Executive Function Predicts the Development of Play Skills for Verbal Preschoolers with Autism Spectrum Disorders

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Executive function and play skills develop in early childhood and are linked to cognitive and language ability. The present study examined these abilities longitudinally in two groups with autism spectrum disorder—a group with higher initial language ($n = 30$) and a group with lower initial language ability ($n = 36$). Among the lower language group, concurrent nonverbal cognitive ability contributed most to individual differences in executive function and play skills. For the higher language group, executive function during preschool significantly predicted play ability at age 6 over and above intelligence, but early play did not predict later executive function. These results suggested that factors related to the development of play and executive function differ for subgroups of children with different language abilities and that early executive function skills may be critical in order for verbal children with autism to develop play. ***Autism Res*** *2016, 9: 1274–1284*. © 2016 International Society for Autism Research, Wiley Periodicals, Inc.

Keywords: autism; executive function; inhibition; spatial working memory; play; language

Introduction

Autism spectrum disorder (ASD) is marked by significant impairments in social communication and repetitive or stereotyped behaviors that are evident in the early years of life, although the presentation of symptoms and degree of impairment is variable [American Psychiatric Association (APA), 2013]. In addition to these symptoms, individuals with ASD often experience significant difficulties with play, particularly pretend and symbolic play [APA, 2013] and executive function [see Hill, 2004; Kenworthy, Yerys, Anthony, & Wallace, 2008 for reviews]. Play and executive function have been posited to relate to one another based on theoretical arguments; examining their development longitudinally will contribute to a better empirical understanding of the relation between these domains. Clinically, understanding how individual differences in these domains unfold over time may help identify potential treatment targets. For instance, if early executive dysfunction contributes to later emerging play deficits in children with ASD, particularly initiating or generating spontaneous pretend play [Jarrold, Boucher, & Smith, 1994; Rutherford & Rogers, 2003], it would be important to develop interventions to improve executive function skills.

Executive function (EF) includes working memory, inhibition, generativity, and set shifting, which underlie goal-directed thought and behavior [Hill, 2004]. A variety of tasks are sensitive to the development of EF skills in toddlers, preschoolers, and young children [e.g., Carlson, 2005; Carlson & Meltzoff, 2008], yet examining the early development of EF among children with ASD [Dawson, Meltzoff, Osterling, & Rinaldi, 1998; Dawson et al., 2002; Griffith, Pennington, Wehner, & Rogers, 1999; McEvoy, Rogers, & Pennington, 1993; Stahl & Pry, 2002; Yerys, Hepburn, Pennington, & Rogers, 2007] is complicated by inclusion of children who often have general cognitive delays. General cognitive level, rather than ASD, may account for observed executive dysfunction among toddlers and young preschoolers with ASD [Dawson et al., 2002; Griffith, Pennington, Wehner, & Rogers, 1999; Yerys, Hepburn, Pennington, & Rogers, 2007]. Children with ASD are first distinguished on executive functioning tasks from typically developing *and* developmentally delayed children by late preschool [Dawson, Meltzoff, Osterling, & Rinaldi, 1998; Faja & Dawson, 2013; McEvoy, Rogers, & Pennington, 1993; Pellicano, 2007; Pellicano, Maybery, Durkin, & Maley, 2006; Smithson et al., 2013]. These studies indicate that deficits in inhibition,

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Received August 01, 2014; accepted for publication January 13, 2016
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The authors do not have any interests that might be interpreted as influencing the research.
Published online 18 February 2016 in Wiley Online Library (wileyonlinelibrary.com)
DOI: 10.1002/aur.1608

working memory, flexibility and planning are present by preschool for many children with ASD, but not universal, making examination of individual differences particularly important.

Play also differs qualitatively and quantitatively for children with ASD compared with children without ASD [e.g., Hobson, Lee, & Hobson, 2009; Jordan, 2003]. Spontaneous play in ASD is less complex, frequent, and novel than in comparison children [Charman & Baron-Cohen, 1997; Rutherford, Young, Hepburn, & Rogers, 2007]; symbolic play development is delayed [Ungerer & Sigman, 1981]; and some play behaviors are atypical [e.g., VanMeter et al., 1997]. The play of children with ASD often lacks creativity and imagination and has a persistent sensory-motor or ritualistic quality [APA, 2000]. And, by 36 months of age, children with ASD differ on measures of pretend play, but not functional or sensorimotor play, as compared with typically developing children and developmentally delayed children matched on mental age [Rutherford, Young, Hepburn, & Rogers, 2007], suggesting that deficits in pretend play are autism-specific and not solely attributable to cognitive deficits.

Executive dysfunction is theorized to contribute to play deficits in ASD [e.g., Dawson et al., 2002; Jarrold, 2003; Jarrold, Boucher, & Smith, 1996; Rutherford, Young, Hepburn, & Rogers, 2007]. For instance, difficulty spontaneously generating flexible behavior may drive reduced spontaneous pretend play, which requires inhibition of the actual use of objects and flexible generation of novel alternatives. In highly structured play situations, such as explicitly prompted pretending, children with ASD perform more similarly to comparison groups [Charman & Baron-Cohen, 1997; Jarrold, 2003; Jarrold, Boucher, & Smith, 1996]. These highly structured situations may have reduced executive function demands, particularly lower generativity demands, due to examiner selection of materials and prompting to do something with them—although this possibility was not explicitly tested in these studies. In one study that examined the relation between EF and play in children with ASD, pretend play was specifically related to concurrent generativity, as measured by the variety of actions made on novel toys during a 60 sec observation [Rutherford & Rogers, 2003].

Alternatively, it is possible that play may underlie EF development. Play provides a context in which EF skills can be practiced and improved [Diamond, 2011]. Early in development, shifting attention to follow a caregiver's lead during simple give-and-take games with novel objects or behaviors may provide a foundation for later executive control skills [Posner, Rothbart, Sheese, & Voelker, 2012]. In the first year of life, functional, or pre-symbolic, play emerges, while directing pretend actions to others (e.g., pretend feeding) emerges around the first birthday and symbolic play using objects to represent other things emerges in the second half of the second year [Fein, 1981; McCune, 1995; Orr & Geva, 2015]. Thus, pretend play emerges relatively early in typical development and involves complex thought, allowing children to separate themselves from external stimuli and think more abstractly, which may contribute to EF development [Vygotsky, 1978].

To date, there is little empirical evidence about the direction of the relation between EF and play during development. Indeed, among typically developing preschoolers, existing evidence of a relation between play and executive function is correlational [Carlson, White, & Davis-Unger, 2014; Kelly & Hammond, 2011]. In sum, reduced EF may limit play, and/or play impairments may reduce opportunities for practicing EF skills.

A final factor—language ability—warrants careful consideration in ASD beyond general cognitive level [Munson et al., 2008]. Luria [1961] and Vygotsky [1978] theorized that language is integral to top–down control when problem solving, which would make it central to EF. Among typically developing preschoolers, expressive language level consistently predicts the development of EF [e.g., Carlson, Mandell, & Williams, 2004; Kray, Eber, & Lindenberger, 2004; Wolfe & Bell, 2004]. And, using language for labeling during a task improves the EF performance of toddlers [Miller & Marcovitch, 2011] and preschoolers [Jacques & Zelazo, 2005; Muller, Zelazo, Leone, & Hood, 2004]. Furthermore, among typically developing preschoolers and young children, speech directed at oneself has been suggested to underlie the relation between pretending and EF [Carlson, White, & Davis-Unger, 2014].

In ASD, language deficits may be closely tied to both EF and play performance [Williams, Reddy, & Costall, 2001]. Older, verbal children and adolescents with ASD are less able to use verbal strategies during EF tasks than typically developing children [e.g., Joseph, McGrath, & Tager-Flusberg, 2005; Landa & Goldberg, 2005; Wallace, Silvers, Martin, & Kenworthy, 2009]. Play corresponds with language ability and IQ in ASD, even among children who have fewer than 20 different words [Thiemann-Bourque, Brady, & Fleming, 2012]. As well, play skills during preschool predict the later language level of children with ASD [Kasari et al., 2012]. In sum, language skills may contribute to play and EF impairments in ASD and is, therefore, an important factor to consider when examining the relation between play and EF.

The primary objective of the current study was to examine the *longitudinal* relationship between EF and play in ASD and test the hypotheses that EF influences the development of play and vice versa. One longitudinal study has examined the precursors of pretend play in preschoolers with ASD [Rutherford, Young, Hepburn,

& Rogers, 2007]. The current study builds on this work by examining predictors of both play and executive function. In particular, this study expands the measurement of executive function by using multiple measures. Our EF battery targeted spatial working memory and inhibition, which are emphasized in models of executive function during the preschool period [Wiebe, Espy, & Charack, 2008]. The tasks in our battery were also selected for feasibility with the mental age range of our sample at both time points and because their neural underpinnings have also been examined by administering them to nonhuman primates. Similarly to the study conducted by Rutherford, Young, Hepburn, & Rogers [2007], which used lab-based measures of pretend play, the current investigation used an experimental measure of symbolic and pre-symbolic (or functional) play. The lab-based task involved using toy objects to act on a doll (i.e., pre-symbolic) or using generic placeholders such as a block or bag to represent an object in a play scheme with a doll (i.e., symbolic). For instance, in the pre-symbolic condition, a child might use a toy sandwich to feed a doll, wherein a red block may represent a sandwich when feeding a doll in the symbolic condition. We focused our measurement of play in the current study on pre-symbolic and symbolic use of toys because symbolic play is specifically impaired among children with ASD. Using pre-symbolic trials allowed for more sensitive measurement of emerging skills in young children with ASD who were anticipated to have delays in this domain. Given the importance of language ability in EF among typically developing children, these hypotheses were tested in two groups with ASD—children with higher and lower initial language ability—in order to better understand the impact of language ability on EF and play development in ASD.

Method

Participants

The sample consisted of 66 children with ASD (55 boys, 11 girls) who provided EF, play, and cognitive data at two time points in a larger longitudinal study on development in ASD. An additional 8 children provided data at the first time point, but failed to provide complete data at the second time point[1] and were not included in analyses. Children were recruited via local parent advocacy groups, hospitals, clinics, public schools, and the Department of Developmental Disabilities [see Dawson et al., 2004 for details]. Exclusionary criteria included the presence of a neurological disorder of known etiology, significant sensory or motor impairment, major physical anomalies, history of serious head injury, or neurological disease. Assessments were conducted across multiple visits during each of two time points. Participants' ages ranged from 34 to 52 months ($M = 43.3$, $SD = 4.4$) at the first time point, and from 68 to 82 months ($M = 74.3$, $SD = 3.0$) at the second time point. The duration between the first and second time point ranged from 21 to 40 months ($M = 31.1$, $SD = 4.6$). Children were diagnosed using the Autism Diagnostic Interview [ADI-R; Lord, Rutter, & LeCouteur, 1994] and Autism Diagnostic Observation Schedule-Generic [ADOS-G; Lord et al., 2000] and clinical observation. Final diagnostic judgment was made based on DSM-IV criteria [APA, 2000] by expert clinicians using all available information. All procedures were reviewed and approved by the University's Human Subjects Division and a parent or legal guardian of each child provided written informed consent.

Cognitive ability at the first time point was assessed using the Mullen Scales of Early Learning [Mullen, 1995], a measure of language, perceptual, and motor abilities appropriate for infants through preschoolers. At the initial assessment, the mean Mullen subtest T-scores were as follows: Visual Reception, $M = 28.3$, $SD = 12.1$, range = 20–61; Fine Motor, $M = 25.2$, $SD = 9.4$, range = 20–59; Receptive Language, $M = 26.4$, $SD = 10.3$, range = 20–59; Expressive Language, $M = 26.4$, $SD = 10.4$, range = 20–58, and composite standard scores ranged from 49 to 106 ($M = 59.3$, $SD = 15.8$). A composite nonverbal ability developmental quotient score was calculated for each child by taking the average age equivalent score on the Visual Reception and Fine Motor scales and dividing by chronological age. A composite verbal ability score was calculated in the same way from the Receptive Language and Expressive Language subscales.

At the second time point, cognitive ability was assessed using the Upper Preschool core of the Differential Ability Scales [DAS; Elliott, 1990], a measure of verbal and nonverbal reasoning abilities. The mean DAS composite standard scores were as follows: Verbal Cluster, $M = 72.4$, $SD = 22.3$, range = 50–127; Nonverbal Ability Cluster, $M = 76.3$, $SD = 23.5$, range = 43–124; and, composite standard scores (i.e., General Conceptual Ability Score) ranged from 44 to 131 ($M = 72.0$, $SD = 22.8$).

Neurocognitive Battery

At both time points, all children completed developmentally appropriate batteries that were designed to measure precursors of EF [see Griffith, Pennington, Wehner, & Rogers, 1999; McEvoy, Rogers, & Pennington, 1993; for examples of these measures with children with ASD in the same age range]. The

[1]The proportion of children who failed to provide adequate data at the second time point did not differ by language classification at the initial assessment, χ^2 (1, $N = 74$) = 3.18, $P = 0.07$.

neurocognitive tasks were designed to be particularly sensitive to spatial working memory and inhibition. All tasks presented a series of trials with two possible responses, such that children had a 50% chance of guessing correctly for a given trial. A reach to the correct location was scored as correct. The percent correct across all trials was computed for each task: A-Not-B with 5 s Delay, A-Not-B with 12 s Delay, A-Not-B with Invisible Displacement, and Spatial Reversal (see below for details). A composite was computed by calculating the mean score for the four variables at Time 1 (Cronbach's $\alpha = 0.53$). Not all children provided data for all variables, so the Time 1 composite required data for at least two of the four variables. A Time 2 composite was computed by calculating the mean score of the two variables at that time point, A-Not-B with Invisible Displacement and Spatial Reversal (Cronbach's $\alpha = 0.60$). The Time 2 composite required data for at least one of the two variables.

A-not-B with 5 sec and 12 sec delays (Time 1 only). A reward was placed under a cup on the left or right side as the child watched. A screen briefly obstructed the two cups. Then the child was encouraged to find the reward. Initially, the obstruction lasted 5 sec. Rewards were hidden on the same side until two consecutive correct reaches were made, then the reward was hidden in the cup on the opposite side (i.e., a reversal). After two reversals followed by two consecutive correct choices, the delay increased to 12 sec. The task was discontinued either when the child completed two more reversals followed by two consecutive correct choices at 12 sec or when 24 trials were administered [Diamond, 1985].

A-not-B with invisible displacement. As the child watched, a reward was placed inside a box at the center of the table with the open side facing the child. Then, the open side was closed. While the child watched, the tester slid the box to the right or left. A screen then briefly obscured the box and an identical, empty box was placed on the other side of the table, equidistant from the child. The screen was lifted, and the child was prompted to find the reward. After two consecutive correct trials, the side was reversed. The task continued until three reversals were followed by two consecutive correct trials or a maximum of 14 trials were administered [Diamond, Prevor, Callender, & Druin, 1997].

Spatial reversal. The child was told, "I am hiding an {object}." On the first trial, the examiner hid objects under both identical cups on the right and left of the child while a screen obscured them. The screen was lifted and the child was encouraged to find the reward. For subsequent trials, a screen obscured both cups while a single reward was hidden under the cup on the side initially chosen by the child. Over the course of 20 trials, the hiding side was reversed after every four consecutive correct trials [Kaufman, Leckman, & Ort, 1990].

Assessment of Pre-Symbolic and Symbolic Play

Spontaneous pre-symbolic and symbolic play acts were measured in blocks of three trials each. Target actions were: feeding, putting to sleep, brushing teeth, combing hair, giving a bath, and giving a drink. The order of the blocks (pre-symbolic and symbolic) and the three actions that were targeted for pre-symbolic versus symbolic trials were counterbalanced across participants. Before switching blocks, any items that were not passed spontaneously were verbally and nonverbally prompted using scripted directions and gestures (e.g., by saying "Wally is hungry, give him a sandwich" and holding the stomach for the *feeding* trial), but responses for prompted items were not included in the score. Then children were given a break before beginning the other block.

For each trial, a doll and play objects were placed in front of the child.[2] For symbolic play trials, stimulus objects were: a block to represent food, a box top and plastic bag to represent a bed and pillow, a cylindrical shaped block to represent a toothbrush, a tongue depressor to represent a comb, a shoebox to represent a bathtub, and a plastic object to represent a cup. Corresponding functional objects (e.g., a plastic sandwich, a doll blanket and pillow, a toy toothbrush, etc.) were used for pre-symbolic trials. Children were presented with a unique doll and object(s) for each condition. For example, during the *symbolic feeding* trial, the experimenter presented only a doll and red block to the child, ensured that the child looked at both items, and said, "You can play" without providing additional instruction or prompting. Each trial lasted 1 min. For every 20 sec that the child did not play with all of the toys in the trial set (i.e., doll *and* object(s)), did not play at all, or did not perform the target action, the examiner

[2]Although the materials, task demands and duration of the play measure were constrained, Pre-symbolic and Symbolic Play scores correlated with clinician ratings of play during the ADOS, which provided a longer opportunity to spontaneously demonstrate play skills with a wider range of toys. At Time 1, the play measure significantly related to the average of reverse coded functional and symbolic play codes from the ADOS, $r(63) = 0.37$, $P = 0.003$ and Spearman's $\rho = 0.37$, $P = 0.003$. At Time 2, play also significantly related to ADOS play codes, $r(60) = 0.61$, $P < 0.001$ and Spearman's $\rho = 0.59$, $P < 0.001$. This suggests that the experimental measure of pre-symbolic and symbolic play related to spontaneous play behavior observed during an open-ended, play-based clinical assessment.

Table 1. Correlations Between Executive Function and Play Measures

Combined group							
Measure	T1 Play	T2 EF	T2 Play	T1 Verbal	T1 NV	T2 Verbal	T2 NV
Time 1 EF	0.20	0.30*	0.30*	0.34**	0.35**	0.32**	0.31**
Time 1 Play		0.31**	0.53***	0.30*	0.35**	0.34**	0.40***
Time 2 EF			0.36**	0.47***	0.45***	0.51***	0.54***
Time 2 Play				0.17	0.27*	0.26*	0.46***

* ≤0.05, ** ≤0.01, *** ≤0.001.

Note: T1 Verbal and NV are the verbal and nonverbal Mullen IQ scores. T2 Verbal and NV are the verbal and nonverbal DAS composite scores.

repeated the statement, "You can play with all of these" and gestured to all of the toys. No further verbal or physical prompts were provided during the trial. After 1 min, the toys were removed from the table and the next doll and object(s) were presented.

At Time 1, trials were scored for the presence of the target pre-symbolic or symbolic play action. For example, for the *symbolic feeding* trial, the behavioral target was placing the block near the mouth including the chin or nose, but not eyes or ears. Likewise, the target for the pre-symbolic "feeding" trial was placing the toy sandwich near the mouth, chin or nose. Unprompted target actions performed on the doll, self, or another person were credited with a score of "1" whereas other symbolic actions performed on the self or another were not credited. If the target action was not performed, the trial was scored as '0.' This yielded a total play score ranging from 0 to 6 (0–3 for pre-symbolic play acts and 0–3 for symbolic play acts). The same clinician administered this measure to all children at Time 1. Behavioral ratings were made live by the clinician. Any instances of ambiguity were resolved by immediate review of the videotapes. Intra-observer agreement was assessed by having the initial coder rescore a randomly selected 10% of the children from videotape more than 4 months after the first coding, without reference to the first scores. For inter-observer agreement, an independent coder reviewed the same videotapes without reference to the initial scoring. Intra- and inter-observer agreement for the total play score were $r = 0.97$ and 0.96, respectively.

At Time 2, only the highest-level action was scored using the following hierarchy: target action to the doll (3 points); other symbolic action to the doll (2 points); all other symbolic actions to self or others (1 point); no symbolic actions (0 points). Trained clinicians who administered the task scored responses live using the same criteria for target responses as Time 1. If the response was unclear, children were prompted, "Tell me what you are doing." Clinicians also rated their level of certainty that the child was pretending with highest ratings assigned when child behavior explicitly indicated pretending (e.g., sound effects).

Language and Nonverbal Correlates within the Sample and Formation of Subgroups

We first examined the relations between verbal IQ, nonverbal IQ, EF, and play using Pearson correlations. As shown in Table 1, EF was moderately correlated across time points, and play was highly correlated over time. As well, Time 1 EF was moderately correlated with T2 play and Time 1 play was moderately correlated with T2 EF. EF composite scores and play scores at both time points were significantly related to concurrent verbal and nonverbal IQ scores. Given the significant correlations between the EF, play and verbal IQ scores, which were consistent with theoretical predictions, we examined our hypotheses within subgroups based on language.

The sample was divided on the basis of language ability scores derived from the Mullen Scales at the first time point. We selected one group of children for whom both Expressive and Receptive Language T-scores equaled 20 (i.e., floor) and a second group of children with at least one T-score of 21 or higher. Thirty children (4 girls) comprised a *higher language ability* group. The remaining 36 children (7 girls) comprised the *lower language ability* group. The language groups significantly differed on both EF composite scores, but not on play scores. Details of the composites and the scores contributing to them are presented in Table 2. The two language ability groups did not differ in sex distribution, $\chi^2(1, N = 66) = 0.44$, $P = 0.51$. The duration between time points did not differ between the groups, $t(63) = -0.52$, $P = 0.60$. Age did not differ by group at Time 1, $t(64) = 0.18$, $P = 0.86$, higher language group: $M = 43.2$, $SD = 4.0$; lower language group: $M = 43.4$, $SD = 4.7$, or at Time 2, $t(63) = 0.89$, $P = 0.38$, higher language group: $M = 74.0$, $SD = 2.7$; lower language group: $M = 74.6$, $SD = 3.2$.

Statistical Procedure

After confirming that assumptions for these analyses were met, separate hierarchical regressions were computed for each group to test predictors of (a) play and

Table 2. **Descriptive Statistics for Variables Contributing to EF and Play Composites**

	Lower language group		Higher language group	
	M (*SD*)	*N*, Range	*M* (*SD*)	*N*, Range
Time 1 EF composite*	0.69 (0.15)	36, 0.35–0.91	0.77 (.07)	30, 0.64–0.94
A not B 5 s % correct	0.86 (0.16)	31, 0.35–1	0.88 (0.10)	26, 0.67–1
A not B 12 s % correct	0.78 (0.21)	31, 0.30–1	0.80 (0.15)	25, 0.55–1
A not B w/ID % correct**	0.60 (0.21)	34, 0.14–1	0.74 (0.14)	30, 0.43–1
Spatial Reversal % correct**	0.61 (0.13)	33, 0.22–0.80	0.70 (0.12)	29, 0.35–0.80
Time 1 Spontaneous Play	2.6 (2.0)	35, 0–6	3.4 (1.8)	29, 0–6
Time 2 EF composite**	0.68 (0.14)	36, 0.17–0.88	0.78 (0.12)	30, 0.35–1
A not B w/ID % correct*	0.70 (0.12)	30, 0.14–1	0.82 (0.18)	29, 0.14–1
Spatial Reversal % correct*	0.67 (0.12)	30, 0.20–0.85	0.72 (0.08)	27, 0.55–0.80
Time 2 Spontaneous Play	9.2 (5.7)	33, 0–17	10.7 (5.1)	27, 0–17
Nonverbal Intelligence				
Time 1 Mullen Nonverbal***	54.6 (10.9)	36, 34–79	78.5 (15.2)	30, 54–104
Time 2 DAS Nonverbal***	64.4 (20.8)	35, 43–114	90.2 (18.4)	30, 48–124

* <0.05, ** <0.01, *** <0.001 for differences between groups.

Note: The scores of both groups were statistically above chance for all EF measures. For the Time 1 Spontaneous Play measure, 7 children in the lower language group (20%) and 2 children in the higher language group (7%) had scores of 0. For the Time 2 Spontaneous Play measure, 4 children in the lower language group (11%) and 2 children in the higher language group (7%) had scores of 0. Skewness and kurtosis were acceptable for both groups and time points. Further, at Time 2, clinician confidence of pretending did not differ between groups, nor was there a significant interaction between group and performance on the first versus second block of trials.

(b) EF at age 6. In the first step, Time 2 DAS Nonverbal Ability and Time 2 Age were entered along with Time 1 performance in the domain being tested (i.e., either play or EF). Step 2 then tested whether Time 1 EF predicted Time 2 Play or whether Time 1 Play predicted Time 2 EF.[3]

Results

Development of Play and EF in the Lower Language Ability Group

Among the children with lower initial language ability, Time 2 play was best predicted by concurrent nonverbal cognitive ability and Time 1 play when Time 2 age was controlled. Time 1 executive functioning did not account for additional variance in this group. Similarly, Time 2 executive functioning was best predicted by concurrent nonverbal cognitive ability. Time 1 play and executive functioning did not account for additional variance in this group (see Table 3).

[3]We considered calculating Poisson regressions when play was the dependent variable, to potentially account for biases in regression associated with count data. Briefly, Poisson regression yields the same results obtained with hierarchical regression. It cannot be used when EF is the dependent variable, because EF is not a count measure with integer values. We have not reported Poisson regressions because our play data are not positively skewed at T2, means for both groups were approximately 10, there was no evidence of heteroskedasticity, and the dependent variable for the play measure at T2 is not count data but rather a score based on the level of symbolic play demonstrated on each trial. Reported hierarchical regression is appropriate (i.e., assumptions for standard OLS regression have been satisfied); and lead to equivocal conclusions as the more conservative Poisson approach.

Development of Play and EF in the Higher Language Ability Group

Within the group with higher language ability at baseline, analyses indicated that initial EF ability at 3–4 years significantly predicted later play ability at age 6 above and beyond initial play ability, concurrent age, and concurrent nonverbal cognitive ability. The opposite was not true; play ability at age 3–4 did not predict executive ability at 6 years. Indeed, none of the variables predicted Time 2 EF in this group (see Table 4).

Discussion

The current study investigated whether the executive functioning abilities of preschoolers with ASD predicted presymbolic and symbolic play skills at 6 years of age and whether play abilities of preschoolers predicted later executive functioning at age 6. Given the theory that language may underlie the connection between EF and pretend play and support the development of both in typically developing children, this question was examined in two groups of children with ASD—those with higher initial language during preschool and those with lower language abilities upon standardized testing. Concurrent relations between EF, play, and verbal IQ, as well as the different EF levels of the two groups, further supported this division.

For children with ASD who had higher language ability as preschoolers, individual differences in EF predicted later play skills. The relation between EF and play was specific: earlier EF predicted play, whereas play did not predict later EF. In contrast, the EF and play

Table 3. **Hierarchical Regression Results for Lower Language Ability Group**

Variable	B	SE B	β	R^2 or ΔR^2
Predicting Play				
Step 1				0.50***
T2 Nonverbal	0.09	0.04	0.33*	
T2 Age	−0.14	0.24	−0.08	
T1 Play	1.33	0.41	0.49**	
Step 2				0.02
T1 EF	5.20	4.94	0.15	
Predicting EF				
Step 1				0.34**
T2 Nonverbal	0.003	0.001	0.44**	
T2 Age	0.01	0.007	0.30	
T1 EF	0.19	0.15	0.20	
Step 2				0.01
T1 Play	0.008	0.01	0.11	

* ≤0.05, ** ≤0.01, *** ≤0.001.

Table 4. **Hierarchical Regression Results for Higher Language Ability Group**

Variable	B	SE B	β	R^2 or ΔR^2
Predicting Play				
Step 1				0.37*
T2 Nonverbal	0.13	0.05	0.43*	
T2 Age	0.14	0.33	0.07	
T1 Play	0.92	0.52	0.31	
Step 2				0.11*
T1 EF	23.7	11.4	0.34*	
Predicting EF				
Step 1				0.09
T2 Nonverbal	0.002	0.001	0.24	
T2 Age	0.002	0.008	0.04	
T1 EF	0.22	0.29	0.15	
Step 2				0.05
T1 Play	0.02	0.01	0.25	

* ≤0.05, ** <0.01, *** <0.001.

skills of 6-year-olds who had lower language ability as preschoolers were best predicted by concurrent nonverbal cognitive ability. These results are consistent with models of play development in ASD that involve general cognitive ability [Jarrold, 2003; Jordan, 2003] and the specific cognitive domain of EF [Dawson et al., 2002; Jarrold, Boucher, & Smith, 1996; Rutherford, Young, Hepburn, & Rogers, 2007]. Interestingly, the aspect of cognition that best related to play development differed depending on the language level, such that executive function played a greater role in predicting play if basic language skills were in place. The specificity uncovered here is reminiscent of research documenting highly specific longitudinal predictive relations among joint attention, language, and subsequent theory-of-mind development in typically developing children [Brooks & Meltzoff, 2015].

It is important to consider the aspects of EF that our battery emphasizes. The current study employed tasks that were sensitive to inhibition and spatial working memory. The ability to inhibit may support the development of pretend play because it allows suspension of reality and the development of alternative scenarios, whereas working memory may allow for the manipulation of mental representations during play. These tasks, in addition to being theoretically linked to core play skills, were selected because they were consistent with the measurements used in other investigations of executive development among young children with ASD [e.g., Dawson, Meltzoff, Osterling, & Rinaldi, 1998; Dawson et al., 2002; Griffith, Pennington, Wehner, & Rogers, 1999; McEvoy, Rogers, & Pennington, 1993; Stahl & Pry, 2002]. Related tasks have been linked to the integrity of the dorsolateral prefrontal cortex in non-human primates [e.g., Diamond & Goldman-Rakic, 1989], suggesting that they may be sensitive to the development of pathways associated with EF. Finally, given mixed findings among older individuals with ASD in inhibition and spatial working memory [Kenworthy, Yerys, Anthony, & Wallace, 2008], tasks in these domains may be particularly sensitive to individual differences in the development of EF. Mixed results in comparisons of ASD to typical development would be expected if there are greater individual differences in impairment among individuals with ASD for these executive subdomains.

The current investigation highlights the possibility of subgroups with different patterns of individual differences and adds to the existing literature examining longitudinal outcomes related to EF. Specifically, division of our sample based on early language level revealed a different pattern of relations between early abilities and later levels of play and EF. In one group, outcomes were more closely tied to general cognitive ability whereas early EF predicted later play skills in the other. In previous research with a group comprised only of verbal, non-cognitively impaired preschoolers with ASD [Pellicano, 2007, 2010], performance on an EF battery predicted later social cognition. Thus, for children with ASD with higher language ability, early executive ability during preschool appears to predict both social cognition and play during the early school years. In contrast, previous work with a sample with mixed cognitive abilities did not find a relation between performance on these tasks and later social or communication development [Munson et al., 2008b]. Differences in measurement of play and EF, age range, and separation into subgroups based on language level may account for differences in results compared with Rutherford, Young, Hepburn, & Rogers [2007] who found joint attention, rather than executive function or imitation, best predicted subsequent play skills in preschoolers with ASD and cognitive delays.

Our results are not without limitations. First, we conducted several analyses without correction for multiple comparisons in order to present the pattern of relations between variables. Thus, our results should be interpreted with caution, and it will be important to replicate this work. Second, in conducting longitudinal work with children with ASD, the present study faced the challenge of selecting measures that are simultaneously appropriate for a very wide range of developmental levels and sensitive to individual differences in performance. Executive function is thought to be most involved in guiding behavior and thinking at the precise point where well-learned problem solving strategies become ineffective. Thus, measures that are challenging for children with higher developmental levels and may require EF would be too difficult for children with lower levels and, as a result, fail to capture EF abilities. For children performing at floor or ceiling on a measure, other factors, such as general cognitive ability, may appear to play a more significant role. Indeed, examination of Table 2 suggests that the groups were performing at different levels on several measures across the two time points. For example, spatial reversal performance differed between the two groups at both time points, suggesting it may be more susceptible to the contribution of language. Nonetheless, both groups performed above chance on EF measures and had a wide range of individual scores that in most cases spanned from floor to ceiling. Despite differences in the group means, the ranges had considerable overlap, suggesting that these measures were sensitive to individual EF differences in both groups.

Selection of developmentally appropriate play measures also posed a challenge. We selected a lab-based measure of spontaneous play given the theoretical importance of pre-symbolic and symbolic play in ASD and in relation to EF development. Yet, this task provided a narrow lens for capturing spontaneous play abilities and may have failed to detect behaviors that would be present in other, more familiar settings and with other toys. In order to address this, we examined the correspondence between the lab-based play measure of pre-symbolic and symbolic play employed in this study and the play items of the ADOS, which provides numerous opportunities for spontaneous play with a wider range of toys over the course of a 30–60 min observation. Experimental play scores related to ADOS scores collected at both time points.[4] As well, given the delays in the development of play skills in ASD, we included scores for both symbolic and pre-symbolic actions, which resulted in a measure that was sensitive to the play skills of a majority of children in our sample at both time points. As with previous investigations that used more structured play situations [Charman & Baron-Cohen, 1997; Jarrold, 2003; Jarrold, Boucher, & Smith, 1996], most children with ASD in our sample exhibited at least some pre-symbolic play acts at each time point, demonstrating that they not only engaged with the materials but were able to demonstrate some basic pretending. Although we did not prompt children beyond encouraging them to play with the objects and gesturing to the objects in order to provide an opportunity for spontaneous play with the materials and keep language demands comparable, the constrained task structure and limited stimulus set may have facilitated a higher level of play than expected for children with ASD in more open-ended settings. Another challenge in measuring play is that our measures required adult interpretation of play behaviors—as is often the case because there is not typically a "right answer" during spontaneous play. However, the ability to convey symbolic play to others greatly benefits from functional language. That is, toy play may be more clearly interpreted when accompanied by labeling. To this end, we explicitly defined target behaviors such as laying the doll on/under the blanket for the pre-symbolic "sleepy" item and under a plastic bag for the symbolic version of this item and confirmed that groups did not differ for clinician ratings of confidence that the action constituted pretending. Parent report measures may potentially provide an additional and useful perspective for interpreting the play of children with lower language abilities. In addition to focusing on adult observation of play, our measure emphasized the content of play, but not the quality. For instance, we did not explicitly evaluate the spontaneity or playfulness of children in our study. Future work would benefit from examining a wider range of play measures.

Finally, our selection of language groups based on floor performance on a standardized measure of expressive and receptive language ability provides a somewhat arbitrary cutoff for language abilities among children with ASD. However, we selected this approach because it provides a rough classification of language across a range of items administered in a standardized way, compares performance to the expected chronological age level, and has potential clinical utility given its wide use in assessment batteries.

The current study highlights the need to examine individual differences in children with ASD over time. Pretend play abilities may be one avenue for developing symbolic thinking [Lillard et al., 2013; Piaget, 1952] and provide a way to practice and test social and emotional behaviors [Erikson, 1951]. Among children with

[4]We further explored this by creating a composite score from the Vineland Play and Leisure subscale, the Imaginary Play items from the ADI-R and the Play items from the ADOS and substituted this play variable into our regression analyses with essentially the same results: Time 2 nonverbal scores significantly predicted both play and EF among the lower language group, but Time 1 EF did not predict Play or vice versa. For the higher language group, Time 1 EF predicted Time 2 Play, but Time 1 Play did not predict Time 2 EF.

ASD who received early intervention targeting either play or joint attention skills as preschoolers, baseline play level was predictive of language and cognitive ability at a 5-year follow up [Kasari, Gulsrud, Freeman, Paparella, & Hellemann, 2012]. EF is also closely related to social cognitive development, theory of mind, and academic success among typically developing children [Blair, 2002; Hughes, 1998; Peterson et al., 2003]. If EF is involved in the ability to bridge between automatic and novel problem solving, it may be critical for learning. Assuming play can be learned, as Kasari and colleagues suggest with their demonstration of intervention for ASD targeting play, then having early inhibition and working memory skills would greatly support the development of play skills. In sum, our results provide important clues about individual differences and subgroups in ASD that may be useful in predicting developmental outcomes.

Acknowledgments

This research was supported by the National Institute of Child Health and Human Development (U19HD34565, P50HD066782, K99HD071966, U54 HD083091), the National Institute of Mental Health (U54MH066399), and the Cure Autism Now Foundation. The project is the sole responsibility of the authors and does not necessarily reflect the views of the funding agencies. We thank the Early Development Study team for research assistance, and we especially thank the participants and their families. These data were presented at the Society for Research in Child Development in Seattle, WA in 2013.

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