Support or competition?

Dynamic development of the relationship between manual pointing and symbolic gestures from 6 to 18 months of age

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Dynamic Skills Theory (DST) posits that skills within domains may promote or suppress other skills as they first develop, resulting in spurts of growth in one skill concurrently with regression in another. I test this premise by examining development of two preverbal representational skills: manual pointing and symbolic gestures. Pointing is a robust early communicative gesture, indicating infants' awareness of others' attention, but limited in ability to represent infants' conceptual repertoires as they grow beyond the immediate environment. Symbolic gestures are more specific but less flexible representational tools. Both skills predict language, yet no study has addressed the effects of these skills on each other. I observed the gesturing behavior of 10 infants over 8 months in a gesture-rich environment to test the effects of each skill on the other. Supporting DST, results show early pointing predicted earlier, but not more, symbolic gesturing, while symbolic gesturing did suppress pointing frequency.

Keywords: symbolic gesture, pointing, infants, longitudinal, Dynamic Skills Theory

In the Infant Classroom of the UC Davis Center for Child and Family Studies where caregivers systematically use symbolic gestures along with words in their interactions with the children, Anthony (11 months) and Ryan (12 months) were eating snack with their caregiver, Trisha. The boys sat in small chairs at a low table. Ryan frequently stood up from his chair and Trisha repeatedly reminded him of the classroom rules saying "Ryan, if you want more snack, you have to sit down", using corresponding symbolic gestures for more (fingertips of both hands tapping each other), snack (finger tips of one hand tapping mouth), *and* sit (index and middle finger of right hand tapped on top of index and middle finger of left hand). *Ryan watched her hands as she gestured, and sat back down, pointing to his bowl. Trisha took this as an indication that he wanted more snack and she placed several more spoonfuls of*

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pasta in his bowl. After finishing his pasta, Ryan pointed *toward Trisha's side of the table again. Trisha asked, "Do you want more pasta?" again performing the gesture for* more*. Ryan continued to* point*, so Trisha tried something else. "Ryan, do you want more juice?" she asked, using the gestures for* more *and* drink (fist of one hand with extended thumb to mouth, tipping head back as if drinking). *Ryan gestured "More", and Trisha poured the juice into Ryan's cup. After drinking his juice, Ryan got up from his chair again, once again eliciting Trisha's reminder of the rules. This time, Ryan waved his hands, with palms down, back and forth in front of his torso, performing the gesture used to symbolize* All done*. "O.k.", replied Trisha, "It looks like you're done with snack. Let's wash your face, then you can go play", she said performing the gestures for* all done*,* wash*, then* play*.*

Meanwhile, Ryan's 13.5-month old classmate, Angie, demonstrated that she knew precisely what she wanted for snack and asked for it directly. Angie and her caregiver, Carrie, were in the playground outside when Angie gestured fish *by slightly puckering her lips, then opening and closing her mouth; then Angie* pointed *to the door of the classroom. Carrie asked Angie if she wanted to go inside the classroom to look at the fish tank. Carrie took Angie inside the classroom, crossed to the far side of the room, then lifted her up to see the fish tank. Angie turned around in Carrie's arms, and* pointed *back toward the other side of the classroom, and again gestured* fish*. Carrie tried to point out the fish tank to Angie again, but Angie kept looking back the other way. Carrie told Jennifer (the lead teacher for the infant classroom) that Angie was gesturing "Fish" but pointing to the other side of the room. Jennifer replied "Angie's mom brought some fish crackers in with her this morning. They're in a plastic bag in the fridge. Maybe that's what she wants." Carrie retrieved the fish crackers from the fridge, took Angie to the snack tables, and gave her the fish crackers. Angie smiled, then started to eat.*[1]

Both Ryan and Angie demonstrate the combined use of a common gesture (manual pointing) and symbolic gestures that were modeled for them by their caregivers. Ryan, the younger of the two children, relies primarily on the very generalizable pointing gesture to communicate what he wants, but uses a symbolic gesture to clarify his intention when his caregiver asks him. Meanwhile, Angie uses a more precise symbolic gesture to communicate her specific desires, using manual pointing in the absence of a more specific gesture to draw her caregivers' attention to the location (refrigerator) of the item she wants. Both of these children demonstrate very skilled use of intentional communicative signals. How will their use of both manual pointing and symbolic gestures change over time as they learn a number of referent-specific symbolic gestures modeled by their caregivers? Were their earlier communicative pointing behaviors an indicator of later symbolic gesture skills? Will they still use pointing frequently once they have learned a greater number of specific symbolic gestures?

Dynamic Skills Theory posits that individual skills within and across domains may either promote or suppress other skills, particularly when they are first developing (Fischer & Bidell, 1998). This dynamic interplay may result in spurts of growth in one skill concurrently with regression in a related skill. In the current study, I test this premise of Dynamic Skills Theory by examining the development of two preverbal communication skills: manual pointing and the use of symbolic gestures, also known as "infant signs," which infants learn primarily from caregiver modeling.

Though pointing also occurs in the ocular and oral modalities (e.g., Mather & Fisk, 1985; Rochet-Capellan, Laboissière, Galván, & Schwartz, 2008), it is the infants' use of manual pointing this is the focus of this study because of the robust literature supporting its relationship to oral language and its use as an intentional communicative act, and because, as a manual gesture, its use may come into conflict with the use of symbolic gestures which also require use of the hands. The current study does not include measurement of children's vocalizations because of methodological limitations on the collection of such data for the current sample; however, in the literature review that follows, I describe the relationship of each of these preverbal communication skills to oral language because their relationships to oral language may help explain the relationship of these skills to one another.

Pointing

Both the ability to communicate intentionally and the ability to use symbols as representations begin prior to speech. Around nine months of age, infants expand their intentional communication in interactions to include objects outside of the interaction (Bakeman & Adamson, 1986), thus engaging in triadic joint attention (Striano & Rochat, 1999). From then on, children require a broadening array of communicative tools in order to include their interaction partners in their expanding realm of interests. It is at this point that gestures — intentional motor acts used by children as communicative cues (Bakeman & Adamson, 1986; Bates, Camaioni, & Volterra, 1975) — emerge in interactions with others.

Manual pointing — which eventually takes the form of an extended arm, hand, and index finger — is a robust, early gesture (Bates et al., 1975), used across cultures and even by blind infants (Iverson & Goldin-Meadow, 1997), indicating its universal nature. Pointing is a flexible communication tool, and there are many ways that preverbal children use manual pointing, including to share their attention and interests (Liszkowski, Carpenter, Henning, Striano, & Tomasello, 2004), to answer questions and share information (Liszkowski, Carpenter, Striano, & Tomasello, 2006), and even to indicate an absent referent to someone with whom

they share representational common ground (Liszkowski, Shafer, Carpenter, & Tomasello, 2009). Manual pointing also indicates infants' awareness of others' attention and intention (Tomasello, Carpenter, & Liszkowski, 2007), and predicts later language development (Iverson & Goldin-Meadow, 2005).

Though the status of pointing as a symbolic or representational act has been debated, there is no doubt that it is linked to language development (Goldin-Meadow, 2007). For example, the number of different referents children indicate with pointing at 18 months predicts the breadth of vocabulary at 42 months (Rowe & Goldin-Meadow, 2009b). One mechanism for this positive relationship between pointing and lexical skills in speech may be that pointing — particularly when paired with a word that represents something other than the referent of the point — draws richer and more elaborate language from adults (Goldin-Meadow, Goodrich, Sauer, & Iverson, 2007). Further, parents' pointing is strongly related to children's language skills, even explaining the relationship between poverty and vocabulary (Rowe & Goldin-Meadow, 2009a). However, Rodrigo, Gonzalez, and Ato (2006) found that older toddlers' use of instrumental gestures including pointing was negatively related to their language development. Further, Stefanini and colleagues investigated children's use of pointing in a naming task between the ages of 2 and 7 years, and found that children's use of pointing was negatively associated with both child age and lexical skills (Stefanini, Bello, Caselli, Iverson, & Volterra, 2009). It may be that children who are delayed in their language are those still using pointing to communicate. Thus, the relationship between pointing and oral language changes somewhat over the course of development through infancy and early childhood, with pointing during infancy predicting children's later language development, but pointing during later toddlerhood and early childhood being an indication that children's language may be delayed.

It is the interactional context that is the context and impetus for symbolic development (Trevarthen & Hubley, 1978), including both gestures and speech. Children's understanding of others as intentional agents precipitates and facilitates their understanding of symbols as representations of their own or another's attention or intention (Sharon, 2005). Children as young as one year old understand a number of adult behaviors — including gestures — as intentional communicative cues (Behne, Carpenter, & Tomasello, 2005). This understanding of communicative and representational acts, and desire to use them, precedes language development (Wagner, 2006). At first, simple gestures indicative of the child's general direction of attention or desire — for example, pointing and showing — are sufficient to relay information about proximal referents (Bates et al., 1975; Bates, O'Connell, & Shore, 1987). However, pointing and other simple indicative gestures have limited ability to represent infants' conceptual and intentional repertoires as these extend beyond the immediately perceptible environment (Werner & Kaplan,

1984). More specific communication tools are needed to effectively represent and communicate children's expanding interests (Bakeman & Adamson, 1986).

Symbolic gestures

Preverbal children reveal their representations and communicative intentions through a variety of means. Young children can reveal their mental activity through symbolic play without and prior to using language (Ungerer, Zelazo, Kearsley, & O'Leary, 1981). Beyond simple expression, preverbal children are also capable of intentional and content-specific symbolic communication with others. The research of Acredolo and Goodwyn (1985, 1988) revealed that children as young as 10 months can use symbolic gestures — such as tapping fingers to lips for "eat", or panting with tongue out for "dog" — in communicative interactions with adult caregivers. Children both invent symbolic gestures spontaneously (Acredolo & Goodwyn, 1985) based on the actions performed on or by objects or in routines (Namy, Acredolo, & Goodwyn, 2000; Werner & Kaplan, 1984), and learn gestures that are modeled for them (Goodwyn & Acredolo, 1993; Goodwyn, Acredolo, & Brown, 2000). Children can represent a range of different concepts through invented or modeled symbolic gestures, including requests (e.g., tapping fingers in palm for "more") objects (i.e., palm down, hand flapping up and down from wrist for "ball"), and actions (e.g., wiping palm over the back of other hand for "wash") (Acredolo & Goodwyn, 1988), and more abstract ideas such as emotions (e.g., running finger from corner of eye down cheek for "sad"), feelings (e.g., palms together under cheek for "sleepy"), and time concepts (e.g., closed fist tapping open palm for "wait") (Vallotton, 2008a, 2008b). Further, children use a broader lexicon of symbolic gestures if they grow up in a gesture-rich environment, (Iverson, Capirci, Volterra, & Goldin-Meadow, 2008).

After concluding that symbolic gestures are a normal part of preverbal communication in typically developing children (Acredolo & Goodwyn, 1988), there was still concern that they may compete with oral language development, slowing children's progress toward common language milestones. Parents were concerned that children using symbolic gestures would not be motivated to learn oral language because the gestures were an effective, and perhaps easier, mode of communication. This idea is somewhat consistent with a Dynamic Skills Theory framework (Fischer & Bidell, 1998) in which related skills — including those in the language domain — may either support or compete with one another as they develop. To address these concerns, Acredolo and Goodwyn conducted a longitudinal experiment in which one treatment group of young children and their families was taught to use a specific set of symbolic gestures, another treatment group

was taught to verbally label the same concepts, and a third was provided with no intervention. The results of this study revealed that children typically learned the symbolic gesture for a given concept prior to using the word (Goodwyn & Acredolo, 1993), but that greater use of symbolic gestures actually supported both the lexical and syntactic aspects of children's language development, helping them reach language milestones faster and expanding their vocabularies (Goodwyn et al., 2000). Those children in the symbolic gesture treatment group had language skills that were advanced over the verbal labeling treatment group as well as the no treatment control group. Thus, symbolic gestures are an effective means of pre-verbal communication, and they promote the development of oral language. These results are further supported by work by Rowe and Goldin-Meadow (2009b) that showed that the number of meanings conveyed by children through gesture when they were one and a half years old predicted their verbal lexicon when they were three and a half years old.

Relation of symbolic skills to one another

If we consider manual pointing, symbolic gesture, and the use of oral language to be three related skills within a developmental domain, we can summarize their relationships such that pointing frequency, the variety of pointing referents, and enhanced use of symbolic gestures in infancy (up to approximately 18 months) support the development of oral language. Turning the relationship around, we may wonder about the impact of the onset of speech on children's use of gestures. There is some indication in the literature that children's use of pointing does diminish as their oral lexicon expands (Stefanini et al., 2009), though both older children and adults continue to use pointing in complement of speech. Work of Rodrigo and colleagues (2006) showed that toddlers with delayed speech continue to use more gestures. Further, though there has been no definitive description published in the literature, it appears from one small study (Grinbaum, 2001) and numerous parent- and teacher- reports that children's use of symbolic gestures also diminishes and eventually stops as children learn oral language. Thus while both manual pointing and symbolic gestures are expected to diminish over time, these two gestural skills may have somewhat different trajectories and somewhat different relationships to oral language. Though the current study does not include an examination of oral language, it is an important context to keep in mind as its relationship to the two gesturing skills may affect their trajectories, and their relationships to one another.

The current study

Both pointing and symbolic gesturing are common components of early preverbal communication (Acredolo & Goodwyn, 1988; Tomasello et al., 2007), and both predict language development (Goldin-Meadow et al., 2007; Goodwyn et al., 2000); thus these behaviors may be seen as related sets of skills in the domain of language and communication. The current study addresses a gap in the literature on early gesture use by examining the basic trajectories of the frequency of pointing and symbolic gestures in the context of caregiver–child interaction, and tests the nature of the relationship of these two communication tools to each other as they develop from 6 to 18 months of age. Specifically, I test the following hypotheses:

1. Early manual pointing — as an indicator of infants' communication skills — will predict development of a greater variety of symbolic gestures.
2. Use of symbolic gestures — as more specific representational and communication tools — will suppress infants' use of less specific manual pointing.

Methods

Observation site

I documented the gesturing behavior of 10 typically developing, hearing infants who were in an infant classroom at the University of California, Davis' laboratory school, named the Center for Child and Family Studies (CCFS). Infants attended the classroom four days per week for three hours per day. The teachers and student caregivers in the infant classroom of the CCFS used symbolic gestures as a way to communicate with the preverbal infants. The children learned the symbolic gestures from caregiver modeling; children were never explicitly taught or forced to use symbolic gestures, but learned the gestures through naturally occurring interactions with caregivers. (For a detailed description of the specific symbolic gestures used by caregivers and children, see Fusaro and Vallotton, 2011.)

Participants

The infants were 3 boys and 7 girls who were between 4 and 11 months when observations began, and between 12 and 19 months at the end of eight months of data collection. Though each infant was observed for eight months, the number of infants observed at any given month of age varied because they entered the classroom and the current study at different ages, with few infants and few observations at the ends of the age continuum (4–5 months and 19 months). Thus, I limit the current study to the period of 6 to 18 months of age.

Data collection

Infants were filmed during spontaneous interactions with caregivers during the typical classroom routines; approximately half of the observations of each infant occurred during free play, and half during snack time. Because this study was intended to capture the naturally occurring interactions between children and their caregivers, caregivers were given no specific instructions for interacting with infants for the purpose of this study, thus the gestures that occurred during their interactions were spontaneous on the part of both caregiver and child. Each interaction was filmed for 5 minutes. The order of filming infants was random, though there was an effort to film an infant twice in one day — once during free play and once during snack — and it was rare for an infant to be filmed more than two times in a single day. Infants were observed an average of 42 times each over eight months. The intervals between recordings were 5.52 days on average (sd = 10.72). However, this includes two gaps of approximately one month in the observation intervals that corresponded with breaks between University quarters when the laboratory school was not in operation. Not including these necessary breaks in data collection, the intervals between observations were 3.48 days on average (sd = 5.4).

Data on oral language were not collected for this sample. Data collection was done naturalistically in the childcare environment, and the constraints of this situation in terms of camera placement meant that it was possible to get consistent visual information on the children, but not possible to get consistent auditory information. For example, the camera was often at one end of the classroom, unobtrusively filming a child at the other end of the classroom, with nine other infants and six adults in the room, obscuring the auditory aspects of the interaction of focus. Thus while oral language is a critical skill to consider in the interpretation of the hypotheses tested in the current study, the focus of this study is on the relationship of two types of manual gestures — pointing and symbolic gestures.

Coding

A team of coders used micro-analytic (event-based, second-by-second) coding of each video to record every gesture performed by infants. These included gestures initiated spontaneously by the infant, and those that were in response to caregivers' words or gestures (for more information on the conversational context of these gestures, and infants' initiations toward or responses to caregivers, see Vallotton, 2009, or Vallotton, 2011b). The coding focused on the form of the gesture. For symbolic gestures, because the gestures each corresponded to a specific concept, the form and referent shared the same label, for example "more" referred to the action in which infants tapped the closed fingers of each hand together, and "sad" referred to the motion of running one finger from the eye down the cheek. For

the pointing gesture, because the focus of the coding was on form, only the word "point" was recorded; the referent of the point was not captured. Thus, both the frequency and variety of the children's symbolic gestures can be derived, but only the frequency of pointing can be determined, and not the variety of pointing referents.

Variables

For each interaction observed, variables include the child's identification (ID number), child's age in tenths of months, the frequency of pointing, frequency of symbolic gestures, and variety of symbolic gestures. Further, a variable identifying the child's age of entry into the classroom was created to control for the length of time they had been exposed the use of symbolic gestures. A measure of early pointing was created by deriving each child's average pointing frequency per 5-minute interaction between 10 and 12 months of age. In order to use earlier symbolic gesturing behavior to predict later pointing behavior for the same child, I created a variable that averaged the child's symbolic gesture variety during the observations in the previous month. The name and descriptions of each variable, including the variable transformations described below, are provided in Table 1.

Because the children's behaviors were spontaneous rather than elicited, there were many observations in which there was no gesturing behavior, making the numerical data erratic. To smooth the data for statistical modeling, I created running averages for each of the time-varying gesture variables by averaging the values from three observations together; for example, values of variables in observations A, B, and C were averaged to create observation 1; values in episodes B,C, and D were averaged to create observation 2; and so on. See Table 1 for the names and descriptions of each variable.

Analytic Strategy

For each question, I fit a series of multi-level growth models with observations nested within children over time, using SAS PROC MIXED maximum likelihood (ml) method of estimation. Multi-level growth modeling uses data with multiple observations per individual to create a basic growth trajectory of the dependent variable based on a time-related factor, in this case, child age. This trajectory includes the overall level of the dependent variable, and rates of change in that variable over time; these levels and rates of change can then be predicted by factors that vary either between persons (e.g., child gender or age at beginning of study) or within persons over time (e.g., prior behavior in another domain). Readers interested in multi-level growth modeling with longitudinal data are encouraged to consult Singer & Willett, 2003 for detailed description and instructions on the

Table 1. Variable names, labels, and descriptions.

Name	Label	Description
ID	Infant ID	Identifies which infant is the focus of the observation
AGE	Infant age in months, centered at 6 months	This time-varying variable describes infant's age in tenths of months; it was calculated by subtracting the child's birth date from the date of observation, then dividing that sum by 30.42, the average number of days in a month. We centered this variable at 6 months.
ENTRY_AGE	Age the infant began attending the classroom	This time-invariant variable describes the infant's age, in tenths of months, when they first started attending the infant classroom; it was calculated by subtracting the child's birth date from the opening date of the class for that year, then dividing that sum by 30.42, the average number of days in a month
EARLY_POINTING	Average pointing frequency between 10 and 12 months	This time-invariant variable describes the average frequency of the infant's pointing gestures in all observations for that infant when they were between 10 and 12 months old.
POINT	Pointing frequency	This time-varying variable describes the number of times the infant pointed during the current 5-minute observation
SG_FREQ	Symbolic gesture frequency	This time-varying variable describes the number of times the infant used a symbolic gesture during the current 5-minute observation
SG_VAR	Symbolic gesture variety	This time-varying variable describes the number of different symbolic gestures the infant used during the current 5-minute observation
POINT_ RA	Running average of pointing frequency	This time-varying variable describes the average number of times the infant pointed during the last three 5-minute observations
SG_FREQ_RA	Running average of symbolic gesture frequency	This time-varying variable describes the average number of times the infant used a symbolic gesture during the last three 5-minute observations
SG_VAR_ RA	Running average of symbolic gesture variety	This time-varying variable describes the average number of different symbolic gestures the infant used during the last three 5-minute observations
$\sqrt[3]{}$POINT_RA	Cube root of the running average of pointing frequency	This time-varying variable is the cube root of the average number of times the infant pointed during the last three 5-minute observations
$\sqrt[3]{}$SG_VAR_RA	Cube root of the running average of symbolic gesture variety	This time-varying variable is the cube root of the average number of different symbolic gestures the infant used during the last three 5-minute observations
$\sqrt[3]{}$SG_VAR_PM	Cube root of the average symbolic gesture variety in the prior month.	This time-varying variable is the cube root of the average number of different symbolic gestures the child used across all of the episodes in the month prior to the current observation.

use of multi-level growth modeling to examine developmental trajectories with multi-wave data.

I used the untransformed running average variables to model the basic trajectories of gesturing behaviors over time for descriptive purposes. However, because these data were not normally distributed, and the error variance remaining after fitting basic growth models was not normally distributed, I created cube root transformations of each of the running average variables in order to normalize the distributions of the variables for complex modeling. I used the cube root transformations of the gesturing variables in models intended to test the two research questions.

For both the descriptive and predictive models, I used two criteria to determine whether each change in the models made a significant contribution. First I used the significance of the change in the deviance statistic (−2 Log Likelihood; −2LL) which assesses overall model fit. Second I used the significance of the t-test associated with the beta-values for each term in the model.

To create the descriptive models of the growth of each gesturing behavior over time, I began with an unconditional means model which I used as a baseline against which I could compare the subsequent models. Next I tested multiple specifications of child age, beginning with linear age, then quadratic age, etc., until I found the specification that produced the best model fit.

To address the first hypothesis, I used the cube root of the running average of symbolic gesture variety ($\sqrt[3]{}$SG_VAR_RA) as the outcome. After fitting an unconditional baseline growth model, I tested the effect of early pointing (EARLY_POINTING) on the level and growth rates of the variety of infants' symbolic gestures, controlling for the infants' age of entry into the program. I tested the effect of early pointing on the level of gesture variety by including the main effect of the early pointing variable. I tested the effect of early pointing on the rate of change in symbolic gesture variety over time by including the interaction of early pointing and infant age (EARLY_POINTING*AGE); I tested the interaction with multiple specifications of age, beginning with just linear, then linear and quadratic, and so on. Finally I chose the best model by including only the interactions with age that contributed to the fit of the model.

For Question 2, after fitting an unconditional baseline growth model, I tested the effects of children's symbolic gesture variety from the previous month ($\sqrt[3]{}$SG_VAR_PM) on the frequency of their current pointing behavior ($\sqrt[3]{}$POINT_RA), while controlling for the child's current symbolic gesture frequency ($\sqrt[3]{}$SG_VAR). I tested the effect of prior symbolic gesture variety on the level of pointing frequency by including the main effect of prior symbolic gesture variety. I tested the effect of prior symbolic gesture variety on the rate of change in pointing frequency by interacting symbolic gesture variety in the previous month with each specification of age, beginning with just linear age, then linear and quadratic, and so on.

Results

Developmental trajectories of early pointing and symbolic gesture use

The results of the fitted growth models presented in Table 2 reveal that the trajectories of pointing frequency, symbolic gesturing, and symbolic gesture variety are complex. Figure 1 displays these trajectories, as well as the raw data for each of these variables plotted against child age. As seen in Figure 1, there are many observations of children in which no gestures are observed; this has the result of bringing the average values down substantially, and lowering the levels of the trajectories. Thus the shapes, rather than the levels, of the trajectories are more informative.

Table 2. Unconditional growth models for the running averages of pointing frequency and the frequency and variety of symbolic gesturing in a population of 10 infants observed over 8 months.

	Parameter		Pointing Frequency	Symbolic Gesturing Frequency	Symbolic Gesturing Variety
Fixed Effects					
	Initial Status at 6 Months				
	INTERCEPT	γ_{00}	−0.3334 (0.3720)	−0.0867 (0.2971)	0.2264 (0.3164)
	Rate of Change each Month				
	Linear (AGE)	γ_{10}	0.7465 (0.4821)	−0.1355 (0.1408)	0.1573 (0.1983)
	Quadratic $(AGE)^2$	γ_{20}	−0.4120~ (0.2175)	0.0554* (0.0236)	−0.1436 (0.0894)
	Cubic $(AGE)^3$	γ_{30}	0.0910* (0.0411)	−0.0029* (0.0012)	0.0377* (0.0169)
	Quartic $(AGE)^4$	γ_{40}	−0.0081* (0.0034)		−0.0035* (0.0014)
	Quintic $(AGE)^5$	γ_{50}	0.0002* (0.0001)		0.0001* (0.0000)
Variance Components					
L 1:	Within-child	σ^2_ε	0.8988***	0.7740***	0.1443***
L 2:	Between-child	σ^2_1	0.0845~	0.2909*	0.7794*
Fit Statistics					
	−2LL Growth Model		1074.4	1030.9	403.4
	−2LL Means Model		1150.0	1113.0	521.5

~ $p < .10$, * $p < .05$, ** $p < .01$, *** $p < .001$

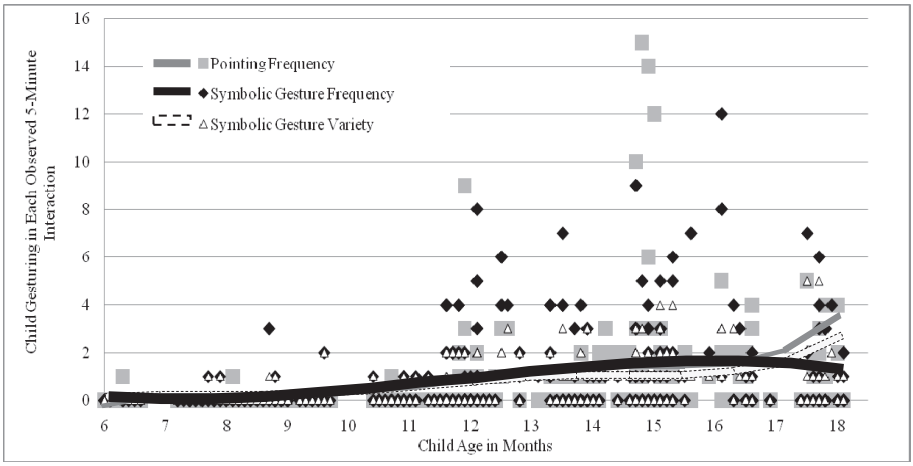

Figure 1. Scatter plot of children's spontaneous pointing and symbolic gesture behavior in 5-minute caregiver–child interactions for infants between 6 and 18 months old, with fitted unconditional growth models.
The low levels of the average trajecotries are due to the high number of observations in which no child gestures were observed.

Both pointing frequency and symbolic gesture variety have quintic growth trajectories between 6 and 18 months, in which growth starts slowly, then increases more rapidly between 11 and 13 months, slows down between 13 and 15 months, then increases again between 16 and 18 months at a faster rate than previously. Thus at the ends of these trajectories, children are once again increasing their average pointing frequency and the average variety of symbolic gestures they use in a given interaction. The increases in these trajectories between 16 and 18 months are due less to increases in the higher numbers of gestures in any given observation, and more to a decrease in the number of observations in which there were no gestures observed.

Unlike the frequency of pointing and the variety of symbolic gestures, the frequency of symbolic gestures during interaction with caregivers has a cubic growth trajectory. Like the other trajectories, growth is slow until 11 months, with more rapid growth after 11 months; then the trajectories diverge with symbolic gesture frequency increasing between 11 and 14 months, leveling off, then decreasing between 16 and 18 months. Thus between 16 and 18 months of age, children use symbolic gestures less frequently, but use a greater variety of gestures when they do; meanwhile these children use pointing more frequently.

Effects of early pointing on change in symbolic gesture variety

The results of the first research question are revealed in the suite of fitted growth models presented in Table 3. The first model is the basic growth model of symbolic

Table 3. Symbolic Gesture Variety: Fitted models for the longitudinal effects of early pointing on symbolic gesture variety (cube root of running average) in a sample of 10 infants.

Parameter		Quintic Growth Model	Quintic Growth controlling Entry Age	Effects of Early Pointing Frequency, controlling Entry Age
Fixed Effects				
Initial Status at 6 Months				
INTERCEPT	γ_{00}	0.30250 (0.21480)	−0.45120 (0.75160)	−0.18280 (0.75960)
ENTRY_AGE	γ_{01}		0.17330 (0.12940)	0.19630 (0.12390)
EARLY_POINTING	γ_{02}			−1.73190* (0.76730)
Rate of Change each Month				
Linear (AGE)	γ_{10}	−0.19390 (0.19710)	−0.00495 (0.22360)	−0.04805 (0.20840)
ENTRY_AGE	γ_{11}		−0.06297~ (0.03474)	−0.06435* (0.03175)
EALY_POINTING	γ_{12}			0.59060*** (0.16590)
Quadratic $(AGE)^2$	γ_{20}	0.02401 (0.08382)	0.05386 (0.08483)	0.00613 (0.08437)
ENTRY_AGE	γ_{21}		0.00401 (0.00254)	0.00371 (0.00230)
EALY_POINTING	γ_{22}			−0.04784** (0.01439)
Cubic $(AGE)^3$	γ_{30}	0.00653 (0.01535)	0.00017 (0.01563)	0.01357 (0.01579)
Quartic $(AGE)^4$	γ_{40}	−0.00100 (0.00125)	−0.00063 (0.00126)	−0.00179 (0.00123)
Quintic $(AGE)^5$	γ_{50}	0.00004 (0.00004)	0.00003 (0.00004)	0.00006 (0.00004)
Variance Components				
L 1: Within-child	σ^2_ε	0.0910***	0.0904***	0.0896***
L 2: Between-child				
In Intercept	σ^2_0	0.1682~	0.1366~	0.1451~
Between-child in linear growth	σ^2_1	0.0011~	0.0009	0.0007
Covariance 01	σ_{01}	−0.0092	−0.0074	−0.0063
Fit Statistics				
Deviance		207.4	202.0	190.5

~ $p < .10$, * $p < .05$, ** $p < .01$, *** $p < .001$

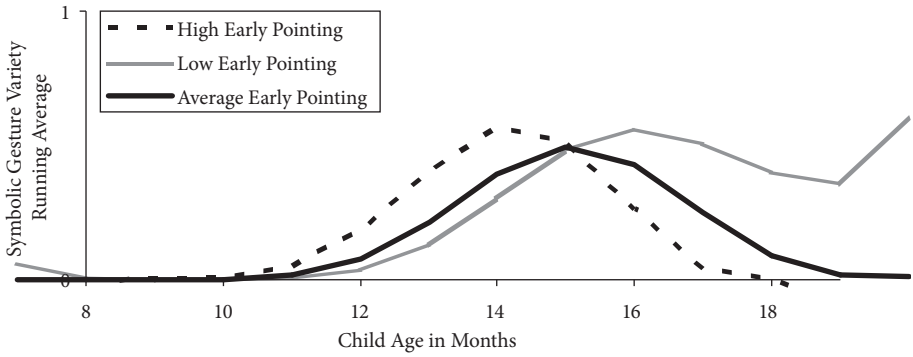

Figure 2. Supportive effect of early pointing frequency (between 10 and 12 months) on development of symbolic gesture variety during caregiver–child interactions.

gesture variety established in the first set of analyses. The second model controls for the age at which children entered the classroom and began to be exposed to symbolic gestures on a regular basis. The third model includes the children's average early pointing frequency — between 10 and 12 months — as a predictor of the level of and growth in symbolic gesture variety. As seen in the beta values associated with the effect of early pointing on the rate of change in symbolic gesture variety, early pointing initially increases then decreases the rate of change in symbolic gesture variety. These results are depicted in Figure 2. The trajectories depicted in this figure are for children who had average early pointing frequency (black line), and those who pointed one standard deviation more (dashed line) or less (grey line) frequently. These plotted trajectories reveal that infants' early pointing behavior predicted earlier, but not more, use of a variety of symbolic gestures. That is, infants who pointed more between 10 and 12 months had an earlier increase in their use of a variety of symbolic gestures, followed by an earlier decrease in gesture variety, compared to infants who had pointed less.

Effects of symbolic gesture variety on change in pointing frequency

The results of the second research question are revealed in the suite of fitted growth models presented in Table 4. The first model is the basic growth model pointing frequency established in the first set of analyses. The second model controls for the effect of concurrent symbolic gesture variety measured in the same observation. Finally, the third model includes the children's average symbolic gesture variety during the previous month as a predictor of the level of pointing frequency. In this case, the interactions between previous symbolic gesture variety and age reveal a change in the effect of previous symbolic gesturing on the current frequency of pointing. These results are depicted in Figure 3.

Table 4. Pointing Frequency: Fitted models for the longitudinal effects of symbolic gesture variety on the development of pointing frequency (cube root of running average) in a sample of 10 infants.

Parameter		Quintic Growth Model	Effect of Current Symbolic Gesture Variety	Effects of Symbolic Gesture Variety in Last Month
Fixed Effects				
Initial Status at 6 Months				
INTERCEPT	γ_{00}	−0.01964 (0.20200)	−0.16410 (0.14370)	−0.22150 (0.16750)
$\sqrt[3]{}$SG_VAR	γ_{01}		0.83790*** (0.04509)	0.76950*** (0.04703)
$\sqrt[3]{}$SG_VAR_PM	γ_{02}			−1.62520* (0.65640)
Rate of Change each Month				
Linear (AGE)	γ_{10}	0.02482 (0.20200)	0.01993 (0.14670)	0.08079 (0.19050)
$\sqrt[3]{}$SG_VAR_PM* (AGE)	γ_{11}			0.82020** (0.31150)
Quadratic $(AGE)^2$	γ_{20}	−0.07535 (0.09105)	−0.02379 (0.06616)	−0.02364 (0.08094)
$\sqrt[3]{}$SG_VAR_PM* $(AGE)^2$	γ_{21}			−0.13580** (0.04520)
Cubic $(AGE)^3$	γ_{30}	0.02488 (0.01720)	−0.00594 (0.01252)	−0.00033 (0.01460)
$\sqrt[3]{}$SG_VAR_PM* $(AGE)^3$	γ_{31}			0.00668** (0.00203)
Quartic $(AGE)^4$	γ_{40}	−0.00245~ (0.00143)	−0.00046 (0.00104)	−0.00075 (0.00119)
Quintic $(AGE)^5$	γ_{50}	0.00008~ (0.00004)	0.00001 (0.00003)	−0.00005 (0.00004)
Variance Components				
L 1: Within-child	σ^2_ε	0.1526***	0.0794***	0.0696***
L 2: Between-child				
In Intercept	σ^2_0	0.0492*	0.0850*	0.0466*
In Effect of Past Symbolic Variety	σ^2_1			0.0432*
Covariance 01	σ_{01}			0.0276
Fit Statistics				
Deviance		397.7	155.0	93.5

~ $p < .10$, * $p < .05$, ** $p < .01$, *** $p < .001$

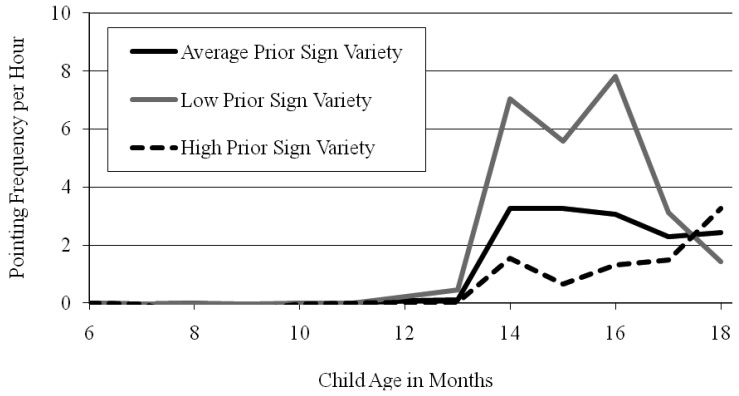

Figure 3. Suppressive effect of prior symbolic gesture variety (one month earlier) on spontaneous pointing frequency during caregiver–child interactions.
The jaggedness of the trajectories is the result of basing the graphing on the effect of one standard deviation of gesture use during each age period; the standard deviations change from month to month, thus the difference between the average trajectory and the high- and low- trajectories vary.

The trajectories depicted in Figure 3 are for children who had average early previous symbolic gesture variety (black line), and those who used one standard deviation more (dashed line) or less (grey line) symbolic gesture variety in the previous month. As seen in this figure, between 13 and 16 months, children who used a greater variety of symbolic gestures pointed less frequently in the next month, while those who used fewer symbolic gestures pointed more. It appears that between 16 and 18 months, this effect begins to reverse. This finding is consistent with the idea that those children who have a greater variety of symbolic gestures at their fingertips do not rely as heavily on the pointing gesture, while those with fewer symbolic gestures use pointing more frequently in their communicative interactions between 13 and 16 months of age. Thus, symbolic gesturing does, in fact, suppress the use of pointing.

The relationship between symbolic gesture variety and pointing frequency changed, almost reversing, between 16 and 18 months of age, such that those who used a greater variety of symbolic gestures used pointing *more* frequently in the next month. It may be that children who use a greater variety of symbolic gestures earlier are also those who develop oral language earlier, thus while these children relied on their symbolic gestures between 13 and 16 months, as they begin to develop oral language, they integrate pointing into their oral language, thus toward the end of the trajectory, the use of symbolic gesture variety predicts a greater use of pointing as it becomes integrated, rather than suppressing the use of pointing.

Discussion

Among the infants in this sample, when children communicated more frequently, they did so through both the manual pointing gesture and the modeled symbolic gestures. Pointing predicted earlier use of symbolic gestures; and in any given interaction, pointing and signing were positively correlated. However, infants' symbolic gestures did compete with and somewhat suppress infants' pointing in interactions with caregivers. As more specific communication and representation tools, symbolic gestures may function like specific words for the preverbal child, reducing the need for pointing. From the perspective of Dynamic Skills Theory, pointing can be seen as a supportive grower to symbolic gestures, and symbolic gestures can be seen as a competitive grower to manual pointing. Considering the relationship of each of these skills to oral language, it is possible that symbolic gestures are replaced entirely by spoken words, while pointing remains a communication tool in the child's repertoire, even though it, too, diminishes somewhat as the oral lexicon grows (Stefanini et al., 2009).

Further speculating on the role of oral language in these results, the finding that between 16 and 18 months of age, children use symbolic gestures less frequently, but use a greater variety of these gestures while also using pointing more frequently is consistent with the idea that the use of symbolic gestures will fade as oral language emerges, while the use of pointing will become integrated with oral language and will continue to be used consistently in communicative contexts.

The finding from the first research question, that early pointing predicts an earlier increase but also an earlier decrease in the use of symbolic gestures, is also consistent with an interpretation of these skills in the context of oral language development. The research of Goodwyn, Acredolo, and Brown (2000) showed that the use of symbolic gestures was associated with advanced oral language development. These early pointers become earlier symbolic gesturers, and most likely also early talkers as well, reducing the need for symbolic gestures.

The finding that the suppressive effect of symbolic gestures on pointing frequency reverses between 16 and 18 months might be explained by the idea that children who use a greater variety of symbolic gestures earlier are also those who develop oral language earlier. Thus while these children relied on their symbolic gestures rather than pointing between 13 and 16 months, between 16 and 18 months they likely began to use oral language more and thus began to integrate pointing into their oral language. This integration is potentially responsible for the trend seen toward the end of the trajectory, that the use of symbolic gesture variety predicts a greater use of pointing rather than suppressing the use of pointing.

The results of this study reveal a complex but theoretically consistent set of relationships between manual pointing, use of symbolic gestures, and potentially the

lexical aspects of oral language. Early pointing supports the development of symbolic gesture variety, and according to other studies, predicts earlier syntactical development and greater lexical skills in oral language as well (Goldin-Meadow, 2007; Iverson & Goldin-Meadow, 2005). Meanwhile, use of symbolic gestures suppresses the frequency of pointing as symbolic gestures take on the role of words, but as symbolic gestures fade while oral language emerges, pointing re-emerges as it is integrated into multi-modal communication.

This set of findings also suggests a shifting role for pointing in early development. When children are preverbal they use pointing in place of words; after the onset of oral language, pointing is integrated into language to serve as a complement and support to language (McNeill, 1998). Future studies should simultaneously examine manual pointing, modeled symbolic gestures, and oral language to in order to verify that the shapes of these trajectories of skills investigated in this study and their relationships to each other are in fact influenced by their relationship to language.

The lack of data on these children's oral language is a serious limitation of this study, particularly for the interpretation of the results in relationship to language. Future studies should test the relationships suggested by this study between manual pointing, symbolic gestures, and oral language; though these data remain challenging to collect, the increase in the availability of high-powered audio-visual equipment, including long-range focused microphones and smaller wireless microphones, should make such data easier to collect.

The children in this sample were in an enriched gesturing environment. On one hand, this presents a limitation to the current study in that the results may not be relevant to those whose caregivers do not use symbolic gestures on a regular basis. However, these data also present a unique opportunity to look at the relationship between symbolic gestures and pointing in a sample of infants observed frequently over time. The use of symbolic gestures — also know as "infant signs" or "baby signs" — is becoming an increasingly common practice among parents and child care providers; thus, the findings of this study may be relevant to the development of multimodal communication of an increasing number of children in the United States and internationally.

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Note

1. Both anecdotes are direct observations made by the author while conducting research on gesture at the UC Davis Center for Child & Family Studies, a laboratory school where student teachers use symbolic gestures in routine interactions with the infants and toddlers. Names have been changed, but age and gender are accurate. The second anecdote was previously described in Vallotton (2011a).

References

Acredolo, Linda, & Susan Goodwyn (1985). Symbolic gesturing in language development: A case study. *Human Development*, 28, 40–49.

Acredolo, Linda, & Susan Goodwyn (1988). Symbolic gesturing in normal infants. *Child Development*, 59, 450–466.

Bakeman, Roger & Lauren B. Adamson (1986). Infants' conventionalized acts: Gesture and words with mothers and peers. *Infant Behavior & Development*, 9 (2), 215–230.

Bates, Elizabeth, Luigia Camaioni, & Virginia Volterra (1975). The acquisition of performatives prior to speech. *Merrill-Palmer Quarterly*, 21, 205–226.

Bates, Elizabeth, Barbara O'Connell, & Celia Shore (1987). Language and communication in infancy. In Joy D. Osofsky (Ed.), *Handbook of infant developoment* (pp. 149–203). Oxford, UK: John Wiley & Sons.

Behne, Tonya., Malinda Carpenter, & Michael Tomasello (2005). One-year-olds comprehend the communicative intentions behind gestures in a hiding game. *Developmental Science*, 8 (6), 492–499.

Fischer, Kurt W. & Thomas R. Bidell (1998). Dynamic development of psychological structures in action and thought. In William Damon (Ed.), *Handbook of child psychology* (5th ed., Vol. 1, pp. 467–561). New York: John Wiley & Sons, Inc.

Fusaro, Maria & Claire Vallotton (2011). Giving a nod to social cognition: Developmental constraints on the emergence of conventional gestures and infant signs. In Gale Stam & Mika Ishino (Eds.) *Integrating Gestures: The Interdisciplinary Nature of Gesture,* (pp. 121–136). Amsterdam, Netherlands: John Benjamins.

Goldin-Meadow, Susan (2007). Pointing sets the stage for learning language — and creating language. *Child Development*, 78, 741–745.

Goldin-Meadow, Susan, Whitney Goodrich, Eve Sauer, & Jana M. Iverson (2007). Young children use their hands to tell their mothers what to say. *Developmental Science*, 10 (6), 778–785.

Goodwyn, Susan & Linda Acredolo (1993). Symbolic gesture versus word: Is there a modality advantage for onset of symbol use? *Child Development*, 64 (3), 688–701.

Goodwyn, Susan, Linda Acredolo, & Catherine A. Brown (2000). Impact of symbolic gesturing on early language development. *Journal of Verbal and Nonverbal Behavior*, 24 (2), 81–103.

Grinbaum, Livna (2001). *Symbolic gesturing as a caregiving tool: Facilitating communication and regulation in infants and toddlers*. University of California, Davis.

Iverson, Jana M., Olga Capirci, Virginia Volterra, & Susan Goldin-Meadow (2008). Learning to talk in a gesture-rich world: Early communication in Italian vs. American children. *First Language*, 28, 164–181.

Iverson, Jana M. & Susan Goldin-Meadow (2005). Gesture paves the way for language development. *Psychological Science*, 16, 367–371.

Iverson, Jana M. & Susan Goldin-Meadow (1997). What's communication got to do with it? Gesture in congenitally blind children. *Developmental Psychology*, 33, 453–467.

Liszkowski, Ulf, Malinda Carpenter, Anne Henning, Tricia Striano, & Michael Tomasello (2004). Twelve-month-olds point to share attention and interest. *Developmental Science*, 7, 297–307.

Liszkowski, Ulf, Malinda Carpenter, Tricia Striano, & Michael Tomasello (2006). 12- and 18-month olds point to provide information for others. *Journal of Cognition and Development*, 7, 173–187.

Liszkowski, Ulf, Marie Schäfer, Malinda Carpenter, & Michael Tomasello (2009). Prelinguistic infants, but not chimpanzees, communicate about absent entities. *Psychological Science*, 20, 654–660.

Mather, Jennifer A. and John D. Fisk (1985). Orienting to targets by looking and pointing: Parallels and interactions in ocular and manual performance. *Quarterly Journal of Experimental Psychology, 37A*, 315–338.

McNeill, David (1998). Speech and gesture integration. In Jana M. Iverson & Susan Goldin-Meadow (Eds.), *The nature and functions of gesture in children's communication* (pp. 11–27). San Francisco: Jossey-Bass.

Namy, Laura L., Linda Acredolo, & Susan Goodwyn (2000). Verbal labels and gestural routines in parental communication with young children. *Journal of Nonverbal Behavior*, 24 (2), 63–79.

Rochet-Capellan, Amélie, Rafael Laboissière, Arturo Galván, & Jean-Luc Schwartz (2008). The speech focus position effect on jaw-finger coordination in a pointing task. *Journal of Speech, Language, and Hearing Research*, 51, 1507–1521.

Rodrigo, María J., Angela González, & Manuel Ato (2006). Co-development of child–mother gestures over the second and third years. *Infant and Child Development*, 15, 1–17.

Rowe, Merideth L. & Susan Goldin-Meadow (2009a). Differences in early gesture explain SES disparities in child vocabulary size at school entry. *Science*, 323, 951–953.

Rowe, Merideth L. & Susan Goldin-Meadow (2009b). Early gesture *selectively* predicts later language learning. *Developmental Science*, 12 (1), 182–187.

Singer, Judith D. & John B. Willett (2003). *Applied longitudinal data analysis: Modeling change and event occurrence*. New York: Oxford University Press.

Sharon, Tanya (2005). Made to symbolize: Intentionality and children's early understanding of symbols. *Journal of Cognition and Development*, 6 (2), 163–178.

Stefanini, Silvia, Arianna Bello, Maria C. Caselli, Jana M. Iverson, & Virginia Volterra (2009). Co-speech gestures in a naming task: Developmental data. *Language and cognitive processes*, 24, 168–189.

Striano, Tricia & Philippe Rochat (1999). Developmental link between dyadic and triadic social competence in infancy. *British Journal of Developmental Psychology*, 17, 551–562.

Tomasello, Michael, Malinda Carpenter, & Ulf Liszkowski (2007). A new look at infant pointing. *Child Development*, 78 (3), 705–722.

Trevarthen, Colwyn & Penelope Hubley (1978). Secondary intersubjectivity: Confidence, confiding and acts of meaning in the first year. In Andrew Lock (Ed.), *Action, gesture and symbol: The emergence of language* (pp. 183–229). London: Academic Press.

Ungerer, Judy A., Philip R. Zelazo, Richard B. Kearsley, & Kathleen D. O'Leary (1981). Developmental change in the representation of objects in symbolic play from 18 to 34 months of age. *Child Development*, 52 (1), 186–195.

Vallotton, Claire D. (2008a). Infants take self-regulation into their own hands. *Zero To Three*, 29, 29–34.

Vallotton, Claire D. (2008b). Signs of emotion: What can preverbal children "say" about internal states? *Infant Mental Health Journal*, 29, 234–258.

Vallotton, Claire D. (2009). Do infants influence their quality of care? Infants' communicative gestures predict caregivers' responsiveness. *Infant Behavior and Development*, 32, 351–365. doi: 10.1016/j.infbeh.2009.06.001

Vallotton, C.D. (2011). Babies open our minds to their minds: How "listening" to infant signs complements and extends our knowledge of infants and their development. Accepted for publication in the *Infant Mental Health Journal,32*, 1–20.

Vallotton, C.D. (2011). Sentences and conversations before speech? Gestures of preverbal children reveal cognitive and social skills that do not wait for words. In Gale Stam and Mika Ishino (Eds.), *Integrating Gestures: The Interdisciplinary Nature of Gesture* (pp. 105–119). Amsterdam, Netherlands: John Benjamins.

Wagner, Manuella (2006). *First steps to communication: A pragmatic approach*. Tübingen, Germany: Narr Francke Attempto Verlag.

Werner, Heinz & Bernard Kaplan (1984). *Symbol Formation*. Hillsdale, NJ: Lawrence Erlbaum Associates.

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