Developmental Trajectories of Adaptive Behavior from Toddlerhood to Middle Childhood in Autism Spectrum Disorder

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Abstract

Longitudinal growth modeling was utilized to examine adaptive behavior over eight years across the three time points (i.e., ages 2-10). Seventy-six parents completed the Vineland Adaptive Behavior Scales interviews of adaptive behavior. Child participants completed standardized developmental testing and an executive function task in toddlerhood and the Autism Diagnostic Observation Schedule across all time points. Growth models were specified for communication, daily living skills, and socialization domains of adaptive behavior. Mental age in toddlerhood was a significant predictor of trajectories of communication, daily living skills, and socialization. Executive function and autism severity were significant predictors of socialization. Findings suggest executive function as a potential target for promoting the growth of adaptive behavior skills in addition to autism symptomology.

Key Words: adaptive behavior; autism spectrum disorder; developmental trajectory

Adaptive behavior is considered critical to performing tasks independently and is associated with quality of life in childhood (Gardiner & Iarocci, 2015; Tasse et al., 2012). The term *adaptive behavior* is commonly used to describe an individual's functional skills within developmentally appropriate, everyday activities (American Association on Intellectual and Developmental Disabilities [AAIDD], 2013). These skills include communication (e.g., comprehending and expressing language), daily living skills (e.g., eating and dressing), and socialization (e.g., forming friendships and play skills) (AAIDD, 2013). In adults with developmental disabilities, better adaptive skills are associated with greater opportunities for employment and increased independence in residential settings (Farley et al., 2009; Foley et al., 2013; Woolf, Woolf, & Oakland, 2010).

Children with Autism Spectrum Disorder (ASD) demonstrate adaptive behavior difficulties across the lifespan regardless of intellectual functioning (Bolte & Poustka, 2002; Duncan & Bishop, 2015; Farley et al., 2009; Freeman et al., 1999; Liss et al., 2001; Kanne et al., 2011; Klin et al., 2007). Research suggests that children with ASD who have IQs in the average to above-average range have unexpected difficulties in adaptive behavior (Kanne et al., 2011; Kenworthy et al., 2010; Klin et al., 2007; Pugliese et al., 2015). Therefore, adaptive behavior is a significant area for establishing goals in clinical, home, and school settings (Tasse et al., 2012). More longitudinal research is needed to understand how adaptive behavior changes over time in children with ASD. This information is necessary to develop tailored interventions that will promote meaningful change. The purpose of the current study was to examine developmental trajectories of adaptive behavior from toddlerhood to middle childhood in children with ASD. We also examined the extent to which areas of cognitive functioning, autism severity, and maternal education predicted these trajectories.

Adaptive Behavior Construct

Adaptive behavior has a long history in conceptualization and measurement dating back to the Renaissance and Reformation period in the 1800s as a way to describe individuals with intellectual disability (Price, Morris, & Costello, 2018; Sheerenberger, 1983, Sparrow, Cicchetti, & Saulnier, 2016) and has been an integral component of an intellectual disability since AAIDD published its first manual in 1959 (Heber 1961; AAIDD, 2010). Models of adaptive behavior incorporate multidimensional measurement of conceptual (communication), practical (daily living skills), and social (socialization) skills (AAIDD, 2010; Sparrow et al., 2016; Tasse et al., 2012). The Vineland Adaptive Behavior Scales is a widely known measurement tool of adaptive behavior that defines the construct "as the performance of daily activities required for personal and social sufficiency" (Sparrow et al., 2016, p .10). Adaptive behavior becomes more complex across the lifespan, depends upon social contexts, is defined by the performance of skills rather than abilities, and is modifiable (Sparrow et al., 2016). Understanding how adaptive behavior develops in childhood is essential to identify malleable factors and critical time points for targeted interventions.

Functional and Social-Ecological Model of Adaptive Behavior

Adaptive behavior can be conceptualized through a functional and social-ecological lens or a functionality model. The functionality approach is defined by Luckasson and Schalock (2013) as "a systems perspective towards understanding human functioning in intellectual disability that includes human functioning dimensions, interactive systems of supports and human functioning outcomes" (P.658). Adaptive behavior is considered a critical dimension of human functioning in the multidimensional model originally proposed by AAIDD (Luckasson et al., 2002; Schalock et al., 2010). Understanding the role of the environment and multidimensionality of human functioning, systems of supports, and human functioning outcomes underlie the components of the functionality model. Systems of supports involve the interactions between a person and their environment and include resources and strategies that lead to increases in human functioning, defined as socio-economic status, health status, and subjective well-being (Luckasson & Schalock, 2013). Understanding adaptive behavior and the social-ecological factors associated with adaptive behavior will provide evidence for developing strategies of supports to promote human functioning. The present study aimed to examine the development of adaptive behavior over time and understand the impact of other critical dimensions of human functioning on adaptive behavior including intellectual functioning and context (personal and environmental factors).

Adaptive Behavior in Autism Spectrum Disorder

Research on adaptive behavior in ASD has focused on identifying patterns of relative strength and challenges within the adaptive behavior domains of communication, socialization, and daily living skills and comparing adaptive behavior skills to same age peers without disabilities and peers with other neurodevelopmental disorders. Cross-sectional studies in children ages 2-17 with ASD and average to above-average IQs have reported the greatest delays on socialization skills and moderate delays on communication and daily living skills (Chang et al., 2015; Kanne et al., 2011; Klin et al., 2007; Paul, Loomis, & Chawarska, 2014; Yang, Paynter, & Gilmore, 2016). Longitudinal studies in children ages 2-18 report a negative association between age and adaptive behavior standard scores, suggesting that adaptive behavior skills are not developing at the same pace for children with ASD as compared to same age peers without disabilities (Pugliese et al., 2015; Szatmari et al., 2009). Studies including comparison groups of children without disabilities matched for chronological age or other neurodevelopmental disorders matched for developmental age and/or chronological age report that children with ASD have adaptive behavior deficits (MacDonald, Lord, & Ulrich, 2013; Mouga, Almeida, Café, Duque, & Oliveira, 2014; O'Donnell, Deitz, Kartin, Nalty, & Dawson; Park, Yelland, Taffe, & Gray, 2012).

Research on developmental trajectories of adaptive behavior has focused on the overall growth of adaptive behavior over time, as well as within specific domains. Longitudinal studies in individuals with ASD across the lifespan ranging from 2 years to 58 years of age and a range of intellectual functioning report increases in daily living skills (Baghdadli et al., 2011; 2018; Bal et al., 2015; Green & Carter, 2014; Smith, Maenner, & Seltzer, 2012). Studies focused on the development of overall adaptive behavior beginning in toddlers and preschoolers with ASD report gains in adaptive behavior over time; however this growth is often lower than expected as evidenced by some individuals having lower standard or age equivalent scores over time (Baghdadli et al., 2012; 2018; Bal et al., 2015; Farmer et al., 2018; Franchini et al., 2018; Lord et al., 2015; Meyer, Powell, Butera, Klinger, & Klinger, 2018; Szatzmari et al., 2015).

Previous studies examining developmental trajectories of adaptive behavior in children with ASD have typically used either standard scores or age-equivalent scores. These scores represent performance compared to individuals in the normative sample at the same average chronological age. Individuals with ASD have adaptive behavior delays compared to their same age peers without disabilities; therefore making the use of these scores problematic when modeling growth of skills (Grimm et al., 2015; Maloney & Larrivee, 2007). Normed or standard scores are considered inappropriate for modeling growth over time due to not capturing changes in mean and variances in the individual (Grimm et al., 2015). Use of raw scores allows for the ability to examine the change in skills over time in the population within an individual (Grimm, Kuhl, &

Zhang, 2013; Grimm et al., 2015). To our knowledge, this is one of the first studies to use raw scores when examining developmental trajectories of adaptive behavior in children with ASD.

Adaptive Behavior and Dimensions of Human Functioning in ASD

Previous studies examining predictors of adaptive behavior in children with ASD have reported relationships with adaptive behavior and other human functioning dimensions, including intellectual functioning and context (personal factors and environmental factors). Intelligence includes mental abilities such as reasoning, problem-solving, cognition, abstract thinking, planning, and learning. Context represents ecological perspectives as conceptualized across multiple interrelated factors, including personal factors, such as child-level characteristics, and environmental factors, such as socioeconomic status (Luckasson & Schalock, 2013).

Intellectual Functioning. Studies report that intellectual functioning predicts adaptive behavior in people with ASD. IQ is usually an important predictor of adaptive behavior in early childhood and adolescence (Bolte et al., 2002; Bal et al., 2015; Bagdhali et al., 2012;2018; Kanne et al., 2011 Flanagan et al., 2015; Mouga et al., 2014; Szatzmari et al., 2015), although this association does not always appear to hold for longitudinal studies of individuals with high functioning ASD (Munson et al., 2008; Pugliese et al., 2016). These discrepancies in findings may be due to an increasing gap over time between IQ and adaptive behavior in individuals with average to above average IQs (Farmer et al., 2018; Kanne et al., 2011; Kenworthy et al., 2010).

Personal Factors. Another area of interest that may influence adaptive behavior is executive function. Executive function is an umbrella term for complex cognitive processes involved in goal-directed behavior (Garon, Bryson, & Smith, 2008; Pennington & Ozonoff, 1996; Zelazo & Müller, 2011). In children without disabilities, executive function is thought to be critical for the development of several important functional life skills including school readiness, academic achievement, social skills, and physical health (Best, Millar, & Naglieri, 2011; Blair & Razza, 2007; Fitzpatrick, McKinnon, Blair, & Willoughby, 2014; Fuhs et al., 2014; LeFevre et al., 2013; Viterbori et al., 2015). Three studies have shown that executive function skills as measured by parent-report are a significant predictor of adaptive behavior in children with ASD (Gilotty et al., 2002; Pugliese et al., 2015; 2016). Gilotty and colleagues (2002) examined the relationship between executive function skills as measured by parent-report using the Behavior Rating Inventory of Executive Function (BRIEF; Gioia, Isquith, Guy, & Kenworthy, 2000) and adaptive skills using the Vineland Adaptive Behavior Scales (VABS; Sparrow, Balla, & Cicchetti, 1984) in children with ASD ages 6-17. The authors found that impairments in executive function strongly correlated with deficits in communication and socialization (Gilotty et al., 2002). In children with high functioning ASD ages 4-23, Pugliese and colleagues (2015) found that parent-reported executive functions were associated with adaptive behavior. Specifically, parent-reported difficulties in initiation were associated with poorer adaptive behavior scores. Parent-reported difficulties in working memory were associated with poorer communication and daily living skills scores. Pugliese et al. (2015) also reported that difficulties organizing materials significantly predicted poorer daily living scores and cognitive flexibility difficulties predicted poorer socialization scores (Pugliese et al., 2015). In a longitudinal study, executive function difficulties were associated with poorer daily living skills and socialization, but not communication. Specifically, self-monitoring difficulties were associated with poorer overall adaptive behavior. Inhibitory control difficulties were associated with poorer daily living skills and socialization skills (Puglise et al., 2016). Pugliese et al. (2016) replicated their previous cross-sectional findings and provided evidence that cognitive flexibility difficulties were associated with poorer socialization. To our knowledge, no studies have included laboratory-based measures of executive function.

Studies show mixed findings for the relationship between autism symptoms and adaptive behavior. While some studies report non-significant findings or weak associations, other studies report negative associations between autism symptoms and adaptive behavior skills in children with varying levels of intellectual functioning in preschoolers and elementary-aged children (Franchini et al., 2018; Kanne et al., 2011; Klin et al., 2007; McDonald et al., 2015; Perry et al., 2009). McDonald and colleagues (2015) reported that higher levels of repetitive and restricted ASD symptoms were associated with poorer adaptive behavior skills. Two studies have reported negative associations between social and communication symptoms and adaptive behavior skills (Kanne et al., 2011; Kenworthy et al., 2010). These conflicting findings may be due to the various age ranges, the inclusion of children with varying levels of intellectual functioning, and measurement differences. Studies used parent-report and clinical observation methods. For studies using parent-report measures of autism symptoms using the Autistic Diagnostic Interview-Revised (Kanne et al., 2011; McDonald et al., 2015), an association with the parent-report measure of adaptive behavior may be expected. However, studies using clinical observation using the ADOS reported conflicting results (Kim et al., 2016; Klin et al., 2007; Kenworthy et al., 2010 McDonald et al., 2015). Therefore, the relationship between autism symptoms and adaptive behavior warrants further exploration of these associations over time.

Environmental Factors. In addition to intellectual functioning and personal factors, environmental factors may influence adaptive behavior outcomes, such as maternal education. Maternal education is identified as an important predictor of child outcomes in general child literature (Carneiro, Meghir, & Parey, 2012). Less maternal education has been associated with lower language skills from toddlerhood to middle childhood in children born prematurely (Luu et al., 2009; Potijk, Kerstjens, Bos, Reijnevald, & de Winter, 2011). In a study examining early intervention outcomes in toddlers ages 15-38 months with ASD, higher maternal education was associated with greater cognitive gains (Itzchak & Zacor, 2011). Maternal education has not been associated with differential growth in adaptive skills within many different samples of children (e.g., infants and toddlers born prematurely, school-aged children without disabilities, and school-aged children with ASD) (De Battista et al., 2016; Bornstein, Hahn, & Suwalsky, 2013; Pugliese et al., 2015). Nevertheless, this relationship has not been examined from early toddlerhood to middle childhood.

The Present Study

The current study examined the developmental trajectories of adaptive behavior from toddlerhood to middle childhood in children with ASD. The aims of the current study were (1) to examine the developmental trajectories of adaptive behavior in children with ASD from toddlerhood to middle childhood, and (2) examine the extent to which, mental age, performance on an executive function task, and maternal education in toddlerhood and autism severity measured at each time point predict developmental trajectories of adaptive behavior in children with ASD.

Method

Participants and Recruitment

Participants were part of a larger longitudinal study conducted at the [*removed for review]*. The longitudinal study included approximately 220 children with a diagnosis of ASD, another developmental disability (e.g., DS or Fragile X syndrome), or a history of typical development enrolled between 1997 and 2007. The present study focused only on participants with ASD. Participants included 76 individuals with ASD (see Table 1 and Table 2 for participant demographics and characteristics). Participants were invited to complete a comprehensive assessment battery at up to three time points: Toddlerhood (i.e, 1-3 years old, *M* = 2.83 years, *SD* = .45, N=39), Preschool (i.e., 4-6 years old, *M* = 4.95 years, *SD* = .53, N = 45), and Middle Childhood (i.e., 7-11 years old, *M* = 8.88 years, *SD* = 1.44. N = 45). All participants had at least one time point of data collection. Participants were recruited from community-based referral sources, including health and early education agencies and parent/support advocacy groups, such as [*removed for review*].

[Insert Tables 1 and 2 here]

Inclusion in the ASD group of the study was based on the child meeting four out of five criteria including: (1) previous clinical diagnosis of ASD, (2) scores above the "Autism Spectrum" cutoff on the Autism Diagnostic Observation Schedule (ADOS; Lord, Rutter, DiLavore, & Risi, 1999), (3) scores above the "Autism" cutoff on the Autism Diagnostic Interview-Revised (ADI-R; Lord et al., 1994), (4) endorsements of specific symptoms on a DSM-IV checklist by a licensed clinical psychologist with experience in autism identification, and (5) a current clinical diagnosis of ASD.

Measures.

Demographic and health information. Parents completed a questionnaire providing demographic information regarding their child's date of birth, gender, ethnicity, and diagnosis; as well as information regarding maternal employment.

Adaptive behavior. Adaptive behavior was assessed using Vineland Adaptive Behavior Scales, Interview Edition (VABS; Sparrow et al., 1984), a standardized parent interview assessment. The VABS assesses adaptive behavior across three domains from birth to 90 years of age (i.e., communication, daily living skills, and socialization). The VABS was administered for 76 participants one (N = 42), two (N = 19), or three (N=15) times. For 10 participants, the Vineland Adaptive Behavior Scales-II (VABS-II; Sparrow et al., 2005) was administered at the third time point. Their VABS-II raw scores were recoded into VABS raw scores using the items that were matched for both assessments. Raw scores were used in the analyses.

Mental age. Mental age was assessed in toddlerhood using the Mullen Scales of Early Learning (MSEL; Mullen, 1995), a standardized assessment of development for children ages 3 to 68 months of age. The MSEL has five domains including Gross Motor, Fine Motor, Visual Reception, Expressive Language, and Receptive Language (Mullen, 1995). Overall mental age was used in this study because the use of overall mental age as compared to standard scores assists with floor effects (Munson et al., 2008). Overall mental age was calculated by adding the age equivalency scores from the Fine Motor, Visual Reception, Expressive Language, and Receptive Language domains and dividing by four.

Executive function. The Spatial Reversal Task (Kaufmann, Leckman, & Ort, 1989) was used to assess both cognitive flexibility and working memory in toddlerhood. This task required the child to (1) maintain the previous location of a reward in working memory, and (2) flexibly shift reward association between two locations (Yerys et al., 2007). During experimental trials, a screen is put in place, and a reward is hidden under one of two cups. The screen is lifted, and the child is allowed to search for the reward. If the child is correct, the procedure is repeated for four consecutive searches, and the side of hiding is reversed following every four consecutive trials for 23 trials. Scoring includes the number of correct searches across 23 trials, the number of sets achieved, the number of perseverative responses after the side of hiding is changed, and the number of failures to maintain a set (i.e., three correct searches followed by an incorrect search). A perseverative response is defined as when a child is incorrect and immediately searches in the incorrect position again. The number of perseverative responses was used in this analysis (Yerys et al., 2007).

Autism symptoms. The Autism Diagnostic Observational Schedule (ADOS; Lord, Rutter, DiLavore, & Risi, 1999) is a standardized assessment that includes observations during a 30-40-minute session using developmentally appropriate toy-based and social interactions and was assessed at all three time points. Autism severity scores are derived from specific algorithms that have been developed and tested within each module. Autism severity scores range from 1-10, with values of 3 or less indicating a low risk of ASD, 4-6 indicating moderate risk and scores at 7 or above indicating a significant risk of ASD (Risi et al., 2006).

Data Analysis Plan

Longitudinal growth modeling was utilized to examine adaptive behavior over eight years across the three time points (i.e., ages 2-10). As shown in Table 2, there was a significant proportion of missing data across the three time points. Data were assumed to be missing completely at random based on Little's (1988) MCAR test non-significant value of χ^2 (165) = 188.68, p = .10. Missing completely at random assumes that the probability of the incomplete data is completely unrelated to observed or unobserved variables.

Missing data were handled using full information maximum likelihood estimation(FIML) in MPlus (Muthén & Muthén, 2012). FIML is recommended for use with longitudinal data due to the larger amount of missing data (Grimm et al., 2015). FIML estimation allows for each participant to contribute to the estimation of models based on their available data. Therefore, participants with only one time point are included in analyses as FIML produces unbiased estimates compared to listwise deletion (Newman, 2014; Dong & Peng, 2013). Probabilities are used for each observation and integrated over the missing data values (Allison, 2012; Grimm et al., 2015). FIML uses all available information provided by participants and produces reliable unbiased estimates. However, the *T* statistic, or the minimum fit function test statistic or χ^2, is inflated with smaller sample sizes (<100). Therefore, Bartlett corrected test statistics using missing data-scaled sample size were calculated for each model to assess model fit. The Bartlett correction is recommended for models with small samples and missing data treated with FIML in growth model analyses (McNeish & Harring, 2017). Specifically, corrected χ^2 and Root Mean Square Error of Approximations (RMSEAs) were calculated. RMSEAs are recommended for assessing model fit of longitudinal data (Grimm et al., 2015). Model fit was evaluated using RMSEA with good fit indicated by a value of < 0.08 and acceptable fit of < 0.10 (Enders, 2010; Grimm et al., 2015; McNeish & Harring, 2017).

Growth modeling examines intraindividual change, interindividual differences, interrelationships among genetic, behavioral, or environmental factors, and predictors of intraindividual changes and interindividual differences (Grimm et al., 2015). In this study, the structural equation modeling (SEM) approach was used. The linear growth model identifies intraindividual change trajectories that remain constant over time but differ between individuals. The linear growth model identifies a latent intercept or an initial starting score on the adaptive behavior domain, and a latent slope, representing the rate of change in adaptive behavior scores over the three time points. To examine nonlinearity in trajectories, the quadratic growth model adds a latent quadratic factor of time to the linear growth model and represents the average acceleration of the developmental trajectory (Grimm et al., 2015). Raw scores were used from the communication, daily living skills, and socialization domains are the VABS and are recommended to capture growth (Grimm et al., 2015).

Results

Linear and quadratic models were specified for each of the adaptive behavior domain raw scores from the VABS: communication, daily living skills, and socialization. For each domain, linear and quadratic models were evaluated that included maternal education, mental age, and executive function in toddlerhood as covariates and autism severity across the three time points as time-varying covariates (See Table 3 for growth parameters).

Communication

A quadratic growth model best fit the communication growth trajectory (RMSEA = .10, 90% CI [.03, .17], Bartlett corrected RMSEA = .07, 90%CI [.00, .16])). Higher mental ages in toddlerhood were associated with higher communication ($\beta = 1.13$, $p < .001$) scores in toddlerhood, controlling for maternal education, executive function, and autism severity. Higher mental age in toddlerhood was associated with a greater rate of change in communication ($\beta = 1.14$, $p <$ 001) controlling for maternal education, executive function, and autism severity. Mental age in toddlerhood was a significant predictor of the communication quadratic factor ($\beta = -.18$, $p < .001$).

Daily Living Skills

A linear model best fit daily living skills growth trajectory (RMSEA= .11, 90% CI [.06, .17], Bartlett corrected RMSEA = .08, 90%CI [.00, .14])). Higher mental ages in toddlerhood were associated with higher daily living skills ($\beta = 1.13$, $p < .001$) scores in toddlerhood, controlling for maternal education, executive function, and autism severity. Higher mental age in toddlerhood was associated with a greater rate of change daily living skills (β = .38, p < .001) controlling for maternal education, executive function, and autism severity

Socialization

A quadratic growth model best fit socialization growth trajectory (RMSEA = .10, 90% CI [.02, .17], Bartlett corrected RMSEA = .07, 90%CI [.00, .16]). Higher mental age in toddlerhood was associated with a greater rate of change socialization (β = .67 p = .002) scores controlling for maternal education, executive function, and autism severity. Mental age in toddlerhood was a significant predictor of the socialization quadratic factors (β =-.08, p = .012).

Increases in perseverative errors were associated with a decrease in socialization skills (β = -.68 p = .04) controlling for maternal education, mental age, and autism severity. The effect of the time-varying covariate of ADOS severity scores was -1.34, indicating that for every increase 1 point of autism severity, socialization scores decrease by 1.34 points controlling for maternal education, mental age, and executive function.

Discussion

Longitudinal studies on adaptive behavior beginning in toddlerhood have typically used standard or age-equivalent scores to characterize adaptive behavior over time. The current study used raw scores to characterize the growth of skills over time and examined the child and environmental variables associated with change. Examination of raw scores allowed for the current study to characterize growth in skills over time within individuals with ASD rather than comparing their growth in skills in reference to the average growth of a typically developing peer (Grimm et al., 2015; Maloney & Larrivee, 2007). All domains of adaptive behavior showed growth over time. Despite an increase in adaptive behavior skills and IQ scores across the three time points, adaptive behavior standard scores did not significantly improve and were still significantly delayed from the standardization sample. Mental age in toddlerhood was the only significant predictor of the average communication, daily living skills, and socialization raw scores in toddlerhood, and mental age and executive function in toddlerhood were significantly associated with the rate of change in socialization skills from toddlerhood to middle childhood. Children with higher mental ages in toddlerhood had higher communication scores in toddlerhood and a greater rate of change from toddlerhood to middle childhood controlling for diagnostic status and executive function in toddlerhood.

Findings from the current study supported quadratic growth of communication and socialization and linear growth of daily living skills. These findings should be interpreted with caution, as there are only three time points. However, Baghdadli and colleagues (2012) have reported quadratic growth of adaptive behavior with stronger acceleration in early childhood and plateaus of adaptive behavior skills have been reported in adolescence and adulthood (Bal et al., 2015; Meyer et al., 2018; Smith et al., 2012; Pugliese et al., 2016). Future studies should examine the timing of acceleration of growth of adaptive behavior. Early childhood may be an important period for interventions to target these skills.

Mental age in toddlerhood was a significant predictor of adaptive behavior in toddlerhood and the growth of adaptive behavior over time. These findings support previous research in preschoolers and school-aged children regarding the relationship between mental age and adaptive behavior (Baghdadli et al., 2012; Flanagan et al., 2015; Kanne et al., 2015). Previous studies in toddlers with ASD reported significant relationships between MSEL scores and adaptive behavior scores in toddlerhood (Paul et al., 2014; Yang et al., 2016); however, this is the first study, to our knowledge, to report this finding longitudinally in toddlers with ASD using the MSEL as related to linear and quadratic growth of adaptive behavior over time.

The number of perseverative responses in the Spatial Reversal task in toddlerhood was negatively associated with the growth of socialization skills from toddlerhood to middle childhood. This finding indicates that increased difficulties in a task assessing cognitive flexibility and working memory are associated with less growth in socialization skills over time. Previous studies have reported associational findings with parent-reported cognitive flexibility difficulties and socialization (Pugliese et al., 2015;2016). This is the first study to report this finding using a laboratory-based task of executive function as a predictor of developmental trajectories. This finding highlights the significance of cognitive flexibility skills. Interventions that target cognitive flexibility skills may be critical to promoting growth of socialization skills over time. Future studies should seek to replicate this finding with use of both laboratory-based tasks and parent-report assessments of executive function.

Autism severity was associated with the socialization developmental trajectory. This finding replicates previous studies using ADOS severity scores (Kenworthy et al., 2010) and studies reporting autism severity associations with growth trajectories of socialization skills (Szatmari et al., 2015). Many interventions for children with ASD primarily focus on reducing core symptoms of ASD, including social and communication impairments. These impairments, as measured by diagnostic tools, are not necessarily associated with communication and daily living skills adaptive behavior outcomes. Interventions targeting autism symptoms may not impact adaptive behavior domains of communication and daily living skills. Therefore, there is a critical need for interventions to target both autism symptoms and adaptive behavior.

Limitations

This study had several limitations. First, this study was conducted from 1997-2007. This sample may not represent current children with ASD, and an exploration of cohort effects is warranted. Second, there was a large proportion of missing data. Corrections were made using FIML and the Bartlett scaling factor for missing data. More complete data would inform fit of the growth models assessing developmental trajectories of adaptive behavior more accurately. Second, there were only three time points in this study, which limits the ability to capture the true shape of a developmental trajectory. Future research should seek to collect additional time points to determine whether a linear or quadratic fit best describes the developmental trajectories. Additional time points would also allow for the examination of whether predictors in early childhood influence trajectories in adolescence and adulthood. Third, executive function was not a significant predictor of daily living skills and communication in the current study. This may be due to the measurement issue of task impurity with executive function laboratory-based tasks. Task impurity refers to task performance relying on multiple areas of executive function; in this case, the Spatial Reversal task captures both cognitive flexibility and working memory (Friedman et al., 2008). Spatial reversal was also correlated with mental age. While this task has been used in other studies in children with ASD, no psychometric properties have been reported in this population (Griffith, Pennington, Wehner, & Rogers, 1999; Yerys et al., 2007). Future studies should seek to incorporate parent-report based measures of executive function with laboratory-based executive function batteries that have demonstrated reliability and validity. Fourth, participants were recruited from one metro area and also lack diversity indicating that findings are not generalizable to all individuals with ASD. Future research should seek to recruit diverse samples from multiple locations. Fifth, while use of raw scores was chosen to capture growth in skills of adaptive behavior over time, this approach is not without its limitations. Raw score items may not be weighted appropriately, and items differ in difficulty level, suggesting that they may not be attributable to an interval scale of measurement (Grimm et al., 2013). Future studies may consider the use of additional types of scores, such as item response theory ability estimates that can be modeled simultaneously with growth trajectories(Grimm et al., 2013).

The current study used a variable-centered approach to examine the development of adaptive behavior over time. Several recent studies have adopted person-centered approaches to examine the heterogeneity of the development of adaptive behavior over time and identify subgroups that display similar patterns of adaptive behavior. These studies report two or three groups displaying differential patterns of adaptive behavior over time (Bal et al., 2015; Farmer et al. 2018; Lord, Bishop, & Anderson, 2015; Szatmari et al., 2015). Larger sample sizes are necessary for this approach, and future studies should continue to examine the contribution of predictors of trajectories of adaptive behavior over time. Finally, the present study only considered the impact of two human functioning dimensions on adaptive behavior. To fully understand adaptive behavior, future studies should also examine the impact of health, participation, and systems of supports on adaptive behavior outcomes.

Conclusion

The current study extends the growing literature by examining developmental trajectories of adaptive behavior from toddlerhood to middle childhood using raw scores and examining the impact of executive function and developmental trajectories of autism severity on these trajectories. While adaptive behaviors demonstrate growth over time, there is evidence for persistent delays relative to same age peers without disabilities. The research presented in this study makes contributions to understanding the influence of mental age, executive function, and autism severity on adaptive behavior in growth over time. Mental age was identified as a significant predictor for developmental trajectories of communication, daily living skills, and socialization. Executive function and autism severity trajectories were significant predictors of socialization. These findings have important implications for interventions, including further evaluations of evidence-based practices and targeting adaptive behavior explicitly within early intervention programs.

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Table 1 Participant Demographics

Characteristic	*n*	%
Sex		
Male	61	82.4
Female	13	17.6
Race		
African American	6	1.00
Asian	2	3.00
Caucasian/White	59	88.1
Maternal Education		
High School Graduate	3	4.5
Partial College	17	25.8
College Graduate	30	45.5
Post Graduate Training	16	24.2

Table 2 Participant Characteristics

Characteristic	*Toddlerhood* *M(SD)* N=39	*Preschool* *M(SD)* N=45	*Middle Childhood* *M(SD)* N=45
Age (in years)	2.83(.45)	4.95(.53)	8.88(1.33)
Executive function (# of perseverative responses on Spatial Reversal)	12.4(4.55)		
Mental age (in months)	19.5(6.41)	35.3(11.4)	73.5(23.2)
Intelligence Quotient	58.5(15.1)	63.0(17.0)	80.1(24.3)
Autism Diagnostic Observation Schedule Severity Score	7.15(1.71)	6.78(1.72)	6.90(2.01)
Adaptive Behavior Raw Scores			
Communication	23.1 (14.1)	52.4(22.0)	88.5(26.3)
Daily Living Skills	24. 7(10.6)	48.5(16.4)	86.4(27.8)
Socialization	28.0(7.67)	45.5(13.9)	63.1(18.7)
Adaptive Behavior Standard Scores			
Communication	59.2 (14.0)	65.7(22.5)	68.6(23.2)
Daily Living Skills	62.1 (10.6)	59.2(12.0)	50.3(21.3)
Socialization	60.9(11.4)	64.8(12.2)	60.9(14.1)

Note. ASD= Autism Spectrum Disorder. Mental age and Intelligence Quotient were measured by the Mullen Scales of Early Learning at Time and Time 2 and by the Leiter International Scales of Performance at Time 3.

Table 3

Parameter Estimates for Growth Models for Communication, Daily Living Skills, and Socialization

	Communication			Daily Living Skills			Socialization		
Time Invariant Covariate	Intercept	Linear Slope	Quadratic Slope	Intercept	Linear Slope	Quadratic Slope	Intercept	Linear Slope	Quadratic Slope
Mental age	1.13***	1.14***	-.18***	1.14***	.38***		.09	.67**	-.08**
Executive Function	-.60	.08	-.38	-.24	.01		.20	-.68**	.10
Maternal Education	4.25*	1.99	-.05	2.41	.78		3.56**	-.42	.14*
Time Varying Covariate	Effect			Effect			Effect		
Autism Symptoms	-.67			-.26			-1.34**		

Note. *$p < .10$ ** $p < .05$ ***$p < .001$