants with ASD using DSM-IV-TR criteria (American Psychiatric Association, 2000). In addition, all participants met criteria established by the NICHD/NIDCD Collaborative Programs for Excellence in Autism

(Lainhart et al., 2006) using the Autism Diagnostic Interview (ADI; Le Couteur et al., 1989) or Autism Diagnostic Interview–Revised (ADI-R; Lord, Rutter, & Le Couteur, 1994) and/or the Autism Diagnostic Observation Schedule (Lord et al., 2000; ADOS) or the Autism Diagnostic Observation Schedule, Second Edition (Lord et al., 2012; ADOS-2). Table 1 provides information on characterization measures in the sample.

All participants possessed a full scale IQ estimate at or above 70 (range 72-154) measured by the Wechsler Abbreviated Scale of Intelligence-four subtest version (Wechsler, 1999; n = 22), Wechsler Intelligence Scale for Children-III (Wechsler, 1991; n = 8), or Wechsler Intelligence Scale for Children-IV (Wechsler, 2003; n = 34). Full scale IQ estimates were taken from the participants' first evaluation. Exceptions were made for children who received a Wechsler Preschool and Primary Scale of Intelligence-III, (Wechsler, 2002) in which case the IQ score from the subsequent assessment was taken to provide a more reliable and stable IQ estimate. Participants with co-morbid genetic conditions, traumatic brain injury, and known neurological disorders that may affect cognitive functioning were excluded.

Participants were primarily Caucasian (81%), with smaller proportions of African American (10.3%) and Asian (8.6%) individuals. Approximately 11% of the participants were Hispanic or Latino/a. The majority of participants' mothers were educated at the graduate school level (48.1%), with smaller numbers attending college (37%), partial college (7.4%), or high school (7.4%).

Measures

ASD diagnoses were confirmed in all participants through the ADI/ADI-R (n = 54), a standardized caregiver interview, and/or the ADOS/ADOS-2 (n = 56), a standardized interactive play-based assessment that assesses ASD symptoms in the areas of communication, reciprocal social behavior, and repetitive behaviors and stereotyped interest patterns.

Behavior Rating Inventory of Executive Function, Parent Form (BRIEF; Gioia, Isquith, Guy, & Kenworthy, 2000). The BRIEF is an informant report questionnaire that assesses the behavioral manifestation of executive function abilities in children. The overall Global Executive Composite (GEC) score is divided into two main indices, the Behavioral Regulation Index (BRI) and the Metacognition Index (MCI). The BRI is further divided into three scales (initiate, emotional control, shift) and the MCI is divided into five scales (inhibit, organize/plan, organization of materials, working memory, monitor). Higher scores indicate more executive function problems, with T-scores above 65 indicating clinically significant ratings. The BRIEF has demonstrated acceptable reliability, and both convergent and discriminant validity are well established (Gioia et al., 2000).

The Vineland Adaptive Behavior Scales, First and Second Edition (VABS, VABS-II; Sparrow et al., 1984; Sparrow et al., 2005). The VABS is a standardized, structured parent/caregiver interview of adaptive skills. For the purposes of the current study, the Communication, Daily Living, and Socializations domain standard scores were used. Each domain standard score has a mean of 100 and standard deviation of 15. The VABS has demonstrated strong reliability and validity (Sparrow et al., 2005). The VABS (n = 40) and VABS-II (n = 130) was given as an interview in the current study.

Data Analyses

In order to characterize change in adaptive behavior scores over time, Reliable Change Indices (RCI; Jacobson & Truax, 1991) were calculated for consecutive observations on the VABS within each participant. For example, four RCIs were calculated for a participant who received five consecutive VABS administrations. The RCI determines change across two occasions, accounting for measurement error. RCIs were characterized as *improved*, *deteriorated*, or *unchanged* (see Figure 1). In order to determine clinical significance of the change, the second VABS score in each RCI (t+1) was categorized using VABS adaptive skill level descriptions (see Figure 2). Scores of 85 or less were classified as "low," and scores between 86 and 115 were classified as "acceptable" and encompassed both the "adequate" and "high" qualitative descriptors on the VABS. In this respect, an observation classified as *unchanged* whose t+1 score was categorized as "low" would be more clinically worrisome than an observation classified as *unchanged* whose t+1 score was in the "acceptable" range.

To examine whether prior estimates of EF (t) predicted later adaptive behavior (t+1) a series of hierarchical multiple regressions were conducted using VABS (t+1) domain scores as the dependent variable. For all regression analyses, prior age (t), baseline IQ, prior VABS score (t), interval of time between assessments, and the interaction term for age and interval of time between assessments (to control for the amount of time between evaluations that may vary as a function of age) were entered in the first block, followed by the prior BRIEF GEC (t) score in the second block. Gender and years of maternal education were initially entered into the regression equation, but were omitted from further analyses due to nonsignificant findings.

Exploratory analyses were conducted to examine which specific EF domains predicted later estimates of adaptive behavior. BRIEF subscales were entered as predictors of subsequent VABS domain scores along with the variables described above. Due to multi-collinearity between BRIEF subscales, each subscale was entered independently of other BRIEF subscales, but in combination with the other variables of interest in the previous analyses. Due to the number of comparisons in these models, findings at $p < .05$ may be significant by chance; therefore, we have included estimates of effect size along with significance.

Results

RCI Analyses

Reliable change status for consecutive observations of VABS scores is presented in Figure 1. Overall, there were 170 VABS observations among participants, resulting in 110 RCI classifications. Across all of the domains, 61-72% of cases were classified as unchanged with roughly equal proportions classified as improved (12-20%) or deteriorated (16-20%). When considering the descriptive adaptive level of the $t+1$ score, observations characterized as being in the Low adaptive range at t+1 contained a higher proportion of RCI scores that deteriorated or remained unchanged than observations that were in the Acceptable range (see Figure 2).

Main Regression Analyses

Correlations among the variables of interest are presented in Table 2 and results of regression analyses are presented in Table 3.

Higher Communication scores at time *t*, lower age, less time between assessment, and the age*time between assessment interaction were significant predictors of subsequent Communication scores in the first model, accounting for 33% of the variance ($F_{5,85} = 8.53$, $p < 0.001$). When the BRIEF GEC score was added, the model remained significant ($F_{6,84} = 7.68$, $p < 0.001$), but GEC was not a significant predictor of Communication scores.

Greater time *t* Daily Living Skills scores and lower age were significant predictors of subsequent Daily Living Skills scores ($F_{5,85} = 3.38$, $p < 0.01$), accounting for 17% of the variance in scores. When the EF composite was added to the model, the only significant negative predictors of Daily Living Skills were age and BRIEF GEC score. The inclusion of the GEC score into the model accounted for an additional 4% of the variance in VABS scores ($F_{4,86} = 3.63$, $p < 0.01$).

Higher Socialization scores at time *t*, lower age, and the age*time between assessment interaction term were significant predictors of subsequent Socialization scores and the overall model was significant ($F_{5,85} = 4.08$, $p < 0.01$), accounting for 19% of variance in subsequent scores. When EF scores were included in the model, higher baseline Socialization scores, younger age, shorter amount of time between assessment, greater EF problems, and the interaction term between age and interval between assessment predicted lower subsequent Socialization skills ($F_{4,86} = 4.97$, $p < 0.001$). Inclusion of EF in the model explained an additional 7% of the variance in scores.

Notably, IQ was not a significant predictor of adaptive behavior in any domain. The age*time between assessment interaction signifies a complex relationship between the variables, where adaptive behavior varied as a function of age and assessment interval, but is not readily meaningful.

Exploratory Regression Analyses

When BRIEF subscales were individually entered into the model predicting VABS Communication scores, problems with monitoring ($t_{80} = -2.69$, $p < 0.01$, $d = -0.60$) significantly predicted lower Communication skills. The model as a whole was significant ($F_{6,80} = 7.95$, $p < .001$) and explained 37.3% of the variance in scores.

For the Daily Living Skills domain, difficulties with inhibition ($t_{83} = -2.59$, $p < 0.05$, $d = -0.57$) and monitoring skills ($t_{80} = -3.86$, $p < 0.001$, $d = -0.86$) significantly predicted lower VABS scores when entered in isolation. Both models were significant ($F_{6,83} = 4.02$, $p < .01$ and $F_{6,80} = 5.62$, $p < .001$, respectively) and explained 22.5% and 28.3% of the variation in Daily Living Skills scores.

When BRIEF subscales were entered separately to predict VABS Socialization scores, problems with inhibition ($t_{83} = -2.47$, $p < 0.05$, $d = -0.54$), shifting ($t_{82} = -2.47$, $p < 0.05$, $d = -0.55$), and monitoring ($t_{80} = -4.22$, $p < 0.001$, $d = -0.94$) skills were significant predictors. All models were significant ($F_{6,83} = 4.21$, p < .01; $F_{6,82} = 4.17$, p < .01; and $F_{6,80} = 6.64$, p < .001, respectively) and explained between 23.3 and 33.3% of the variance in Socialization.

Discussion

This is the first longitudinal study in children with ASD without ID to (1) track adaptive behavior into young adulthood and (2) investigate how behavioral manifestation of EF is associated with future adaptive behavior. The present investigation of 64 individuals with ASD without ID documented overall impairments in adaptive behavior skills that do not improve in the majority of the sample and demonstrated that impairments are related to EF problems rather than IQ. Consistent with prior research (Lee & Park, 2007; Liss et al., 2001), mean levels of initial adaptive behavior skill ratings in the present sample fell approximately one to two standard deviations below the population mean.

Our findings supported the hypothesis that adaptive behavior skills would stagnate, but not generally decline, as children with ASD without ID move into young adulthood. RCI analyses indicated that for the vast majority of consecutive VABS observations in the sample, adaptive behavior standard scores remained impaired and unchanged over time, despite intact cognitive abilities. When the qualitative adaptive level (e.g., “low” vs. “acceptable”) at the subsequent observation (*t*+1) was taken into account, the vast majority of observations that did not change or that declined ended up in the low range. Notably, a smaller proportion of observations remained in the acceptable adaptive skill range, suggesting adequate outcome during these periods. Taken together, these findings are worrisome and indicate that the majority of observations within the sample of individuals with ASD without ID remained impaired when compared to the normative sample. Although age standardized scores are not expected to change over time in typical development, it is notable when scores that are significantly depressed in relation to both age and IQ do not improve in a group of individuals who are actively receiving clinical guidance as evidence by their repeated evaluations.

With respect to change in specific domains of adaptive skill level over time, regression analyses indicated Daily Living Skills standard scores declined as age increased. While differences in type of score (standardized vs. raw) and adaptive measure may account for differences between our findings and Smith and colleagues’ (2012) findings of increases in daily living raw scores until age 30, they stand in sharp contrast to studies that have documented increases in VABS standard scores over time (Freeman et al., 1999; Szatmari et al., 2009). However, other studies of ASD report negative associations between age and adaptive skills in cross-sectional designs (Duncan & Bishop, 2015; Pugliese et al., 2015). Further research is needed to clarify the trajectory of daily living skills over time.

The relationship between age and Communication and Socialization skills was qualified by an interaction between age and length of time between evaluations. The interaction was significant in initial analyses and remained significant when EF was incorporated in the analyses. This term was included to control for heterogeneity in the data set, and its clinical interpretation is potentially less meaningful with only two time points. We believe that this relationship may signify a potential non-linear relationship between age and adaptive behavior, and that future studies should assess adaptive behavior in all participants at several regular intervals to provide more meaningful results.

Our findings aligned with prior evidence for markedly lower adaptive skills than intellectual ability in individuals without ID (Klin et al., 2007; Pugliese et al., 2015). Initial ratings of adaptive behavior in the present sample fell 2-3 standard deviations below initial IQ scores. Strikingly, IQ was not a significant predictor of later adaptive behavior in any domain, despite the wide variance in cognitive abilities. This is in contrast to prior longitudinal research demonstrating that lower IQ is associated with slower adaptive gains (Freeman et al., 1999; Green & Carter, 2014; Smith et al., 2012). The discrepancy in findings may be attributable to the inclusion of youth with ID in previous longitudinal samples. Taken together, it appears that for the growing numbers of children with ASD without ID, IQ may not be the most important, or only, determining factor in outcome.

Finally, this first investigation of behavioral manifestation of EF as a predictor of adaptive behavior provides further support of a negative relationship between global real-world EF problems and adaptive behavior in youth with ASD previously reported in cross-sectional data (Gilotty et al., 2002; Pugliese et al., 2015). Initial EF evaluation revealed a profile of EF problems that is highly consistent with previous reports (Hill, 2004; Kenworthy et al., 2008). Problems with global EF contributed to lower adaptive behavior scores above and beyond demographic variables and IQ in the VABS Daily Living and Socialization domains, accounting for 4-7% of the variance in scores, but not the Communication domain. Although we cannot speak to a causative relationship, these results clearly indicate deficits in real-world EF skills are associated with later adaptive impairments in youth with ASD. Results from the present study support clinical observations that the gap between environmental expectations and the actual ability of a child with ASD widens over time, and EF accounts for a proportion of this change.

Our exploratory analyses attempted to isolate the relationship between specific EF skills and adaptive behavior. In the current study, poorer monitoring skills were a robust predictor of lower subsequent adaptive behavior across VABS domains. Self-monitoring refers to the ability to monitor one's own actions and progress toward a predefined goal and adjust one's behavior accordingly. Impaired self-monitoring has been linked to several symptom domains in ASD including perseverative responding, repetitive behaviors, and joint attention impairments (Hill, 2004), however, this is the first study to link monitoring to adaptive behavior. Successful execution of goal-directed behaviors is critical to the development of real world communication, daily living, and socialization skills. Monitoring skills in ASD may be impaired from an early age and/or may not be improving rapidly enough across development to keep pace with increased environmental demands. As such, explicitly targeting the improvement of self-monitoring and associated self-management skills may improve outcome in ASD.

Problems with inhibition related to poorer scores in Daily Living Skills and Socialization domains. Inhibition denotes the ability to voluntarily and deliberately suppress an automatic behavioral response. This skill, as measured by neuropsychological tasks, was initially thought to be preserved in ASD (Ozonoff & Strayer, 2001; Pennington & Ozonoff, 1996), but more recent work is suggestive of impairments among youth without ID (Christ, Holt, White, & Green, 2007; Hill, 2004; Luna, Doll, Hegedus, Minshew, & Sweeney, 2007). Behavioral manifestation of EF might be implicated in such skills as turn-taking during conversations with peers or learning a new way to do a chore by inhibiting the previously learned method. Yerys and colleagues (2009) reported that children with ASD and co-morbid Attention-Deficit/Hyperactivity Disorder (ADHD) symptoms had greater impairments in inhibition compared to children with ASD without ADHD as well as poorer adaptive behavior.

The present longitudinal study replicated our previous cross-sectional finding (reference removed for blinded peer review) that poorer shifting abilities predict lower subsequent adaptive behavior skills within the Socialization domain. Shifting skills represent the ability to intentionally shift thoughts and actions in response to contextual changes and are an area of weakness in youth with ASD (Granader et al., 2014; Rosenthal et al., 2013) associated with social communication impairments (Kenworthy et al., 2008; McEvoy, Rogers, & Pennington, 1993). Poor shifting abilities, such as difficulty compromising due to lack of flexible thinking, resisting new social situations, or difficulty with transitions resulting in “meltdowns” may significantly impact relationships for individuals with ASD throughout the lifespan. Indeed, gains in social skills were observed in children with ASD who participated in a randomized controlled trial to improve flexibility (Kenworthy et al., 2014) indicating that shifting abilities are important to real world behavioral outcomes.

Limitations

The current study has several limitations and suggests areas for future direction. Participants’ performance was assessed via parent-report measures, an indirect measurement of abilities, which may have led to an incomplete or biased understanding of the participant. Utilization of lab-based measures of EF and other-informant report (i.e., teacher) would strengthen the conclusions made by this study. Although we calculated change in VABS scores across several assessment points in a large sample of children, each change score was treated as a separate case to increase the sample size. Due to our sample size, some findings with medium effect sizes were only significant at the $p < .05$ level, which indicates the need for replication in a larger sample. Although we attempted to control for the heterogeneity in age of assessment and assessment interval by including the interaction term, future research should explore these research questions using a cohort assessed at similar ages and intervals. Also, the relatively small number of participants assessed at 3 or more time points (n=32) precluded the use of HLM, which will be essential to truly model trajectories of EF and adaptive behavior. It is also possible that change over time on adaptive behavior could represent regression toward the mean, as opposed to true clinical change. Additionally, we focused specifically on EF and key cognitive and demographic variables to predict outcomes in adaptive behavior. Future research should consider other variables such as comorbid psychopathology, intervention, and family factors in addition to EF skills. Finally, we must also note that, based on the education level of the participants' mothers in this study, our sample had much higher than average social economic status. Although maternal education was not a significant predictor of adaptive behavior in this study, it is still the case that this sample may have had more access to treatment than is typical, making the findings of declining adaptive behavior even more concerning.

Conclusion

Adaptive skills are impaired in youth with ASD without ID and there are minimal improvements on standardized scores over time. Results from this study support the notion that real-world EF skills are important to adaptive behavior outcomes. Specifically, inhibition, shifting, and monitoring skills played a significant role in predicting future adaptive behavior scores. It will be important to target adaptive skills, and the EF skills that contribute to them, in individuals with ASD across development in order to improve outcome.

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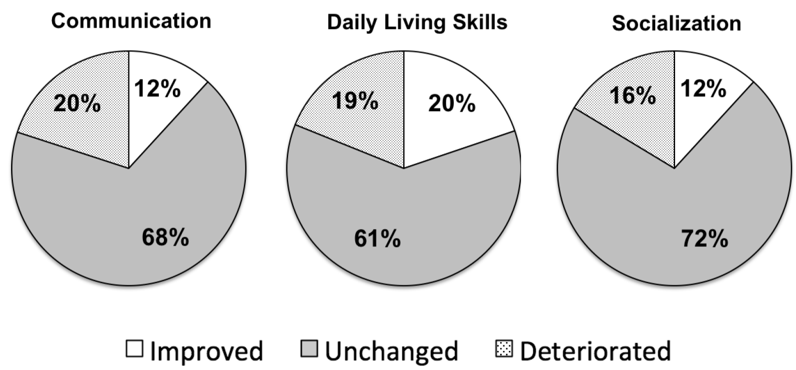

Figure 1.

RCI Status for Sample by VABS Domain Scores.

Note: Numbers indicate the percentage of consecutive occurrences classified as improved, unchanged, or deteriorated.

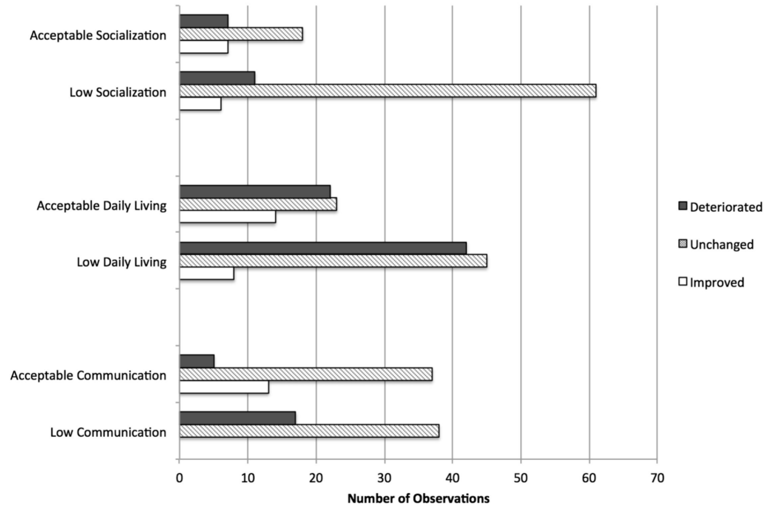

Figure 2.

RCI Status for VABS Domain Scores Grouped by acceptable (e.g., adequate or high scores ranging from 85-115) and low (scores of 85 or less) VABS Adaptive Level at t+1: Most of the unchanged adaptive scores remained in the low (Impaired) range at t+1.

Table 1

Sample Demographics, EF and Adaptive Behavior Descriptives at first VABS evaluation.

	M	SD	n
Age (years)	8.43	2.29	64
Full Scale IQ	107.03	19.83	64
ADOS Social + Communication Total	12.13	4.54	56
ADOS Restricted & Repetitive Behaviors	3.39	3.74	
ADI Reciprocal Social Interaction	18.33	5.55	
ADI Verbal Communication	15.36	5.07	54
ADI Restricted, Repetitive and Stereotyped Behaviors	6.26	2.91	
BRIEF Behavior Regulation Index	66.48	10.35	
Inhibit	64.79	11.97	
Emotional Control	60.76	11.21	
Shift	69.32	13.54	
BRIEF Metacognition Index	64.03	11.22	
Initiate	61.85	10.22	64
Organize/Plan	62.79	12.93	
Organization of Materials	57.00	10.66	
Working Memory	64.00	11.94	
Monitor	64.07	11.16	
BRIEF Global Executive Composite	66.00	10.54	
VABS Communication	86.44	16.53	
VABS Daily Living Skills	79.61	14.11	64
VABS Socialization	76.11	14.27	

Note: Age listed is the age at first VABS administration; BRIEF scores are reported as T scores (M = 50, SD = 10) and VABS scores are reported as standard scores (M = 100, SD = 15).

Table 2

Correlations among Vineland Variables at time t and t+1 and BRIEF at time t

	1	2	3	4	5	6
1. *t* Communication	---					
2. *t*+1 Communication	.44**	---				
3. *t* Daily Living	.55*	.34**	---			
4. *t*+1 Daily Living	.32**	.63**	.29**	---		
5. *t* Socialization	.59**	.32**	.63**	.35**	---	
6. *t*+1 Socialization	.28**	.59**	.29**	.66**	.35**	---
7. *t* BRIEF GEC	−.29**	−.21*	−.38**	−.27**	−.45**	−.35**

GEC = Global Executive Composite score

Table 3

Parent Reported Executive Functioning Difficulties Predict Subsequent Adaptive Skills

	Communication			Daily Living Skills			Socialization		
Predictor	***B***	**SE *B***	***t***	***B***	**SE *B***	***t***	***B***	**SE *B***	***t***
Block 1									
Baseline VABS	0.29	0.11	**2.55** *	0.27	0.12	**2.28** *	0.35	0.09	**3.24** **
Age	−5.21	1.52	− **3.44** **	−4.12	1.70	− **2.42** *	−3.07	1.46	− **2.10** *
IQ	0.14	0.08	1.64	0.03	0.08	0.40	0.05	0.07	0.74
Time between Measures	−12.47	3.97	− **3.14** **	−6.95	4.53	−1.53	−7.64	3.85	−1.98
Age*time between measures	1.23	0.42	**2.91** **	0.86	0.48	1.81	0.90	0.41	**2.23** *
Model Summary	$F_{5,85} = 8.53^{***}$, $R^2 = 0.33$			$F_{5,85} = 3.38^{**}$, $R^2 = 0.17$			$F_{5,85} = 4.08^{**}$, $R^2 = 0.19$		
Block 2									
Baseline VABS	0.25	0.11	**2.18** *	0.20	0.12	1.68	0.24	0.101	**2.12** *
Age	−5.14	1.50	− **3.42** **	−4.05	1.67	− **2.43** *	−3.02	1.41	− **2.15** *
IQ	0.16	0.08	1.95	0.06	0.08	0.74	0.09	0.07	1.27
Time between Measures	−12.14	3.94	− **3.08** **	−6.99	4.44	−1.57	−7.41	3.71	− **2.00** *
Age*time between measures	1.21	0.42	**2.89** **	0.88	0.47	1.87	0.90	0.39	**2.28** *
BRIEF GEC	−0.21	0.13	−1.62	−0.30	0.15	− **2.06** *	−0.36	0.13	− **2.79** **
Model Summary	$F_{6,84} = 7.68^{***}$, $R^2 = 0.35$			$F_{6,84} = 3.63^{**}$, $R^2 = 0.21$			$F_{6,85} = 4.97^{***}$, $R^2 = 0.26$		

Note: Regression weights reported are unstandardized;

* $p < .05$,

** $p < .01$,

*** $p < .001$.