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Exploring Infant Gesture and Joint Attention as Related Constructs and as Predictors of Later Language

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Abstract

In infancy, use of gesture and the ability to engage in joint attention with others both predict later language development. Conceptually, gesture and joint attention abilities may reflect a similar underlying social communicative skill. However, these abilities are often studied separately. Despite the fact that gesture is often used in episodes of joint attention, little is known about the degree to which measures of gesture use and joint attention ability are associated with one another or how they similarly, or differentially, predict children's language abilities. Participants in the current study were 53 infants. At 12-months, multiple measures of infants' gesture use were gleaned from a free-play interaction with a parent. Infants' responding to and initiating joint attention were measured via the Early Social-Communicative Scales (ESCS, Mundy et al., 2003). Infants' expressive and receptive language was measured at 24-months with the Mullen Scales of Early Learning (Mullen, 1995). A factor analysis including gesture and joint attention measures indicated that at 12-months joint attention, particularly responding to joint attention, reflects a similar underlying construct with infant gesture use, yet they uniquely predict later language ability.

Introduction

In infancy, use of gestures and the ability to engage in joint attention with others are both predictors of later language development. Children who engage in more episodes of joint attention with an experimenter have greater vocabulary skills later on (Mundy & Gomes, 1998), as do children who gesture about more objects during parent-child interactions (Rowe & Goldin-Meadow, 2009a). Further, there is quite a bit of overlap in how gesture use and joint attention are typically measured, yet, depending on the research paradigm being used, either from the joint attention realm or that of gesture research, these skills are often not examined in tandem. Thus, little is known about the degree to which common measures of gesture use and joint attention ability are associated with one another or how they similarly, or differentially, predict children's language abilities. In the current study, we examine both

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gesture and joint attention in 12-month-olds to determine how they relate to one another and to language skills one year later.

Gesture and Joint Attention

Gestures are a form of nonverbal communication through physical movements of the body (Cartmill, Demir, & Goldin-Meadow, 2012). Gestures are often categorized according to the relation with their meaning. The most common types of gestures seen in infancy are deictic and conventional gestures (Cartmill et al., 2012). Conventional gestures are culturally determined and do not necessarily have any logical connection to their intended meaning, such as nodding one's head to mean 'yes'. Deictic gestures indicate a referent and are thus contingent upon the immediate context, such as pointing to, showing, or holding out a hand to ask for an object. Deictic gestures emerge early ontogenetically, around 8- to 10-months, and are those gestures which are most typically discussed and observed in research regarding different motivations or communicative intentions behind gestures (e.g., Behne, Liszkowski, Carpenter, & Tomasello, 2012; Cameron-Faulkner, Theakston, Lieven, & Tomasello, 2015; Cochet, Jover, Rizzo, & Vauclair, 2016; Ramenzoni & Liszkowski, 2016).

Bates, Camaioni, and Volterra (1975) were among the first to record the development of children's gesture use in detail. They observed three infants for overlapping periods over the course of the first and second year of life, with a focus on the infants' production of communicative preverbal gestures. Bates and colleagues described a developmental progression starting with unintentional, automatic communication of needs developing into intentional use of conventional signals. Around 10 months, they observed that children begin to use 'performatives' or gestures as an intentional means of communicating requests or to direct another's attention. Based on their observations, the researchers categorized the infants' gestures into two underlying motives, protoimperative and protodeclarative, both of which characterize goals regarding manipulation of a partner's behavior. According to the authors, protoimperative gestures involve using one's partner to obtain an object. For example, when an infant points to a toy because they want their partner to give it to them. Protodeclaratives, on the other hand, involve using an object to obtain the attention of one's partner. For example, when an infant points to a new toy in order to direct her partner's attention to that toy or to herself. More recently researchers have posited a more rich interpretation of declarative gestures, such that infants may be gesturing not only to direct their partner's attention but also to share an emotional or attentional state with their partner (Liszkowski, Carpenter, Henning, Striano, & Tomasello, 2004; Tomasello, Carpenter, & Liszkowski, 2007). Indeed, around the end of the first year, infants have also been observed to use gestures to provide information about the location of an object (Liszkowski, Carpenter, Striano, & Tomasello, 2006). Several researchers have operationalized infants' gestures according to this more rich interpretation, describing them as imperative, which are requesting, or declarative, which include sharing attention, emotion, and information (e.g., Cochet & Vauclair, 2010; Murillo & Capilla, 2016). Indeed, researchers often focus exclusively on infants' declarative pointing as it is considered more cognitively complex.

Engaging in joint attention involves sharing attention with a partner to a third entity, such as when an infant is attending simultaneously to both a parent and a toy (Seibert, Hogan, &

Mundy, 1982; Tomasello & Farrar, 1986). Bids for joint attention can include eye contact or gaze shifts or the use of deictic gestures. These behaviors are used to direct a partner's attention toward objects, thus creating an object of shared attention, or to monitor a partner's attention. For both gaze and gestures, the ability to follow others' bids for joint attention tends to precede infants' own production of bids, or initiation of joint attention (Carpenter, Nagell, & Tomasello, 1998; Camaioni, Perucchini, Bellagamba, & Colonnesi, 2004; Behne et al., 2012). However, the use of gestures is typically seen as a more evident marker of infants' intention to share attention with their partner, and thus more advanced joint attention behavior (Seibert, Hogan, & Mundy, 1982; Mundy, Kasari, Sigman, & Ruskin, 1995). In fact, Rowe (2000) found that the majority of pointing gestures produced during interactions between 14-month-olds and their mothers were used to direct the other's attention. Pointing to initiate joint attention can also be accompanied by gaze-checking, or gaze-alternation, in which the infant looks back and forth between the partner and the object. Infants' ability to gaze-check emerges toward the end of the first year (Masur, 1983; Matthews, Behne, Lieven, & Tomasello, 2012), around the same time that infants are also beginning to point to initiate joint attention. Thus, our discussion of gesture and how it relates developmentally to joint attention focuses mainly, but not exclusively, on deictic gestures, and even more specifically on pointing.

Overt attention directing behaviors, or the engagement in joint attention through the production of deictic gestures can emerge as early as 8- to 10-months of age and include both imperative and declarative motives. The age at which these behaviors emerge varies widely and can depend on how they are measured. For example, in their norming study of a parent-report measure of early communicative skills, Fenson and colleagues (1994) found that at least 50% of their sample produced showing and giving gestures by 8 months, and pointing and requesting gestures by 10 months. A more recent study, in which attention-directing gestures were elicited from infants using laboratory-based tasks, similarly found that at 10 months approximately 60% of their sample exhibited showing and giving, and 75% produced requesting behaviors. Moreover, even at 12 months approximately only 40% of infants exhibited pointing (Cameron-Faulkner et al., 2015). These relatively low incidents of pointing in 12-month-olds (~50%) remains even when a point-eliciting task is utilized (Behne et al. 2012). Typically infants are able to appropriately respond to bids for joint attention or attention-directing gestures around 9- to 10-months (Butterworth, 1991), beginning with the ability to follow points to nearby objects and those within their visual field. However, it is not until around 14- to 15-months, that infants are typically able to reliably follow points to objects farther away or outside of their visual field (Morissette, Ricard, & Gouin Décarie, 1992 as cited by Desrochers, Morissette, & Ricard, 1995,). Delgado and colleagues (2002) examined infants' following ability when an experimenter both looked at and pointed to a target object. Within their sample of 15-month-olds, they found that most of the infants (more than 95%) performed above chance when the target was within their visual field, whereas fewer than half of the infants could follow to target outside of visual field at levels greater than chance, Thus, there is wide variability in the emergence of attention-directing gestures and engagement in joint attention in infants during the first and into the second year of life. Part of that variability may be explained by differences in how these behaviors are measured.

Relations to Language

There is a growing body of evidence demonstrating the relations between children's language abilities and their earlier gesture and joint attention skills. The amount of time that mother-child dyads spend engaged in joint attention at 11-months predicts receptive vocabulary measured four months later (Carpenter et al., 1998). Further, the quality of such joint attention interactions at 15 months is predictive of expressive language skills at 21 months (Tomasello & Farrar, 1986). However, in these studies joint attention is measured at the dyad level which may obscure individual child-level differences. Individual differences in children's ability to initiate and respond to bids for joint attention in an experimental task (the Early Social-Communicative Scales: ESCS; Mundy et al., 2003) toward the end of the first and into the second year also predicts later expressive and receptive language skills at 24- and 30-months (Delgado et al., 2002; Morales et al., 2000; Mundy & Gomes, 1998). There is also evidence that amount of pointing at 12-months predicts productive vocabulary size at 20-months (Camaioni, Caselli, Longobardi, & Volterra, 1991). A recent meta-analysis examined the relation between pointing and language, including studies that measured pointing from 9- to 33-months and expressive and receptive language ranging from 9- to 54-months (Colonnesi, Stams, Koster, & Noom, 2010). They found a primary effect of pointing predicting language across studies, and the effect was also found for pointing with a declarative motive but not for pointing with an imperative motive, supporting the idea that declarative gestures are more cognitively complex or advanced. Gesture use measured at 14-months (specifically the diversity of meanings conveyed via gesture, including deictic and conventional gestures) predicts receptive vocabulary size at 42- and 54-months (Rowe & Goldin-Meadow, 2009a; Rowe, Ozçalişkan, & Goldin-Meadow, 2008), even with the child's early spoken vocabulary controlled. Parent reported child gesture at 15-months has been found to predict expressive language skill at 2- and 3-years (Kuhn, Willoughby, Wilbourn, Vernon-Feagans, & Blair, 2014) Gesture use also predicts increasingly complex use of spoken language, as the use of gesture+speech combinations predicts the onset of two-word utterances (Ozçalişkan & Goldin-Meadow, 2005), and sentence complexity at age three (Rowe & Goldin-Meadow, 2009b).

While these findings show robust relations between joint attentional abilities and language, and between gesture and language, studies do not typically examine them in tandem. The goal of the current study was thus to compare concurrent measures of infants' gesture and joint attention to illuminate the extent of the overlap between these two constructs, and how they similarly or differentially predict developing language abilities.

Current Study

Based on the concurrent development of infants' gesture and joint attention abilities, we propose two contrasting hypotheses regarding the relations between these sets of skills. The first is that gesture and joint attention are reflections of a similar underlying social-cognitive skill. The second is that gesture and joint attention are in fact separable and unique skill sets.

Evidence for the first hypothesis comes from Tomasello and his colleagues, who argue that engaging in joint attention requires an understanding of the psychological relation between a person and an object and relies on the infant's ability to represent her own as well as her partner's goal-related intentional behavior (Tomasello, Carpenter, Call, Behne, & Moll, 2005). This is considered a "rich" interpretation of infants' behavior. Researchers have also theorized for decades about the underlying social cognitive skills associated with or reflected in infants' production and comprehension of gestures. For example, and in many ways similar to the theory of joint attention presented by Tomasello and colleagues (2005), Blake & Dolgoy (1993) suggested that infants' use of gesture, in particular the steep increase in gesture use observed around the one-year mark, reflects "more abstract (but not yet representational) views of relationships between objects and between objects and people" (p. 97). As defined by Goldin-Meadow & Morford (1985), gestures are "motor acts which appear to be used symbolically for communicative purposes". This definition implies that interpretation of an action as gesture (i.e., whether it is communicative or not, and if so what is being communicated) lies with the receiver and would require a representation of the gesturer's intent. Additionally, this definition implies that the producer of a gesture should have some idea of how their gesture will be interpreted. Thus, this first hypothesis would suggest that the production and comprehension of gestures are expected to be related to joint attention skills in that they are two manifestations of the same social cognitive process.

The alternative hypothesis is that gesture and joint attention reflect unique social cognitive skills. For example, it is possible that using gestures, specifically declarative gestures, to communicate may reflect an underlying foundation in intention understanding, while joint attention may not. It has been suggested that responding to bids for joint attention (RJA) is in fact based upon the domain-general process of associative learning, rather than reflecting an understanding of intentions (Corkum & Moore, 1995; Triesch, Teuscher, Deak, & Carlson, 2006). Specifically, following another's gaze or point does not necessitate an understanding of your partner's psychological relation to an object, but may instead be an adaptive response in which you have learned that following a gaze or point will lead to something interesting. It is possible, and even likely, that initiating joint attention (IJA) will align with gesture production regardless of whether or not they reflect a similar foundation, due to the fact that gesture is often used to initiate joint attention. RJA, on the other hand, is captured by looking at infants' *responses* to those gestures. In addressing this alternative, we will be specifically focused on how RJA aligns with gesture, as observation of a clear separation between gesture and RJA would provide the best evidence that gesture and joint attention do in fact reflect separable skill sets. It is worth noting that in the current study we are not directly measuring what underlying skill or cognitive capacities are being manifested in infant's behavior, however examining how different measures of gesture and joint attention are or are not associated with one another can potentially provide evidence in favor of one or the other hypotheses outlined above.

The purpose of the current study is to examine common measures of early gesture and joint attention to determine how these skills do or do not cohere and whether they similarly or differentially predict language development. The specific research questions are:

1. Do infants' gesture and joint attention abilities relate to one another at 12-months?
2. Are the measures that compose these constructs highly associated such that they may be considered a single underlying factor, or do they each provide unique

information? Specifically, is there shared variance among measures of gesture and joint attention?

3. What is the pattern of relations between gesture, joint attention, and later language ability?

If the hypothesis that gesture use and joint attention ability are unique, yet founded on a similar underlying social-cognitive skill is supported, we would expect to find consistent correlations and common shared variance across the two sets of measures. Similarly, we would expect both gesture and joint attention to predict out to infants' later language skills and that a combination or composite of these skills would be a potentially stronger predictor of language ability. On the other hand, if gesture and joint attention abilities in fact reflect more separable skill sets with unique underpinnings, we would expect to see a lack of correlation between the two sets of skills. Specifically, we would expect to see a separation of RJA from gesture. Further, we would predict separable and differential relations with later language, as well.

Methods

Participants

The current sample was drawn from a larger sample of 102 infants participating in a longitudinal study starting at 1 month through 24 months (Reeb-Sutherland et al., 2011; Reeb-Sutherland, Levitt, & Fox, 2012; Sorondo & Reeb-Sutherland, 2015; Yoo & Reeb-Sutherland, 2013). Families were recruited from counties surrounding a large mid-Atlantic university. For the current analyses we used data from the 12-month and 24-month visits of the larger study, as these were the visits where gesture, joint attention, and language development were assessed. We included only those infants who participated in both the free play interaction and the ESCS (Mundy et al., 2003) at 12 months. Of the original 102 dyads, 29 did not return to participate in the 12-month visit. Further, 20 additional dyads were excluded from analysis for the following reasons: twelve dyads did not participate in the parent-child interaction, three mothers did not speak English during the parent-child interaction (1 Spanish, 1 Chinese, 1 Korean), and one child did not participate in the ESCS. This resulted in a sample of 53 mother-infant dyads. Twenty-three of the infants were female. Most mothers had a Bachelor's or graduate degree (n=43), 1 mother had an Associate's degree, and 9 had a high school diploma or below. Thirty-three mothers self-identified as Caucasian, 12 as African-American, 3 as Asian, 3 as Hispanic and 2 as other. At the 12-month visit, infants were on average 12.24 months old (Range = 11.90 – 12.63; SD = .20). Average age of the infants at the second visit was 25.40 months (Range = 24.40 – 26.30, SD = .52). The procedures described herein were approved by the Institutional Review Board at the University of Maryland, College Park, and written informed consent was obtained from all caregivers prior to any assessment or data collection in accordance with the Declaration of Helsinki.

Procedure

During the 12-month visit, dyads took part in a 10-minute videotaped, free play interaction. During these interactions, dyads were provided an assortment of age appropriate toys and instructed to play with them as they normally would. These interactions were then transcribed and coded for gesture production. In addition, experimenters administered the ESCS as a measure of infants' joint attention abilities. At the 24-month visit, experimenters administered the Mullen Scales of Early Learning (Mullen, 1995) as a measure of infants' language abilities.

Transcription and coding

All speech and gestures during the mother-infant videotaped interactions at 12 months were transcribed by research assistants trained to transcribe reliably using the CHAT conventions of the Child Language Data Exchange System (CHILDES; MacWhinney, 2000). The unit of transcription was the utterance, bounded by grammatical closure, a pause of more than two seconds, or transition in speaker. Transcription reliability was established by having a second reliable coder transcribe 20% of the videotapes; reliability was assessed at the utterance level and was achieved when coders agreed on 95% of transcription decisions. When coders disagreed, a third transcriber was consulted.

Measures

Measures of gesture, joint attention, and language can all be gleaned from naturalistic observations. However, deriving all of our measures from one interaction would likely result in inflated correlations due in part to the manner in which they were collected. Since the goal of the current study is to examine overlap between these constructs, we chose to use measures of gesture, joint attention, and language that are commonly used in the field, and that were each assessed using separate tasks. This should lead to less biased relations among constructs.

Gesture—Infant gesture production was coded from the transcripts of the ten-minute free play interactions that took place between the parent and child during the 12-month visit. Gesture *tokens*, or the total number of child gestures, served as our measure of gesture quantity. Gesture *types*, or the total number of different meanings conveyed in gesture, served as our measure of gesture diversity (e.g., Goldin-Meadow & Mylander, 1984; Rowe & Goldin-Meadow, 2009a). For deictic gestures, the meaning is determined as the object referred to by the gesture (e.g., the meaning of a point to a cup is "cup"). For conventional gestures, the meaning is defined as the culturally agreed upon translation of the gesture (e.g., nodding the head means "yes"). These measures of gesture include only conventional and deictic gestures due to the fact that no infants produced any representational gestures. This is in line with previous research suggesting that representational gestures are not typically exhibited by children until around 26 months (Ozcaliskan & Goldin-Meadow, 2011). We further broke down these measures into how many conventional (conventional gesture tokens), and deictic (deictic gesture tokens) the infants produced. We also coded infants' pointing gestures according to whether they were imperative or declarative points, and calculated the total number of imperative and declarative points infants produced. Lastly, we created a measure of infants' deictic gestures that were not points (non-point deictic tokens). These consisted of mainly of requestive gestures (68%), but also included showing (8%), and giving (24%). Reliability between two independent coders was assessed for 10% of the free-play interactions. Agreement between coders was 98% (k= .94; N=206) for identifying gestures, 96% (k= .95; N=166) for assigning meaning to gestures, and 96% (k= .88; N=90) for coding social motivations of pointing gestures.

Joint attention—Infants' ability to engage in joint attention was measured at 12 months using the ESCS (Mundy et al., 2003). The ESCS is a 20-min videotaped structured assessment designed to measure a variety of nonverbal communication skills in the 6- to 30-month period, including joint attention, behavioral requests, and social interaction. For this assessment, an experimenter performs specific actions presenting toys and playing different games with the child in an attempt to elicit specific social behaviors. These behaviors are coded based on pragmatic function or communicative goal. Specifically, two categories were considered: initiating joint attention (IJA), and responding to joint attention (RJA). These two categories are further broken down into what are considered to be higher-level and lower-level behaviors. Higher-level IJA behaviors refer to the use of spontaneous points or showing gestures, with or without coordinated gaze shifts between partner and object, to share the experience of an active mechanical toy with the tester during the 20-minute assessment interaction. Lower-level IJA behaviors refer to the use solely of eye contact and gaze shifts, no gesture, to share experience with the tester also during the 20-minute assessment. These different types of behaviors are considered higher- and lower-level in part because the use of gestures more clearly involves an intent to communicate as compared to gaze shifting, and further the use of deictic gestures to manipulate a partner's attention tends to emerge after the use of gaze shifting (e.g, Seibert et al., 1982; Mundy et al., 1995). Total frequencies of these behaviors are referred to as PS-IJA (pointing and showing) and EC-IJA (eye contact) in the following analyses. Lower-level RJA is considered a measure of infants' following of proximal points, whereas higher-level RJA is considered a measure of infants' following distal points. Thus, in the following analyses, Proximal-RJA (P-RJA) refers to the percent out of six trials in which an infant turns her head and eye gaze toward the object of the tester's point within a storybook. Distal-RJA (D-RJA) refers to the percent out of 8 trials in which an infant correctly turns her attention in response to experimenter points outside of her visual regard. Total RJA scores refer to the summed percentage scores for P-RJA and D-RJA, and thus produces a total possible score of 200 percent. Twenty percent of the sample was coded by two independent coders and sound inter-rater reliability was achieved with alphas of .87 for IJA (.88 for EC-IJA, .89 for PS-IJA), and .96 for RJA (.85 for P-RJA, .95 for D-RJA). In the current analyses, we utilized both PS- and EC-IJA scores. This allowed us to examine differential relations with the gesture and language measures based on whether infants initiate joint attention with or without the use of gestures. Analyses were conducted using both P- and D-RJA in place of the total RJA score and results for both mirrored those of the total RJA scores, suggesting that, in the current sample, the two sub categories similarly captured infants' ability to follow points, be they proximal or distal. Therefore, in the current analyses we only consider the combined total RJA scores.

Child language ability—Infant's expressive and receptive language ability was measured at 24-months using the Mullen Scales of Early Learning (MSEL: Mullen, 1995). The MSEL is a standardized, validated measure, with good reported internal reliability (.83–.95) and test-retest reliability (.70). The Receptive Language scale is made up of 33 items assessing infants' ability to understand words or simple phrases and respond accordingly. The

Expressive Language scale consists of 28 items assessing infants' ability to use language productively, for example naming objects or labeling pictures. The Mullen scales produce standardized *T*-scores (M=50, SD=10) that were used in the current analyses.

Results

Descriptive statistics of infants' gesture, joint attention, and language measures are presented in Table 1. There was wide variability in infants' gesture and joint attention abilities. For example, infants ranged from producing 0 to 19 total gesture tokens during the 10-minute naturalistic interaction, EC-IJA scores ranged from 0 to 43, PS-IJA scores ranged from 0 to 7, and RJA scores ranged from 0 to 156. At 24- months, infants' average expressive and receptive language scores were right around 50 on the Mullen, which, since the standardized *T* scores were used, suggests that the infants in this sample were exhibiting language skills that would be expected for their age, on average.

Examinations of the distributions of all of the variables showed that some of the gesture measures were significantly positively skewed and inspection of histograms indicated a trend where infants were either producing any (one or more) of the specific kinds of gestures or none at all. This was true for conventional gestures, imperative points, and declarative points. Treating these variables as continuous and normally distributed in analyses would thus be inappropriate, so we recalculated these as dichotomous measures where a score of 1 indicated that the infant did produce that kind of gesture during the free play interaction, and a score of 0 indicating that the infant did not. Frequency statistics for the three dichotomized gesture measures, conventional gestures, imperative points, and declarative points, are presented in Table 2. Roughly a third of the infants produced conventional gestures and, likewise, roughly a third of the infants produced imperative points during the free play interaction. Approximately half of the infants produced declarative points. All other variables exhibited approximately normal distributions.

To address the first research question regarding the extent to which gesture and joint attention skills are related to one other, we first calculated correlations between child gesture and joint attention measures at 12 months. For pairs of continuous variables, Pearson product-moment correlations were calculated. For pairs in which one of the variables was dichotomous and the other was continuous, point-biserial coefficients were calculated. Phi coefficients were calculated for the relations between two dichotomous variables. The results shown in Table 3 reflect the appropriate test used based on the type of measures being compared.

Looking at the relations among the various gesture measures we found that, not surprisingly, total gesture tokens were positively associated with all the other gesture measures suggesting that children who gestured more also used more different kinds of gestures. Further, imperative pointing, declarative pointing, and non-point deictic tokens were all positively correlated with total deictic tokens. However, the relation between deictic and conventional gesture production was not significant, and the relations between imperative points, declarative points, and non-point deictic gestures were also not significant. PS-IJA was positively correlated with deictic gesture tokens, and was marginally related to declarative pointing production. RJA was positively correlated with gesture types, tokens, deictic gestures, and declarative pointing production. However, we did not find a significant relation between IJA and RJA, and EC-IJA was not related to any of the gesture measures.

We next conducted an exploratory factor analysis as a way to determine whether child gesture measures and joint attention skills provide similar information, and perhaps reflect a similar underlying social-cognitive skill, or if gesture and joint attention are in fact more separable skill sets which provide unique information about infants' early social-cognitive ability. Initially, we included all measures of gesture and joint attention in a principle axes factor model. However, the model did not converge, indicating poor fit. We next removed conventional gesture tokens, imperative point tokens, non-deictic gesture tokens, and EC-IJA from the model, based on the results of the correlation analyses. None of the removed gesture measures were significantly correlated with either joint attention measure. Likewise, EC-IJA was not correlated with any of the gesture measures nor with RJA. Thus, there would be no expectation for these measures to load on similar factors with the other measures. Upon removing these measures, the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was .79, indicating a cohesive correlation pattern amongst the variables and that a factor analysis could produce reliable factors (Field, 2000). Again using principle axes factoring, two factors were extracted accounting for 72% of the original variance (Table 4). Gesture tokens, gesture types, and deictic tokens all loaded on the first factor, while producing declarative points, PS-IJA and RJA all loaded onto the second factor.

To examine our third research question regarding the pattern of relations between gesture, joint attention, and language ability, correlational analyses were conducted to address how well each original measure of child gesture and joint attention as well as the factor scores predicted language ability at 24-months. The results of these analyses are displayed in Table 5. Seven infants did not complete the language measure at 24-months resulting in a sample size of n=46 for this analysis. Gesture types, production of imperative points, and RJA were all significantly, positively associated with expressive language at 24 months. Gesture tokens, producing conventional gestures, and scores on both factors were all marginally positively correlated with expressive language at 24 months. Surprisingly, EC-IJA was negatively correlated with expressive language at 24 months. Gesture types, whether or not the child produced imperative points, and RJA were also significantly associated with receptive language at 24 months, as were scores on both factors. Gesture tokens, deictic tokens, and production of declarative points were all marginally positively related to expressive language at 24 months. Thus, associations were very similar whether predicting expressive or receptive language. And, expressive and receptive language scores on the Mullen were correlated at 0.64 ($p < .001$).

To determine the gesture or joint attention measures that best simultaneously predict later language, a series of regression analyses were run with infants' 24-month language as the dependent variable. Because the factor scores were significantly related to receptive and not to expressive language, we first chose receptive language scores as the dependent variable, thus allowing for a comparison in predictive power across both independent measures and the factor scores. In the first model, any gesture or joint attention measure that was significantly correlated with 24-month receptive language in the previous analyses was entered into the model. This model included, gesture types, production of imperative points, and RJA, and explained approximately 29% of the variance. However, gesture types was not a significant predictor. Thus, in the second model this measure was removed, which did not significantly reduce the fit of the model (F=0.12, p=.73) and resulted in a model which explained 28% of the overall variance in infants' 24-month receptive language abilities. To examine how well the derived factor scores predict later language, a third model was examined in which scores on the second factor were considered as the sole predictor. While it is a significant predictor, this model explained less variance than Model 2. An additional model including scores on the first factor along with those on the second factor was also conducted, however this model did not explain any additional variance than Model 3 with factor two scores alone. Because the second factor partially reflects RJA scores, a direct comparison of factor 2 scores and RJA was conducted using the Fischer r-to-z transformation to compare the correlation coefficients. They were not significantly different (z = 0.11, p = .91).

A second series of regression models were run with expressive language scores at 24 months as the outcome. Any gesture or joint attention measure that was significantly correlated with 24-month expressive language was entered into the model. This included gesture types, production of imperatives, RJA, and EC-IJA. This model explained approximately 31% of the variance, and all variables except gesture types were significant or moderately significant predictors Thus, gesture types was removed from the second model. This final model explained approximately 30% of the variance in 24-month expressive language.

Discussion

It is well established in the literature that, in infancy, gesture use and the ability to engage in episodes of joint attention are predictors of later language ability (e.g. Delgado et al., 2002; Morales et al., 2000; Rowe & Goldin-Meadow, 2009a; Rowe et al., 2008), and both have been implicated as reflecting significant social-cognitive development in infancy (e.g., Tomasello, 1995; Blake & Dolgoy, 1993). The current study examined two possible hypotheses regarding the relations between gesture and joint attention. The first being that they are based on and reflect a common underlying social-cognitive skill, and the second that they are rather reflections of unique and separable skill sets. In short, our results provide some support for the first hypothesis in that infants' gesture production and responding to joint attention skills reflect similar underlying abilities, yet they also uniquely predict later language skills.

More specifically, results of the correlation analysis presented support the first hypothesis, as responding to joint attention was positively correlated with four of the seven gesture measures. And while EC-IJA was not correlated with any gesture measures, PS-IJA was significantly positively correlated with deictic gesture tokens and marginally with production of declarative points. Through the factor analysis, we found that a two factor solution was the best fit for the data. With infants' production of declarative points, PS-IJA, and RJA all loading onto the second factor, this suggests a common factor underlying these skills, and potentially points to a common social-cognitive skill being reflected through these particular measures. However, we were not able to include all of the original measures of both gesture and joint attention in this analysis. Due to the lack of correlation amongst several of the measures, the original model did not converge which indicated that a cohesive factor structure could not be determined. Thus, the two factor model represents a combination of infants' total use of gestures (gesture types and tokens), their overall deictic gesture use, whether or not an infant produced any declarative points, PS-IJA and RJA.

Taking the results of the correlation analysis and the factor analysis together, a few tentative conclusions can be drawn. First, while infants' overall gesture use was strongly related to their responding to joint attention ability, not all of the different kinds of gestures were. Specifically, gesture types was most strongly related to RJA, followed by gesture tokens, deictic tokens, and the production of declarative points. Deictic tokens and declarative points were also related to PS-IJA. The production of conventional gestures, imperative points, and non-pointing deictic gestures were not related to either type of IJA or to RJA. This suggests that different kinds of gestures may be tapping in to different underlying social communicative skills that do not necessarily overlap with the skills required to engage in joint attention. As defined earlier, imperative gestures are typically used to affect a partner's behavior, not necessarily a partner's attention state, as is the case with declaratives. In fact, in their seminal paper, Bates and colleagues (1975) described imperatives as using a partner as the means toward achieving a non-social goal, such as retrieving a toy, whereas declarative gestures were described as using an object to obtain a social-goal, i.e., their partner's attention. Further, more recent research extends the interpretation of infants' declarative gestures to include the motivation to *share* attention or even information with a partner (Liszkowski et al., 2004; Liszkowski et al., 2006; Tomasello et al., 2007). The trials used to measure RJA in the current study were all examples of declarative gestures on the part of the experimenter; pointing at and looking toward pictures either in a book or around the room. The relation we see here between declarative points and RJA seems to reflect this.

We expected to find a relation between IJA and gesture use due to the nature in which both constructs are measured, and this is indeed what we found. The relation was specific to PS-IJA, which was measured as infants' production of declarative gestures (both points and showing), reflects infants' use of gesture as opposed to gaze to initiate joint attention. This operationalization likely led to the significant relation found between PS-IJA and deictic tokens as well as the marginal relation with production of declarative points. While the relation between PS-IJA and deictic gesture tokens can be explained in terms of a similar underlying construct, we believe that these two measures are more simply measuring the exact same ability. Most of the non-pointing deictic gestures were requests (67%), or imperative gestures, which could help to explain why these were not related to RJA nor to IJA. However, imperative pointing and non-pointing deictic gestures were not related. This may be because infants were either requesting by reaching or pointing imperatively, but not both.

Interestingly, we did not find a relation between conventional gestures and joint attention. This finding suggests that there is indeed something unique about deictic gestures, and in this case specifically declarative pointing, that distinguishes them from other kinds of gesture but that is shared with joint attention ability. Post hoc analysis showed that out of the 40 total conventional gestures produced (across all of the infants) more than half of these were clapping in celebration or to indicate “good job”. Conventional gestures are different from deictic gestures first and foremost because, by definition, they do not involve a specific object or referent. In this sample, it is likely that these gestures may be more akin to routines and as such would not be tapping into our theoretical foundational skill of intention understanding.

Further, it appears that there is a dissociation between infants’ responding to and initiating joint attention, and between EC-IJA and the measures of gesture. In exploring the differences between RJA and IJA, Mundy and his colleagues have repeatedly found no correlation between the two constructs (Mundy & Gomez, 1998; Mundy et al., 2007; van Hecke et al., 2007), and have proposed that responding to and initiating joint attention are differentially related to executive processes and their underlying neural networks (Mundy & van Hecke, 2008). Evidence for this theory, known as the multiple process model (Mundy, Card, & Fox, 2000), suggests that responding to joint attention (RJA) is regulated by a reflexive attention-regulating function that develops early in infancy. Initiating joint attention (IJA), on the other hand, is regulated by activation of systems in the frontal lobe that develop later in infancy and are associated with functions such as working memory, dual-task processing, and representational encoding. However, this theory would imply that RJA does not in fact tap into a similar skill set as gesture use, which we find evidence for here. One other possibility is that IJA as measured during the ESCS may also be capturing infants’ proclivity to engage with a stranger, the experimenter. Thus, the measures of gesture use during the free-play may be a more accurate measure of infants’ likelihood to initiate joint attention than the IJA measures from the ESCS, which could explain why those measures were more strongly correlated with RJA. Further research is needed to examine what might explain such a discrepancy between IJA and RJA.

Taken as a whole, the results presented here provide some support for the hypothesis that gesture and joint attention are reflections of a similar underlying social-cognitive skill. However, this conclusion is based on specific measures of gesture and joint attention. Thus, further research is needed to determine what this common underlying skill is. One possible candidate is the ability to understand the intentions behind others’ actions. There is evidence that infants engage in joint attention and use gestures in such a way that suggests an understanding of intentions (e.g., Camaioni et al., 2004; Liszkowski et al, 2004; Liszkowski, Carpenter, & Tomasello, 2008; Woodward & Guajardo, 2002), and support the idea that at least by the end of the first year of life, infants understand the psychological relations between people and objects, or more broadly with the physical world (although see Corkum & Moore, 1995 for a more conservative theory on the basis for joint attention behaviors in infancy). The current study did not include a direct measure of intention understanding. Thus, while we found evidence for an overlap between gesture and joint attention skills, we cannot speak directly to our proposal that this is due to the shared foundational skill of understanding others’ actions in terms of the psychological relations between people and objects or events. Previous research has shown a strong relation between both gesture skill (Heimann et al., 2006; Camaioni et al., 2004) and joint attention (Carpenter et al., 1998; Sodian & Kristen-Antanow, 2015) and measures of intention understanding. The research presented here expands on these by exposing the congruence between these two sets of skills. Future work that incorporates an imitation or completing a failed action task, for example, would provide more empirical evidence for the hypothesis we present theoretically herein, that it is intention understanding which drives these relations.

There were several significant predictive relations between infants' early gesture and joint attention and later language ability, but interestingly, when pitted against each other in the regression analyses only infants' production of imperative points and RJA remained as significant predictors of infants' later receptive language ability. This suggests that at 12 months those infants who are pointing at all as compared to those who aren't yet pointing (as indexed by the imperative pointing dichotomous variable) and those infants who exhibit greater understanding of others' intentions as measured via their responding to bids for joint attention that tend to exhibit stronger receptive language skills later on. It is important to note that RJA and production of imperative points each significantly predict later language above and beyond the effect of the other. This indicates that, while there is evidence for shared variance among certain joint attention and gesture measures, there is also something unique enough about RJA and production of imperative points that they separately predict later language. It is worth discussing what makes RJA and imperative pointing unique both from each other and from the other measures.

The predictive power of RJA and imperative pointing was also shown in relation to later expressive language. Surprisingly, EC-IJA was negatively related to later expressive language. Previous work comparing RJA and IJA have produced equivocal findings regarding their relations to language ability, with some finding, as we did, that RJA was more predictive of later language than IJA (Mundy, Kasari, Sigman, & Ruskin, 1995), and yet others finding that individual differences in both IJA and RJA predict later expressive and receptive language skills (Delgado et al., 2002; Morales et al., 2000; Mundy & Gomes, 1998). Perhaps the negative relation between EC-IJA and expressive language is an indication that infants who, at 12 months of age, are persisting to use eye gaze rather than gestures to initiate joint attention will show weaker growth in language skills over time. However, more work is needed to parse apart the differences between RJA and IJA, their role in later development, and what the underlying sources of these differences might be.

As we have discussed, we believe RJA may be reflecting infants' underlying skill for intention understanding. Declarative pointing, as opposed to imperatives, are considered by some researchers to be a more obvious example of infants demonstrating an understanding of others as intentional agents because they seem to suggest an appreciation of the attentional state of the communicative partner, while an imperative gesture might only require an understanding of one's partner as a causal agent (Camaioni, 1993; Camaioni et al., 2004; although see Tomasello et al., 2007 for a more rich interpretation of both declarative and imperative gestures). Thus, the unique variance explained by RJA and imperative pointing may reflect the different underlying skill sets. But if imperative pointing does not reflect intention understanding, what makes it such a strong predictor of later language? This finding is actually somewhat surprising and is in contrast to previous findings (Colonnesi et al., 2010). In considering why production of imperative points would be more predictive than production of declarative points, it is possible that at 12 months it is meaningful to distinguish between pointers and non-pointers. That is, the dichotomous measure of production of imperative points may be capturing whether infants point at all.

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The dichotomous measure of production of declarative points, being strongly correlated with RJA is likely also a reflection of intention understanding and may also be further categorizing pointers into more versus less sophisticated pointers. This sophistication of pointing may become a more important predictor of language skills, and more differentiated from *responding* to joint attention, later on in infancy.

Not surprisingly, based on the relations between the individual measures and later language skill, infants' scores on both factors were predictive of later receptive language skills. The relation with the first factor, which reflects infants' overall gesture use, seems to capture that relation between gesture production (i.e., types and tokens) and later language. The relation with the second factor, which reflects the common variance among infants' declarative pointing production, use of deictic gestures to initiate episodes of joint attention, and responding to joint attention, may reflect a relation between a shared underlying skill set amongst those measures and later language ability. However, the results of the third regression model indicate that the second factor, which may be reflecting infants' intention understanding is, no better at predicting later language than the combined explanatory power of RJA and production of imperative points. In a direct comparison of RJA and the second factor, there was no difference in strength of correlation with later language. This suggests that, while we have provided evidence for an overlap between several measures of gesture and joint attention, we do not gain any predictive power by considering a statistical combination of these measures.

There are some limitations to the current study worth noting. First, is that while it was a benefit to use common ways of measuring gesture and joint attention and to glean these measures from distinct activities so they were not artificially inflated, a more robust examination might include additional measures of both constructs. Second, within the confines of this one study, we were not able to confirm the results of our exploratory factor analysis, as this would require a second sample. We found evidence for an overlap between certain measures of gesture and joint attention, future work is needed to determine the robustness of this two factor model using confirmatory factor analytic methods with a new group of infants.

In sum, infants' use of gestures and the ability to engage in episodes of joint attention have long been studied as precursors to later language skill, however gesture and joint attention are often discussed in two separate veins of literature. The current findings provide some support for the hypothesis that gesture and joint attention are reflections of a similar underlying social-cognitive skill, potentially intention understanding, yet future work is needed to determine whether intention understanding serves as this foundation. Further, despite the fact that gesture and joint attention measures hang together, they do both uniquely predict later language ability. Thus, there is something unique about each skill for fostering later language development. We will learn more about this if future research examines measures of both gesture and joint attention simultaneously in studies of early social cognition and language development.

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Table 1

Descriptive statistics of child gesture, joint attention, and language measures

	Mean (SD; Range)
Gesture	
Tokens	6.70 (4.86; 0–19)
Types	4.45 (2.54; 0–12)
Conventional Tokens	1.06 (2.19; 0–11)
Deictic Tokens	5.64 (4.22; 0–19)
Imperative Points	0.85 (1.96; 0–9)
Declarative Points	1.26 (2.17; 0–10)
Non-point Deictic Tokens	3.62 (2.44; 0–9)
Joint Attention	
EC-IJA	13.28 (9.04; 0–43)
PS-IJA	0.77 (1.40; 0–7)
RJA	62.26 (38.16; 0–156)
24 month Mullen	
Expressive	53.62 (9.88; 35–70)
Receptive	53.47 (9.44; 30–74)

Note: For gesture and joint attention measures, n=53; for 24mo Mullen, n=46. EC-IJA - Eye Contact to Initiate Joint Attention, PS-IJA - Pointing/Showing to Initiate Joint Attention, RJA - Responding to Joint Attention

Table 2

Descriptives for the dichotomized gesture measures

	Did not produce n (%)	Produced n (%)
Conventional Tokens	34 (64.2)	19 (35.8)
Imperative Points	35 (66.0)	18 (34.0)
Declarative Points	27 (50.9)	26 (49.1)

Note: n=53

Table 3

Correlations between child gesture and joint attention measures at 12 months (n=53)

	Gesture							Joint Attention		
	Types	Tokens	Produced Conventional	Deictic Tokens	Produced Imperative Points	Produced Declarative Points	Non-point Deictic Tokens	EC-IJA	PS-IJA	RJA
Types	--	.83***	.34*	.83***	.38**	.50***	.61***	.06	.21	.38**
Tokens		--	.32*	.89***	.29*	.50***	.58***	.12	.23	.36**
Prod. Conventional			--	.03	.21	.05	.07	.07	−.05	.22
Deictic Tokens				--	.38**	.56***	.59***	.14	.29*	.28*
Prod. Imperative Points					--	.25~	.00	.00	.09	.07
Prod. Declarative Points						--	.14	.01	.27~	.35**
Non-point Deictic Tokens							--	.01	.05	−.02
EC-IJA								--	−.06	−.09
PS-IJA									--	.14
RJA										--

~ $p < .10$

* $p < .05$

** $p < .01$

*** $p < .001$

EC-IJA - Eye Contact to Initiate Joint Attention, PS-IJA - Pointing/Showing to Initiate Joint Attention, RJA - Responding to Joint Attention

Table 4

Factor analysis of the gesture and joint attention measures at 12 months (n=53)

	Factor Loadings	
Measure	**Factor 1**	**Factor 2**
Gesture		
Tokens	.84	.05
Types	1.00	−.06
Deictic Tokens	.88	.07
Prod. Declarative Points	−.10	.88
Joint Attention		
PS-IJA	.03	.31
RJA	.10	.36
Factor Statistics		
Eigenvalue	3.41	.91
Variance explained (%)	56.75	15.22

Note. The two factor solution was selected on the basis of a cutoff criterion of explaining at least 70% of the original variance; PS-IJA - Pointing/ Showing to Initiate Joint Attention, RJA - Responding to Joint Attention

Table 5

Correlations between child joint attention and gesture measures and factor scores at 12 months and language at 24 months (n=46)

	24 months	
	Mullen Expressive Language	**Mullen Receptive Language**
12 months		
Tokens	.25~	.26~
Types	.30*	.34*
Prod. Conventional	.25~	.09
Deictic Tokens	.16	.26~
Prod. Imperative Points	.31*	.38*
Prod. Declarative Points	.24	.29~
Non-point Deictic	.04	.13
EC-IJA	−.31*	−.22
PS-IJA	.05	.09
RJA	.36*	.38*
Factor 1	.25~	.30*
Factor 2	.29~	.36*

~ $p < .10$

* $p < .05$

EC-IJA - Eye Contact to Initiate Joint Attention, PS-IJA - Pointing/Showing to Initiate Joint Attention, RJA - Responding to Joint Attention

Table 6

Regression models predicting infants' receptive language skills at 24 months (Mullen) based on 12 month gesture and joint attention skills (n=44)

	Mullen Receptive Language Scores at 24 months		
	β-coefficient (standard error)		
Predictors	**Model 1**	**Model 2**	**Model 3**
Intercept	44.55 (2.79)	44.92 (2.56)	53.58 (1.33)
Gesture Types	0.20 (0.58)		
Prod. Imperative Points	6.84 (2.85) *	7.27 (2.55) **	
RJA	0.09 (0.04) *	0.09 (0.03) **	
Factor 2			3.73 (1.50) *
R^2 (%)	28.60	28.4	12.60

* $p < .05$

** $p < .01$

RJA - Responding to Joint Attention

Table 7

Regression models predicting infants' expressive language skills at 24 months (Mullen) based on 12 month gesture and joint attention skills (n=44)

	Mullen Expressive Language Scores at 24 months	
	***β*-coefficient (standard error)**	
Predictors	**Model 1**	**Model 2**
Intercept	49.66 (3.58)	50.08 (3.43)
Gesture Types	0.28 (0.60)	
Prod. Imperative Points	5.83 (2.95)~	6.41 (2.66)*
EC-IJA	−.32 (.15)*	−.31 (.14)*
RJA	0.08 (0.04)~	0.09 (0.03)*
R^2 (%)	31.00	30.70

~ $p < .10$

* $p < .05$

EC-IJA - Eye Contact to Initiate Joint Attention, RJA - Responding to Joint Attention