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ORIGINAL PAPER

Predicting Intentional Communication in Preverbal Preschoolers with Autism Spectrum Disorder

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Abstract Intentional communication has previously been identified as a value-added predictor of expressive language in preverbal preschoolers with autism spectrum disorder. In the present study, we sought to identify value-added predictors of intentional communication. Of five theoretically-motivated putative predictors of intentional communication measured early in the study (at study entry and 4 months after), three had significant zero-order correlations with later intentional communication (12 months after study entry) and were thus added to a linear model that predicted later intentional communication scores controlling for initial intentional communication scores at study entry. After controlling for initial intentional communication, early motor imitation was the only predictor that accounted for a significant amount of variance in children's later intentional communication.

Keywords Autism spectrum disorder · Intentional communication · Motor imitation · Predictors · Longitudinal

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Introduction

Approximately 25–30% of children with autism spectrum disorder (ASD) will fail to develop flexible, spontaneous, communicative expressive language abilities over the course of their lifetime (Anderson et al. 2007; Tager-Flusberg and Kasari 2013). This is an issue of vital concern, because the development of expressive language by school age (i.e., 5–6 years) has been associated with better long-term life outcomes and improved adaptive functioning (DeMyer et al. 1973; Gillberg and Steffenburg 1987; Kobayashi et al. 1992; Paul and Cohen 1984). A greater understanding of the factors that contribute to early expressive language development, particularly in children with ASD, could pave the way for the development of newer and more effective interventions for this population.

The Role of Intentional Communication in Language Development

In the effort to understand the complex processes surrounding the language development of young children with ASD, much attention has been given to skills that precede and predict the emergence of language, such as intentional communication. Intentional communication describes the purposeful use of both verbal and nonverbal acts (such as gestures, sign language, prelinguistic vocalizations, or words) to convey a message to another person (Wetherby et al. 1988). For example, a child may point towards an item, vocalize, and gaze toward their communication partner to indicate their desire to request or comment on the item. Alternatively, a child might bring their hand to their mouth in an exaggerated motion to request food (using the standard American Sign Language sign for this word), or shake their head up and down (a conventional gesture indicating agreement) when a parent asks if they want to eat. As typically developing children progress through the prelinguistic stage of development towards the use of multiword referential speech, their transition is dominated by the use of intentionally communicative acts (Bates 1979; Coggins and Carpenter 1981; Wetherby et al. 1988). Initially these acts are largely gestural in nature, but as development progresses these acts become increasingly complex, integrating prelinguistic vocalizations and single word utterances (Carpenter et al. 1983; Wetherby et al. 1988). Thus, intentional communication is an early social communicative skill that sets the stage for the development of flexible, spontaneous, communicative expressive language in typically developing children.

In comparison to their typically developing peers, children with ASD exhibit deficits in the use of nonverbal communicative behaviors that comprise the majority of early intentional communication acts, particularly those used to share positive affect (sometimes referred to as "comments" or "declaratives"; McEvoy et al. 1993; Mundy et al. 1987; Stone et al. 1997). However, both requesting and commenting intentional communication acts have been shown to correlate with later language production (McDuffie et al. 2005; Sigman and Ruskin 1999; Plumb and Wetherby 2013; Yoder 2006). A recent longitudinal correlational investigation showed that intentional communication, collapsed across behavior regulatory (i.e., requesting) and declarative (i.e., commenting) functions, predicts expressive and receptive language growth in initially preverbal preschoolers with ASD, even when controlling for several other correlates of language growth (Yoder et al. 2015). Thus, intentional communication can be considered a "value-added" predictor of language abilities in this population.

The Utility of Identifying Value-Added Predictors of Intentional Communication

Given the importance of intentional communication in the development of language, it is appropriate to consider ways to effect change in this skill in young children for whom it is delayed or absent. To this end, it is useful to consider factors that precipitate the development of intentional communication, particularly in young children with ASD. This consideration begins with the identification of value-added predictors of intentional communication. Value-added predictors are those that explain significant variance in outcomes of interest after controlling for other correlated predictors (Yoder et al. 2015). Sechrest (1963) referred to these predictors as those that "*add to* or *increase* the validity of predictions" made based on other available data. Compared to zero-order correlates (i.e., variables that are significantly correlated with the outcome when no other variable is controlled for), value-added predictors are better candidates for true causes of variance in outcomes of interest, because they allow us to rule out some alternative explanations for the observed association. Identifying child skills and parent behaviors that significantly predict the development of intentional communication allows us to chart out potential influences on intentional communication development. Identifying which of those predictors have added value allows us to limit our focus to child and/or parent behaviors that are potentially causal. This is a preliminary step towards the focused development of interventions that target important parent behaviors or child prerequisite skills, in order to facilitate the cascading development of language outcomes observed in typically-developing children.

Theoretical Support for Putative Predictors of Intentional Communication

We chose five putative predictors based on theory that supports their role in the development of communication. Because the transactional model of development posits that both child- and parent-centric factors contribute and interact to influence communication development, we selected both child-focused and dyadic variables (i.e., those tracking parent behaviors that were dependent on child behaviors to some extent) as putative predictors (McLean 1990; Sameroff 2009; Woynaroski et al. 2014). Child-centric putative predictors included responding to joint attention (RJA), motor imitation, and object play. Dyadic putative predictors were parent linguistic responses and parent responsive physical play.

RJA

RJA refers to a child's tendency to respond to bids from another person for shared attention around an object or event by following the direction of the other person's point or gaze, and visually attending to the referent of that point or gaze (Scaife and Bruner 1975; Bakeman and Adamson 1984). Both theory and the sequence of typical development support RJA as a foundational skill upon which the emergence of intentional communication depends. Typically developing children first learn to respond to bids for joint attention from their caregiver, and subsequently begin to initiate their own bids for joint attention through communicative gestures. In fact, much of early intentional communication by typically developing toddlers serves the purpose of establishing or engaging in shared attention around an object or event (Bruner 1981; Wetherby et al. 1988). RJA can be viewed as the ability to understand declarative intentional communication acts, and this ability is theoretically prerequisite to the ability to initiate declarative intentional communication acts, which make-up a portion of intentional communication as a whole. This theory motivated our selection of RJA as a putative predictor of intentional communication.

Motor Imitation

The ability to mimic the movements and actions of others has been proposed as a fundamental skill for early cognitive and social development (McDuffie et al. 2007). It is the foundation of reciprocal actions between children and adults, which serve as the primary context in which children learn to communicate (Stone et al. 1997). Nadel et al. (1997) have argued that motor imitation is inherently communicative and should be viewed as a developmental milestone which "underlies the shift from primary (i.e., pre-intentional) to pragmatic (i.e., intentional) communication." Motor imitation is indicative both of attention to others and of an ability to learn through observation (Carpenter 2006). Intentional communication hinges on a child's awareness of the interaction partner as a potential recipient of communicative actions, as well as their ability to learn by imitating communicative acts modeled by parents (Carpenter et al. 1998). Motor imitation may also be pivotal in the development of the understanding of the individual agency and intentions of others (Meltzoff and Gopnik 1993; Carpenter et al. 1998). Such an understanding is essential for the development of intentional communication, because intentionally communicative acts imply the capacity to recognize and influence the attentional state of an interaction partner (Carpenter 2006). These theoretical links motivated our selection of motor imitation as a putative predictor of intentional communication in this population.

Object Play

The way that young children explore and play with objects also has theoretical ties to the development of communication in young children and those with ASD (Baranek et al. 2005). Object play refers to the manner in which young children engage with objects and toys. Early in life, object play is characterized by sensory exploration (e.g., banging, mouthing, shaking; Uzgiris 1976; Belsky and Most 1981). As children develop, they add increasingly complex levels of object play to their developmental repertoire. For example, they use toy objects functionally, in a manner that is consistent with their cultural purpose (e.g., "driving" a toy car by moving it, or "feeding" a doll by putting a spoon to the doll's mouth; Weisler and McCall 1976; Belsky and Most 1981). Children also exhibit symbolic play with toys, by substituting one object to represent another (e.g., pretending a block is a brush and "brushing" a doll's hair), or assigning absent attributes to objects (e.g., pretending there is soup in a bowl and that it is hot; Weisler and McCall 1976; Belsky and Most 1981). Higher levels of object play are theorized to be indicative of representational thinking and symbolic capacity (Mundy et al. 1987). Experimental evidence suggests that even early experiences with object exploration are tied to the development of social interest and theory of mind (Sommerville et al. 2005; Libertus and Needham 2011). All of these are component skills that are essential to the development of intentional communication. Furthermore, objects are often the "subject matter" of intentionally communicative acts, so children with greater familiarity with the properties and functions of this subject matter may have more reason to initiate shared engagement around these objects for declarative purposes. For these reasons, we included object play as a putative predictor of intentional communication.

Parent Linguistic Responses and Parent Responsive Physical Play

Two dyadic predictors (parent linguistic responses and parent responsive physical play) were chosen because of theory and evidence that supports the role of parental responsiveness in the development of language and social communication, both in typically developing children and those with disabilities (Tamis-LeMonda et al. 1996, 2001). Theory suggests parental responsiveness could foster early intentional communication in a variety of ways. Parents that respond to their child's attentional leads with language and play signal to their child that they are willing interaction partners who share their focus of attention (Kaye and Charney 1980; Dunham et al. 1991). By responding with linguistic input, they provide a model for the child's future communicative attempts, and teach the back and forth nature of conversation (Kaye 1982; Dunham et al. 1991). By responding with play actions, parents draw the child's interest back to the "subject matter" of the conversation (objects and events), and their physical response may serve as a signal for the child to take their own turn, possibly by intentionally communicating about the objects or events of play.

Parental responsiveness is particularly beneficial because it "stays on topic" or pertains to the child's focus of attention (Bloom 1993). For example, parent linguistic responses involve parents providing verbal input that "stays on topic" by describing or commenting on the actions or objects being referenced by the child. Parent responsive physical play involves parents "staying on topic" during play exchanges by responding to a child's use of a toy with physical play that imitates the child's play actions or expands on the child's play actions with the same object.

To our knowledge, this type of physical play response (here termed “parent responsive physical play”) has not yet been examined separately from parent linguistic responses as a predictor of intentional communication. However, the combination of these two responses has been theorized to facilitate a supported state of joint engagement between the parent and the child (Bruner 1981; Tomasello and Farrar 1986; Bakeman and Adamson 1984), which has been implicated as a context that heightens the probability children with ASD will benefit from linguistic responses, which in turn affect language development in young children with ASD (Bottema-Beutel et al. 2014).

Purpose and Research Question

The purpose of this investigation was to identify theoretically-supported predictors that accounted for significant variance in later intentional communication outcomes, after controlling for initial intentional communication scores and intercorrelation among predictors. Our research question was as follows: Out of five putative predictors of intentional communication (RJA, motor imitation, object play, parent linguistic responses, and parent responsive physical play), which are value-added predictors of later intentional communication in preverbal preschool children with ASD, when initial intentional communication is controlled?

Method

Participants

The current study was conducted using data taken from a longitudinal study examining language development in preverbal preschoolers with ASD (Yoder et al. 2015). Participants were 61 young children with ASD (10 female, 51 male), a subset of the 87 participants of a larger study for whom estimates of the outcome variable, intentional communication, were available from key measurement periods (Yoder et al. 2015). At study outset, participants were between the ages of 24 and 48 months. If children had an existing diagnosis of autism or PDD/NOS through licensed and experienced community providers, their diagnoses were confirmed using the revised diagnostic algorithm on Autism Diagnostic Observation Schedule Module I (ADOS; Lord et al. 2000; Gotham et al. 2007), administered by research staff who were research reliable on this instrument. Children who did not enter the study with a previous diagnosis were assessed and diagnosed by a licensed clinician on the research team who was independently research reliable on the ADOS and who had experience with evaluating young children with ASD. Research diagnoses were based on best clinical judgment that the child met criteria for autism or PDD/NOS according to the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition-Text Revision (American Psychiatric Association 2000), which was confirmed by ADOS and a clinical interview. No participants had additional auditory, visual acuity or motor impairments, metabolic or progressive neurologic disorders, or identified genetic syndromes. At study entry, all participants used 20 words or less, according to parent report on the MacArthur-Bates Communicative Development Inventories: Words and Gestures checklist (Fenson et al. 2007) and used no more than five different words during a 15-min language sample. No intervention was provided as part of the study, but parents of participants reported that their children received an average of 14.25 h of therapy (e.g., physical therapy, speech and language therapy) per month. Parents of participants also reported achieving a mean formal education level of 1–2 years of college or technical school. Additional participant descriptive information is summarized in Table 1.

Study Design

For the larger study (Yoder et al. 2015), participants were given a battery of assessments at several time points. For the present study, we used a longitudinal correlational design to examine five theoretically-motivated predictors of intentional communication. Measures of initial intentional communication were taken from study entry, and measures of later intentional communication were taken 12 months after study entry. Variables representing each predictor were derived from measures taken at study entry and 4 months later (measures of predictors of interest were collected across two early time points in the larger study in order to reduce the burden on families during the initial assessment). Measurement periods, procedures, variable derivation, and descriptive statistics are presented for all predictor and outcome variables in Table 2.

Measures

This investigation used a combination of parent reports, as well as standardized tests and observational assessments, to measure constructs of interest. Some measurement procedures were used to assess several constructs, and whenever possible, variables used in analyses were derived from multiple measurement procedures. The rationale for the use of composite variables to represent constructs of interest is described later. The measurement procedures relevant to the current investigation are described here.

Table 1 Participant characteristics

Time Period	Measure	Min	Max	*M*	*SD*
Study entry					
	Chronological age[a]	20.67	47.86	34.92	7.19
	Mental age	3.75	26.50	12.43	4.97
	DQ	12.90	75.18	36.58	14.96
	Parent-reported total hours of therapy[b]	0	90	14.26	-0.11
	MCDI words understood	0	367	85.58	89.87
	MCDI words said	0	18	4.31	5.45
	UCS # different words	0	5	0.75	1.21
	Intentional communication	5	49	22.63	11.89
	ADOS CSS	5	10	8.32	1.62
1 year later					
	MCDI words understood	0	396	119.12	103.11
	MCDI words said	0	396	60.7	88.77
	UCS different words	0	36	6	7.96
	Intentional communication	9	153	61.30	37.15

ADOS Autism Diagnostic Observation Schedule; *CSS* Calibrated Severity Score; *DQ* Developmental Quotient (mental age/chronological age ×100); *M* Mean; *Max* Maximum value in distribution of participant scores; *MCDI* MacArthur Bates Communicative Development Inventories: Words and Gestures; *Min* Minimum value in distribution of participant scores; *SD* Standard Deviation; *UCS* Unstructured Communication Sample

[a]In months

[b]Per month

ADOS

Module 1 of the ADOS, originally developed as the Prelinguistic ADOS (DiLavore et al. 1995), was used to verify ASD diagnoses of participants at study entry. The ADOS is a semi-structured, standardized assessment of social interaction, communication, and play, and has well-established diagnostic reliability and validity (Gotham et al. 2007; Lord et al. 1994). Diagnostic cutoffs were chosen based on revised scoring algorithms published by Gotham and colleagues (2007). The calibrated severity scores (Gotham et al. 2009) were used to describe our sample.

Mullen Scales of Early Learning (MSEL; Mullen 1995)

The MSEL was designed to assess early cognitive development in children ages 0–5 years, and provides a score for mental age, which is the age equivalency score as averaged from four subscales: Visual Reception, Fine Motor, Receptive Language, and Expressive Language. Strong evidence for the convergent validity of age-equivalency scores provided by the MSEL was documented by Bishop et al. (2011). This assessment was administered at study entry, and the mental age and developmental quotient (mental age/chronological age ×100) were used to describe our sample.

Unstructured Communication Sample (UCS; Yoder et al. 2015)

The UCS was administered at study entry and 12 months later, in order to obtain a naturalistic measure of child intentional communication. The UCS is a lab-specific communication sampling procedure. In the UCS procedure, the child interacted with a researcher around a standard set of developmentally appropriate toys for 15 min. Researchers responded naturally to communicative actions from children with topic-following comments, and periodically asked questions that were relevant to child play behaviors. Researchers refrained from redirecting child play or directly prompting child language.

Communication and Symbolic Behavior Scales-Developmental Profile Behavior Sample (CSBS-DP; Wetherby and Prizant 2002)

The CSBS-DP is a structured assessment that was designed to assess the communicative and symbolic abilities of children with functional communication skills between developmental levels of 6 months and 2 years. In the behavior sample, an examiner presented each participant with a series of structured communication temptations, with the child's parent present. The CSBS-DP was administered at each assessment period in the larger study (Yoder et al. 2015). The CSBS served as an additional

Table 2 Constructs, Measurement procedures, and variables derived for predictors and outcome

Construct	Variable type	Procedure	Variable	Min	Max	*M*	SD
Object Play	Component	CSBS[a]	1st object use subscale	0	8	2.1	2.15
	Component	DPA[a]	Number of different play actions exhibited	2	27	12.3	6.27
	Analyzed	Composite	Average of z-scores of component variables	-1.3	2.3	0	0.9
Motor Imitation	Analyzed	MIS[a]	Total raw score	0	29	8.5	6.7
RJA	Component	CSBS[a]	Attention following subscale	0	6	1.9	2.1
	Component	ESCS[b]	Number of correct responses to eight bids for shared attention	0	8	2.4	2.7
	Analyzed	Composite	Average of z-scores of component variables	−0.9	1.9	0	0.9
Parent Linguistic Responses	Analyzed	PCFP[b]	Number of 5-s intervals with responsive adult utterance that pertains to child's referent	5	121	43.2	26.3
Parent responsive physical Play	Analyzed	PCFP[b]	Number of 5-s intervals with responsive adult physical play which involved the object or action referenced by the child	2	116	53.2	25.7
Initial IC	Component	UCS[a]	Number of 5-s intervals with intentional communication acts	0	18	4.3	4.6
	Component	CSBS[a]	Number of 5-s intervals with intentional communication acts	4	36	18.3	8.5
	Analyzed	Composite	Sum of scores from component variables	5	49	22.6	11.9
Later IC	Component	UCS[c]	Number of 5-s intervals with intentional communication acts	0	67	16.9	15.2
	Component	CSBS[c]	Number of 5-s Intervals with intentional communication acts	8	130	44.2	25.6
	Analyzed	Composite	Sum of scores from component variables	9	153	61.3	37.1

CSBS Communication and Symbolic Behavior Scales-Developmental Profile Behavior Sample; *DPA* Developmental Play Assessment; *ESCS* Early Social Communication Scales; *IC* Intentional Communication; *MIS* Motor Imitation Scale; *PCFP* Parent–Child Free Play; *RJA* Responding to Joint Attention; *UCS* Unstructured Communication Sample

[a]At study entry

[b]4 months after study entry

[c]12 months after study entry

sampling context for child intentional communication. In addition, the attention following subscale score from the behavior sample contributed to the aggregate variable for RJA. The variable quantifying object play was derived in part using the weighted raw score of the object play subscale (Scale 17) from the behavior sample.

Early Social Communication Scales (ESCS; Mundy et al. 2003)

The ESCS is a structured assessment that was given 4 months after study entry. Administration of the ESCS involves approximately 20 min of videotaped interaction between the child and a researcher, during which time the researcher presents a series of prescribed situations intended to elicit child communication in three domains: social interaction, joint attention, and behavioral regulation. The RJA score from this procedure contributed to the aggregate variable representing RJA.

Motor Imitation Scale (MIS; Stone et al. 1997)

Motor imitation ability was assessed at study entry using the MIS, a structured observational measure that involves examiner presentation of 16 motor imitation items. Items included body movements, such as clapping hands and waving, as well as meaningful and nonmeaningful object actions, such as shaking a noisemaker and tapping a spoon on a table. During the assessment, the examiner demonstrated each target item, and then immediately verbally prompted the child to repeat the action, by saying, "You do it." Child responses to each item were scored as follows: 2 points for immediate and accurate imitation, 1 point for partial imitation, and 0 points for failed or delayed imitation. The MIS has strong inter-rater and inter-item reliability, and strong MIS test-retest reliability has been demonstrated in a sample of 30 young children with developmental disorders (Stone et al. 1997).

Developmental Play Assessment (DPA; Lifter 2000)

The DPA was administered at study entry to assess play abilities of participants. A 10 min video recorded sample of the child's spontaneous play was collected. Two groups of toys were presented in the presence of a researcher, who commented descriptively on the child's play actions but refrained from directing the play. Play actions, which ranged from functional to symbolic play, were counted and scored using adapted DPA scoring procedures. A copy of the scoring manual is available upon request from the first author. This assessment yielded a score reflecting the number of unique functional play actions exhibited by each participant, and this score was used in combination with the play score from the CSBS to derive a variable for child object play.

Parent–Child Free Play (PCFP; Yoder et al. 2015)

The PCFP is a lab-created assessment procedure that was intended to serve as a naturalistic measure of parent and child play and linguistic behaviors. The procedure is a loosely structured assessment, which consists of 10 min of free play with toys and 5 min of book-sharing. During the procedure, parents were asked to play with their child "as [they] would at home," and provided with a standard set of developmentally appropriate toys. After providing instructions, the researcher left the parent–child dyad to play in the room. The researcher returned after 10 min with three age-appropriate books for the dyad to "look at" for 5 min. Both parent variables (parent linguistic responses and parent responsive physical play) were derived from this assessment. The PCFP was administered 4 months after study entry.

Variable Derivation and Rationale for Use of Composite Variables

Six variables (representing five theoretically-motivated predictors and one predicted outcome) were derived using scores taken from one or a combination of assessments. Table 2 lists variables chosen to quantify each construct, corresponding assessments, and methods of derivation. When possible, multiple measures of a single construct were used to derive the variable intended to quantify that construct.

Measurement theory asserts that the average of multiple scores taken from different measures of the same construct is more likely to be representative of a person's true score, because random measurement error is averaged out of the score (Shavelson et al. 1989). In addition, when scores are meant to represent generalized abilities, particularly for a behavior that is likely to be exhibited across multiple environments and with multiple interaction partners (such as communication or play), then it is better to use scores derived from multiple measures that vary across relevant contextual aspects (such as structuredness or interaction partners). These scores are more likely to represent a generalized ability than scores taken from a single assessment context (Sandbank and Yoder 2014). Finally, it has been consistently shown that aggregating measures longitudinally across occasions and assessment formats (e.g., structured or unstructured) yields gains in reliability and validity, which is a particularly important consideration for criterion variables in tests of incremental validity (Hunsley and Meyer 2003). Specifically for young children with disabilities, variables derived from multiple measures of a construct have been shown to be more stable than variables derived from a single measure (Sandbank and Yoder 2014). This was the rationale that motivated our *a priori* decision to create composite measures of constructs whenever possible, even when the effort required that we aggregate over separate testing occasions (i.e., study entry and 4 months later), or assessment format (i.e., highly structured and semi-structured).

Component variables were required to be moderately correlated (i.e., above 0.4) to be considered for aggregation (Cohen 1988). Component variables that were taken from procedures that used incomparable scales or that provided participants with different numbers of opportunities to exhibit a given behavior were z-transformed to ensure equal weighting prior to aggregation. Z-transformed component variables were averaged, and untransformed scores were summed, to create composite variables for use in analyses (See Table 2).

Variable Derivation

The total raw score from the MIS was used as the metric for motor imitation. All other measurement procedures used for variable derivation were video-recorded, and resulting media files were coded using Procoder DV (Tapp 2003) or Playcoder (Tapp and Yoder 2000) and extensive observational coding manuals (which can be requested from the corresponding author). Twenty percent of all videos were randomly chosen for recoding by a second coder to measure inter-observer reliability. Coding discrepancies were discussed to prevent observer drift. Reliability is reported as intraclass correlation coefficients (ICCs), which were computed using a two-way random model for absolute agreement.

Intentional Communication

Intentional communication was coded from the UCS and the CSBS using a 5-sec partial-interval coding method.

Because of the differing physical arrangement of the UCS and the CSBS (i.e., playing on the floor vs. seated at a table), intervals from the UCS were first marked for "code-ability," based on whether both the child and adult were visible on the screen. Code-able intervals were then marked for the presence of intentional communication acts, which were defined as any of the following: (a) words, (b) conventional signs, (c) conventional gestures that inherently convey a culturally-defined messages (such as a wave, shoulder shrug, or shh gesture) coupled with attention to an adult, (d) unconventional gestures that demonstrated coordinated attention to an object and adult (such as giving or showing an object), or (e) non-word vocalizations coupled with coordinated attention to object and person. This yielded a score indicating the number of code-able intervals with intentional communication acts exhibited during the UCS procedure. Reliability estimates for intentional communication acts coded from the UCS at Times 1 and 3 were 0.99 and 0.99, respectively. Because of the structured seating arrangement of the CSBS, it was not necessary that videoed media first be marked for code-able intervals. Instead, the entire videoed procedure was coded for intentional communication using the same partial-interval coding method used for the UCS. Reliability estimates for intentional communication acts coded from the CSBS at Times 1 and 3 were 0.97 and 0.99, respectively. The final variable used to represent intentional communication was derived by summing scores from both component variables.

Object Play

The variable for object play was derived from two procedures: the CSBS and DPA. For the CSBS, a score of object play skills was taken from the play subscale (Scale 17), following scoring procedures outlined in the CSBS-DP manual. Reliability for object play acts from the CSBS was 0.97. For the DPA, play actions were coded from an extensive predetermined list of possible object actions afforded by the toy sets (coding manual available upon request from corresponding author), using a timed-event behavior sampling method on specially-developed custom software (Playcoder; Tapp and Yoder 2000). Banging, shaking, mouthing, and atypical examining actions were not coded as play actions, unless they were consistent with the function of the toy (e.g., banging a hammer). This yielded a score that reflected the number of different play actions exhibited during the DPA. Reliability for play actions coded from the DPA was 0.99. The final variable reflecting object play was derived by averaging the z-scores of the two component variables from the CSBS and the DPA.

RJA

RJA was aggregated from two scores taken from the CSBS and ESCS. For the CSBS, the score from the attention following subscale (Scale 3) was used as a measure of RJA. Reliability for RJA coded from the CSBS was 0.97. For the ESCS, event behavior sampling was used to code instances of RJA, defined as any instance in which the child looked in the direction of the adult's bids for shared attention, across a series of eight presses. This yielded a score that reflected the number of correct RJA responses out of eight possible opportunities. Reliability for RJA coded from the ESCS was 0.99. Z-scores of the two component variables were averaged to create the analyzed RJA variable.

Parent Linguistic Responses and Parent Responsive Physical Play

Both parent linguistic responses and parent responsive physical play were coded from the PCFP. Media files of the procedure were divided into 5-s coding intervals. On the first pass, coders identified intervals in which the child and parent were visible on the screen as "code-able," using a momentary interval coding method. On the second pass, coders used a partial-interval coding method to examine code-able intervals and to flag those intervals that had at least one child attention or communicative lead. Child attention leads were defined as active looks or touches of an object, which were initiated or adopted by the child. Child communicative leads were any intentional communication act. On the third pass, flagged intervals were coded for the presence of parent linguistic responses (parent verbal responses which pertained to the object or action referenced by the child lead) or parent responsive physical play actions (parent physical play which involved the object or action referenced by the child lead) or both. To calculate the total number of intervals featuring parent linguistic responses, intervals with only parent linguistic responses were added to intervals with both parent linguistic responses and parent responsive physical play. Reliability for parent linguistic responses was 0.97. Similarly, parent responsive physical play was calculated as the total number of intervals featuring only parent responsive physical play plus intervals that featured both parent responsive physical play and parent linguistic responses. Reliability for parent responsive physical play was 0.99.

Data Analysis Plan

To identify value-added predictors of intentional communication, we first examined zero-order correlations between theoretically motivated putative predictors and the predicted outcome. Theoretically motivated putative predictors included (a) RJA, (b) motor imitation, (c) object play, (d) parent linguistic responses, and (e) parent responsive physical play. All theoretically motivated predictors that were significantly correlated with later intentional communication were entered in the same analysis step in a linear model that predicted later intentional communication scores and controlled for initial intentional communication. This method allows us to test the added value of each predictor after controlling for the intercorrelation among predictors. Predictors that failed to account for significant variance in the predicted outcome were then dropped from the model. A final model that featured only significant predictors and initial intentional communication scores was then compared to a model that included only initial intentional communication scores. Data that were missing at random, which accounted for 0–11% of cases depending on the variable, were handled using multiple imputation (Enders 2010).

Although no intervention was delivered as part of the study, the number of hours of therapy received by the child in the community was considered as a background variable that might potentially explain variance in the outcome we wished to predict. To explore whether this background variable should be included as a covariate in our model, we examined whether parent-reported hours of therapy per month received by the child at study entry was correlated with later intentional communication. The two variables were not significantly correlated, so number of hours in therapy was not included as a covariate in any of the models.

Results

Preliminary Analyses

All analyses were conducted using the statistical program R (R Core Team 2013). To check that our data satisfied the assumptions of multivariate normality and homoscedasticity, we examined plots of standardized residuals against fitted values, and normal QQ-plots. The data met these assumptions; consequently, no variables were transformed for the purposes of satisfying assumptions of the linear model. To identify the potential presence of multicollinearity in our dataset, we examined condition indices for each variable. This method is suggested by Belsley et al. (1980) as a robust alternative to the examination of intercorrelation among variables, since correlation is neither a necessary nor a sufficient condition for collinearity. Condition indices for the full model ranged from 1 to 9.78. Condition indices with values below 10 are thought to indicate weak near-dependencies, or low collinearity among variables (Belsley et al. 1980). Undue influence was monitored via inspection of leverage plots. No evidence of undue influence was found.

Correlations among predictors are presented in Table 3. In addition to initial intentional communication, the variables that were significant zero-order correlates of the outcome variable included RJA, object play, and motor imitation. Neither of the dyadic variables (parent linguistic responses or parent responsive physical play) were significantly correlated with later intentional communication. Thus, three theoretically motivated predictors were identified for the linear model predicting later intentional communication and controlling for initial intentional communication.

Primary Analyses

Results from the regression model with all four correlated predictors indicated that motor imitation and early intentional communication were the only significant predictors after controlling for the other correlated predictors. Thus, our reduced model included only initial intentional communication scores and motor imitation. We then compared this reduced model to one that included only initial intentional communication scores. The model which included both motor imitation and initial intentional communication scores accounted for significantly more variance among later intentional communication scores than a model that

Table 3 Intercorrelations between predictor and outcome variables

	RJA	Motor imitation	Object play	PLR	PRPP	Initial Int Comm
Motor imitation	0.52**					
Object play	0.24	0.54**				
PLR	0.09	0.22	0.00			
PRPP	0.07	0.20	−0.04	0.49**		
Initial Int Comm	0.54**	0.48**	0.40**	0.09	−0.15	
Later Int Comm	0.40**	0.51**	0.28*	−0.08	0.15	0.59**

PLR parent linguistic responses; *PRPP* parent responsive physical play; *RJA* responding to joint attention; *Int Comm* intentional communication

* $p < .05$. ** $p < .01$

included only initial intentional communication scores (Adjusted R^2 change = 0.064, p = .01). Results are detailed in Table 4.

Discussion

The goal of this study was to identify value-added predictors of intentional communication, which has been shown to be a value-added predictor of language development in preverbal children with ASD (Yoder et al. 2015). Identifying predictors that account for variance in outcomes of interest helps to highlight those predictors whose manipulation may have an effect on the outcomes of interest. Specifically, the identification of a value-added predictor of intentional communication allows us to better understand the factors that may contribute to the development of prelinguistic communication skills. This can set the stage for the development of interventions that use this knowledge to effect change in intentional communication, which might in turn affect language outcomes.

Our results indicated that motor imitation was the only theoretically-motivated predictor that emerged as a value-added predictor of later intentional communication in children with ASD. These results add to mounting evidence suggesting imitation is a pivotal skill that serves as a foundation for subsequent intentional communication development in children with ASD. Previous work has shown that imitation is a core deficit in this population (Rogers 1999; Rogers et al. 1996; Smith 1998; Smith and Bryson 1994; Stone et al. 1997), and is associated with the development of joint attention (Carpenter et al. 2002), communicative gestures (Carpenter et al. 2002), and expressive language (Stone and Yoder 2001). Taken together, these results suggest imitation should serve as a primary target for early intervention in preschoolers with ASD.

It is useful to consider the mechanism by which motor imitation may contribute to the development of intentional communication in children with ASD. Some research suggests that the developmental sequence of intentional communication and other social communication skills differs for children with ASD relative to their typically developing peers. In small longitudinal studies of skill emergence, Carpenter et al. (1998) documented imitation skills emerging after responsive joint attention and communicative gestures in typically developing children, while Carpenter et al. (2002) observed a reversed pattern of emergence (in which motor imitation emerged prior to responsive joint attention and communicative gestures) in a majority of their sample of children with ASD. As well, single subject studies of interventions that targeted imitation in children with ASD have documented collateral effects on coordinated joint attention and spontaneous language (unprompted meaningful word use; Ingersoll and Schreibman 2006). Thus, children with ASD that learn to imitate may use it as a means to learn to share, follow, and eventually direct (through intentional communication) the attention of others.

Limitations and Future Investigations

Although the current study illuminates the potential importance of motor imitation in the development of intentional communication in young children with ASD, it should be noted that there are limits to the definitive conclusions that can be drawn from the identification of predictors that have added value. That RJA and object play were not identified as value-added predictors of intentional communication should not be construed as evidence that those skills are not important learning targets in and of themselves,

Table 4 Unstandardized coefficients, standard errors, and t values for full model predicting later intentional communication

Model	Variable	Coefficient	SE	*t*	*p*	*Adj R^2*
Base model						0.339
	Initial IntComm	1.85	0.33	5.56	0.000	
	Intercept	19.77	8.50	2.33	0.000	
Full model						0.387
	Initial Int Comm	1.45	0.41	3.55	0.000	
	RJA	−0.56	5.53	−0.10	0.919	
	Motor Imitation	1.86	0.84	2.21	0.033	
	Object Play	−2.65	5.39	−0.49	0.624	
	Intercept	12.82	11.69	1.10	0.279	
Final model						0.403
	Initial Int Comm	1.39	0.36	3.83	0.000	
	Motor imitation	1.68	0.68	2.48	0.016	
	Intercept	15.63	8.24	1.90	0.063	

Int Comm intentional communication; *RJA* responding to joint attention as they may be pivotal to the development of other social communication skills. As well, Yates and Taub (2003) suggest it is important to consider the applied value of the validity increment added by the criterion variable (in this case, motor imitation). That is, tests of incremental validity may highlight predictors that are not highly malleable and are therefore inappropriate targets for intervention. In such a case, we might choose to ignore a value-added predictor and instead focus intervention efforts on other predictors that we know to be highly malleable. Fortunately, motor imitation is a malleable skill that has been successfully targeted and increased with intervention (Ingersoll and Schriebman 2006; Ingersoll 2010).

This study does not provide definitive evidence of a causal influence of motor imitation on intentional communication. Longitudinal correlational investigations are a valuable tool for highlighting potentially causal explanations for variance in outcomes of interest by documenting the association, establishing temporal precedence of a putative cause before a putative affected variable, and controlling some of the alternative explanations for the association of interest (e.g., early intentional communication possibly driving the association of interest). However, no correlational study can account for every alternative explanation. Future correlational investigations should seek to replicate this result to determine whether this finding is generalizable to other samples of initially preverbal children with ASD. Experimental investigations could examine whether changes in intentional communication caused by intervention were preceded and mediated by changes in motor imitation.

It would be especially useful to conduct high quality studies that rigorously examine whether interventions that target imitation effect generalized changes in motor imitation that translate to gains in subsequent intentional communication skills. Traditional behavioral approaches have taught motor imitation using discrete trial training and a single discriminative stimulus, such as “do this” (Leaf and McEachin 1999; Maurice et al. 1996), but this approach has been criticized because its use of a highly structured learning environment and artificial reinforcers are likely to bring target behaviors under tight stimulus control, limiting the extent to which those behaviors generalize across multiple relevant contexts (Ingersoll and Schreibman 2006; Ingersoll 2010). Our goal in teaching motor imitation is to effect generalized change in a child’s ability to imitate functional actions with and without objects. This goal can be accomplished if researchers attend to the functionality of imitation targets, the extent to which the intervention programs foster generalization, and the extent to which outcome measures capture generalized (as opposed to context-bound) changes in behavior. If the functionality of imitation targets is considered, “teaching motor imitation” can be reimagined as teaching children to imitate communicative gestures (functional actions) and play with toys (functional actions with objects). To effect generalized change in these behaviors, researchers may use a naturalistic intervention such as Reciprocal Imitation Training, which employs loose teaching, the use of natural reinforcers, and multiple common discriminative stimuli to program for generalization (Ingersoll 2008). To verify that the intervention has caused a generalized change in motor imitation ability (rather than rote acquisition of a handful of targeted actions), researchers should track outcomes using structured assessments of motor imitation (such as the MIS or the Preschool Imitation and Praxis Scale; Vanvuchelen et al. 2011) that are delivered outside of the context of the intervention and feature test items that were not directly taught.

Conclusion

To our knowledge, this is the first study to examine multiple putative predictors of intentional communication in an effort to identify those that have added value. Past work had identified several early child skills and parent behaviors as factors that precede and potentially influence the development of communication in children with ASD. However, it may be difficult and inefficient to target all of these factors directly in therapy. In this study, motor imitation emerges as a key predictor of intentional communication development in children with ASD. Further work should examine the extent of this association, as well as the possibility that it is causal.

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Compliance with Ethical Standards

Conflict of interest Micheal Sandbank declares that she has no conflict of interest. Tiffany Woynaroski declares that she has no conflict of interest. Linda R. Watson declares that she has no conflict of interest. Elizabeth Gardner declares that she has no conflict of interest. Bahar Keceli Kaysili declares that she has no conflict of interest. Paul Yoder declares that he has no conflict of interest.

References

American Psychiatric Association. (2000). *Diagnostic and statistical manual of mental disorders* (4th Ed., text rev.). Washington, DC. doi:10.1176/appi.books.9780890423349.

Anderson, D. K., Lord, C., Risi, S., DiLavore, P. S., Shulman, C., Thurm, A., Welch, K., & Pickles, A. (2007). Patterns of growth in verbal abilities among children with autism spectrum disorder. *Journal of Consulting and Clinical Psychology, 75*(4), 594. doi:10.1037/0022-006X.75.4.594.

Bakeman, R., & Adamson, L. B. (1984). Coordination attention to people and objects in mother-infant and peer-infant interaction. *Child Development, 55*(4), 1278–1289. doi:10.2307/1129997.

Baranek, G. T., Barnett, C. R., Adams, E. M., Wolcott, N. A., Watson, L. R., & Crais, E. R. (2005). Object play in infants with autism: methodological issues in retrospective video analysis. *American Journal of Occupational Therapy, 59*(1), 20–30. doi:10.5014/ajot.59.1.20.

Bates, E. (1979). *The emergence of symbols: Cognition and communication in infancy*. New York: Academic Press.

Belsky, J., & Most, R. K. (1981). From exploration to play: A cross-sectional study of infant free play behavior. *Developmental Psychology, 17*(5), 630–639. doi:10.1037/0012-1649.17.5.630.

Belsley, D. A., Kuh, E., & Welsch, R. (1980). *Regression diagnostics: Identifying influential data and sources of collinearity*. New York: Wiley.

Bishop, S. L., Guthrie, W., Coffing, M., & Lord, C. (2011). Convergent validity of the Mullen Scales of Early Learning and the differential ability scales in children with autism spectrum disorders. *American Journal on Intellectual and Developmental Disabilities, 116*(5), 331–343. doi:10.1352/1944-7558-116.5.331.

Bloom, L. (1993). *The transition from infancy to language: Acquiring the power of expression*. New York: Cambridge University Press.

Bottema-Beutel, K., Yoder, P. J., Hochman, J. M., & Watson, L. R. (2014). The role of supported joint engagement and parent utterances in language and social communication development in children with autism spectrum disorder. *Journal of Autism and Developmental Disorders, 44*(9), 2162–2174. doi:10.1007/s10803-014-2092-z.

Bruner, J. S. (1981). The social context of language acquisition. *Language and Communication, 1*(2–3), 155–178. doi:10.1016/0271-5309(81)90010-0.

Carpenter, M. (2006). Instrumental, social, and shared goals and intentions in imitation. In S. J. Rogers & J. H. G. Williams (Eds.), *Imitation and the social mind: Autism and typical development* (48–70). New York: Guilford Press.

Carpenter, M., Nagell, K., Tomasello, M., Butterworth, G., & Moore, C. (1998). Social cognition, joint attention, and communicative competence from 9 to 15 months of age. *Monographs of the Society for Research in Child Development, 63*(4), i–174. doi:10.2307/1166214.

Carpenter, M., Pennington, B. F., & Rogers, S. J. (2002). Interrelations among social-cognitive skills in young children with autism. *Journal of Autism and Developmental Disorders, 32*(2), 91–106. doi:10.1023/A:1014836521114.

Carpenter, R. L., Mastergeorge, A. M., & Coggins, T. E. (1983). The acquisition of communication intentions in infants eight to fifteen months of age. *Language and Speech, 26*(2), 101–116. doi:10.1177/002383098302600201.

Coggins, T., & Carpenter, R. (1981). The communicative intention inventory: A system for observing and coding children's early intentional communication. *Applied Psycholinguistics, 2*(3), 235–251. doi:10.1017/S0142716400006536.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*. New York: Academic Press.

DeMyer, M. K., Barton, S., DeMyer, W. E., Norton, J., Allen, J., & Steele, R. (1973). Prognosis in autism: A follow-up study. *Journal of Autism and Childhood Schizophrenia, 3*(3), 199–246. doi:10.1007/BF01538281.

DiLavore, P. C., Lord, C., & Rutter, M. (1995). The pre-linguistic autism diagnostic observation schedule. *Journal of Autism and Developmental Disorders, 25*, 355–379. doi:10.1007/BF02179373.

Dunham, P., Dunham, F., Tran, S., & Akhtar, N. (1991). The non-reciprocating robot: Effects on verbal discourse, social play, and social referencing at two years of age. *Child Development, 62*(6), 1489–1502. doi:10.2307/1130821.

Enders, C. K. (2011). *Applied missing data analysis*. New York: The Guilford Press.

Fenson, L., Marchman, V. A., Thal, D. J., Dale, P. S., Reznick, J. S., & Bates, E. (2007). *Macarthur-bates communicative development inventories: User's guide and technical manual* (2nd ed.). Baltimore: Brookes.

Gillberg, C., & Steffenburg, S. (1987). Outcome and prognostic factors in infantile autism and similar conditions: A population-based study of 46 cases followed through puberty. *Journal of Autism and Developmental Disorders, 17*(2), 273–287. doi:10.1007/BF01495061.

Gotham, K., Pickles, A., & Lord, C. (2009). Standardizing ADOS scores for a measure of severity in autism spectrum disorders. *Journal of Autism and Developmental Disorders, 39*, 693–705. doi:10.1007/s10803-008-0674-3.

Gotham, K., Risi, S., Pickles, A., & Lord, C. (2007). The autism diagnostic observation schedule (ADOS): Revised algorithms for improved diagnostic validity. *Journal of Autism and Developmental Disorders, 37*, 400–408. doi:10.1007/s10803-006-0280-1.

Hunsley, J., & Meyer, G. J. (2003). The incremental validity of psychological testing and assessment: Conceptual, methodological, and statistical issues. *Psychological Assessment, 15*(4), 446–455. doi:10.1037/1040-3590.15.4.446.

Ingersoll, B. (2008). The social role of imitation in autism: Implications for the treatment of imitation deficits. *Infants and Young Children, 21*(2), 107–119. doi:10.1097/01.IYC.0000314482.24087.14.

Ingersoll, B. (2010). Brief report: Pilot randomized controlled trial of reciprocal imitation training for teaching elicited and spontaneous imitation to children with autism. *Journal of Autism and Developmental Disorders, 40*(9), 1154–1160. doi:10.1007/s10803-010-0966-2.

Ingersoll, B., & Schreibman, L. (2006). Teaching reciprocal imitation skills to young children with autism using a naturalistic behavioral approach: Effects on language, pretend play, and joint attention. *Journal of Autism and Developmental Disorders, 36*, 487–505. doi:10.1007/s10803-006-0089-y.

Kaye, K. (1982). *The mental and social life of babies: How parents create persons*. Chicago: Harvester Press.

Kaye, K., & Charney, R. (1980). How mothers maintain "dialogue" with two-year-olds. In D. Olson (Ed.), *The social foundations of language and thought* (211–230). New York: Norton.

Kobayashi, R., Murata, T., & Yoshinaga, K. (1992). A follow-up study of 201 children with autism in Kyushu and Yamaguchi areas, Japan. *Journal of Autism and Developmental Disorders, 22*(3), 395–411.

Leaf, R., & McEachin, J. (1999). *A work in progress: Behavior management strategies and a curriculum for intensive behavioral treatment of autism*. New York: DRL Books.

Libertus, K., & Needham, A. (2011). Reaching experience increases face preference in 3-month-old infants. *Developmental Science, 14*(6), 1355–1364. doi:10.1111/j.1467-7687.2011.01084.x.

Lifter, K., Gitlin-Weiner, K., Sandgrund, A., & Schafer, C. (2000). Linking assessment to intervention for children with developmental disabilities or at-risk for developmental delay: The developmental play assessment (DPA) instrument. *Play Diagnosis and Assessment, 12*, 228–261.

Lifter, K., Gitlin-Weiner, K., Sandgrund, A., & Schafer, C. (2000). Linking assessment to intervention for children with developmental disabilities or at-risk for developmental delay: The Developmental Play Assessment (DPA) instrument. In K. Gitlin-Weiner, A. Sandgrund, & C.E. Schaefer (Eds.), *Play diagnosis and assessment* (2nd Ed., 228–261). New York: Wiley.

Lord, C., Risi, S., Lambrecht, L., Cook, E. H., Leventhal, B. L., DiLavore, P. C., Pickles, A., & Rutter, M. (2000). The Autism diagnostic observations schedule- generic: A standard measure of social and communication deficits associated with the spectrum of autism. *Journal of Autism and Developmental Disorders, 30*, 205–223. doi:10.1023/A:1005592401947.

Lord, C., Rutter, M., & Le Couteur, A. (1994). Autism diagnostic interview- revised: A revised version of a diagnostic interview for caregivers of individuals with possible pervasive developmental disorders. *Journal of Autism and Developmental Disorders, 24*, 659–685. doi:10.1007/BF02172145.

Maurice, C., Green, G., & Luce, S. C. (1996). *Behavioral intervention for young children with autism: A manual for parents and professionals*. Austin, TX: Pro-Ed.

McDuffie, A., Turner, L., Stone, W., Yoder, P., Wolery, M., & Ulman, T. (2007). Developmental correlates of different types of motor imitation in young children with autism spectrum disorders. *Journal of Autism and Developmental Disorders, 37*(3), 401–412. doi:10.1007/s10803-006-0175-1.

McDuffie, A., Yoder, P., & Stone, W. (2005). Prelinguistic predictors of vocabulary in young children with autism spectrum disorders. *Journal of Speech, Language and Hearing Research, 48*(5), 1080–1097. doi:10.1044/1092-4388(2005/075).

McEvoy, R. E., Rogers, S. J., & Pennington, B. F. (1993). Executive function and social communication deficits in young autistic children. *Journal of Child Psychology and Psychiatry, 34*(4), 563–578. doi:10.1111/j.1469-7610.1993.tb01036.x.

McLean, L. K. S. (1990). Communication development in the first two years of life: A transactional process. *Zero to Three, 11*, 13–19.

Meltzoff, A., & Gopnik, A. (1993). The role of imitation in understanding persons and developing a theory of mind. In S. Baron-Cohen, H. Tager-Flusberg & D. Cohen (Eds.), *Understanding other minds: Perspectives from autism* (335–366). New York: Oxford University Press.

Mullen, E. M. (1995). *Mullen scales of early learning* (AGS ed.). Los Angeles, CA: Western Psychological Services.

Mundy, P., Delgado, C., Block, J., Venezia, M., Hogan, A., & Seibert, J. (2003). *A manual for the abridged Early Social Communication Scales (ESCS)*. Coral Gables, FL: University of Miami.

Mundy, P., Sigman, M., Ungerer, J., & Sherman, T. (1987). Nonverbal communication and play correlates of language development in autistic children. *Journal of Autism and Developmental Disorders, 17*(3), 349–364. doi:10.1007/BF01487065.

Nadel, J., Guérini, C., Pezé, A., & Rivet, C. (1999). The evolving nature of imitation as a format for communication. In J. Nadel & G. Butterworth (Eds.), *Imitation in infancy: Cambridge studies in cognitive perceptual development* (209–234). New York: Cambridge University Press.

Paul, R., & Cohen, D. J. (1984). Outcomes of severe disorders of language acquisition. *Journal of Autism and Developmental Disorders, 14*(4), 405–421. doi:10.1007/BF02409831.

Plumb, A. M., & Wetherby, A. M. (2013). Vocalization development in toddlers with autism spectrum disorder. *Journal of Speech, Language, and Hearing Research, 56*(2), 721–734. doi:10.1044/1092-4388(2012/11-0104).

R Core Team (2013). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org/.

Rogers, S. J. (1999). An examination of the imitation deficit in autism. In J. Nadel & G. Butterworth (Eds.), *Imitation in infancy* (pp. 254–283). New York: Cambridge University Press.

Rogers, S. J., Bennetto, L., McEvoy, R., & Pennington, B. F. (1996). Imitation and pantomime in high-functioning adolescents with autism spectrum disorders. *Child Development, 67*, 2060–2073.

Sameroff, A. J. (Ed.). (2009). *The transactional model of development: How children and contexts shape each other*. Washington, DC: American Psychological Association.

Sandbank, M. S., & Yoder, P. (2014). Measuring representative communication in 3-year-olds with intellectual disabilities. *Topics in Early Childhood Special Education, 34*, 133–141. doi:10.1177/0271121414528052.

Scaife, M., & Bruner, J. S. (1975). The capacity for joint visual attention in the infant. *Nature, 253*(5489), 265–266. doi:10.1038/253265a0.

Sechrest, L. (1963). Incremental validity: A recommendation. *Functional and Psychological Measurement, 13*(1), 153–158. doi:10.1177/001316446302300113.

Shavelson, R. J., Webb, N. M., & Rowley, G. L. (1989). Generalizability theory. *American Psychologist, 44*(6), 922–932. doi:10.1037//0003-066X.44.6.922.

Sigman, M., & Ruskin, E. (1999). Continuity and change in the social competence of children with autism, down syndrome, and developmental delays. *Monographs of the Society for Research in Child Development, 64*(1), 1–139. doi:10.1111/1540-5834.00009.

Smith, I. M. (1998). Gesture imitation in autism I: Nonsymbolic postures and sequences. *Cognitive Neuropsychology, 15*(6–8), 747–770. doi:10.1080/026432998381087.

Smith, I. M., & Bryson, S. E. (1994). Imitation and action in autism: A critical review. *Psychological Bulletin, 116*(2), 259–273. doi:10.1037/0033-2909.116.2.259.

Sommerville, J. A., Woodward, A. L., & Needham, A. (2005). Action experience alters 3-month-old infants' perception of others' actions. *Cognition, 96*(1), B1–B11. doi:10.1016/j.cognition.2004.07.004.

Stone, W. L., Ousley, O. Y., & Littleford, C. D. (1997). Motor imitation in young children with autism: What's the object? *Journal of Abnormal Child Psychology, 25*, 475–485. doi:10.1023/A:1022685731726.

Stone, W. L., Ousley, O. Y., Yoder, P. J., Hogan, K. L., & Hepburn, S. L. (1997). Nonverbal communication in two-and three-year-old children with autism. *Journal of Autism and Developmental Disorders, 27*(6), 677–696. doi:10.1023/A:1025854816091.

Stone, W. L., & Yoder, P. J. (2001). Predicting spoken language level in children with autism spectrum disorders. *Autism: The International Journal of Research and Practice, 5*(4), 341–361. doi:10.1177/1362361301005004002.

Tager-Flusberg, H., & Kasari, C. (2013). Minimally verbal school-aged children with autism spectrum disorder: The neglected end of the spectrum. *Autism Research, 6*(6), 468–478. doi:10.1002/aur.1329.

Tamis-LeMonda, C. S., Bornstein, M. H., & Baumwell, L. (2001). Maternal responsiveness and children's achievement of language milestones. *Child Development, 72*(3), 748–767. doi:10.1111/1467-8624.00313.

Tamis-LeMonda, C. S., Bornstein, M. H., Baumwell, L., & Melstein Damast, A. (1996). Responsive parenting in the second year: Specific influences on children's language and play. *Early*

Development and Parenting, 5(4), 173–183. doi:10.1002/(SICI)1099-0917(199612)5:4<173::AID-EDP131>3.0.CO;2-V.
Tapp, J. (2003). *ProcoderDV*. Nashville, TN: Vanderbilt Kennedy Center.
Tapp, J. T., & Yoder, P. J. (2000). *Playcoder: Aiding the coding of play in toddlers*. Software for Windows. Vanderbilt University: Jon.Tapp@vanderbilt.edu.
Tomasello, M., & Farrar, M. J. (1986). Joint attention and early language. *Child development, 57*(6), 1454–1463. doi:10.2307/1130423.
Uzgiris, I. C. (1976). Organizations of sensorimotor intelligence. In M. Lewis (Ed.), *Origins of intelligence: Infancy and early childhood* (123–163). New York: Plenum. doi:10.1007/978-1-4684-6961-5_5.
Vanvuchelen, M., Roeyers, H., & De Weerdt, W. (2011). Objectivity and stability of the preschool and imitation and praxis scale. *The American Journal of Occupational Therapy, 65*, 569–577. doi:10.5014/ajot.2010.ajot00000414.
Weisler, A., & McCall, R. R. (1976). Exploration and play: Resume and redirection. *The American Psychologist, 31*(7), 492–508. doi:10.1037/0003-066X.31.7.492.
Wetherby, A. M., Cain, D. H., Yonclas, D. G., & Walker, V. G. (1988). Analysis of intentional communication of normal children from the prelinguistic to the multiword stage. *Journal of Speech, Language, and Hearing Research, 31*(2), 240–252. doi:10.1044/jshr.3102.240.
Wetherby, A. M., & Prizant, B. M. (2002). *Communication and symbolic behavior scales: Developmental profile*. Baltimore: Paul H. Brookes.
Woynaroski, T., Yoder, P. J., Fey, M. E., & Warren, S. F. (2014). A transactional model of spoken vocabulary variation in toddlers with intellectual disabilities. *Journal of Speech, Language, and Hearing Research, 57*(5), 1754–1763. doi:10.1044/2014_JSLHR-L-13-0252.
Yates, B. T., & Taub, J. (2003). Assessing the costs, benefits, cost-effectiveness, and cost benefit of psychological assessment: We should, we can, and here's how. *Psychological Assessment, 15*(4), 478–495. doi:10.1037/1040-3590.15.4.478.
Yoder, P., Watson, L. R., & Lambert, W. (2015). Value-added predictors of expressive and receptive language growth in initially nonverbal preschoolers with autism spectrum disorders. *Journal of Autism and Developmental Disorders, 45*(5), 1254–1270. doi:10.1007/s10803-014-2286-4.
Yoder, P. J. (2006). Predicting lexical density growth rate in young children with autism spectrum disorders. *American Journal of Speech-Language Pathology, 15*(4), 378–388. doi:10.1044/1058-0360(2006/035).