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Do Infants Influence their Quality of Care? Infants' Communicative Gestures Predict Caregivers' Responsiveness

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Abstract

Infants' effects on adults are a little studied but important aspect of development. What do infants do that increases caregiver responsiveness in childcare environments? Infants' communicative behaviors (i.e. smiling, crying) affect mothers' responsiveness; and preschool children's language abilities affect teachers' responses in the classroom setting. However, the effects of infants' intentional communications on either parents' or non-parental caregivers' responsiveness have not been examined. Using longitudinal video data from an infant classroom where infant signing was used along with conventional gestures (i.e. pointing), this study examines whether infants' use of gestures and signs elicited greater responsiveness from caregivers during daily interactions. Controlling child age and individual child effects, infants' gestures and signs used specifically to respond to caregivers elicited more responsiveness from caregivers during routine interactions. Understanding the effects of infants' behaviors on caregivers is critical for helping caregivers understand and improve their own behavior towards children in their care.

Keywords

child effects; caregiver responsiveness; infant signing; gesture; childcare

Introduction

As more children spend significant time in childcare and early child education programs, the training of non-parental caregivers to provide responsive care to young children in a group care setting becomes paramount. Research has shown that in addition to parental responsiveness, the responsiveness of professional caregivers in childcare promotes children's social (Burchinal, et al., 2006) and language development and academic outcomes (Hirsh-Pasek & Burchinal, 2006). Even biological mothers often need help accurately reading their infants' behaviors as communicative cues (i.e. Brazelton, Koslowski, & Main, 1975; Censullo, 1994; Landry, Smith, & Swank, 2006); it may be even harder for a non-parental caregiver who doesn't know the infant very well and whose attention is split between multiple children. Therefore, one challenge to enhancing children's positive experiences in childcare is helping professional caregivers attune to the individual children in their care, providing contingent responses even though children may be too young to communicate their specific needs through language.

An important influence on adults' responsiveness to infants is the infants themselves (Bell & Harper, 1977; Karraker & Coleman, 2005). Child effects— the notion that children elicit different responses from caregivers based on their unique characteristics and behaviors

(Bell, 1968; Sameroff & Chandler, 1975; Scarr & McCartney, 1983) – is an understudied aspect of child development, though it can exert a strong influence on a child's experiences. Caregivers in group care settings interact with and care for multiple children who each bring unique characteristics and developing social behaviors. Even if caregivers strive to treat all children with equal attention and warmth, they may be influenced by unconscious biases or preferences for certain infant characteristics. It is important to determine the infant characteristics and behaviors that may systematically influence caregiver responsiveness, and help caregivers become aware of their own differential responses to prevent potential inequities in care.

There is a dearth of research on children's effects on their caregivers, especially non-parental caregivers. There are a few studies of the effects of toddlers and preschoolers on their teachers' responsiveness, but no such studies of infants' effects on non-parental caregivers. A small body of research on infants' effects on mothers has described effects of negative distress cues, such as crying, but has not examined the effects of variation in infants' positive communication cues. Variation in positive communicative behaviors such as eye contact, gesturing, and vocalizing, begins prior to speech and may impact caregiver responsiveness. The current study examines the effects of one type of infant communicative behavior – infant gesturing – on the responsiveness of non-parental caregivers.

Infant Effects on Mothers: Infant Characteristics and Communicative Behavior

Assuming that non-parental caregivers are influenced by the same infant characteristics as mothers, the research on infant effects on mothers provides a reasonable foundation for developing hypotheses for infants' effects on professional caregivers. Research has shown that mothers' responses to their children are affected by child temperament (Crockenberg & Leerkes, 2003), gender (Weinberg, Tronick, Cohn, & Olson, 1999), appearance (Weiss, 1981), attachment-related behaviors (Goodman, Hans, & Bernstein, 2005), and premature birth (Macey, Harmon, & Easterbrooks, 1987). Several studies have found that infant characteristics predict both infant behavior and mother behavior. However, it is difficult to determine whether infant behavior actually affects maternal behavior because maternal and infant behavior are theoretically reciprocal and statistically correlated.

Goldberg (1977) described the infant's role in reciprocal infant-caregiver social interactions. She described infants as participating in their own socialization by co-creating interactions with their caregivers using the behaviors under their control – such as crying, making eye contact, and smiling – to capture their parents' attention. Further, she described the “socially competent infant” as an infant whose behaviors are readable and who can reinforce the adult's sense of competence by responding contingently to adults' behaviors. For example, a socially competent infant may smile in response to eye contact, or stop crying in response to a parent's attempts to comfort. Some research on mother-child interactions supports the basic tenets of Goldberg's ideas that infants' readability and responsiveness to caregivers affects caregivers' sense of efficacy and responsiveness to their infants. For example, in a micro-analytic study, Murray and Trevarthen (1986) confirmed the role of infants' contingent responsiveness in shaping mothers' behavior by examining mothers' speech to their 2-month old babies during interaction via live-feed video cameras, and comparing that to mothers' infant-directed speech when the video of the infant was played back to the mother. In the second situation, the behavior mothers saw from the infant was exactly the same as the first, but it was not contingent to her own behavior because it was pre-recorded. Mothers' speech to the non-contingent infant behavior was significantly different than speech to the infant who was responding to her. When mothers were faced with the non-contingent infant video, they displayed less infant-focused speech, expressed more negative emotion, and made more imperative and declarative statements, rather than interrogatives. Thus, infants' abilities to provide contingent responses to their caregivers influences how

much caregivers' attend to the infant, as well as the content and emotional tone of caregivers' infant-directed speech.

Bell and Ainsworth (1972) examined the effects of infant behavior on mother-child interactions over time. Using a longitudinal design, they showed both mothers' effects on infants and infants' effects on mothers. They found that infants who cry more at 6 months of age have mothers who respond less at 12 months; and on the other hand, mothers who respond to infants' cries more readily at 6 months have infants who cry less at 12 months. Goodman, Hans, and Bernstein (2005) found that infants' avoidance of their mothers' interaction attempts at 12 months predicted lower quality maternal communication when children were two years. And Leerkes and Crockenberg (2002) found that the ease with which distressed infants could be soothed predicted their mothers' sense of efficacy as a parent; and both infants' distress and mothers' sense of efficacy predicted mothers' sensitivity to their infants. Thus, there is some evidence that, consistent with Goldberg's ideas, infants' communicative behaviors reinforce or diminish parental responsiveness. However, these studies have focused on infants' distress cues rather than on positive communicative cues or infants' contingent responses to caregivers.

Child Effects on Non-Parental Caregivers: Child Age and Language Skills

The few studies that have examined effects of children on non-parental caregivers have focused on slightly older children – toddlers and preschoolers – who are using vocal language. One observational study of childcare providers' response patterns to toddlers and preschoolers showed that caregivers' responses varied by child age and by differences in children's expressive language (Girolametto & Weitzman, 2002). Taking a bidirectional perspective on child-caregiver interaction, this study provides evidence that caregiver responsiveness and child communication skills are related, but does not indicate a direction of influence. A study by Rudasill, Rimm-Kaufman, Justice, & Pence (2006) found that preschoolers' temperaments and language skills both predicted their relationships with teachers, but that teacher effects accounted for particularly discordant child-teacher relationships. This study again provides evidence for the importance of child communication skills in establishing positive relationships with non-parental caregivers in educational settings, and it highlights the importance of accounting for teacher effects when determining children's effects on relationships and interactions with caregivers.

Infant Signing: Making Infant Communication Visible to Caregivers and Scientists

Children's language skills influence the quality of their relationships with non-parental caregivers; however, individual differences in communication skills do not begin with language. Infants use a variety of behaviors to communicate long before they speak, including eye gaze, gestures, and preverbal vocalizations (i.e. Wagner, 2006; Carpenter, Mastergeorge, & Coggins, 1983). Infants learn many conventional gestures ubiquitous in their social environments; for example, most infants will learn gestures to reach and show with their arms, point and wave with their hands, and shake and nod with their heads. Crais, Douglas, and Campbell (2004) documented the development of many conventional gestures in infants between 3 and 24 months old. They documented that the average age at which infants will begin to reach to be picked up is around 6.5 months, waving begins around 8.4 months, showing an object begins around 9.5 months, pointing begins on average around 10.6 months. The authors documented that nodding and shaking the head come much later, with shaking for "no" around 13.3 months, and nodding for "yes" around 15.9 months on average (Crais, Douglas & Campbell, 2004). These data are consistent with that of others who have documented pointing, showing, reaching, and giving between 8 and 15 months (e.g. Carpenter, Nagell, & Tomasello, 1998).

Along with these conventional gestures which most infants learn, many infants invent or learn symbolic gestures through routines and games with parents (Acredolo & Goodwyn, 1985, 1988). In a parent diary study of children between 11 and 20 months old, Acredolo and Goodwyn documented that infants will typically learn request gestures first, such as “up” or “outside”, followed by gestures naming objects such as “dog” or “car”. Further, infants can learn signs modeled for them by caregivers (a.k.a. infant signs) to explicitly communicate their thoughts and needs with caregivers (Goodwyn & Acredolo, 1993). There is natural variation between infants in the developmental timing and frequency of communicative behaviors (i.e. Crais, Douglas, & Campbell, 2004; Mundy et al., 2007), and it is possible that differences in these preverbal communication skills influence the qualities of infants’ interactions with their parental and non-parental caregivers, just as differences in their language skills will later in development.

Though variation in communicative behavior begins prior to speech, it is still difficult for caregivers to accurately read infants’ intentions or needs from pre-linguistic behaviors. Similarly, it is difficult for scientists to detect which infant behaviors are intentional, which are communicative, and which are indicative of explicit cognition. However, infant signing – use of gestures as symbolic representations – makes infants’ communicative cues visible to both scientists and caregivers. A number of studies utilizing parents’ reports have shown that infants’ signs are visible as clear communication cues to parents (Acredolo & Goodwyn, 1985; 1988). And observational studies utilizing trained researchers unfamiliar with the infants provides evidence that signing makes infants’ communicative cues visible scientists as well (Bates, 1980; Vallotton, 2008).

It is possible that infant signing actually increases the variation in the frequency of and clarity of infants’ communicative behaviors. However, whether such cues are actually increased or simply revealed, their effects on caregivers will be the same. By making infants’ communicative cues and communicative responses visible to their caregivers, infant signs may elicit more responsive care from non-parental caregivers.

The Current Study: General Infant Effects and Effects of Infant Signing on Caregiver Responsiveness

The current study examines the general child effects of individual infants on their caregivers’ responsiveness and the effects of infants’ communicative gestures, including modeled signs, on caregivers’ responsiveness during caregiver-child interactions in a group care setting. To disentangle the effects of individual caregivers and individual infants on caregivers’ responsiveness, I use a sample from an early child education classroom in which multiple children interacted with multiple caregivers, and vice versa, in one-on-one dyads.

As well as being an important group to study to improve training and quality of care, non-parental infant caregivers in group-care present a unique opportunity to examine infants’ systematic effects on caregiver responsiveness across multiple caregivers. In order to determine whether infants’ communication skills affect the responsiveness of care they receive, it is necessary to account for both differences in teachers (as seen in Rudasill, et al., 2006) and the overall effects of the infants themselves – the sum of the individual differences in infant characteristics that may elicit different levels of responsiveness from their caregivers. That is, differences in infants’ time-invariant characteristics must be accounted for in order to assess the true effects of their time-varying behavior, such as gesturing, on caregiver responsiveness.

Questions

General infant effects:

- 1) Do some infants systematically receive more or less responsive care across non-parental caregivers in a group care setting?

Infant communicative behavior effects:

- 2) Does the frequency or variety of infants' gestures and signs elicit more responsive care?
- 3) Does infants' contingent responsiveness to their caregivers elicit responsive care?
- 4) Does infants' use of infant signs elicit more responsive care than use of conventional pointing?

Methods

Participants

Participants were 18 student caregivers and 10 infants in a childcare setting. Caregivers were 17 female and 1 male university undergraduates studying child development and serving as caregivers six hours per week, which fulfilled an internship requirement for their Bachelor's degree in Human Development. Most caregivers were juniors or seniors in college, and most were between 20 and 23 years old (data on caregiver ages were not collected). Infants were 7 females and 3 males between 4 and 19 months of age during the course of the study. This sample was a convenience sample enrolled in the Infant and Toddler program at the UC Davis child development laboratory. Participation in the study was voluntary for the caregivers, and infants' parents provided voluntary consent for infant participation (no caregivers or parents of infants declined to participate).

Classroom Features

There are two particular features of the infant classroom important to this study: the use of infant signing as a caregiving tool, and the pattern of caregiver participation that created variation in infant-caregiver dyads.

Infant signing as a caregiving tool—Caregivers were taught to systematically use a form of infant sign language, now known as the Baby Signs® Program (Acredolo & Goodwyn, 1992), in conjunction with speech during routine interactions with the infants. It was implemented in the research site classroom based on the positive effects of infant signing on language development (Goodwyn, Acredolo, & Brown, 2000), and on the relationships between parents and children (Acredolo & Goodwyn, 1992). The Director believed that using signs could promote early bi-directional communication between infants and non-parental caregivers, and that this communication would help caregivers attune to the specific needs and personalities of the preverbal children in their care.

Caregivers' use of infant signing was reinforced through modeling by the Head Teacher, and through instructive posters placed around the classroom. Children were not explicitly taught to use signs, but learned the signs modeled by caregivers. The use of infant signs in the classroom created additional visible variation in children's communicative behaviors that are the focus of this study.

Caregiver participation—The second important classroom feature is the pattern of caregiver participation. The classroom operated four mornings per week over the academic year. During each academic quarter (10 weeks) caregivers participated two days per week and were assigned the same two children each day. Thus in any given quarter caregivers interacted with a minimum of two children, and children interacted with a minimum of two

caregivers. At the end of each academic quarter, caregivers had the choice to discontinue participation or stay for up to three quarters; in this sample, 4 caregivers stayed for two academic quarters while 14 were in the classroom for only one quarter. Thus, over the course of the study, children could be cared for by as many as six caregivers (over the course of observations, each infant was observed interacting with between 3 and 5 individual caregivers, $m = 4.30$). Further, though assigned to two primary children, caregivers often interacted with others as well (over the course of observations, the number of individual infants with whom the caregivers were observed to interact ranged from 1 to 5, $m = 2.22$). This variation in interaction partners for both children and caregivers is critical to the detection of child effects across multiple caregivers.

Measuring Caregiver and Child Interaction Behavior

Videotaping—Caregiver-child interactions were filmed in 5-minute episodes during normal classroom routines; the order of filming specific dyads was randomized. Each caregiver was filmed an average of 12 times over the course of each academic quarter (10 weeks). Some videotapes were eliminated from the study based on low sound quality, leaving a final sample of 185 observations; an average of 10.28 observations per caregiver.

Caregiver responsiveness—An observational measure of caregiver responsiveness consisted of 17 different appropriately responsive behaviors each rated on a scale of 1 (almost never) to 7 (almost always). The measure was created for the purpose of this study in collaboration with the staff of the early child education site where this study was conducted. It was based on the attachment-related caregiver sensitivity measures found in the literature (e.g. Arnett, 1989; Howes, Galinsky, & Kontos, 1998) and on the philosophy of this particular early child education program. Items on the measure included behaviors such as “follows child’s gaze and pointing,” and “gives child warning before making transitions.” Not all behaviors were observed during each interaction, thus coders were instructed to code them “as applicable”; scores were averaged across all applicable items to create the total responsiveness score for each observation. The instrument used to rate caregiver responsiveness, including all 17 items on which caregivers were rated, can be seen in the appendix.

Inter-rater reliability. The raters of caregiver responsiveness were University students who had not interacted with the child in this study. Three raters independently rated each interaction; ratings were averaged across items and across raters to create a total responsiveness score between 1 and 7 for each interaction. Raters were trained on practice tapes and achieved 90% agreement prior to beginning independent coding. Average inter-rater agreement across items was greater than 90% for all coded episodes.

Infant gestures and signs—I have operationalized Goldberg’s (1977) concept of infants’ readable cues as the frequency and variety of their use of communicative gestures¹, as determined by trained coders; this includes both conventional gestures (i.e. pointing, waving), and the infant signs modeled by caregivers. I use infants’ signing behavior specifically in response to their caregivers’ signs as an indicator of infants’ responsiveness to caregivers’ communication attempts, operationalizing Goldberg’s concept of infants’ contingent responsiveness to adults.

Gestures (including infant signs) were defined as intentional, communicative motor behaviors performed in the context of an interaction. Each gesture performed by infants and caregivers in each episode was recorded – including the definition of the sign (e.g. point,

¹Unless otherwise indicated, I use *gestures* to refer to both conventional gestures and modeled signs.

more, sad) and a marker of time noting at which second in the episode it was performed. Each sign was pre-defined as either a conventional gesture (e.g. point, nod, wave) or an infant sign (e.g. more, sad). A complete list and descriptions of all signs recorded is available from the author. Gestures were also coded in one of four conversational context categories: (1) Initiation: gesture not preceded by another gesture in the last 5 seconds²; (2) Continuation: gesture preceded by a gesture of different content by same individual within 5 seconds; (3) Imitation: gesture preceded by same gesture by different person within 5 seconds; (4) Reply: gesture preceded by different gesture by different person within 5. See the appendix for more information on coding of conversational context.

Inter-coder reliability. Coders of infant gestures were a separate group from those who coded caregiver responsiveness. Inter-coder reliability was assessed using Cohen's (1960) Kappa. Coders obtained a Kappa of .75 or above on five consecutive episodes before coding independently. Agreement was reassessed on 15% of episodes; Kappa was greater than .82 on all reassessed observations.

Variables

Each variable is described in more detail below. Descriptive statistics are presented in Table 1.

Caregiver ID—Caregiver ID is a nominal variable indicating which caregiver is being observed in the caregiver-child interaction. Analysis was organized by caregiver ID, and results are averaged across caregivers.

Caregiver responsiveness—Caregiver responsiveness (*RESPONSIVE*) represents the caregivers' time-varying score on the responsiveness measure during each observation of caregiver-child interaction. It was calculated by averaging the ratings of responsive behaviors, for those behaviors rated, within each observed interaction. This variable varies from one observation to the next both within and between caregivers.

Caregiver experience—Caregiver experience (*EXPERIENCE*) is the amount of time, in tenths of months, that the caregiver has been in the infant classroom. The minimum time caregivers had been in the classroom prior to observation was 0.30 months (or 9 days), and the maximum time caregivers had been in the classroom at their last observation was 5.42 months (or 5 months and 13 days). If all caregivers entered the classroom at once, this variable would co-vary entirely with infant age. However, because there was caregiver turnover twice during the year (at each academic quarter break), this variable does not completely co-vary with child age.

Infant ID—Infant ID is a series of time-varying dummy variables (*IN_1* to *IN_10*), one for each infant, identifying with which infant the caregiver was primarily interacting during each observation. That is, in one observation, Caregiver 42 may be interacting with Infant 2 (*IN_2*), and in the next observation, she may be interacting with Infant 5 (*IN_5*); the dummy variables capture this information and allow the unique effects of individual infants on caregiver responsiveness to be tested.

²Five seconds was used as a conservative yet somewhat arbitrary marker of conversational timing. Through visual and auditory review of the gesturing episodes it was determined that if a child or caregiver were to respond to another's gesture, it would happen within 5 seconds, and that those occurring more than 5 seconds later were not responses as indicated by changes in attention and gesture content.

Age—Infant age (*AGE-6*) is a time-varying variable calculated as the age of the infant, in tenths of months, on the date of the caregiver-child interaction, centered at 6 months. Infants were between 4 and 19 months during the course of this study, however data is limited to observations between 5 and 17 months because there were too few observations at the tale ends to be confident of the results. Thus infant age at the beginning of observation was between 4.9 and 11.6 months of age ($m = 8.67$), and our last observations of infants were when they were between 9.6 and 17.5 months ($m = 13.26$).

Gender—Infant gender (*BOY = 1*) is a time-invariant dummy variable.

Infant gesture frequency and variety—Using the gesture definitions and types – conventional gestures or infant signs – I created variables measuring the frequency of infant pointing (*POINT*), and the frequency and variety of infants signs (*SIGN_FREQ*, *SIGN_VAR*) performed by the infant during each 5-minute interaction. I also created variables describing the total gesturing frequency (*TOTAL_FREQ*) and variety (*TOTAL_VAR*) of all communicative gestures, including both conventional gestures and infant signs performed by the infant during each interaction.

Infant responsive gesturing—Using the conversational context coding, I calculated the percentage of caregivers' gestures to which infants responded with a gesture of their own for each 5-minute interaction. I did this by calculating the ratio between the caregivers' total gestures and the number of infants' gestures that were coded as either an imitation or a reply. The resulting variable, responsive gesturing (*RESP_GEST*) is a ratio ranging from 0 (infant responded to none of the caregiver's gestures) to 1 (infant responded to all of the caregiver's gestures).

Analyses

General Infant Effects on Caregiver Responsiveness

To test whether some infants systematically received more or less responsive care than others, I fit a series of multi-level (2-level) regression models, with observations nested within caregivers, using SAS PROC MIXED maximum likelihood (ml) method of estimation. Use of multi-level models nested within caregiver allows prediction of within- and between-caregiver variation in responsiveness. First I fit an unconditional model to estimate average caregiver responsiveness across all observations – all caregivers and all children; this model serves as a baseline of comparison for subsequent models. Next I added infant age to account for the effect of infants' general development on caregiver responsiveness. Then I added nine of ten infant dummy variables, using the infant who received the most average care across caregivers (*IN_6*) as the intercept; the fitted values of each dummy variable capture the effects of each individual infant on the responsiveness of care they received across all the caregivers with whom they interacted. I tested multiple specifications of infant age and interactions between infant identity and infant age to determine whether slopes were systematically different for some infants. I used a linear contrast test to determine whether the average care received by the three male infant was the same as the average care received by the seven female infants.

The final model addressing Question 1 is shown in Equation (1); its interpretation is provided below.

$$[RESPONSIVE]_{ij} = [\pi_{0i} + \pi_{1i}(AGE_{ij} - 6) + \pi_2(IN_1_{ij}) + \pi_3(IN_2_{ij}) + \pi_4(IN_3_{ij}) + \pi_5(IN_4_{ij}) + \pi_6(IN_5_{ij}) + \pi_7(IN_7_{ij}) + \pi_8(IN_8_{ij}) + \pi_9(IN_9_{ij})]$$

where $([\zeta_{0i}] \sim N[0] [\sigma^2_0 \quad \sigma_{01}])$

In Equation (1), parameter π_{0i} is the intercept and can be interpreted as average care received by Infant 6 at 6 months of age, and π_{1i} is the average effect of each additional month of infant age on caregiver responsiveness. Parameters π_2 through π_{10} are the average effect of each infant on caregiver responsiveness across all caregivers, compared to Infant 6. In addition to fixed effects to be estimated, there are two variance components in Equation (1): ζ_{0i} is the between-caregiver variance, and ϵ_{ij} is the within-caregiver variance across observations.

The linear contrast test of the equivalence of caregiver responsiveness to boys and caregiver responsiveness to girls is represented by the following null hypothesis:

$$H_0 = (IN_1 + IN_2 + IN_9) / 3 = (IN_3 + IN_4 + IN_5 + IN_6 + IN_7 + IN_8) / 7 \quad (2)$$

Effects of Infant Signing on Caregiver Responsiveness

To answer Question 2, I added infants' total gesturing frequency (*TOTAL_FREQ*) and variety (*TOTAL_VAR*) to the model that already included infant identity and age; I tested interactions with age to test for a change in the effect of infants' cues as infants get older. To address Question 3, I added infants' responsive gesturing (*RESP_GEST*) to the model already including infant identity and age, and total signing frequency and variety. The final model addressing Question 3 is shown in Equation (3); its interpretation is provided below.

$$[RESPONSIVE_{ij}] = [\pi_{0i} + \pi_{1i}(AGE_{ij} - 6) + \pi_2(IN_1_{ij}) + \pi_3(IN_2_{ij}) + \pi_4(IN_3_{ij}) + \pi_5(IN_4_{ij}) + \pi_6(IN_5_{ij}) + \pi_7(IN_7_{ij}) + \pi_8(IN_8_{ij}) + \pi_9(IN_9_{ij})] \\ \text{where } ([\zeta_{0i}] \sim N[0] [\sigma^2_0 \quad \sigma_{01}])$$

In Equation (3), the parameters for infant age and individual infant effects share the same interpretation as the parallel parameters in Equation (1), as do the within- and between-caregiver variance components. However, in Equation (3), the intercept parameter π_{0i} is interpreted as average care received by Infant 6 at 6 months of age when she uses no gestures or signs. Parameter π_{11i} is the effect of each additional gesture the infant performed during the specific interaction. Parameter π_{12i} is the effect of the total variety of unique gestures the infant performed. And parameter π_{13i} is the effect of the percentage of caregivers' gestures to which infants responded with a gesture.

Finally, to address Question 4, I tested whether infants' use of infant signs elicited more responsive care than conventional pointing by adding the variables for conventional pointing (*POINT*) and the frequency (*SIGN_FREQ*) and variety (*SIGN_VAR*) of signs to the model that already included infant age and each individual infant effect; again I tested interactions with infant age to see if there was a change in the effect of infants' cues.

The final model addressing Question 4 is shown in Equation (4); its interpretation is provided below.

$$[RESPONSIVE_{ij}] = [\pi_{0i} + \pi_{1i}(AGE_{ij} - 6) + \pi_2(IN_1_{ij}) + \pi_3(IN_2_{ij}) + \pi_4(IN_3_{ij}) + \pi_5(IN_4_{ij}) + \pi_6(IN_5_{ij}) + \pi_7(IN_7_{ij}) + \pi_8(IN_8_{ij}) + \pi_9(IN_9_{ij})]$$

Equation (4) is similar to Equation (3) and parameters π_{0i} through π_{10} , and the variance components can be interpreted as they were in Equation (3). However, in Equation (4), the question predictors are modified by their interactions with infants' age. Parameter π_{14} is the effect of infants' pointing frequency when they are 6 months old, and parameter π_{15} is the change in the effect of pointing each subsequent month. Similarly, π_{16} is the effect of infant sign frequency at 6 months, and π_{17} is the change in its each subsequent month; π_{18} is the

effect of infant sign variety at 6 months, and π_{19} is the change in the effect of infant sign variety each subsequent month.

As a follow-up to the results of Questions 3 and 4, I used cross-tabs to examine whether infants were more likely to use conventional gestures or infant signs to imitate or reply to caregivers, as compared to their use of gestures and signs to initiate or continue communication. I used a chi-square test to determine whether there were significant differences in combinations of these behaviors. I also conducted a post-hoc test to determine whether the changing effects of infant signing on caregiver responsiveness were due to the increasing experience caregivers had with the children. I added the caregiver experience (*EXPERIENCE*) variable indicating the number of months caregivers had been in the infant classroom into Equation (4), then examined whether caregiver experience reduced the effects of infant behavior or infant age.

Results

Model A (in Table 2) provides a baseline model describing average caregiver responsiveness, and showing the variation in responsiveness both within caregivers over time, and between caregivers on average. The majority (88%) of variance in caregiver responsiveness lies within caregivers across interactions, while only 12% of variation lies between caregivers (see the Level 1 and Level 2 variance components in the unconditional Model A). That is, there is wide variation in the responsiveness provided by an individual caregiver from one time to the next; and part of that variation may be explained by the particular infant with whom she is interacting.

Results of the fitted models for Questions 1, 2, and 3 are presented in Table 2. Results of the fitted models for Question 4 are presented in Table 3. Below I discuss the findings for each research question.

General Infant Effects

Some infants elicit more or less responsive care across caregivers. Three infants received systematically different care as compared to Infant 6 who received the most average care across all interactions. At 12 months of age, for example, the estimated responsiveness to Infant 9 was 6.7424, which is 1.4 standard deviations higher than the responsiveness to Infant 6 (who received average responsiveness), and 2.1 standard deviations greater responsiveness than care received by Infant 4, who received the lowest level of responsiveness. The results for the effects of each infant on caregiver responsiveness can be seen in Table 2, in the column under Model B.

Overall, as infants got older the care they received was more responsive. There were no interactions between infant identity and age, indicating that in general the change in caregiver responsiveness related to age was the same for all infants. Figure 1 shows the trajectory of caregiver responsiveness experienced by infants on average at each age, and the trajectories of three infants who each experienced care significantly different from average.

The linear contrast test that I performed while fitting Model B showed that there were gender differences in the average responsiveness children received, with boys experiencing significantly greater responsiveness from caregivers when accounting for the effect of infant age and overall infant effects. At 6 months of age, boys experienced an average caregiver responsiveness rated at 5.20, while the average for 6 month old girls was 4.75 ($df = 17$, $F = 167.61$, $p < .001$), an effect of 0.55 standard deviations in average caregiver responsiveness.

Overall the basic infant-effects model (Model B) explained 19% of the total variance in caregiver responsiveness compared to the unconditional model. Together, infant age and infant identity explained 12% of within-caregiver variation, and 73% of between-caregiver variation in responsiveness.

Effect of Infants' Communicative Behavior Frequency and Variety

The total frequency and variety of infant's readable communication cues did not elicit greater responsiveness from caregivers. As seen in Model C (Table 2), taking infants' signs and conventional gestures together, neither the total frequency nor variety of all of infants' gestures appear to elicit greater responsiveness from caregivers. Similarly, there were no significant interactions between infant age and total frequency or variety of gestures, indicating that there was no change in effect as children got older.

Effects of Infants' Communicative Behavior In Response to Caregivers

Infants' use of signs specifically to respond to caregivers elicited greater responsiveness from caregivers. Although the overall frequency and variety of gestures did not predict caregiver responsiveness, infants' use of gestures specifically in response to caregivers' gestures predicted more general responsiveness from caregivers, controlling for infant age, individual infant effects, and overall frequency and variety of gestures (see Model D, Table 2). Figure 2 shows the effect of infants' use of gestures to respond to caregivers on caregivers' responsiveness to infants. The central black represents caregivers' responsiveness to infants when infants are at the average level of responsive gesturing for their age; the gray line represents caregiver responsiveness when infants are one standard deviation higher on responsive gesturing, and the dashed line represents infants one standard deviation below average responsive gesturing. As seen in Figure 2, prior to 10 months of age, this variable does not distinguish between the care received by infants because infants younger than 10 months are not using gestures to respond to caregivers. However, after 10 months infants' responsive gesturing behavior is increasingly influential on the quality of care they receive, as there is increasing variation in infants' responsive gesturing in interactions with caregivers.

Comparing the variance components of Models C and D, the inclusion of infants responsive gesturing explains an additional 7% of total variation in caregiver responsiveness, including equal portions of within- and between-caregiver variation. Overall, compared to the unconditional Model A, Model D explains 26% of variation in caregiver responsiveness, including 18% of variation within caregivers, and 77% of variation between caregivers.

Effects of Conventional Pointing and Infant Signing on Caregiver Responsiveness

Both conventional pointing and infant signing affect caregiver responsiveness. When only the main effects of infant pointing and signing frequency and variety were entered into the model, none of them had significant effects on caregiver responsiveness (see Model E, Table 3). However, when interacted with infant age, the impact of each of these infant behaviors on caregivers is revealed (Model F). Because all three of these behaviors are highly correlated, the interpretation of the impacts of each behavior on caregiver responsiveness must be considered in light of the other behaviors as controls. (When infants' responsive gesturing was added to Model F, the effects of each of the other gesturing variables remained similar to their values presented in Table 3 Model F, and the effect of Responsive Gesturing was still positive and significant, $b = 1.6447$, $se = 0.9491$, $df = 132$, $p = .08$). The results described below are interpreted from the final fitted model, Model F.

Although there were no main effects of infants' pointing and signing, both pointing and infant signing frequency increasingly affected caregiver responsiveness as infants got older;

that is, there was an interaction between infants' gesture behaviors and infant age. Figure 3A shows the impact of infants' pointing on caregiver responsiveness across infant ages. The dark center line represents the trajectory of caregiver responsiveness during interactions in which children are using an average frequency of pointing and average frequency and variety of infant signs. The gray line shows caregiver responsiveness to infants when they use one standard deviation more pointing during their interactions, and the dotted line shows caregiver responsiveness to infants using a standard deviation less than average. The increasing disparity between the upper and lower lines is a result of two things: first, the impact of infant pointing on caregiver responsiveness increases with infant age; and second, the variation in infant pointing from one interaction to the next increases through infancy.

In addition to pointing, both infant signing frequency and variety impacted caregiver responsiveness in complementary ways as infants get older. Figure 3B shows the impact of infants' signing frequency and variety on caregiver responsiveness across infant ages. Again, the black line represents caregiver responsiveness to infants using average signing and pointing. The gray line represents caregiver responsiveness to infants when they use higher signing frequency (one standard deviation higher), but use average pointing frequency and sign variety; and the dashed black line represents caregiver responsiveness to infants when they use one standard deviation higher sign variety and average pointing and signing frequency. Earlier in infancy signing variety has a greater impact on caregivers' responsiveness; that is, when infants use a greater variety of signs, they experience a higher quality of care. But signing variety wanes in importance as infants get older, and its impact even reverses such that infants using a higher variety receive lower quality of care, when controlling for pointing and signing frequency. On the other hand, infants' signing frequency actually appears to have a negative impact on caregiver responsiveness early in infancy, but has a positive impact later in infancy, when controlling for pointing frequency and sign variety. Referring to Figure 3B, there appears to be a cross-over point for both trajectories between 15 months of age.

I tested the possibility that the change in the effect of infants' gesturing behavior on caregiver responsiveness was due to the effect of caregivers' increase in experience over time, presumably because as they gain experience they may also become more sensitive to infants' cues. However, when I controlled for the length of time caregivers' had been in the classroom, there was no change in the main effect or change in the effect of infant sign frequency and variety on caregiver responsiveness.

Which Gestures Do Infants Use to Respond to Caregivers?

I was prompted by the findings of Questions 3 and 4 to test whether infants use more conventional gestures or infant signs to respond to caregivers' signs. Infants in the current sample were equally likely to use the modeled signs to respond to caregivers' gestures as they were to use conventional gestures such as pointing, nodding, or shaking their heads. The chi-square test revealed no significant pattern between the type of gesture (symbolic, conventional) and conversational context (initiation, continuation, imitation, reply) ($X^2 = 0.658$, $df = 3$, $p = .883$).

Discussion

The quality of care received by individual infants varies even among carefully trained and supervised caregivers. Variation in caregivers' responsiveness is partially explained by children's characteristics and their communicative behaviors. The classroom in which this study was conducted was a high-quality childcare, yet individual infants elicited significantly different qualities of care; a difference that is in part based on infant gender. Because the infants elicited this differential care across multiple caregivers, it is truly an

infant effect rather than a relationship dynamic between the infants and specific caregivers. These results reveal that even at a very young age, infant characteristics influence their relationship environments.

When an infant uses clear communicative behaviors to respond specifically to her caregiver's communication attempts, the caregiver is more responsive overall to the infant. This finding supports Goldberg's notion of the socially competent infant who reinforces her caregivers, motivating them to engage and respond. It is particularly interesting that it is not the total frequency and variety of communicative cues that elicits greater responsiveness, rather, it was the cues that were specifically in response to the caregiver that affected caregiver responsiveness to infants. This finding also confirms that infants play an active role in shaping interactions and eliciting quality of care. Infants may affect caregivers not only through their individual stable characteristics (i.e. gender), but also in their time-varying behavior which changes both over time as infants age and on a daily, or even momentary, basis.

Though the total frequency and variety of all gestures does not appear to impact caregiver responsiveness, when pointing and infant signs are looked at separately, their effects are revealed. The effects of infant sign frequency and variety on caregiver responsiveness change with children's age. One explanation for this change in impact is that caregivers are adapting to infant behavior. At same time that there is a cross-over in the importance of infant sign frequency and variety to caregiver responsiveness (15 months), there are also changes in the trajectories of these two variables (refer to Table 1 for average gesturing at each age); infants' signing frequency is leveling off while infants' signing variety begins to increase rapidly. Caregivers may be more attentive and responsive to novel or rare behaviors by the infant. As a greater variety of infant signs becomes more common, its impact on caregiver behavior wanes; and as the frequency of infant signs levels off, greater frequency becomes more noticeable.

Limitations and Future Directions

Though it enabled me to use the child fixed effects design in a way a larger sample may not, the small sample size and variety of ages of the infants in the sample limit my confidence in the results on the tail ends of the age distributions. More important than sample size is the fact that the infants in this study were exceptional; they were exposed to the use of infant signs, and most were using them on a regular basis at home and in childcare. This signing made visible infants' intentional communication with caregivers, but there is also the possibility that the results of this study apply only to infants who use signs. I believe that this is unlikely, however, because the results showed that infants use both conventional pointing and signs to respond to caregivers, and that caregivers are more responsive to infants who use more gestures, regardless of whether those gestures were conventional pointing or infant signs. Thus, to some degree, these results are likely to apply to infants who use only conventional gestures. Further, as the rising popularity of infant signing has shown, there is no reason to believe that most typical infants – and perhaps also most delayed infants – cannot learn to use infant signs.

It seems likely that the same infant behaviors that affect professional caregivers – such as the communicative gesturing behaviors examined in this study – also affect parents. However it is difficult to rigorously test the presence of such infant effects on parents given the reciprocal dynamics of the parent-child relationship, and the inability to examine infant effects across multiple parents compared to multiple children controlling for factors such as child age, birth order, gender, and parents' prior experience with children. Twin studies may be useful in parsing out variance in infant-parent relationships that are due to infant effects and those that are parent effects.

An important infant behavior that was not captured in this study was the development and use of language. The ages of infants in this study overlap with the age period in which most typically developing children begin to use language, and it is likely that the older infants in this study were using words to communicate, as well as gestures, by the end of the observations in this study. Further, because the use of infant signs actually promotes language development (Goodwyn, Acredolo, & Brown, 2000), it is possible that the infants who were using more signs were also those using more words in interactions with their caregivers. Though this would not account for the effect of earlier gesturing on caregiver responsiveness, nor the effect of infants' responsive gesturing, it may be related to the effect of later gesturing on caregiver responsiveness. Because infant signing promotes language development, but the onset of language may actually suppress infant signing as words take over the role of symbolic gestures, it is likely that there is a complex and changing relationship between these two skills. The growth of language and suppression of signs could potentially explain the results presented in Figure 3B – that after 15 months, infants using a greater variety of signs receive less responsive care from caregivers. Perhaps those infants still using a greater variety of signs at this age are those *not* using much vocal language.

Future studies should examine the impacts of other elements of infant interactive behavior – such as eye contact, affection and proximity seeking, vocalizations, and the transition to language – on the quality of care provided by professional caregivers. While the value of attempting to equalize care across infants is questionable, caregivers should be aware that infant characteristics and behaviors may inadvertently influence their responses. This awareness may provide a way for caregivers to reflect on and intentionally increase their own responsiveness.

The current study was not an experimental design. Though this study addressed the effects of differences in infants' time-varying gesturing behavior on caregiver responsiveness, it remains to be seen whether infants' enhanced use of gestures and signs actually increases the overall level of caregiver responsiveness. Given the results of this study, it seems likely that infant signing does promote greater responsiveness and reciprocity in infant-caregiver interaction; however, future studies should examine this question experimentally.

In summary, infants affect the care they receive from non-parental caregivers. Infants' stable characteristics systematically elicit differential responsiveness from non-parental caregivers. Further, infants' communicative behaviors – which grow over time and change from one moment to the next – affect caregiver responsiveness. Both the typical pointing gesture and modeled infant signs are tools for mutual responsiveness between children and caregivers. Increasing infants' use of gestures and signs may be a means to enhance responsiveness in caregiver-child interaction, a possibility that should be tested experimentally.

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Appendix

Caregiver responsiveness rating.

Caregiver Sensitivity and Responsiveness Instrument

Rater: _____ Date of Rating: _____

Participant: _____ Date of Observation: _____

Start time: _____ End time: _____

Assign score to behaviors immediately after observation:

7 = almost always.....6.....5.....4 = about half of the time.....3.....2.....1= almost never

The Caregiver...

1) ... talks to child appropriately about child's actions _ _ _ _ _

2) ... uses words to describe child's apparent affect _ _ _ _ _

3) ... matches child's affect _ _ _ _ _

4) ... follows child's gaze and pointing _ _ _ _ _

5) ... meets requests of child (within constraints of situation) _ _ _ _ _

6) ... accepts child's bids for physical contact _ _ _ _ _

7) ... face displays positive affect (in accordance with child's affect) _

8) ... maintains open, engaged body posture _ _ _ _ _

9) ... lets infant initiate interaction and activity _ _ _ _ _

10)... gives child warning before transitions _ _ _ _ _

11)...talks to child about caregiver actions (when there is a change) _ _ _

12)...practices turn-taking _ _ _ _ _

13)...offers incremental help _ _ _ _ _

14)...is at child's physical level _ _ _ _ _

15)...seeks or makes eye contact while in close proximity _ _ _ _ _

16)...maintains gaze towards child when child is out of proximity _ _ _ _

17)...is physically oriented towards child (w/i 10 seconds of change) _ _

Conversational context coding.

Table A

Conversational context codes and responsive gesturing variable

Code	Description	Example
Initiation	Gesture not preceded by another gesture in the last 5 seconds	Infant gestures <i>bird</i>
Continuation	Gesture preceded by a gesture of different content by same individual within 5 seconds	Infant gestures <i>bird</i> then <i>points</i>
Imitation	Gesture preceded by same gesture by different person within 5 seconds	Caregiver <i>points</i> , then infant <i>points</i>
Reply	Gesture preceded by different gesture by different person within 5 seconds	Caregiver <i>points</i> , then infant gestures <i>bird</i>
<i>Responsive Gesturing Variable</i>	<i>The percentage of caregiver gestures in a given interaction episode to which the infant responded with either an imitation or a reply.</i>	Caregiver gestures 5 times during the interaction; infant imitates the second gesture, and replies to the fourth gesture; Responsive Gesturing = 0.4.

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Figure 1.
Infant effects on caregiver responsiveness across caregivers through infancy.

Figure 2.

Effect of infants' use of gestures to respond to caregivers (*RESP_GEST*) on caregivers' overall responsiveness in interactions, controlling for general infant effects, infant age, and infants' overall frequency and variety of gesturing.

Panel A. *Effects of infant pointing frequency, controlling for infant signing frequency and variety.* Panel B. *Effects of infant signing frequency and variety, controlling for infant pointing frequency.*

Figure 3.
Effects of infant conventional gestures and infant signs on caregiver responsiveness, controlling for general infant effects, infant age, and infant signing frequency and variety.

Table 1

Descriptive statistics (means, standard deviations, minimum and maximum values) for variables describing caregiver experience and responsiveness and infant characteristics and gesturing during 185 5-minute caregiver-child interactions for a group of 18 caregivers and 10 infants.

Variable Name	Variable Definition	Mean (sd)	Minimum Value Maximum Value
<i>C_ID</i>	<i>Caregiver ID.</i> Series of dummy variables describing which caregiver is being observed during each 5-minute episode.	--	--
<i>RESPONSIVE</i>	<i>Caregiver Responsiveness.</i> Caregivers' score on responsiveness measure, derived by averaging across 17 responsive behaviors, rated from 1 (low responsiveness) to 7 (high responsiveness) during each 5-minute episode.	5.6438 (0.8177)	1.00 6.90
<i>EXPERIENCE</i>	<i>Caregiver Experience.</i> Time since caregiver entered the infant classroom, measured in tenths of months.	2.1063 (1.4206)	0.30 5.42
<i>I_ID</i>	<i>Infant ID.</i> Series of dummy variables describing which infant the caregiver is interacting with primarily during each 5-minute episode.	--	--
<i>GENDER</i>	<i>Infant Gender.</i> Dummy variable describing the gender of each child, in which BOY = 1.	0.3	0 1
<i>AGE</i>	<i>Infant Age.</i> Continuous variable defined as the date of observation minus the child's date of birth, measured in tenths of months. (Presented here in original values; centered at 6 months for purpose of analyses and interpretation.)	11.1530 (2.8957)	4.90 17.50
<i>POINT</i>	<i>Infant Pointing Frequency.</i> Frequency of infant pointing, measured during each 5-minute episode.	0.2920 (1.0327)	0 10
<i>SIGN_FREQ</i>	<i>Infant Sign Frequency.</i> Frequency of infant signing during each 5-minute episode, excluding conventional gestures.	0.6216 (1.6964)	0 12
<i>SIGN_VAR</i>	<i>Infant Sign Variety.</i> Variety of unique infant signs used during each 5-minute episode, excluding conventional gestures.	0.3514 (0.7946)	0 5
<i>TOTAL_FREQ</i>	<i>Infant Total Gesture Frequency.</i> Total gesture frequency, including both conventional gestures and signs, measured during each 5-minute episode.	1.0649 (2.7753)	0 20
<i>TOTAL_VAR</i>	<i>Infant Total Gesture Variety.</i> Total gesture variety, including both conventional gestures and signs, measured during each 5-minute episode.	0.5351 (1.0785)	0 6
<i>RESP_GEST</i>	<i>Infant Responsive Gesturing.</i> The percentage of caregivers' gestures to which infants responded with a gesture of their own during each 5-minute interaction.	0.0343 (0.1079)	0.00 0.72

Table 2

Results of fitted 2-level child fixed effects models for the effects of infant characteristics and communicative behaviors on caregiver responsiveness for a group of 18 caregivers caring for 10 infants.

Parameter	Model A Baseline Model	Model B Infant Age and Fixed Effects	Model C Infant Readable Cues	Model D Infant Response to Caregiver
Fixed Effects				
Intercept	π_{0i} 5.6356 *** (0.0902)	4.6674 *** (0.3605)	4.6237 *** (0.3625)	4.8871 *** (0.3715)
Infant Age in Months				
AGE	π_{1i}	0.1549 *** (0.0349)	0.1654 *** (0.0370)	0.1279 *** (0.0377)
Infant Effects (compared to Infant 6)				
INFANT 1	π_{2i}	0.0606 (0.3228)	0.0464 (0.3210)	0.0186 (0.3222)
INFANT 2	π_{3i}	0.4057 (0.3818)	0.4225 (0.3804)	0.5137 (0.3863)
INFANT 3	π_{4i}	0.6932 * (0.3236)	0.7196 * (0.3234)	0.6024 ~ (0.3269)
INFANT 4	π_{5i}	-0.5899 * (0.2979)	-0.5737 ~ (0.3074)	-0.5818 ~ (0.3080)
INFANT 5	π_{6i}	0.0647 (0.3397)	0.0765 (0.3402)	-0.0065 (0.3523)
INFANT 7	π_{7i}	0.1554 (0.3455)	0.1775 (0.3448)	0.1904 (0.3617)
INFANT 8	π_{8i}	-0.1297 (0.3120)	-0.1489 (0.3110)	-0.2285 (0.3196)
INFANT 9	π_{9i}	1.1456 *** (0.3927)	1.1965 *** (0.3955)	0.9346 * (0.4075)
INFANT 10	π_{10i}	0.3807 (0.4128)	0.4046 (0.4117)	0.4101 (0.4228)
Infant Total Gesture Frequency				
TOTAL_FREQ	π_{11i}		0.0267 (0.0428)	-0.0257 (0.0451)
Infant Total Gesture Variety				

Parameter	Model A Baseline Model	Model B Infant Age and Fixed Effects	Model C Infant Readable Cues	Model D Infant Response to Caregiver
<i>TOTAL_ VAR</i>	π_{12i}		−0.0967 (0.1148)	−0.1102 (0.1135)
Infant Gesture Responsiveness				
<i>RESP_ GEST</i>	π_{13i}			2.2030* (0.8684)
Variance Components				
L 1: Within-caregiver	σ^2_e	0.5876***	0.5188***	0.5181***
L 2: Between-caregiver	σ^2_1	0.0782*	0.0214	0.0194
Fit Statistics				
<i>Deviance</i>		441.3	409.7	355.8
<i>AIC</i>		447.3	435.7	387.8

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

Table 3

Results of fitted 2-level child fixed effects models for the effects of infants' use of pointing and infant signs on caregiver responsiveness for a group of 18 caregivers caring for 10 infants.

Parameter	Model B Infant Age and Fixed Effects	Model E Main Effects of Infant Pointing and Signs	Model F Change in Effects of Infant Pointing and Signs
Fixed Effects			
Intercept	π_{0i} 4.6674*** (0.3605)	4.6359*** (0.3608)	4.7486*** (0.3326)
Infant Age in Months			
AGE	π_{1i} 0.1549*** (0.0349)	0.1579*** (0.0359)	0.1434*** (0.0334)
Infant Effects (compared to Infant 6)			
INFANT 1	π_{2i} 0.0606 (0.3228)	0.0781 (0.3208)	0.0310 (0.2911)
INFANT 2	π_{3i} 0.4057 (0.3818)	0.4347 (0.3798)	0.2942 (0.3470)
INFANT 3	π_{4i} 0.6932* (0.3236)	0.7257* (0.3231)	0.7170* (0.2918)
INFANT 4	π_{5i} -0.5899* (0.2979)	-0.4835 (0.3062)	-0.4839 (0.2940)
INFANT 5	π_{6i} 0.0647 (0.3397)	0.1004 (0.3385)	0.2049 (0.3167)
INFANT 7	π_{7i} 0.1554 (0.3455)	0.1884 (0.3445)	0.1182 (0.3197)
INFANT 8	π_{8i} -0.1297 (0.3120)	-0.1128 (0.3100)	-0.1498 (0.2841)
INFANT 9	π_{9i} 1.1456** (0.3927)	1.1835** (0.3940)	1.065** (0.3603)
INFANT 10	π_{10i} 0.3807 (0.4128)	0.4178 (0.4118)	0.3285 (0.3760)
Effects of Infant Pointing Frequency			
POINT	π_{14i} 0.0973 (0.0771)	0.0973 (0.0771)	-0.7073* (0.3355)
POINT*AGE	π_{15i}		0.0967* (0.0423)
Effects of Infant Signing Frequency			

Parameter	Model B Infant Age and Fixed Effects	Model E Main Effects of Infant Pointing and Signs	Model F Change in Effects of Infant Pointing and Signs
<i>SIGN_FREQ</i>	π_{16i}	−0.1099 (0.0713)	−0.8850*** 0.2581
<i>SIGN_FREQ * AGE</i>	π_{17i}		0.0906** (0.0308)
Effects of Infant Signing Variety			
<i>SIGN_VAR</i>	π_{18i}	0.0486 (0.1411)	1.3398** (0.4630)
<i>SIGN_VAR * AGE</i>	π_{19i}		−0.1611** (0.0557)
Variance Components			
L 1: Within-caregiver	σ^2_ϵ	0.5188***	0.5087***
L 2: Between-caregiver	σ^2_1	0.0214	0.0214
Fit Statistics			
<i>Deviance</i>		409.7	406.2
<i>AIC</i>		435.7	438.2
			388.8
			426.8

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