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Is early joint attention associated with school-age pragmatic language?

Kristen Gillespie-Lynch^{1,2}, Allie Khalulyan³, Mithi del Rosario³, Brigid McCarthy³, Lovella Gomez³, Marian Sigman³, and Ted Hutman³

¹Department of Psychology, University of California, Los Angeles, USA

²Department of Psychology, City University of New York, New York, USA

³Department of Psychiatry and Biobehavioral Sciences, University of California, Los Angeles, USA

Abstract

In order to evaluate evidence for the social–cognitive theory of joint attention, we examined relations between initiation of and response to joint attention at 12 and 18 months of age and pragmatic and structural language approximately 6 years later among children with and without autism spectrum disorder. Initiation of joint attention at 18 months was associated with structural, *but not pragmatic*, language for children with and without autism spectrum disorder. School-age children with autism exhibited difficulties with structural and pragmatic language relative to non-autistic siblings of children with autism and low-risk controls. No evidence of the broader autism phenotype was observed. These findings do not support the social–cognitive theory of joint attention.

Keywords

Autism; infant siblings; joint attention; pragmatic language; structural language

Autism spectrum disorder (ASD) is characterized by social-communicative difficulties including atypical nonverbal and verbal communication. Reduced joint attention, or coordinated attention between social partners to share interest in objects or events, is a core symptom of ASD early in development (e.g. Rozga et al., 2011; Sigman and Ruskin, 1999). Difficulty with pragmatic language (the socially appropriate use of language across different contexts) is also considered a central characteristic of ASD (Bishop and Baird, 2001). Pragmatic language impairments associated with ASD include providing insufficient or excessive information, abrupt topic changes, limited conversational reciprocity, and difficulty interpreting non-literal language (e.g. Philofsky et al., 2007). Atypical pragmatic language may also be a characteristic of the broader autism phenotype (BAP), or subclinical

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Corresponding author: Kristen Gillespie-Lynch, Department of Psychology, 4S-234 College of Staten Island, City University of New York, 2800 Victory Boulevard, Staten Island, NY 10314, USA. kgillyn@gmail.com.

Note: AK is now at the University of Southern California, Department of Psychology.

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traits of autism observed in some first-degree relatives of individuals on the spectrum (Ben-Yizhak et al., 2010; Bishop et al., 2006; Landa et al., 1992; Losh and Piven, 2007).

While it has commonly been thought that structural language (use of systems of meaning such as phonology, syntax, morphology, or semantics) is only impaired among a subset of individuals with ASD, a recent review concluded that certain aspects of structural language (particularly semantics) are impaired in ASD across development and that other aspects of structural language (such as syntax and phonology) are often impaired earlier but not later in development (Boucher, 2012).

A similar dissociation in developmental patterns of impairment is apparent in the trajectories of different types of joint attention. Response to joint attention (RJA; gaze or point following) often becomes less atypical with development in ASD, while initiation of joint attention (IJA; directing others' visual attention with eye movements or gestures) remains atypical across development (Mundy and Jarrold, 2010). Indeed, IJA and RJA may be developmentally and functionally dissociable. While RJA may reflect relatively involuntary orienting to biologically relevant information, IJA may index more voluntary sharing of experiences.

Aims of this study

Why do certain aspects of joint attention and language often remain atypical across development in ASD while other communicative impairments become less apparent with age? A primary aim of this study was to examine developmental relations between IJA and RJA in infancy and later pragmatic and structural language among children with and without ASD in order to elucidate potential mechanisms relating joint attention and language. In particular, we wished to evaluate evidence for the social-cognitive theory of joint attention wherein the development of joint attention from simpler social behaviors (such as shared dyadic attention) reflects a growing understanding of others as intentional agents that in turn scaffolds subsequent symbolic development (Tomasello, 1995). According to this theory, "infants engage in joint attentional interactions when they understand other people as intentional agents" (Carpenter et al., 1998: p. 4). Longitudinal associations between early joint attention and the social, cognitive, and linguistic development of children with ASD (Mundy et al., 1990; Sigman and Ruskin, 1999) and typically developing children (Charman et al., 2000; Mundy and Gomes, 1998) are often considered evidence for the social-cognitive theory of joint attention.

We examined longitudinal relations between joint attention at 12 and 18 months of age and aspects of language that are primarily social (pragmatic language) or primarily representational (structural language) approximately 6 years later among children with and without ASD. We assessed the infant siblings of children with autism, who are at a heightened risk of developing autism (Ozonoff et al., 2011), as well as a low-risk (LR) group of children with no family history of autism. Longitudinal associations between joint attention and both structural and pragmatic language would provide support for a social-cognitive perspective on joint attention wherein joint attention in infancy is a key precursor of later social-cognitive skills such as language and theory of mind (see Charman et al.,

2000). A secondary aim of this study was to evaluate evidence that difficulties with pragmatic and structural language at school age are characteristics of the BAP.

Longitudinal associations between joint attention and structural language

Despite strong evidence for prospective relations between RJA and IJA and structural language development among children with and without ASD (e.g. Brooks and Meltzoff, 2005; Sigman and Ruskin, 1999), these relations may only be apparent during certain stages of development. Among typically developing infants, RJA at 6 (Morales et al., 1998, 2000), 10 (Brooks and Meltzoff, 2005, but see Morales et al., 2000), 12 (Morales et al., 2000), and 15 months (Delgado et al., 2002) was associated with structural language up to 18 months later. However, RJA at 8, 18, and 21 months was not (Morales et al., 2000).

Both IJA and RJA at 16 months were associated with structural language 4 months later (Mundy and Gomes, 1998). Gestural indication (high-level IJA) and RJA at 15 months were associated with structural language skills at a mean age of 5 years for typically developing children with and without a sibling with autism (Malesa et al., 2012). When RJA and IJA were simultaneously included in a model, only IJA predicted later language. The authors suggested that IJA may be more directly related to language development than RJA because it requires both the ability to share attention with another and the *choice* to do so.

Among children with ASD (but not typically developing toddlers), gaze alternation (low-level IJA) at 20 months was associated with structural language at 42 months (Charman et al., 2003; Charman et al., 2000). IJA and RJA at approximately 4 years of age were associated with structural language skills a year later among children with ASD (Mundy et al., 1990; Sigman and Ruskin, 1999). In the only study to our knowledge to examine relations between joint attention and syntactic development in particular, predictive associations between gestural indication and syntactic development 15–26 months later were observed among school-age children with autism (Rollins and Snow, 1998). Similar associations between gestural indication at 14 months and syntactic development 1.5 years later were observed among typically developing infants.

Thus, relations between joint attention and structural language may only be apparent in typical development when joint attention is assessed prior to 18 months of age but may remain evident later in development in autism. Joint attention typically develops gradually from birth until around 18 months of age (e.g. Butterworth and Jarrett, 1991). Given that the development of joint attention is delayed in autism (e.g. Rozga et al., 2011; Sigman and Ruskin, 1999), children with autism may vary from one another in their joint attention skills for a longer period of time than typically developing children do. Thus, we hypothesized that joint attention at 12 months would be related to later structural language for children without autism but not children with autism (whom we expected to exhibit floor effects in joint attention at 12 months). In contrast, we expected joint attention at 18 months to be related to later structural language for children with autism but not typically developing children (because most 18-month-old typically developing children would be expected to show similar levels of joint attention).

Associations between joint attention and pragmatic language

Given robust associations between early joint attention and subsequent structural language skills, we wished to determine whether joint attention also predicts pragmatic language. If joint attention represents an understanding of other people's intentions and desires which subserves language development (as stated in the social-cognitive theory of joint attention), joint attention should predict both structural and pragmatic language skills.

Although concurrent relations between IJA and pragmatic language have been demonstrated for children with ASD (Loveland and Landry, 1986), longitudinal relations between joint attention and pragmatic language have not previously been examined. Loveland and Landry (1986) found that gestural initiation (high-level IJA) predicted the correct production of "I/you" pronouns for children with ASD but not children with developmental language delays. Early childhood RJA has also been associated with adult nonverbal communication for individuals with ASD (Gillespie-Lynch et al., 2012).

The study by Loveland and Landry (1986) suggests that associations between joint attention and pragmatic language may be specific to ASD. Thus, in this study, we predicted that joint attention would be associated with subsequent pragmatic language skills only for children with ASD. Given projected floor effects in joint attention at 12 months among children with autism, we expected these relations to only be apparent for joint attention assessed at 18 months of age. Thus, we expected to find that joint attention at 18 months of age would be related to both structural and pragmatic language at school age for participants with autism.

Method

Participants

Participants in this study were part of a larger infant sibling study conducted at the University of California, Los Angeles. Infant siblings of children with autism (high-risk (HR)) and LR controls were evaluated at 6, 12, 18, 24, and 36 months of age and at school age (between 66.6 and 118.4 months of age: $M = 89.16$ months, standard deviation (SD) = 14.90 months). While our initial aim was to conduct all school-age visits between 60 and 66 months of age, the target window for school-age assessments was broadened to allow collection of this unique longitudinal data in a manner that was compatible with the busy schedules of participating families. This study's sample includes all children from the larger study for whom joint attention was assessed at 12 or 18 months and for whom the *Children's Communication Checklist* (CCC)-2 was administered at school age ($n = 64$).

HR participants were recruited through the University of California, Los Angeles (UCLA) Autism Evaluation Clinic and through other studies at UCLA's Center for Autism Research. Clinical psychologists at the UCLA Autism Evaluation Clinic confirmed diagnosis of autistic disorder among older siblings in the HR group according to *Diagnostic and Statistical Manual on Mental Disorders, Fourth Edition* (DSM-IV-TR; American Psychiatric Association, 2000) criteria using the Autism Diagnostic Observation Schedule (ADOS; Lord et al., 2000) and the Autism Diagnostic Interview-Revised (ADI-R; Lord et

al., 1994). Infants whose older sibling had a medical condition associated with autistic symptomatology, such as Fragile X and Tuberous Sclerosis, were excluded from the study.

LR participants were recruited through public birth records, as well as programs for infants and their mothers. LR participants included first-born children and later-born children with no family history of autism and no diagnosed learning, developmental, or behavioral disorders. Potential HR and LR participants were excluded if they had severe auditory, visual, or motor impairments or a reported history of complications during gestation or birth.

Diagnostic classifications were typically conferred at the 36-month visit ($M = 38.19$ months, $SD = 6.46$ months) although one child who missed the 36-month visit was diagnosed at school age (65.7 months) and two children were rated as concerning at the 36-month visit and received a diagnosis of ASD at school age (66.0 and 69.0 months). A clinician determined whether or not each child met diagnostic criteria for ASD using information from the ADOS, the *Social Communication Questionnaire* (SCQ; Rutter et al., 2003), and in accordance with DSM-IV criteria. One child who did not meet criteria for ASD at 36 months but whose parents reported that she had received an external diagnosis of ASD at school age was excluded from analyses because diagnosis was not verified by the clinician associated with this study.

Participants were classified into the following comparison groups based on risk status and diagnostic outcome: (a) infant siblings of children with autism ($n = 8$) and LR controls ($n = 2$) who met criteria for an ASD (ASD group; $n = 10$), (b) infant siblings of children with autism who did not later meet criteria for an ASD (HR-non-ASD group; $n = 31$), and (c) LR controls who did not later meet criteria for an ASD (LR-non-ASD; group $n = 23$; see Table 1 for group characteristics).

Measures

ADOS—The ADOS, a gold standard diagnostic instrument for ASD, is a semi-structured standardized observational assessment of autistic symptomatology in the domains of social interaction, communication, play, and restricted or repetitive interests (Lord et al., 2000). The ADOS was used to inform clinical diagnoses of participants. Examiners achieved research reliability on administration and scoring of the ADOS according to its authors' specifications.

Clinical Evaluation of Language Fundamentals-4—The *Clinical Evaluation of Language Fundamentals-4* (CELF-4) is a standardized observational measure of structural language skills for individuals from 5 through 21 years of age (Semel et al., 2003). It provides a language structure score: a standardized composite derived from the following sub-scales—word structure, sentence structure, recalling sentences, and formulated sentences. It assesses morphology, syntax, semantics, and metalinguistics. The CELF-4 was not administered to one HR-non-ASD participant. Two participants with ASD were administered the CELF-Pre-school (CELF-P) due to limited language skills. One of these participants did not progress past the floor on the CELF-P and was excluded from analyses. Two HR-non-ASD participants and one LR-non-ASD participant were not administered the CELF-4.

Children's Communication Checklist-2—We assessed school-age language with the CCC-2 (Bishop, 2003), a parent-report measure that captures both structural and pragmatic components of language usage. Because pragmatic language is the ability to use language in socially appropriate ways across a range of contexts, it is difficult to assess with standardized laboratory-based measures. Indeed, the CCC-2 was more effective at distinguishing between autistic children and typically developing children than the Test of Pragmatic Language, a standardized observational measure of pragmatic language (Volden and Phillips, 2010).

The CCC-2 is a 70-item parent-report questionnaire that measures children's communication skills from 4 to 16 years and 11 months of age. There are two domains represented in the CCC-2: Structural and Pragmatic (functional) language. Subscales for each general domain capture both communication weaknesses and strengths. The domains and their related subscales are as follows: (a) Structural Language—Speech, Syntax, Semantics, and Coherence and (b) Pragmatic Language—Initiation, Scripted Language, Context, and Nonverbal Communication. Two additional subscales designed to measure behavioral impairments associated with autism rather than communication difficulties (Social Relationships and Interests) were excluded from analysis. The internal consistency of the subscales ranged from .65 to .80 in the standardization sample of British children described in the CCC-2 manual (Bishop, 2003) and from $\alpha = .71$ to $\alpha = .87$ in a study with American children (Philofsky et al., 2007).

Scores on individual subscales were converted to age-scaled scores that were averaged to generate structural and pragmatic composite scores. The structural composite assessed difficulties with articulation, phonology, vocabulary, syntactic complexity, and discourse structure. The pragmatic composite assessed challenges adapting language to social contexts such as failure to initiate topics about reciprocal interests, repetitive initiations, excessive precision, atypical prosody, lack of understanding of sarcasm and humor, and difficulty producing and understanding facial expressions and gestures. An identical pragmatic composite has previously been used (Norbury et al., 2004; Philofsky et al., 2007) and a similar composite derived from the CCC was shown to have an internal consistency of $\alpha = .91$ in a validation study (Bishop and Baird, 2001). Following validation tests leading to the publication of the CCC-2, the coherence scale was moved from the pragmatic domain to the structural domain because narrative ability may be more related to structural than pragmatic language (Philofsky et al., 2007). Because the internal consistency of these composite scores has not been established in previous research, we examined their internal consistency in our sample. The overall internal consistency of the structural composite was $\alpha = .947$. The overall internal consistency of the pragmatic composite was $\alpha = .922$.

Early Social Communication Scales—The Early Social Communication Scales (ESCS) is a 15- to 25-min structured observation of nonverbal communication skills that typically emerge between 8 and 30 months of age (Mundy et al., 2003). The ESCS was administered at 12 and 18 months of age.

The RJA discussed in this report, distal RJA, represents the proportion of six opportunities to exhibit RJA wherein the child successfully followed the examiner's direction of attention.

Each RJA opportunity began with the examiner centering the child's gaze on the examiner by singing a song or tickling the child. Then the examiner called the child's name as he or she looked and pointed toward a poster affixed to the wall to the left, right, or behind the child. Two sets of three trials (once to each location) were administered at different points during the ESCS.

The two IJA scores used in this report include low-level IJA (gaze alternation), or the frequency with which the child establishes eye contact and alternates gaze and high-level IJA (gestural indication), or the frequency with which the child gestures (pointing and showing) in order to direct the examiner's attention toward an object. Coding of these IJA behaviors is mutually exclusive.

Reliability on the ESCS was achieved using a gold standard, or representative of the entire sample, set of ESCS administrations to participants representing a cross section of risk and outcome groups. Research assistants unaware of participants' outcome classifications and study hypotheses established reliability with a trained coder on 20–23 administrations of the ESCS. Reliability on both IJA and RJA behaviors was assessed using intra-class correlations, which ranged from .86 to .97 and .94 to .97, respectively.

At 12 months of age, IJA was not assessed for one participant with ASD and four HR-non-ASD participants and RJA was not assessed for one participant with ASD and for five HR-non-ASD participants. At 18 months of age, RJA was not assessed for one participant with ASD and one HR-non-ASD participant.

Analytic approach

Given the range of ages at school age in our sample, analyses were conducted with standardized scores. Nonparametric analyses were used because several variables of interest (such as joint attention) were not normally distributed. Group differences in pragmatic and structural language were evaluated with Kruskal–Wallis tests. Post hoc Mann–Whitney tests were used to compare specific groups.

Kendall's tau rank correlations were used to examine associations between RJA, gaze alternation, and gestural indication (at 12 and 18 months of age) and structural and pragmatic language separately for the ASD and non-ASD groups. This analysis approach is consistent with analyses of relations between joint attention and language in a combined group of HR and LR non-ASD participants reported by Malesa et al. (2012).

Bonferroni corrections were not used because power was limited. Thus, findings should be regarded as exploratory. Because we used nonparametric analyses, we did not control for socioeconomic status (SES) in analyses. However, SES was not associated with joint attention variables at 18 months of age nor was it associated with structural language on the CCC-2 or language structure on the CELF-4 at school age. SES was negatively associated with RJA at 12 months of age ($\tau(53) = -.319, p = .005$) and positively associated with the pragmatic composite on the CCC-2 at school age ($\tau(59) = .195, p = .05$).

Results

Analyses of group differences at school age

Group differences were observed for the CCC-2 pragmatic composite ($H(2) = 9.07, p = .011$), the CCC-2 structural composite ($H(2) = 7.40, p = .03$), and language structure on the CELF-4 ($H(2) = 7.02, p = .03$; see Table 2). Relative to HR-non-ASD participants, children with ASD exhibited reduced pragmatic ($U = 69.00, p = .008$) and structural language on the CCC-2 ($U = 67.00, p = .006$) but language structure on the CELF was only marginally reduced ($p = .058$). Relative to LR-non-ASD participants, children with ASD exhibited reduced pragmatic language ($U = 40.50, p = .002$), structural language on the CCC-2 ($U = 60.50, p = .031$), and language structure on the CELF-4 ($U = 35.50, p = .004$). No differences between HR and LR participants without ASD in school-age language skills were observed ($p > .35$). These findings provide evidence of autism-specific difficulties in structural and pragmatic language at school age. Although the HR-non-ASD group demonstrated a range of communication skills, the group *as a whole* did not differ from the LR-non-ASD group, and therefore did not provide support for verbal manifestations of the BAP with the measures assessed for this study. As can be seen in Table 2, evidence of the BAP was also not observed for joint attention, nonverbal IQ, or verbal IQ at 12 or 18 months.

Associations between joint attention and school-age language

As expected, there were no associations between joint attention variables at 12 months and school-age language skills for participants with ASD (see Table 3). At 18 months, there was a marginal association between RJA and structural language on the CCC-2. Gestural indication at 18 months was positively associated with the structural composite of the CCC-2 and language structure on the CELF-4. Surprisingly, none of the measures of joint attention were associated with school-age pragmatic language for participants with ASD.

For participants without ASD, there were no associations between joint attention at 12 months and school-age language (see Table 4). Again, gestural indication at 18 months was associated with structural language on the CCC-2. However, gestural indication at 18 months was only marginally associated with structural language on the CELF-4. There was a marginal association between RJA at 18 months and school-age pragmatic language.

Discussion

Regardless of risk status, children without ASD tended to exhibit better language skills than children with ASD. No evidence of the BAP was observed. This study replicates and extends previous research documenting long-term associations between joint attention and subsequent language skills in ASD by demonstrating associations between 18-month gestural indication and structural language skills at school age. For participants with ASD, 18-month gestural indication was associated with school-age structural language irrespective of whether language was assessed via parent report or a standardized observational measure. Eighteen-month gestural indication was also associated with school-age structural language

for participants without ASD. However, this pattern was only significant with the parent-report measure.

The lack of associations between gestural indication at 12 months and language measures among typically developing participants may be attributable to floor effects due to the prolonged developmental period over which IJA typically emerges. We were surprised to find no relations between gaze alternation and later language skills. However, few studies have distinguished between gaze alternation and gestural indication when relating IJA to language. Relations between gestural indication and language development have been more consistently observed (e.g. Malesa et al., 2012; Snow and Rollins, 1998) than relations between gaze alternation and language. The one prior study to our knowledge that did document specific associations between gaze alternation and later language did not assess gestural indication (Charman, 2003). Thus, observed relations between gaze alternation and language could have been attributable to the co-occurrence of gaze alternation and gesture (which would have been coded as gestural indication in this study) in the context of a coding scheme that focused only on gaze alternation. Gestures are known to scaffold linguistic development (e.g. Iverson and Goldin-Meadow, 2005). It is possible that gestural indication requires more intentionality than simply moving one's eyes as one does for gaze alternation. Perhaps more volitional aspects of joint attention, such as gestural indication, exhibit stronger relations to language than less volitional aspects of joint attention.

RJA may reflect more involuntary aspects of joint attention than both gaze alternation and gestural indication (Mundy and Jarrold, 2010). Indeed, contrary to expectations, RJA was not associated with subsequent language development in this sample. This is surprising because early childhood RJA, but not IJA, was associated with long-term language outcomes for children with autism (Sigman and Ruskin, 1999). The lack of such associations in this study may be due to the very small sample size and the fact that one participant with ASD did not provide RJA data at 18 months. The lack of associations between RJA and later language skills in the typically developing sample was surprising given research linking RJA at 15 months to structural language at around 5 years (Malesa et al., 2012). Relations between RJA and later language may be closely linked to the developmental level when both are assessed. The current findings provide support for the conclusion by Malesa and colleagues that IJA may be more closely linked to later language development than RJA because it indexes a *choice* to communicate.

Theoretical implications

Despite previous literature reporting concurrent links between joint attention and pragmatic language among children with ASD (Loveland and Landry, 1986) and contrary to our hypothesis, no significant relations between early joint attention and later pragmatic language skills were observed in this study. Contrary to our hypothesis, this study did not provide evidence for the social-cognitive theory (Tomasello, 1995) of joint attention. Instead, the current findings may be more consistent with the parallel and distributed processing (PDP) theory of joint attention (Mundy and Jarrold, 2010) wherein joint attention arises from an increasing ability to integrate triadic relations or information about oneself, another, and the conjunction of the self and other in relation to an external object. Structural

language involves mapping forms and meanings onto sounds, words, syntactic structures, and discourse structures. Relations between joint attention and subsequent structural language in this study and previous research (in the absence of longitudinal associations between joint attention and pragmatic language) suggest that structural language may involve higher-level forms of the triadic representations that organize and develop from joint attention according to the PDP model. These findings build upon previous research demonstrating longitudinal links between gestural indication and subsequent syntactic (e.g. Rollins and Snow, 1998) and vocabulary (e.g. Morales et al., 2000) development by suggesting that the ability to represent referential relationships may be the mechanism underlying relations between joint attention and multiple aspects of structural language.

Pragmatic language, like play, requires flexible use of forms and meanings depending on social context. While pragmatic language is closely associated with theory of mind skills in autism (e.g. Losh et al., 2012), both social understanding and aspects of executive function such as set shifting and inhibition may contribute to pragmatic language difficulties in autism (Geurts et al., 2004). The current findings do not provide information about the relative importance of intention reading and executive function to the development of pragmatic language in autism. Although the PDP model states that joint attention is a form of executive function (Mundy and Jarrold, 2010), both the PDP model and the social-cognitive theory of joint attention do not attempt to delineate in detail the ways that joint attention may differentiate with development into distinct systems, such as play, language, theory of mind, or executive function, that contribute in unique ways to subsequent social-cognitive development. It is quite possible that other social-cognitive skills, such as play, would be more directly related to pragmatic language than joint attention was in this study. Indeed, only play and deferred imitation were associated with subsequent language development among young children with autism when joint attention, play, and imitation were entered into the same predictive model (Toth et al., 2006). Future research should examine developmental associations between joint attention, play, executive function, theory of mind, and both pragmatic and structural language to determine if joint attention branches into other skills that are more closely associated with subsequent development than joint attention itself is.

Future research should also assess the relative importance of both social and non-social forms of triadic representation for the development of structural language in order to determine if relations between joint attention and language are specific to social opportunities for triadic representation. Because pragmatic skills are more about interactions between people than about interactions between people and objects, future research should assess whether pragmatic skills are more closely related to dyadic social attention while structural language skills are more intimately linked with triadic joint attention. Examining joint attention in relation to a range of social, cognitive, and linguistic skills that require varying levels of triadic representation will further elucidate the contributions of social understanding and representational skills to social-cognitive development.

The absence of evidence of the BAP

HR-non-ASD participants did not differ from LR-non-ASD participants in language skills at school age. Warren et al. (2012) also found no evidence of pragmatic or structural language difficulties among the siblings of children with autism at school age. However, many potential aspects of the BAP were not examined in this report. Additionally, subdividing the HR-non-ASD group might be a more effective way to characterize the BAP than comparing all HR and LR individuals who did not develop ASD. Indeed, only a subset of siblings of children with autism is likely to exhibit pragmatic deficits associated with the BAP (Ben-Yizhak et al., 2011; Bishop et al., 2006). Methods for identifying siblings who exhibit the BAP remain inconsistent across studies (e.g. see Ben-Yizhak et al., 2011; Bishop et al., 2006). Future research examining potential BAP-related pragmatic difficulties among siblings of children with ASD would benefit from a clear and consistent way to identify the BAP in young children.

Limitations of this study

A small sample of participants with ASD is a significant limitation of this study. With larger sample sizes, lower values of correlation coefficients are required for statistical significance due to increased precision of the sample estimate of the association between variables in the population. In this study, the coefficient of the significant correlation relating gestural indication to the CCC-2 structural composite in the non-ASD sample was smaller in absolute magnitude than nonsignificant correlation coefficients relating pragmatics to IJA in the much smaller ASD sample. Thus, limited power could have obscured relations between joint attention and pragmatic language in the ASD sample. This issue of sample size is a recurrent issue in longitudinal assessment of relations between joint attention and later social-cognitive development. Indeed, the study that first provided evidence for the social-cognitive theory of joint attention by establishing relations between joint attention and later theory of mind had a sample of only 13 typically developing infants (Charman et al., 2000). While relations between joint attention and theory of mind have since been replicated with larger samples, the strength of associations in subsequent studies was marginal, apparent only at circumscribed ages, and/or apparent only when controlling for other variables (Colonna et al., 2008; Nelson et al., 2008). Our findings, in conjunction with previous research, suggest that additional factors besides intention reading are important for understanding the presence or absence of associations between joint attention and subsequent social-cognitive skills.

Reliance on standardized measures of structural and pragmatic language is another limitation of this study. However, standardized and naturalistic measures of language may assess the same capacities among children with autism (Condouris et al., 2003). Nevertheless, a full picture of a child's language requires multiple types of assessments (Tager-Flusberg et al., 2009). Future research should relate performance on standardized measures to natural language samples in a range of contexts.

Ideally, parent-report measures and standardized observations should be more closely matched in their respective domains. Structural language as assessed by the CCC-2 includes articulation, semantics, and coherence as well as syntax while language structure as assessed

by the CELF-4 focuses primarily on syntax and morphology with some contribution of semantics and metalinguistics. The distinction we have made between structural and pragmatic language is somewhat artificial. It is likely that cognitive skills contribute to both pragmatic and structural language and that pragmatic and structural language skills exert bidirectional influences on one another. Indeed, structural language predicts aspects of pragmatic language for individuals on the spectrum (Volden et al., 2009). Additionally, the movement of the coherence subscale from the pragmatic domain to the structural domain with the publication of the CCC-2 suggests that certain aspects of language, such as discourse structure, have elements of both pragmatic and structural language.

Another limitation of this study is our inability to examine bidirectional relations between joint attention and language with the current data. The strongest evidence in favor of the PDP theory of joint attention would be predictive associations between joint attention and later social-communicative skills, such as language and theory of mind, *in the absence* of predictive relations between social-communicative skills and later joint attention. Future research should assess both joint attention and language skills at multiple points across development in order to address this unanswered question.

Conclusion

Our findings are more consistent with the PDP than the social-cognitive theory of joint attention and suggest that joint attention may initially be less reflective of children's understanding of others as referential agents and more reflective of their ability to integrate multiple sources of information. However, the mechanisms underlying the expression of joint attention are complex and likely involve infants' emerging capacity for both social knowledge and information integration. These findings suggest that interventions to help children at risk for autism develop nonverbal communication skills (particularly IJA) may have long-term beneficial effects on their linguistic development.

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Table 1

Participant characteristics by group.

	ASD (<i>n</i> = 10)	HR-non-ASD (<i>n</i> = 31)	LR-non-ASD (<i>n</i> = 23)
Male, <i>n</i> (%)	8 (80.0)	13 (41.9)	14 (60.9)
Caucasian, <i>n</i> (%)	7 (70.0)	21 (67.7)	19 (82.6)
High SES, <i>n</i> (%)	6 (60.0)	8 (25.8)	12 (48.0)
ESCS 12 months age, <i>M</i> (<i>SD</i>)	12.2 (.3)	12.5 (0.5)	12.3 (0.3)
ESCS 18 months age, <i>M</i> (<i>SD</i>)	18.3 (.4)	18.4 (0.4)	18.5 (0.2)
CCC-2 age, <i>M</i> (<i>SD</i>)	91.1 (16.2)	94.4 (15.4)	81.3 (10.0)
ADOS severity 36 months, <i>M</i> (<i>SD</i>)	5.9 (0.9)	1.3 (0.6)	1.2 (0.7)
ADOS severity school age, <i>M</i> (<i>SD</i>)	6.9 (1.7)	2.7 (2.2)	1.8 (1.6)

ASD: autism spectrum disorder; HR high-risk; LR: low-risk; SES: socioeconomic status; ESCS: Early Social Communication Scales; SD: standard deviation; CCC: *Children's Communication Checklist*; ADOS: *Autism Diagnostic Observation Schedule*.

High SES = annual family income US\$125,000; ESCS age = *age at which joint attention was assessed*; CCC-2 age = age of child when CCC-2 was administered to parent.

Table 2

Participant scores on key measures by group.

	ASD (<i>n</i> = 10)	HR-non-ASD (<i>n</i> = 10)	LR-non-ASD (<i>n</i> = 10)	Overall <i>p</i> value
IJA low 12 months	0.05 (0.49)	−0.24 (0.71)	−0.02 (0.68)	0.165
IJA high 12 months	0.06 (0.07)	0.14 (0.28)	0.05 (0.24)	0.060
RJA 12 months	0.17 (0.50)	0.51 (0.38)	0.44 (0.41)	0.201
Mullen Verbal IQ 12 months	83.85 (17.47)	98.55 (13.08)	94.87 (15.54)	0.051
Mullen Nonverbal IQ 12 months	110.39 (11.19) ^a	122.31 (7.89) ^a	119.49 (11.35)	0.027
IJA low 18 months	1.20 (0.50)	1.05 (0.63)	1.09 (.53)	0.529
IJA high 18 months	0.06 (0.07) ^a	0.22 (0.23) ^a	.16 (.18)	0.040
RJA 18 months	0.34 (0.34) ^a	0.76 (0.29) ^a	.61 (.36)	0.005
Mullen Verbal IQ 18 months	78.46 (25.54) ^{a,b}	101.57 (18.68) ^a	99.85 (17.02) ^b	0.022
Mullen Nonverbal IQ 18 months	93.19 (11.06) ^a	105.56 (10.42) ^a	101.14 (9.75)	0.021
CCC-2 Structural Composite SS	8.00 (3.21) ^{a,b}	10.88 (2.25) ^a	10.65 (2.02) ^b	0.025
CCC-2 Functional Composite SS	7.53 (3.07) ^{a,b}	11.14 (1.96) ^a	11.03 (1.83) ^b	0.011
CELF-4 Language Structure SS	92.44 (20.10) ^b	105.28 (15.39)	110.09 (9.66) ^b	0.030
DAS Nonverbal IQ School-age	106.10 (15.40)	109.85 (14.88)	110.13 (7.90)	0.751

Overall *p* value = significance level for Kruskal–Wallis test of overall group differences.ASD: autism spectrum disorder; HR: high risk; LR: low risk; IJA: initiation of joint attention; RJA: response to joint attention; CCC: *Children's Communication Checklist*; CELF: *Clinical Evaluation of Language Fundamentals*; SS: standard scores; DAS-II: differential ability scales-II.^aHR-non-ASD differs from ASD.^bLR-non-ASD differs from ASD.^{a,b} Groups indicated by shared superscript significantly different on Mann–Whitney U test.Bold values signify statistically significant at $p < .05$.

Each score indicates: Mean (SD).

Table 3

Correlations between joint attention and language at school age for participants with ASD.

	CELF-4 language structure	CCC-2 structural composite	CCC-2 functional composite
IJA low 12 months	$r(6) = .286, p = .322$	$r(7) = .167, p = .532$	$r(7) = .167, p = .532$
IJA high 12 months	$r(6) = -.214, p = .513$	$r(7) = -.000, p = 1.00$	$r(7) = -.000, p = 1.00$
RJA 12 months	$r(6) = .041, p = .893$	$r(7) = -.033, p = .988$	$r(7) = -.167, p = .562$
IJA low 18 months	$r(7) = -.056, p = .835$	$r(8) = -.333, p = .180$	$r(8) = .225, p = .369$
IJA high 18 months	$r(7) = .548, p = .049$	$r(8) = .580, p = .027$	$r(8) = .306, p = .247$
RJA 18 months	$r(6) = .189, p = .524$	$r(7) = .471, p = .087$	$r(7) = .118, p = .669$

ASD: autism spectrum disorder; CELF: *Clinical Evaluation of Language Fundamentals*; CCC: *Children's Communication Checklist*; IJA: initiation of joint attention; RJA: response to joint attention.

Bold values signify statistically significant at $p < .05$

Table 4

Correlations between joint attention and language at school age for participants without ASD.

	CELF-4 language structure	CCC-2 structural composite	CCC-2 functional composite
IJA low 12 months	$r(45) = -.031, p = .762$	$r(48) = -.044, p = .657$	$r(48) = .055, p = .580$
IJA high 12 months	$r(45) = .169, p = .118$	$r(48) = .068, p = .521$	$r(48) = .086, p = .417$
RJA 12 months	$r(44) = -.038, p = .734$	$r(48) = -.072, p = .511$	$r(47) = -.072, p = .516$
IJA low 18 months	$r(46) = -.163, p = .107$	$r(49) = -.108, p = .275$	$r(49) = .084, p = .397$
IJA high 18 months	$r(46) = .170, p = .099$	$r(49) = .214, p = .033$	$r(49) = -.023, p = .819$
RJA 18 months	$r(45) = .094, p = .400$	$r(49) = .059, p = .589$	$r(48) = .204, p = .061$

ASD: autism spectrum disorder; CELF: *Clinical Evaluation of Language Fundamentals*; CCC: *Children's Communication Checklist*; IJA: initiation of joint attention; RJA: response to joint attention.

Bold value signify statistically significant at $p \leq .05$