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To Sign or Not to Sign? The Impact of Encouraging Infants to Gesture on Infant
Language and Maternal Mind-Mindedness

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Abstract

Findings are presented from the first randomised control trial of the effects of encouraging symbolic gesture (or 'baby sign') on infant language, following 40 infants from age 8m to 20m. Half of the mothers were trained to model a target set of gestures to their infants. Frequent measures were taken of infant language development and dyadic interactions were scrutinized to assess mind-mindedness. Infants exposed to gesture did not differ from control conditions on language outcomes, thus no support was found for previous claims that encouraging gesturing with infants accelerates linguistic development. Microgenetic analysis revealed mothers in the gesture training conditions were more responsive to their infants' nonverbal cues and encouraged more independent action by their infant.

To Sign or Not to Sign? The Impact of Encouraging Infants to Gesture on Infant Language and Maternal Mind-Mindedness

Baby sign programmes typically encourage mothers to communicate with their pre-verbal infant using symbolic gestures. Infants readily adopt these gestures and use them to represent objects or concepts, such as 'milk', 'hot', and 'where' before they use the spoken words. It has been claimed that early use of gestures can have a positive impact on children's linguistic and non-linguistic abilities (Acredolo & Goodwyn, 2000; Goodwyn, Acredolo, & Brown, 2000).

Gesture is inextricably linked to language development, with striking parallels observed between attainments in the manual and verbal modalities (see Bates & Dick, 2002). Indeed, gestures often precede and predict linguistic milestones (Iverson & Goldin-Meadow, 2005; Rowe, Ozcaliskan, & Goldin-Meadow, 2009). Deictic gestures (pointing, reaching, grasping) are the first gestures that infants produce, usually at around 10 months of age (Bates, Benigni, Bretherton, Camaioni, & Volterra, 1979; Bates & Snyder, 1987). Deictic gestures perform declarative and imperative functions (Bates, Camaioni, & Volterra, 1975), and have been shown to presage linguistic advances (Iverson & Goldin-Meadow, 2005; Ozcaliskan & Goldin-Meadow, 2005).

The end of the infant's first year sees the onset of symbolic gesturing. The infant produces 'gestural names', hand movements that take on the form or function of items, for example pretending to drink from an empty cup (Bates et al., 1979). These gestures are typically first carried out with the object in hand and gradually become more decontextualized to represent an absent object or bodily function, such as to sleep or eat (Caselli & Casadio, 1995). Infants' first symbolic gestures are similar in content and meaning to their first words, indicating that these gestures are functioning as labels (Bates & Dick,

2002).

Infants' spontaneous production of empty-handed symbolic gestures varies according to their exposure to symbolic gesturing. Italian infants, for example, are raised in a gesture-rich environment and their production of symbolic gestures has been found to be higher than American infants, who produced more deictic than symbolic gestures (Iverson, Capirci, Volterra, & Goldin-Meadow, 2008). Symbolic gestures contribute significantly to the communicative repertoires of Italian infants (Iverson et al., 2008; Volterra et al., 1993), with some children reported to have greater gesture vocabularies than spoken between the ages of 14 and 20 months (Casadio & Caselli, 1989; Iverson, Capirci, & Caselli, 1994).

Of critical concern to developmental psychologists is the question of whether increased symbolic gesture use can accelerate spoken language. Evidence from the Italian infants would suggest not. When the Italian infants had a gesture for an item, they did not use a word for the same item (Iverson et al., 2008) and their spoken vocabulary was significantly smaller than that of the American infants. However, these differences disappeared when verbal and gesture repertoires were combined. Acredolo and Goodwyn (1988) similarly report little overlap between symbolic gestures and words.

There does exist an exceptional group of infants for whom exposure to a rich nonverbal environment benefits speech development. There are hearing children born to deaf mothers. These children are exposed to a high frequency of signing in their linguistic environment and as well as acquiring sign language, they also acquire spoken language earlier than norms (Bonvillian et al., 1983; Folven, 1988; Holmes & Holmes, 1980; Orlansky & Bonvillian, 1984, 1988). This led researchers to question and then empirically investigate whether hearing children, with hearing parents, would also benefit from being taught to gesture before they could speak.

From observations of hearing infants' spontaneous gestures and first words, Acredolo

and Goodwyn (1988) hypothesised a causal relationship whereby symbolic gesturing “speeds along the naming process in the verbal modality” (Acredolo & Goodwyn, 1988, p.464).

Goodwyn and colleagues went on to investigate the effects of training mothers to model symbolic gestures to their preverbal infants (Goodwyn, Acredolo, & Brown, 2000). The infants subsequently scored higher than controls on selected measures of expressive and receptive language, leading the authors to conclude that the gesture training had beneficial effects (Goodwyn et al., 2000).

However, a recent meta-analysis of studies investigating the effects of gesturing with infants drew attention to the methodological weaknesses of this and other studies, and warns against the drawing of any firm conclusions (Johnston, Durieux-Smith, & Bloom, 2005). Johnston et al. identified 17 studies in which typically developing hearing children were exposed to pre-lingual signing or gesturing. Johnston et al. note that none were randomized controlled trials and that many lacked adequate comparison groups or a control group and had small sample sizes and poor follow-up. They also point out that many of the studies failed to report procedures for recruitment or assignment to condition (e.g. Goodwyn et al., 2000) and question the generalizability of findings from 12 studies that involved infants born to deaf parents who were fluent signers (e.g. Pettito et al., 2001). Finally, Johnston et al. noted that most studies failed to monitor whether infants acquired the gestures.

As well as the need for a rigorous methodology when examining the effect of encouraging gesture on infant language, there is also a lack of enquiry into the impact on socio-emotional variables. Gongora and Farkas (2009) suggested gesturing would have a positive impact on maternal interaction, specifically in enhancing the synchrony that is critical to the formation of positive bonds between mother and baby (Feldman, 2007). Whether maternal sensitivity (Ainsworth, 1971) or its more recent manifestation, maternal

mind-mindedness (Meins, 1998) is enhanced by encouraging gestural communication is unknown and warrants further exploration.

Given that the evidence to date remains equivocal, a rigorous investigation needs to be undertaken into the effects of encouraging gesture on language development and to extend it to measure the effect on mother-infant interaction. This research is timely, given the burgeoning market for baby sign products and classes. There is an obligation on psychologists to provide parents, caregivers, and professionals with sound evidence on the advisedness, or otherwise, of using gesture with infants.

In study 1 we present a randomised controlled, longitudinal investigation into the effects of encouraging gesture on a range of measures of infant language development. This included randomly allocating infants to gesture and no-gesture conditions and systematically tracking their development over a 12 month period. In study 2, we subjected a sub-set of the dyads' interactions to intense scrutiny, quantifying social features of the interactions to examine, through microgenetic analysis, whether gesturing brought about subtle changes to the interaction process and, potentially, socio-emotional benefits.

Study 1

While previous research, e.g., Goodwyn et al. (2000), addressed the important issue of whether encouraging gesture influences infant language development, the methodology has been subject to criticism. Hence, conclusions about the worth of encouraged gesture in infancy warrant further examination, and we present the first longitudinal randomized controlled trial. The current study design controlled the gesture input by providing the same set of target items to all dyads, instructing mothers in how to use them, and monitoring the frequency with which they did so. Two control conditions were used: a non-intervention control condition and a verbal training control condition in which mothers modelled the target words during interactions with their infant. This was to control for the fact that mothers

in the gesture conditions used the word for the target items alongside the gestures. By giving all mothers in the gesture and verbal training conditions the same target items we could directly compare the verbal and/or manual adoption of targets, improving upon previous studies where the gesture and control conditions had different target items (Goodwyn et al., 2000).

In addition to random allocation to conditions and matched stimuli, further steps taken to improve upon the methodological limitations of previous studies include appropriate control conditions and balanced gender split. Previous studies have introduced gesture modelling at a time when the infants would already have been producing spontaneous gestures. This study starts earlier, when the infants are just 8 months of age. Furthermore research has not considered the form of gestures that infants are encouraged to use, therefore we included two gesture intervention conditions to test the effects of different forms of gesture. In one condition infants were taught gestures taken from a formal sign language (British Sign Language, or BSL) while infants in the other condition were given symbolic gestures based on the systems taught by baby signing classes and products. By including two forms of gestures for the same targets, the effect of gesture type, over and above generally encouraging symbolic gesturing in infants, could be determined.

METHOD

Participants

40 mother-infant dyads entered the study when infants were aged eight months and were randomly allocated to one of four conditions; symbolic gesture (SG) training, British Sign Language (BSL) training, verbal training (VT), and non-intervention control (NC). Dyads were allocated to an intervention condition sequentially, i.e. the first mother to

respond was allocated to the BSL condition, the second to the SG condition, and so on until each condition had five males and five females.

The mean age of the mothers at the start of the study was 35.46 ($SD = 3.24$). A range of demographic measures was taken, including education, working hours, number of hours infants in childcare, and information about the fathers' education and working hours. No differences were found between conditions ($p > .05$) on any of these measures. All mothers were English-speaking and all except one held an undergraduate university degree.

Materials

Training packs were compiled for parents in the gesture training conditions. These contained illustrations of the target gestures and guidance on how to model the gestures during everyday routines and interactions. Target gestures were chosen from those that baby sign instructors commonly first introduce to parents, e.g. *food*, *more* and *drink*. Each target set contained five object concepts and five non-object concepts to reflect the symbolic gestures that infants typically produce spontaneously (Acredolo & Goodwyn, 1988). The object concepts in Target Set 1 were: *drink*, *hat*, *duck*, *flower*, and *food*. The non-object concepts were: *where*, *more*, *all-gone*, *hot*, and *sleep*.

The second target set of items was arrived at by eliciting feedback from mothers about objects or concepts for which they would find gestures useful. The most commonly cited items then formed Target Set 2. These consisted of object concepts: *biscuit*, *aeroplane*, *book*, *shoe*, and *dog*, and non-object concepts: *sing*, *pain*, *cuddle*, *dirty*, and *bath*. The BSL and symbolic gestures for each target are described in Appendix I.

The symbolic gestures for Target Set 1 were adapted from various commercial baby sign programmes. The second target set was developed after piloting by the research team, and included symbolic gestures that were highly iconic and simple to perform. Photographs of actors performing the symbolic gestures were included in the training packs. Mothers in

the BSL condition were supplied with illustrations of the gestures. Mothers in the verbal training condition received a training pack containing the target words and examples of how to model the word during everyday interactions with their infant.

A semi-structured interview assessed the frequency with which mothers modelled the target items, modelling context, and infants' production and comprehension of the target items. The interview was conducted by telephone twice monthly. Mothers in the gesture training conditions were asked about each target item: (a) "How often do you use this gesture?" (response options: *rarely or never, a few times a week, once a day, more than once a day*); (b) "When do you usually use this gesture? For example do you use this gesture often during meal times or bath times?" (open-ended response); (c) "Do you think that your baby understands this gesture?" (response options: yes or no); If *yes*, "What does your baby do to make you think that he or she understands this gesture?" (open-ended response); (d) "Does your baby produce this gesture?" (response options: yes or no); (e) "Do you think that your baby understands this word?" (response options: yes or no); If *yes*, "What does your baby do to make you think that he or she understands this word?" (Open ended-response); (f) "Does your baby say this word?" (response options: yes or no). Infants were judged to have produced the target gestures and words if they did so spontaneously, rather than in direct imitation or as an elicited response. The interview for mothers in the VT condition followed a similar format but focused on target words rather than gestures.

Infants were assessed during home visits using the following measures of receptive and expressive language:

The Oxford Communicative Development Inventory (CDI): A British adaptation of the MacArthur-Bates CDI (Hamilton, Plunkett, & Schaffer, 2000) including a checklist of words for assessing the development of receptive and productive vocabulary through parental report.

Gestures, Actions and Pretend Play Checklist (GAPP): A parental checklist of infants' use of *communicative gestures* (e.g. conventional gestures such as waving goodbye and deictic gestures), *actions* (e.g. joining in with action games or nursery rhymes such as "round and round the garden"), as well as *symbolic play* (e.g. playing with doll or teddy or imitating an adult), adapted and extended from the words and gestures section of the MacArthur-Bates CDI (Fenson et al., 1994) by Zammit and Schafer (2011).

Preschool Language Scale-3 UK Edition (PLS-3 UK): Two broad subscales to assess age-specific *expressive communication* (including vocal development, social communication, morphology, and syntax) and *auditory comprehension* (including attention, understanding of quantity, quality, spatial concepts, morphology, and integrative thinking skills) in a play context using a range of tasks, and has been standardized in a sample of 1200 children aged 2 weeks to 6 years, 11 months (Zimmerman, Steiner, & Pond, 1997).

Procedure

All mothers were first visited at home by the researcher when infants were aged 8 months. Mothers in the SG and BSL conditions received individual instruction on how to perform gestures for ten target items. They were instructed to model the gestures as frequently as possible in day-to-day interaction with their infants, to always accompany the gesture with the word, to establish eye contact with their infant before performing the gesture, and to pause after performing the gesture to allow the child time to respond. Mothers were given a training pack containing illustrations of the gestures and suggestions on how and when to use them. For example, mothers were taught the sign for *more* and were encouraged to use this gesture at meal times and other opportunities throughout the day, such as asking their child if they would like "more tickles", "more book reading", or "more singing".

Mothers were informed that they would be interviewed by telephone every two weeks and were given a copy of the interview template. Mothers were not requested to keep written records. Frequency of gesture modelling was monitored closely so that mothers reporting *rarely or never* would be excluded from the study. Mothers received a set of ten new gestures when infants reached 12 months of age and added these to their existing repertoire of gestures.

During the 8 month home visit, mothers in the verbal training (VT) condition were encouraged to regularly use the words for the same target items, without gesture instruction. Mothers were informed about the twice monthly interviews and were given a copy of the interview template. The same minimum criterion was applied so that those reporting *rarely or never* would be excluded from the study. The second set of ten target words was introduced when infants reached 12 months.

All the dyads received further home visits when infants were 10, 12, 16, and 20 months. At 12, 16, and 20 months, infants' receptive and expressive language was measured and the dyads were filmed interacting for 10 minutes of free play and 10 minutes of mealtime. A filming session of the same format was also conducted when infants were 10 months. Telephone interviews were conducted twice monthly, starting two weeks after the initial 8 month home visit, until infants left the study at 20 months of age. Infants in the non-intervention control condition (NC) were tested at the same time points as those in the intervention conditions, although these mothers were not provided with any words or gestures and were not interviewed.

RESULTS

Forty mother-infant dyads were recruited via advertisements displayed at local mother and baby groups, Internet parenting community websites, maternity shops, libraries and nurseries, or by responding to emails sent to the University of Hertfordshire staff mailing list

or National Childbirth Trust mailing lists. Baby signing was not mentioned in the advertisements, to avoid recruiting parents who were motivated to take part in a signing study.

The dyads were assessed on four occasions (8, 12, 16, and 20 months), yielding a total of 160 data points. There are six cases (out of 160) of missing data and no attrition. The missing cases include three cases at the 8-month data collection point due to late entry into the study (NC =1, SG =2); one case at the 12-month data collection point (BSL); one case at the 16-month data collection point (SG); one case at the 20-month data collection point (BSL). The PLS-3 UK assessment at 16 months had to be abandoned for two infants in the BSL condition, however all other assessments were taken at this testing point.

Results are reported as follows: First, we examine maternal reported modelling of the target gestures across condition and age. Second, we analyse data on the frequencies with which infants in the BSL and SG conditions produced the target gestures. Third, we examine the effect of condition on infants' production of the target words. Fourth, we assess the effect of condition on infants' receptive and productive language. Finally, we examine individual differences in the impact of gesture training on language.

Maternal reported modelling of the target gestures

Mothers reported how often they modelled each of the target gestures. Response categories were assigned a value to quantify maternal modelling: *rarely or never* = 0, *a few times a week* = 1, *once a day* = 2, *more than once a day* = 3. These scores were summed and divided by the number of target gestures (10 target gestures before 12 months and 20 after) giving an overall reported modelling score (see Table 1). The data from interviews conducted when infants were 10, 12, 16, and 20 months provided a regular measure that coincided with the global language assessments taken at 12, 16, and 20 months.

At 10, 12, and 16 months, mothers met the minimum frequency and modelled the

target set of gestures on average a few times a week to once a day. A mixed-design Analysis of Variance (ANOVA) was conducted to assess the impact of gesture type on reported maternal modelling rate. The between-subjects factor was condition (BSL and SG) and the within-subjects factor was age (10, 12, 16 and 20 months). There was no significant effect of condition on the reported rate of maternal modelling, $F(1,13) = 0.22, p = .64, \eta^2 = .02$. The main effect of age was significant, $F(1.70, 22.14) = 10.08, p < .01, \eta^2 = 0.44$, however there was no interaction between age and condition, $F(1.70, 22.14) = 0.12, p = .86, \eta^2 = .01$. Posthoc comparisons (with a Bonferroni adjustment) indicated that reported maternal modelling was significantly higher when infants were aged 16 months compared to 20 months ($p < .01$). Modelling frequency decreased when infants reached 20 months, probably because at this age infants were talking more and mothers used fewer gestures.

Infants' target gesture production

The next analysis examines whether the infants produced the target gestures. Infants' target gesture and/or word vocabulary was examined at 10, 12, 16, and 20 months. All infants in the gesture-training conditions acquired at least two target gestures over the course of the study, with some infants having a repertoire of 17 gestures by the time they reached 20 months of age. The mean number of target gestures that infants in both gesture training conditions were using at each time point is presented in Table 1.

Insert Table 1 about here

A mixed-design ANOVA was conducted, with condition (BSL and SG) and gender as between-subjects factors, and age (10, 12, 16, and 20 months) as a within-subjects factor. The dependent variable was the number of target gestures produced (at each age). There was no significant main effect of gesture type (BSL and SG), $F(1,13) = 0.88, p = .37, \eta^2 = .06$, or gender, $F(1,13) = .00, p = .97, \eta^2 < .01$. There were no significant interactions (all $p > .35$).

Impact of gesture and verbal training on infants' target word production

Next we considered whether encouraging infants to adopt a gesture for a target item (BSL and SG conditions) facilitated their acquisition of the corresponding word, compared with infants exposed to a similar frequency of verbal labelling (VT condition), and infants whose mothers were not aware of the target items (NC condition). The mean number of target words acquired by infants in each of the conditions is presented in Table 2.

Insert Table 2 about here

A mixed-design ANOVA was conducted, with condition (BSL, SG, VT, and NC) and gender as between-subjects factors, and age (12, 16, and 20 months) as a within-subjects factor. The dependent variable was the number of target words produced (at each age). There was no significant effect of condition on the number of target words acquired, $F(3,30) = 0.33$, $p = .81, \eta^2 = .03$. There was a significant main effect of gender, $F(1,30) = 4.40$, $p = .04$, $\eta^2 = .13$, and a comparison of the estimated marginal means indicated that females acquired a higher number of target words ($M = 7.53$, $SE = 0.69$) than males ($M = 5.40$, $SE = 0.75$). There were no significant interactions between factors (all $p > .22$). Saying the target words alongside the gestures frequently did not accelerate speed of acquisition. Neither, it appeared, did asking mothers to say these target words frequently. Having looked at the impact of gesture training at the level of the target items, we went on to look at measures of language development.

Impact of condition on infants' receptive and productive language development

A series of one-way ANOVA tests revealed no significant differences at 8 months between infants in the four conditions on baseline measures of receptive and productive vocabulary, auditory comprehension, expressive communication, and GAPP scores (all $p > .10$).

A series of mixed-design ANOVAs were then conducted to assess the impact of condition on infant language development throughout the period of study. The between-subjects factors for each ANOVA were condition (BSL, SG, VT, NC) and gender. The within-subjects dependent variable was score on each language measure at 8, 12, 16, and 20 months. A table of infants' mean scores on each of the language measures by age is in Appendix II.

There was no significant main effect of condition on each of the language measures: receptive vocabulary, $F(3,26) = 0.58$, $p = .64$, $\eta^2 = .06$, productive vocabulary, $F(3,26) = 0.13$, $p = .94$, $\eta^2 = .02$, auditory comprehension, $F(3,24) = 0.13$, $p = .94$, $\eta^2 = .02$, expressive communication, $F(3,24) = 0.65$, $p = .59$, $\eta^2 = .08$, gestures, actions and pretend play, $F(3,26) = 0.29$, $p = .83$, $\eta^2 = .03$. The overall language development of all infants was similar regardless of the intervention that they experienced; encouraging gesture did not result in significantly higher scores on any of the language measures. There were no significant main effects of gender, or significant interactions between the factors (all $p > .39$).

Were there individual differences in the effect of gesture on language development?

While no group differences were found, this does not preclude the possibility that these groups contained individuals who benefited from gesture training. We consider here whether variability, inherent in infant data, masked individual gains which were not revealed by condition means. To identify individual gains, data were ranked so that each infant's score on the language measures was replaced by that infant's relative position within the sample, i.e. the infant with the lowest raw score was given a rank score of one, and the infant with the highest a rank score of 40. The dependent variable for the next analyses was change in mean rank from pre-intervention (age 8 months) to post-intervention (age 20 months). These analyses give consideration to individual differences and how these may relate to infants' receptivity to gesture, thus initial ability and gender were included as between-subjects

variables.

Infant's initial ability was categorized as low or high on each language measure depending on whether their mean score at eight months was higher or lower than the median score. General Linear Models (GLM) were conducted with the between-subjects factors: condition (BSL, SG, VT, NC), ability (low, high), and gender. The dependent variable for each GLM was mean rank change on each measure (receptive vocabulary, expressive vocabulary, auditory comprehension, expressive communication, and gestures, actions and pretend play). A significant interaction would signify a contribution of individual differences (i.e. gender and/or ability) to the impact of gesture on infants' language abilities.

This was found to be the case for infants' gain in just one of the measures, expressive communication. The mean change in rank in expressive communication scores is presented in Table 3. There was a significant three-way interaction between condition, gender, and ability on mean rank change in expressive communication score, $F(1,21) = 4.49, p = .05, \eta^2 = .18$. The interaction between ability and condition was then tested for each level of gender. This was significant for male infants, $F(3,21) = 6.65, p < .01, \eta^2 = .11$, though not for females, $F(3,21) = 1.18, p = .34, \eta^2 = .02$.

Insert Table 3 about here

A test of the simple simple effects of intervention within levels of ability (low and high) for males revealed a significant difference between low and high-ability male infants in the BSL condition, $F(1, 21) = 28.90, p < .01, \eta^2 = .39$, and the SG condition, $F(1, 21) = 10.89, p < .01, \eta^2 = .30$. There was no significant difference between low and high-ability male infants in the NC condition in expressive communication score, $F(1, 21) = 0.18, p = .68, \eta^2 = .08$.

Thus, regardless of their initial expressive communication ability, male infants in the control condition did not change in their mean rank ability over the course of the study. On

the other hand, gesture training significantly increased the mean rank of low-ability boys. The interactions between intervention condition and the factors of gender and initial ability were not significant for the other language measures ($p > .05$).

DISCUSSION

Infants exposed to gesture training did not differ significantly in gains in language development. When the language abilities of infants were compared across condition, no overall effect of gesture training was found at any age. Although infants did acquire the gestures and used them to communicate about the target set of referents long before the onset of speech, this did not promote the acquisition of those target words, nor did it boost the infants' language abilities. By including two types of gesture in the evaluation we can be reasonably confident that the absence of an effect on language is not due to the type of gesture used. Infants readily adopted BSL and symbolic gestures for the same target items and neither yielded an effect on language.

To ensure a complete and thorough evaluation of the effect of gesture training on language, we also considered how individual differences might have elicited differential outcomes for infants exposed to gesture. We controlled the variability of the dependent variables by considering infants' scores in terms of their relative position within their condition, rather than raw scores, on each of the language measures. While for the most part this exploration of the data failed to detect any significant effects there was a suggestion that gesturing brought about some language gains for particular children. This effect was specific to male infants who had low baseline expressive communication scores. These infants demonstrated a greater gain in their expressive communication abilities relative to the rest of the sample if they had been exposed to gesture and no gain if they had not.

However, this finding must be treated with caution given that it is specific to three infants only, was not found for any other language measure, and was only detectable when

the dependent variable was mean change in rank within the sample (not mean score). Nonetheless, this may suggest that gesture is beneficial for infants who have weaker language abilities than others. This is consistent with findings from children with language impairments, who have been shown to depend more on the gestural modality. Children with a specific language impairment comprehend speech better when it is accompanied by gesture (Kirk, Pine, & Ryder, 2010), can convey ideas in gesture that they cannot express verbally (Evans, Alibali, & McNeil, 2001), and gesture more than typically developing children (Mansson & Lundstrom, 1996). Where verbal abilities are weak or impaired, gesture may help compensate for language difficulties.

Despite wide distribution of requests for participants, the mothers who responded were highly educated; apart from one, all held a University degree. Maternal education level is the commonly used marker of socioeconomic status (SES) (Bornstein & Bradley, 2003) and impacts directly upon infant language development (e.g. Pan, Rowe, Singer, & Snow, 2005). The quality and quantity of maternal interaction varies as a function of SES, accounting for differences in infant language growth (Hoff, 2003). Therefore, it is possible that we did not detect any effect in our sample of high SES infants because they were already beyond the threshold of improvement. Yet it is precisely these high-SES motivated mothers who are most likely to purchase baby sign products and classes, and for whom we found no evidence to suggest that their infants stand to benefit from encouraged gesture.

Having found little evidence of any global effect of gesture training on infant language, we consider the possibility that it may have changed the mother-infant interaction process and this might be detectable upon closer, microgenetic examination. Our next line of investigation explored longitudinally how encouraging gestured communication between mothers and their preverbal infants impacted upon a mother's interaction with her infant.

Study 2

Aspects such as interactional style, social-emotional ability, and nonverbal communication skills play a significant role in the healthy development of an infant-mother relationship. Whether these processes are amenable to change by manipulation of the quantity or quality of infant and mother gesturing is the question of this study.

Research has begun to examine the wider non-linguistic impact of encouraging infant gesturing upon the dyadic interaction between mothers and infants and early evidence is suggestive of a positive effect. Infants' gestures (spontaneous points and taught symbolic gestures) produced in direct response to caregiver communication have been reported to predict responsiveness from caregivers in the context of a childcare centre. Yet, the frequency and variety of infants' gestures were not found to affect caregiver responsiveness (Vallotton, 2009). Mother-infant dyads that share a gestured system of communication have demonstrated improved synchronic interactions compared to non-gesturing dyads. Gesturing dyads visually engaged with one another for longer, and displayed a higher frequency of tactile interaction behaviors (Gongora & Farkas, 2009). Another study suggests gesture training as a means to reduce infant crying (Thompson, Cotnoir-Bichelman, McKlerchar, Tate, & Dancho, 2007). Only one study to date has measured maternal responses to her infant (Gongora & Farkas, 2009). Current findings are suggestive of an effect, (Gongora & Farkas, 2009; Thompson et al., 2007; Vallotton, 2009) yet this remains to be validated in a larger sample with a control group comparison.

Study 1 yielded a large dataset of videotaped footage of gesture trained and non-gesture trained infants interacting with their mothers at regular intervals over the course of one year. This provides a rich source of data for examining the question of whether gestural communication enhances mother-infant interaction. We speculate that one mechanism by which gesturing in mother-infant pairs may alter interaction is by changing a mother's

perception of her infant, thus driving her to behave in a way which is more sensitive to her child's burgeoning mental abilities. Asking mothers to gesture with their infants from a preverbal age may have encouraged them to perceive their infants as communicative partners, possibly at an earlier age than would normally occur. These mothers may be more likely to attribute meaning to their infants' early vocalisations and hand waves, showing enhanced maternal mind-mindedness.

Maternal mind-mindedness has evolved from the original construct of maternal sensitivity (Ainsworth, 1971) and has been demonstrated to be a better predictor of infant-mother attachment security than maternal sensitivity (Meins, 1998; Meins et al., 2001). Links have been demonstrated between maternal mind-mindedness and children's later understanding of others' mental states, i.e. theory of mind. (Meins et al., 2003). Thus, maternal mind-mindedness is an important precursor of more sophisticated mentalizing abilities and supports socio-emotional development.

Our aim in this study was to evaluate whether maternal mind-mindedness increased in mothers exposed to gesture training. Maternal mind-mindedness can be assessed by microgenetic analysis of a mother's responses to her child during dyadic interaction, applying a well validated coding scheme developed by Meins (1998; 2001). While no overall language benefits of enhanced gesture were found in study 1, close scrutiny of mother-infant dyads at the micro-level may reveal subtle changes in the interaction between gesturing mothers and their infants that would not be seen in the non-gesturing dyads.

METHOD

Participants

A sub-set of 18 participants was randomly selected from the longitudinal sample in study 1 and subjected to microanalysis. This focuses on the effect of gesture training on

maternal mind-mindedness and so does not consider differences in types of gesture training. Thus, participants are described as being in the gesture condition (BSL and SG combined, $n = 9$) or the control condition (VT and NC combined, $n = 9$). Each mother-infant dyad was filmed when the infant was 10, 12, 16, and 20 months of age respectively.

Procedure

Mother-infant dyads were filmed at each time point for 20 minutes, consisting of ten minutes free play and ten minutes snack or mealtime. In the free play sessions, mothers were instructed to play with their infant as they would normally. The films of the free play sessions were then coded by a researcher using the Observer system from Noldus, a computer-based programme that allows behaviors to be coded as they occur with keystrokes corresponding to a user-defined coding scheme. The sessions were coded for maternal mind-mindedness (Meins et al., 2001) on six variables relating to the mother's verbal and nonverbal interaction with her child.

Maternal speech was first coded as a state event, thus capturing the frequency and duration of maternal utterances. Each utterance was then coded, according to its content, as one of five categories: (a) *Appropriate mind-related comments*; accurately describe the thoughts, feelings or desires of the infant in a play context, e.g. "You want to play with the fire engine" – when the infant is reaching for the toy. (b) *Inappropriate mind-related comments*; inaccurately describe the thoughts, feelings or desires of the infant in a play context, e.g. "You don't like the fire engine" – when the infant seems happy playing with the toy. (c) *Encouraging autonomy comments*; encourage the infant to perform actions independently of the mother, not including demands, e.g. "You get the ball" – the mother stays still and motions at the ball so that the child can retrieve it of their own volition. (d) *Imitation*; direct imitations of an infant's utterance, without trying to correct speech. (e) *Other*; comments not in the above categories. The proportion of total maternal speech in the

session coded as each of these comments was calculated for each session. The use of proportional scores controlled for differences in the verbosity of mothers.

All sessions were coded for *change in infant object-directed action* and *change in infant's direction of gaze*. Mothers were coded as *responding to changes in infant object-directed action* or *direction of gaze* if they made a comment contingent to the change or physically responded to the change.

A second coder coded 8 of the 72 videotaped sessions at each age of assessment ensuring equal sampling from the gesture and control condition, and males and females. Using the Observer system, inter-rater reliability was calculated for all coded behaviors. The mean kappa score for the eight infants for all variables indicated a substantial level of agreement, $\kappa = .74$, given the large number of variables.

RESULTS

A composite score of maternal mind-mindedness (MM) at each testing point was calculated by summing the proportion of maternal utterances coded as mind-related comments, imitations or encouraging autonomy and the proportion of changes in infants' direction of gaze and object-directed action that mothers responded to. The mean composite scores of mothers in the gesture and control conditions are presented in Table 4.

Insert Table 4 about here

A mixed-design ANOVA was conducted to determine whether mothers in the gesture and control conditions differed in MM. The between-subjects variables were condition (gesture/control) and the within-subjects factor was infant age (10,12, 16, 20 months). The dependent variable was mothers' composite MM score. The main effect of condition approached but did not reach significance, $F(1,16) = 4.06, p = .06, \eta^2 = .20$. There was no main effect of age, $F(3,48) = 0.94, p = .43, \eta^2 = .06$, and no significant interaction between age and condition, $F(3,48) = 1.71, p = .18, \eta^2 = .10$.

We predicted that mothers who were gesture trained would be more attuned to their child's nonverbal behaviors. We calculated mothers' nonverbal MM by summing and averaging the proportion of changes in infants' direction of gaze and object-directed action that mothers responded to (means reported in Table 4).

A mixed-design ANOVA was conducted, with condition (gesture/control) as a between subjects variable and infant age as the within-subjects variable (10, 12, 16, 20 months). The dependent variable was mothers' nonverbal MM score. There was a significant main effect of condition on nonverbal MM, $F(1,16) = 4.94, p = .04, \eta^2 = .24$ with mothers who had been encouraged to gesture demonstrating a higher amount of nonverbal MM than mothers in the control condition. There was no significant main effect of age, $F(3,48) = 1.36, p = .27, \eta^2 = .08$, and no significant interaction between age and condition, $F(3,48) = 1.42, p = .25, \eta^2 = .08$.

A series of mixed-design ANOVAS were conducted to assess the impact of the between subjects factor condition (gesture/control) on the following dependent variables: mean proportion of utterances that were coded as appropriate mind-related comments, imitations and encouraging autonomy (means reported in Table 5). Infant age was included as a within subjects variable (10, 12, 16, 20 months).

Insert Table 5 about here

Mothers in the gesture condition produced a higher proportion of encouraging autonomy comments than mothers in the control condition, however this difference was borderline significant, $F(1,16) = 3.53, p = .08, \eta^2 = .18$. There was no significant main effect of age, $F(3,48) = 1.05, p = .38, \eta^2 = .06$, and no significant interaction between condition and age, $F(3,48) = 1.49, p = .23, \eta^2 = .09$. There were no significant differences between mothers in the gesture and control condition for the mean proportion of utterances coded as imitation

of infant vocalisations, appropriate mind-related comments, or inappropriate mind-related comments ($p > .05$).

DISCUSSION

Current literature suggests that gesture training may impact upon how caregivers and mothers interact with infants (Gongora & Farkas, 2009; Vallotton, 2009). Using our dataset of videotaped footage from a subset of infants in study 1, we applied a quantitative coding scheme to provide a fine-grained analysis of the impact of gesturing on maternal variables. Despite close scrutiny of the interactions between mothers and infants who were trained to gesture and those who were not, we did not find any significant difference in maternal mind-mindedness overall. We did however uncover subtle differences associating positive changes in a mother's interactions with her infant with gesture training.

Mothers who gestured with their infants encouraged more independent action than mothers who did not gesture with their infants, suggesting an enhanced perception of their infant as capable of intentional action (Meins et al., 2001). This suggests that, by revealing some of their internal thoughts through gesture, infants offered their mothers greater insight into their mental abilities and played a greater role in orchestrating the interaction.

Gesturing mothers were also more responsive to changes in infants' direction of gaze and object-directed action than mother who did not gesture with their infants. This reveals a willingness of the mother to acknowledge her infant's wants and to anticipate her infant's desires (Meins et al., 2001). This responsiveness may arise because gesture training encouraged mothers to focus on their child's nonverbal communicative attempts.

Alternatively, the experience of sharing a gestured system of communication may have resulted in greater proclivity of mothers to interpret and follow the desires of the child. By whatever mechanism, this maternal ability is key to appreciation of the infant's autonomy, a central theme of maternal mind-mindedness and one that appears to be enhanced by gesture.

Maternal responsiveness to infant cues has also been linked to certain cognitive abilities (Donovan & Leavitt, 1978), attention span, and the variety and richness of later symbolic play (Wakschlag & Hans, 1999). Unresponsive parenting in infancy is detrimental to later social development; non-responsive parenting in infancy has been associated with disruptive behavior disorders later in childhood (Bornstein & Tamis-Lemonda, 1997). Thus the implications of an intervention that has the potential to enhance maternal sensitivity are considerable, especially for populations at risk of diminished sensitivity, i.e. depressed mothers (e.g. Field, 1992).

A word of caution must be given to the generalizability of these findings, given that our sample consisted of 18 infants, half of whom had been gesture trained in the context of a controlled scientific study. The extent to which the effect would generalize to a broader population of mothers who gesture (or use baby sign) with their infants remains an open question. While mothers who gestured with their infants scored higher on some behaviors associated with MM, they did not score higher on all aspects of MM. Most significantly, no difference emerged on appropriate mind-related comments, the variable which Meins identified to be the single most significant predictor of attachment security (Meins et al., 2002). One explanation is that the mothers' use of appropriate mind-related comments may already have been at ceiling. A comparison of our mean scores and those reported by Meins et al. (2001) confirms this. In our sample, the mean proportion of maternal comments coded as appropriate mind-related comments was .10. Meins (2001) reported the mean score for appropriate mind-related comments of mothers whose infants were securely attached was .11, while those with insecurely attached infants had a mean score of .05.

Thus we conclude that the mothers in our study were mindful with limited scope for improvement in their mind-mindedness, and as such were likely to foster secure attachments with their infants. Even so, some subtle improvements in the interaction were detected for

those who were in the gesture training condition. This implies that encouraging mothers at risk of not developing secure bonds with their baby to gesture could have a positive impact on maternal mind-mindedness.

GENERAL DISCUSSION

These studies represent a comprehensive evaluation of whether encouraging gesturing within mother-infant dyads brings about linguistic or wider socio-emotional gains. The development of 40 infants' verbal and nonverbal receptive and expressive language abilities was repeatedly assessed in a controlled yearlong longitudinal investigation. Half of the mothers were trained to model gestures to their infants (either BSL or symbolic gestures). The remaining infants were included in either a non-intervention control condition or a verbal training control condition. A comparison of mean scores revealed no differences between conditions; the language abilities of infants who had gesture training were no more advanced than those who had not.

We subjected our data set to further scrutiny to consider individual differences in receptivity to gesture training. This revealed some advantage for a small number of male infants on their expressive communication. Overall however, and despite considerable exploration, our data does not provide evidence to suggest that encouraging infants to gesture benefits language development.

Our findings in the context of previous studies

Our findings do not support studies reporting an effect of increased gesture use on infant language. Data published by Goodwyn et al., 2000 show that, out of a possible 17 comparisons (omitting composite scores from up to 11 different measures), only three favoured infants who had gestured over infants who had not. Furthermore, the magnitude of these effects is weak (Cohen's $d < .5$). Although Goodwyn et al. (2000) claim a beneficial

effect of gesturing on infant language, their data is not dissimilar to that reported here. Goodwyn et al. used the CDI to assess infant vocabulary at five age points and found no significant effect of gesture training on vocabulary at any age; neither did we. Goodwyn et al. found no effect on expressive language at any age. Likewise, we did not detect any significant differences in expressive communication. In terms of infants' receptive language, Goodwyn et al. do report an effect, yet the advantage found for the gesture trained infants was limited to a significant difference in comprehension at 19 months and receptive one-word picture vocabulary test at 24 months, despite repeated testing. Goodwyn et al. reported a significant effect of gesture training on children's mean length of utterance (MLU). However, this was calculated from a sample size of just 50 utterances (half the minimum recommended, Gavin & Giles, 1996) and the effect size of the difference was small ($r = .21$). Although we did not assess MLU, it is highly correlated with vocabulary (Tomasello & Bates, 2001) so we would not anticipate a difference given that we found no significant differences in vocabulary at any age.

We argue that our data complements rather than counters the findings reported by Goodwyn et al.. While we are cautious about over-generalising our findings based on the sample size, our null findings coupled with the limited effects reported in other research, suggest that even a larger sample of infants might uncover only a minimal effect of encouraged gesture.

What do our findings say about the relation between speech and gesture?

Evidence describing a close relation between the emergence of verbal and manual milestones (Bates & Dick, 2002), points towards a unified view of speech and gesture in which both modalities share an underlying neural substrate (McNeill, 1992). Gesture has been claimed to be a forerunner of verbal gains, contributing to advancements in speech (Ozcaliskan & Goldin-Meadow, 2005). A corollary of this is that if gesture drives oncoming

changes in speech, manipulating infants' gestures might advance their verbal abilities. Yet we found no evidence that encouraging advancements in the manual modality promotes language development. However, while gesture has been identified to be a significant precursor of language development, there are many other factors related to linguistic advancements. For example, differences in language learning are related, but not fully explained by differences in speech processing abilities (Kuhl, Conboy, Padden, Nelson, & Pruitt, 2005), cognitive abilities (Colombo, Shaddy, Richman, Maikranz, & Blaga, 2004), and the richness of the child's linguistic environment (Hoff, 2003). Thus, the potential for gesture to drive verbal advancements would be mediated by maturation in other domains. A unified view of speech and gesture still holds if we acknowledge that this relations is dependent upon the intricate interplay between multiple social and cognitive factors beyond the reach of manipulation.

Furthermore, findings that demonstrate a direct relation between infants' spontaneous gestures and verbal language gains are specific to infants' pointing gestures (e.g. Ozcaliskan & Goldin-Meadow, 2005; Rowe & Goldin-Meadow, 2009). Although infants do spontaneously produce symbolic gestures, like the ones we encouraged infants to use, they do so at a minimal level compared to their rate of pointing, and there is no evidence to suggest that their production is directly linked to any language gain, even for Italian infants who produce a greater amount of symbolic gestures (Iverson et al., 2009). This leads to the question of whether encouraging infants to produce more deictic gestures could lead to language gains.

Effects of deprivation vs. additive effects

Perhaps it is unrealistic to expect that the path of language acquisition can be altered by manipulation. Yet we know that in the absence of functional and social factors, infants' language development is delayed. Functional deficits associated with clinical groups, including Down Syndrome, specific language impairment, and autism, contribute to the

developmental language disorders that these populations present (Bates, 2004). The language development of healthy, typically developing infants can be impaired under circumstances of deprivation, for example in low SES households (Hoff, 2003), and when the quantity and quality of the verbal input the infant is exposed to is impoverished (Hammer, Tomblin, Zhang, & Weiss, 2001).

Do the same factors that, when lacking, impair language development also accelerate language development when present in abundance? To answer this we look to studies of infants whose language abilities are above average to determine what factors, if any, can retrospectively predict precocious language. A large study of over 1800 infants found precocity was not predicted by psychosocial factors such as SES, birth order, or parental education or vocabulary. The only significant variable was gender, with the odds of a girl being a precocious talker 41% higher than those of a boy (Skeat, et al., 2009). Thus infants with greater linguistic ability provide no clues to the variables that might be manipulated to accelerate language gains.

While deprivation undeniably has a negative impact on infant language development, the evidence for additive effects is weaker. Furthermore, Skeat et al. (2009) found that precocity was not stable; infants who were precocious talkers at one year of age were not necessarily precocious talkers when retested at age two. Thus, even if an intervention manipulated language development to bring about earlier gains, there is no guarantee that this advantage would be sustained.

So who needs baby sign?

We echo the question articulated by the Johnston et al. (2005) review: “why should language development require intervention in the absence of identified developmental perturbations?” (Johnston et al., 2005, p.245). Based on our findings, there is little support for

the notion that gestural intervention is necessary for healthy developing infants raised in an environment where the quality and quantity of linguistic input is good.

Mothers who access baby sign classes and products are more likely to be high-SES mothers who have the motivation, as well as the financial and time resources, available to them. The message emanating from our research is that the efforts of these mothers may be unnecessary. We have shown that gesture training brings about subtle changes in the mother-infant interaction process, in a sample of well-educated mothers, and in their perception of their infants, yet for most infants this did not advance their language development. This is probably because their language abilities were beyond the threshold of improvement. Not only are infants unlikely to gain any language benefit from baby sign classes, class attendance may offer little benefit to mothers either. We have shown that mothers who attend baby sign classes report significantly higher levels of parental stress than mothers who take their baby to other kinds of mother-baby class (Howlett, Kirk, & Pine, 2010).

Unfortunately some infants are raised in families where the linguistic environment fails to nurture healthy language development. This is where enhanced gesturing may be beneficial, and low-SES is known to be associated with a diminished quality and quantity of parental input (Hoff, 2003). We have provided gesture training at a children's centre attended by low-SES mothers and infants and observed moderate gains in the infants' vocabularies (Kirk, Pine, & Garrick, under review). Our present findings begin to elucidate the mechanisms by which gesture may enrich an impoverished linguistic environment, i.e. by enhancing maternal responsiveness to infants' nonverbal cues and encouraging the mothers' perception of her child as an autonomous agent. Early gesture intervention may have clinical potential where there is risk of language delay or impairment, but there is little evidence that it can 'improve' typically developing infants.

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Tables

Table 1. *Mean (SD) Rate of Target Gesture Production by Infants and Reported Maternal Modelling by Age and Gesture Training Condition*

Infant age	BSL condition <i>n</i> = 10		Symbolic gesture condition <i>n</i> = 10	
	Target gesture production	Maternal modelling frequency	Target gesture production	Maternal modelling frequency
10 months	0.00 (0.00)	1.52 (0.28)	0.10 (0.32)	1.69 (0.59)
12 months	1.20 (1.48)	1.66 (0.34)	1.60 (1.58)	1.72 (0.66)
16 months	6.22 (3.38)	1.06 (0.48)	7.00 (4.92)	1.28 (0.74)
20 months	5.50 (4.35)	0.58 (0.30)	8.67 (5.85)	0.71 (0.66)

Table 2. *Mean (SD) Number of Target Words Acquired by Age and Condition*

Infant age	Condition			
	BSL <i>n</i> = 10	Symbolic gesture <i>n</i> = 10	Verbal training <i>n</i> = 10	Non- intervention control <i>n</i> = 10
10 months	0.00 (0.00)	0.00 (.00)	0.00 (0.00)	0.00 (0.00)
12 months	0.20 (0.42)	0.70 (1.06)	0.40 (0.70)	0.60 (0.97)
16 months	6.60 (5.78)	6.22 (5.09)*	6.60 (5.21)	3.70 (3.02)
20 months	13.40 (6.57)	12.67 (4.72)	14.40 (4.22)	13.40 (3.89)

**n* = 9

Table 3. *Mean (SD) Change in Rank for Expressive Communication Score by Condition, Gender and Ability*

Condition	Low ability		High ability	
	Male	Female	Male	Female
BSL	26.50 (6.36) <i>n</i> = 2	-	-19.17 (5.62) <i>n</i> = 3	-3.88 (11.59) <i>n</i> = 4
Symbolic gesture	8.50 (-) <i>n</i> = 1	13.67 (4.65) <i>n</i> = 3	-21.75 (17.32) <i>n</i> = 2	-1.00 (-) <i>n</i> = 1
Verbal training	1.20 (8.07) <i>n</i> = 5	12.25 (9.72) <i>n</i> = 4	-	-25.00 (-) <i>n</i> = 1
Non- intervention control	-6.00 (7.77) <i>n</i> = 2	11.75 (4.60) <i>n</i> = 2	-0.67 (10.87) <i>n</i> = 3	-9.75 (9.55) <i>n</i> = 2

Table 4. *Mean (SD) Composite Maternal Mind-Mindedness (MM) and Nonverbal MM by Age and Condition*

Infant age	Mean composite MM		Mean nonverbal MM	
	Gesture <i>n</i> = 9	Control <i>n</i> = 9	Gesture <i>n</i> = 9	Control <i>n</i> = 9
10 months	1.73 (0.44)	1.22 (0.62)	0.73 (0.19)	0.48 (0.25)
12 months	1.42 (0.43)	1.53 (0.61)	0.57 (0.23)	0.59 (0.28)
16 months	1.81 (0.44)	1.61 (0.42)	0.78 (0.23)	0.68 (0.21)
20 months	1.80 (0.57)	1.29 (0.49)	0.77 (0.28)	0.51 (0.28)

Table 5. Mean (SD) Proportion of Maternal Utterances that were Classified as Mind-Related by Condition and Age

Infant age	Appropriate mind-related comments		Inappropriate mind-related comments		Encouraging autonomy		Imitation	
	Gesture <i>n</i> = 9	Control <i>n</i> = 9	Gesture <i>n</i> = 9	Control <i>n</i> = 9	Gesture <i>n</i> = 9	Control <i>n</i> = 9	Gesture <i>n</i> = 9	Control <i>n</i> = 9
10 months	0.09 (0.04)	0.09 (0.04)	0.00 (0.01)	0.01 (0.01)	0.12 (0.08)	0.06 (0.04)	0.06 (0.07)	0.12 (0.13)
12 months	0.13 (0.05)	0.09 (0.06)	0.01 (0.01)	0.01 (0.02)	0.10 (0.06)	0.08 (0.05)	0.07 (0.09)	0.10 (0.13)
16 months	0.08 (0.06)	0.10 (0.07)	0.01 (0.01)	0.01 (0.02)	0.11 (0.06)	0.06 (0.04)	0.07 (0.10)	0.09 (0.08)
20 months	0.08 (0.06)	0.09 (0.08)	0.01 (0.01)	0.01 (0.01)	0.06 (0.05)	0.07 (0.08)	0.13 (0.09)	0.12 (0.08)

Appendix I

Description of Gestures

Target Item	BSL gesture	Symbolic Gesture
Aeroplane	Hand in fist shape, thumb and finger protruding horizontally.	Arms extended horizontally out to side, palms down.
All-gone	Palms held up at chest height.	One hand, palm down sweeping horizontally at chest height.
Bath	Hands to body, fingertips lightly touch vertically up and down chest.	One hand rubs other forearm up and down.
Biscuit	Touch elbow of one arm with other hand.	Hands in fist shape, thumbs together and pulling apart as if breaking a biscuit in half.
Book	Palms together and opening to palms facing upwards.	One palm face up, other hand taps it and turns palm up.
Cuddle	Arms crossed on body.	Arms outstretched forward.
Dirty	Hands in fist shape, wrists touch together and twist back and forth.	Move palm of one hand across palm of other from wrist to finger tips and repeat on other hand.
Dog	Index and middle fingers of both hands held extended and pointing down. Hands held near shoulders then move downward.	Mouth open and hands extended and move up and down.
Drink	Cupped hand lifted toward mouth.	Fisted hand with protruded thumb to mouth.
Duck	Primary hand held near mouth with fingertips touching thumb tip. Hand opens and closes repeatedly.	Fingers to thumb opening and closing.
Flower	Primary hand held with index and thumb tips touching then tap either side of nose.	Sniffing.
Food	Primary hand held with fingertips touching thumb tip and then motion toward mouth.	Fingertips to lips.
Hat	Hands either side of head as if pulling on hat.	Tapping head with palm of hand.
Hot	Primary hand held with palm in front of mouth then moves sideways and hand partially closes.	Hand out, palm down retracting.
More	Palm of one hand hits the back of the other hand.	First finger tapped into upward open palm opposite hand.
Pain	Hands lightly touch chest in diagonal movements.	Hands on stomach, shoulders hunched.
Shoe	One hand cupped palm down, other hand palm down slides across top of hand.	Hands both side of foot, action of pulling on a shoe.
Sing	Fore finger and middle finger together, touch side of mouth and spiral up and outwards.	Mouth open, one hand palm flat moved from mouth and extends out.
Sleep	Both hands by corner of eyes, pinching action and eyes close.	Both hands together at side of tilted head.
Where	Hands palms up at chest height, circular action.	Hand palms up at chest height, shoulders up.

Appendix II

Table of Language Means (SD) by Age and Condition

		Age of assessment			
		8 months	12 months	16 months	20 months
Receptive vocabulary	BSL	20.25 (16.10) <i>n</i> = 10	68.83 (61.48) <i>n</i> = 9	117.17 (28.15) <i>n</i> = 10	146.67 (88.98) <i>n</i> = 9
	Symbolic gesture	40.43 (79.63) <i>n</i> = 8	76.56 (80.22) <i>n</i> = 10	131.22 (73.97) <i>n</i> = 9	110.11 (61.73) <i>n</i> = 9
	Verbal training	5.60 (5.34) <i>n</i> = 10	42.60 (31.57) <i>n</i> = 10	129.10 (56.52) <i>n</i> = 10	131.20 (82.21) <i>n</i> = 10
	Non-intervention control	9.11 (8.67) <i>n</i> = 9	37.56 (25.24) <i>n</i> = 10	93.89 (33.00) <i>n</i> = 10	99.00 (66.33) <i>n</i> = 10
Productive vocabulary	BSL	0.00 (0.00) <i>n</i> = 10	4.50 (3.02) <i>n</i> = 9	38.00 (56.39) <i>n</i> = 10	131.83 (110.72) <i>n</i> = 9
	Symbolic gesture	0.71 (1.89) <i>n</i> = 8	3.89 (4.40) <i>n</i> = 10	37.89 (36.94) <i>n</i> = 9	178.11 (98.80) <i>n</i> = 9
	Verbal training	0.50 (1.08) <i>n</i> = 10	5.40 (5.93) <i>n</i> = 10	48.50 (42.48) <i>n</i> = 10	179.80 (97.89) <i>n</i> = 10
	Non-intervention control	0.22 (0.67) <i>n</i> = 9	3.22 (4.52) <i>n</i> = 10	28.67 (36.88) <i>n</i> = 10	164.00 (75.55) <i>n</i> = 10
Auditory comprehension	BSL	6.00 (1.26) <i>n</i> = 10	9.83 (1.47) <i>n</i> = 9	13.00 (2.28) <i>n</i> = 10	18.83 (3.60) <i>n</i> = 9
	Symbolic gesture	5.57 (0.79) <i>n</i> = 8	10.33 (1.66) <i>n</i> = 10	14.00 (1.94) <i>n</i> = 9	19.44 (2.40) <i>n</i> = 9
	Verbal training	6.00 (1.15) <i>n</i> = 10	11.20 (1.14) <i>n</i> = 10	14.00 (2.40) <i>n</i> = 10	18.10 (2.88) <i>n</i> = 10
	Non-intervention control	5.78 (0.97) <i>n</i> = 9	9.67 (1.22) <i>n</i> = 10	13.11 (1.96) <i>n</i> = 10	19.67 (2.69) <i>n</i> = 10
Expressive communication	BSL	6.83 (0.98) <i>n</i> = 10	10.17 (1.83) <i>n</i> = 9	12.00 (1.55) <i>n</i> = 10	20.00 (6.03) <i>n</i> = 9
	Symbolic gesture	6.71 (0.95) <i>n</i> = 8	10.00 (1.50) <i>n</i> = 10	12.44 (2.19) <i>n</i> = 9	19.67 (3.24) <i>n</i> = 9
	Verbal training	5.50 (1.08) <i>n</i> = 10	13.20 (2.44) <i>n</i> = 10	13.20 (2.44) <i>n</i> = 10	17.80 (2.39) <i>n</i> = 10
	Non-intervention control	6.44 (0.73) <i>n</i> = 9	9.22 (1.39) <i>n</i> = 10	11.44 (1.59) <i>n</i> = 10	19.22 (3.07) <i>n</i> = 10
Gestures, actions and pretend play	BSL	6.60 (4.14) <i>n</i> = 10	24.17 (11.36) <i>n</i> = 9	29.83 (6.18) <i>n</i> = 10	49.35 (7.77) <i>n</i> = 9
	Symbolic gesture	9.50 (6.11) <i>n</i> = 8	20.56 (7.18) <i>n</i> = 10	37.00 (12.02) <i>n</i> = 9	49.11 (8.46) <i>n</i> = 9
	Verbal training	7.50 (4.93) <i>n</i> = 10	22.30 (6.20) <i>n</i> = 10	36.40 (11.19) <i>n</i> = 10	49.40 (8.29) <i>n</i> = 10
	Non-intervention control	6.44 (4.00) <i>n</i> = 9	22.50 (6.36) <i>n</i> = 10	35.60 (7.34) <i>n</i> = 10	49.30 (7.67) <i>n</i> = 10