

Oral exploration and reaching toward social and non-social objects in two-, four-, and six-month-old infants

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This study investigates tongue protrusion and how it co-develops with gazing and reaching in two-, four-, and six-month-old infants. We assessed these reactions during infant viewing of a human still-face or a manikin. Results showed that two month olds protruded their tongues and gazed toward both stimuli more than infants in the older age groups, and that four and six month olds reached towards the stimuli more than the two month olds. In the still-face condition, there was a positive correlation between tongue protrusion and gazing. In addition, in the still-face condition, infants at four months preferred tongue protrusion over reaching. But this preference did not occur at six months. The results suggest that infants' tongue protrusions and reaching serve an exploratory function in ambiguous social contexts.

Given the importance of imitation in early human social cognition, many questions have been asked about the developmental origins of this skill. In a seminal study conducted in the late 1970s, Meltzoff and Moore (1977) assessed whether newborn infants imitate various facial gestures. They found that newborn infants imitated several gestures, such as lip protrusion, mouth opening, and tongue protrusion, as well as sequential finger movements. This effect has been replicated by various laboratories and across behaviours such as facial gesture (e.g., Kugiumutzakis, 1999;

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Meltzoff & Moore, 1983), facial expression (e.g., Field, Woodson, Greenberg, & Cohen, 1982), and vocal models (e.g., Chen, Striano, & Rakoczy, 2004; Kuhl & Meltzoff, 1982, 1996). However, some other laboratories have failed to replicate such findings (see Anisfeld, 1996, for a review). Thus, controversy over the interpretation of the tongue protrusion effect continues. Some argue that imitation reflects inter-modal matching and a “like-me” stance (Meltzoff & Moore, 1989), early communicative skills (Heimann, 1998), or an innate releasing mechanism (e.g., Jacobson, 1979; see Anisfeld, 1991, for a review).

One important study assessed tongue protrusion and gazing in infants of four weeks during presentation of a nonsocial light display (Jones, 1996). Infants who looked longer at the light display also produced more tongue protrusions than those who looked less at the display. This finding suggests that tongue protrusions might be utilized, in part, as an exploratory tool with which to investigate interesting objects. In support of this notion a second study presented the infants with a human experimenter who either protruded her tongue or opened her mouth. Infants gazed reliably more at the tongue protrusion face compared to the mouth opening. It was suggested that in previous studies infant tongue protrusion towards experimenter tongue protrusion may simply be due to the novelty of the stimulus and only by chance be an imitative act. However, the relationship between the frequency of tongue protrusions and gaze towards the stimuli was not assessed in Jones’ study. In a third experiment, two infants were observed from 3 to 30 weeks of age. Their oral exploratory and reaching behaviours towards interesting objects were assessed. Infants’ rate of tongue protrusion decreased after reaching skills developed, providing further support for the exploratory function hypothesis of tongue protrusion. Crucially, only infants’ responses toward non-social stimuli were assessed.

Striano and Thoermer (2001) investigated whether infants utilize tongue protrusions, in part, to explore interesting stimuli (as suggested by Jones), or whether infant tongue protrusions are also used to interpret an ambiguous social situation. The authors presented infants with two conditions. One was a social interactive condition, whereas the other featured a still-face condition, which they conjectured was socially ambiguous for the infant. They found a positive correlation between gazing time in a social interaction condition and the number of tongue protrusions observed during a still-face condition. There was, however, no relation between gazing time and number of tongue protrusions during the interaction condition. Consequently, they suggested that early tongue protrusion may not serve only as an exploratory function; rather, it may act as a probing function to an ambiguous social situation. As infants become more experienced during interactions with people, they suggested, it will become less likely that exploratory tongue protrusions would occur in social situations.

The goal of the current study was to further assess the exploratory parameters of infants' tongue protrusion and reaching in a social situation. It has been shown that infants as young as two months of age look at an adult and smile less when she suddenly becomes unresponsive in the middle of an ongoing interaction (Fogel, Diamond, Langhorne, & Demos, 1982). Indeed, Nagy & Molnar (2004) found that infants might use imitation to provoke social interactions at a much younger age. These infant behaviours suggest that certainly by two months, infants expect people to exhibit social behaviour, such as responsiveness during a social interaction. In the present study, we consequently tested infants in two conditions. One featured a human still-face condition. Interestingly, young infants do not manifest a still-face response when a face-like object suddenly becomes unresponsive (Ellsworth, Muir, & Hains, 1993). This suggests that infants can discriminate between human faces and inanimate face-like objects. Therefore, as the second condition, we presented infants with a neutral-face manikin.

We investigated the development of infants' oral exploration and how it co-develops with gazing and reaching toward people or objects at two, four, and six months of age in an ambiguous social (still-face) or a non-social (manikin object) condition. We hypothesized that younger infants might be more likely to orally explore both social and non-social stimuli, whereas older infants, who had more experience interacting with people, might respond to social and non-social stimuli differently. As reaching behaviours gradually replace oral exploration (Jones, 1996) we expected that older infants would protrude their tongues less than younger infants and would reach more towards ambiguous social rather than non-social stimuli. Even though previous research shows that young infants can discriminate a human and a human-like doll with consequent different expectations for each stimulus type, we expected that infants' responses would nevertheless become increasingly differentiated over development.

METHOD

Participants

We tested 128 infants. Thirty-eight infants were excluded due to fussiness, or due to the technical problems. Ninety infants were included in the analyses, 30 infants in each age group—two, four, and six month olds. Fifteen two month olds (mean = 2 months 18 days, 7 boys), 15 four month olds (mean = 4 months 19 days, 10 boys), and 15 six month olds (mean = 6 months 14 days, 8 boys) were tested in a *still-face* condition. Fifteen two month olds (mean = 2 months 19 days, 8 boys), 15 four month olds (mean = 4 months 13 days, 10 boys), and 15 six month olds (mean = 6 months 15 days, 9 boys) were tested in a *manikin* condition. All infants were

born full term and were healthy according to parental reports at the time of testing and medical birth records (1- and 5-min Apgar scores of 8 or above). The participants were recruited from a participant pool consisting of infants born in the Greater Atlanta area. Ninety percent of the parents were from Caucasian, middle-class backgrounds.

Procedure

All infants who were included in our data analyses were in alert state during the test, with alert defined as clearly awake with eyes open and exhibiting attentive behaviours, such as moving their heads to look at objects. Infants reclined in an infant seat, which was placed on a table. The session was videotaped by three cameras. The camera used for coding focused on the infants' face and upper body and provided a profile view of the still-face or manikin. The infant seat was surrounded on three sides (not in front of the infant) by 100×100 cm white frame-boards, in order to reduce visual and auditory noise in the environment. At the very beginning of the test, a smaller white frame-board (30×40 cm) was centered in the infant's visual field, 30 cm from the infant's face. Raising the small frame-board revealed either the adult forming a still-face or alternatively, a manikin. A stopwatch recorded the time of exposure. In the *still-face* condition, the infants were presented with a neutral facial expression, with the female experimenter positioned 30 cm from the infant. In the *manikin* condition, infants were presented with a manikin presenting a neutral face, with the manikin positioned 30 cm from the infant. Infants were exposed to either the still-face or the manikin for one minute.

Measurement

The following behaviours were scored:

Tongue protrusion (TP). "Forward movement of the tongue such that it crossed the inner edge of the lower lip" (derived from Jones, 1996; p. 1955). TP accompanied by sucking fingers or clothes were excluded. The number of TPs was scored over the whole period of stimulus presentation. One TP behaviour was scored as a single occurrence of the behaviour, irrespective of its duration.

Reaching. *Manual reach* and *approach without manual reach*. One or both hands reaching toward the stimulus *or* upper body leaned toward the stimulus without manual reaching. The number of reaching actions was scored over the whole period of stimulus presentation. One reaching behaviour was scored as a single occurrence of the behaviour, irrespective of duration.

Gazing. Gaze directed towards the stimulus. The duration of gazing was recorded over the whole period of stimulus presentation. Then the duration was converted to the proportion of the gazing time, which was defined as the total gazing time divided by the total duration of the stimulus presentation (one minute).

Reliability. A second coder, unaware of the hypothesis, coded a random sample of 20% (18 infants) of the participants, coding the same variables measured above. Three infants for each age group in each condition were scored for reliability. Inter-observer Pearson correlations were high, with tongue protrusion at .88; reaching behaviour at .93; and the duration of gazing at .98.

RESULTS

Descriptive data

The means (and *SE*) of the number of *tongue protrusions* in both the *still-face* and the *manikin* conditions are presented in Figure 1 for each age group. In the *still-face* condition, the mean (and *SE*) of TP at two months was 4.60 (.86); 2.27 (.91) at four months; and .40 (.19) at six months. In the

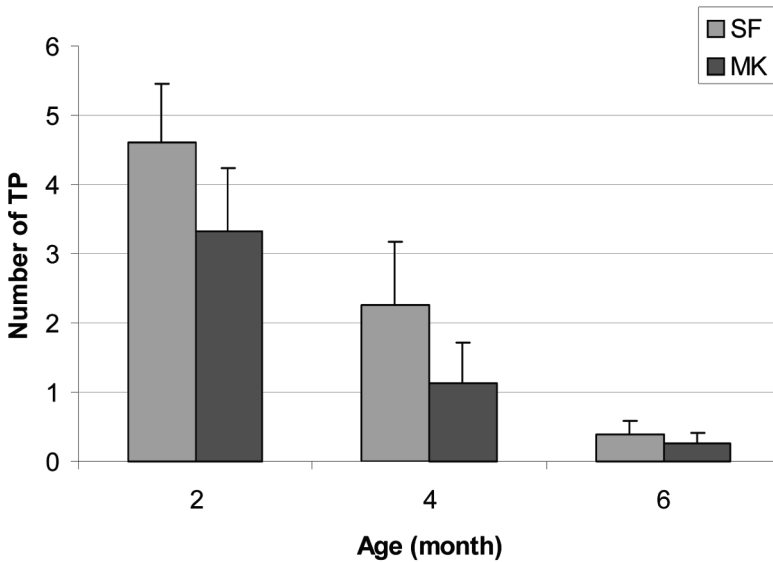


Figure 1. The number of tongue protrusions in still-face and manikin conditions (mean + *SE*) in two-, four-, and six-month-old infants.

manikin condition, the mean (and *SE*) of TP at two months was 3.33 (.92); 1.13 (.58) at four months; and .27 (.15) at six months.

There were no reaching behaviours displayed by infants of two months. However, the means (and *SE*) of the number of *reaching actions* in both *still-face* and *manikin* conditions in four and six month olds are presented in Figure 2. In the *still-face* condition, the mean (and *SE*) of reaching at four months was .13 (.13); .93 (.34) at six months. In the *manikin* condition, the mean (and *SE*) of reaching at four months was .67 (.46); 1.0 (.37) at six months.

The means (and *SE*) of the proportion of *gazing time* (%) in both *still-face* and *manikin* conditions in the three age groups are presented in Figure 3. In the *still-face* condition, the mean (and *SE*) of gazing time at two months was 88.11 (2.57); 49.03 (10.25) at four months; and 65.15 (4.98) at six months. In the *manikin* condition, the mean (and *SE*) of gazing time at two months was 74.89 (7.57); 45.24 (10.16) at four months; and 59.15 (4.81) at six months.

Tongue protrusion

First, to examine the developmental trends and context effect of tongue protrusion, we performed a 2 condition (Still-face vs. Manikin) \times 3 Age

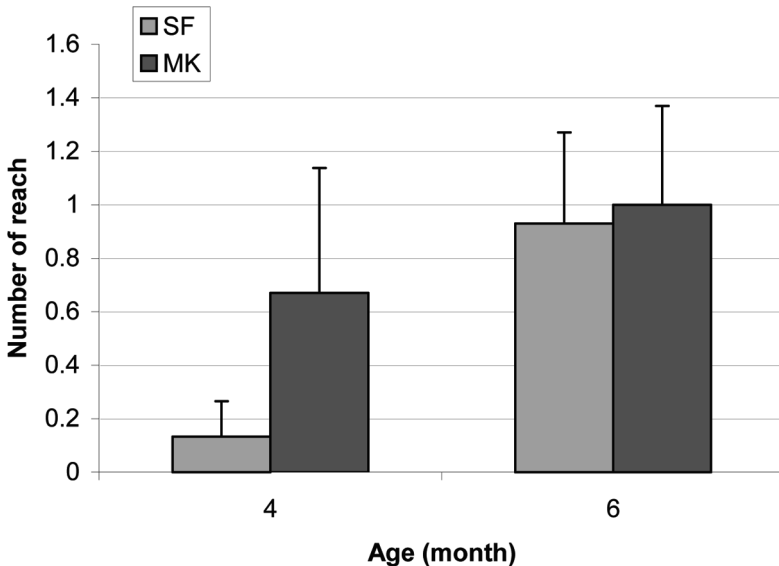


Figure 2. The number of reaches (mean + *SE*) in still-face and manikin conditions in four- and six-month-old infants.

(two-, vs. four-, vs. six-month) ANOVA. A significant main effect of age was found, $F(2, 84) = 14.48$, $p < .001$. Tukey's post hoc tests showed that two month olds produced significantly more tongue protrusions in both conditions than four month olds ($p < .01$), and six month olds ($p < .001$). There was no significant difference in tongue protrusions between four and six month olds ($p > .10$). No effects of condition were found and there were no interactions between condition and age.

We also examined whether infants protruded tongues toward the stimulus while gazing at the target. As few infants displayed tongue protrusion without gazing, Mann–Whitney tests were used. In both the *still-face* condition and the *manikin* condition, infants were more likely to protrude their tongues while gazing at the target when compared to not gazing ($w = 2505$, $p < .001$ in *still-face*; $w = 2364$, $p < .001$ in *manikin*).

There was a significant correlation between infants' gazing time at the *still-face* stimuli and the number of tongue protrusions, $r = .44$, $p < .05$, but no relationship between gazing at the *manikin* stimulus and the number of tongue protrusions, $r = .25$, $p = .148$.

Reaching

As none of the two month olds produced reaching behaviours (see *descriptive data*, above), only four and six month olds were included in this series of analyses.

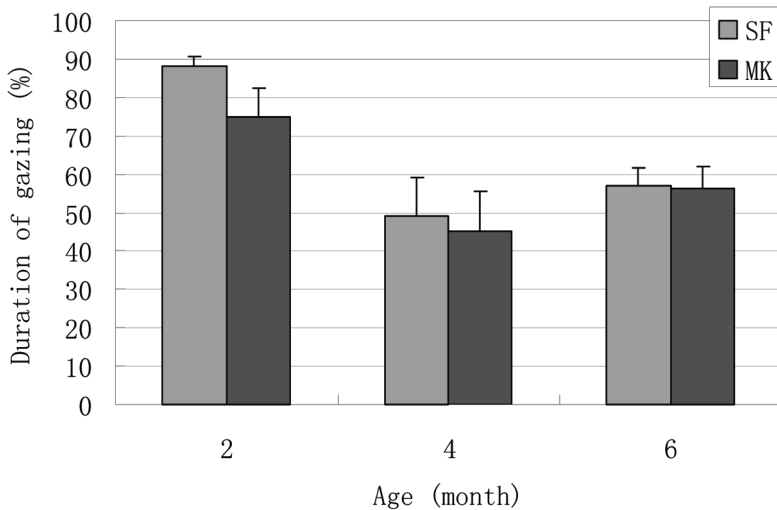


Figure 3. The duration of gazing (proportion) (mean + SE) in still-face and manikin conditions in two-, four-, and six-month-old infants.

A bivariate correlation test showed significant positive correlations between infant age in days and the number of reaching actions in the *still-face* condition, $r = .38$, $p < .05$. There was no correlation found for the *manikin* condition, $r = .09$, $p = .64$.

The number of reaching behaviours in different ages and conditions was not normally distributed, as Anderson–Darling normality tests showed p values were all less than .0001. Therefore Mann–Whitney tests were used to examine whether there were any differences in the number of reaching behaviours between four and six month olds, in the different conditions. In the *still-face* condition, the results showed that the rate of reaching behaviours in six month olds was significantly higher than that of the four month olds ($w = 194.50$, $p < .05$). In the *manikin* condition, the rate of reaching behaviours did not differ between the two age groups ($w = 213.00$, $p = .35$).

We also examined the relation between reaching behaviours and tongue protrusions. As almost half the sample at both four and six months did not produce tongue protrusion or reaching behaviours, we analyzed the number of those infants who did perform these behaviours (see Table 1). In the *still-face* condition, more four month olds used tongue protrusions than reaching, $\chi^2(1) = 6.00$, $p < .05$; whereas six month olds did not produce either behaviour more than the other, $\chi^2(1) = .50$, $p = .48$. In the *manikin* condition, neither group preferred one behaviour more than the other, $\chi^2(1) = 0$, $p = 1.00$ at four months, and $\chi^2(1) = 1.00$, $p = .37$ at six months.

Gazing

A 3 Age (two months, four months, six months) \times 2 Condition (*manikin* vs. *still-face*) ANOVA on the proportion of time that infants gazed at the stimulus was also performed. There was a significant main effect of age, $F(2, 48) = 20.14$, $p < .001$. Tukey's post hoc tests revealed that two month olds gazed more than four month olds ($p < .001$) and six month olds ($p < .001$). There was no significant difference between gaze time of four and six month olds ($p > .10$). No other main effects or interactions were found.

TABLE 1
The number of infants displaying behaviours in both still-face (SF) and manikin (MK) conditions

		<i>TP only</i>	<i>Reach only</i>	<i>Reach + TP</i>	<i>No reach, no TP</i>	<i>Total</i>
SF	4-month	6	0	1	8	15
	6-month	3	5	1	6	15
MK	4-month	3	3	1	8	15
	6-month	3	6	0	6	15

DISCUSSION

The present study investigated the development of infants' oral exploration and its co-development with gazing and reaching towards people and objects at two, four, and six months of age. Broadly, we found that two-month-old infants orally explored both social and non-social stimuli, whereas older infants responded with reaching more often. In addition, older infants responded differentially to the social and non-social stimuli, utilizing different behaviours to interact with the two conditions when compared with the behaviour of the younger infants.

The finding that TP behaviour was elicited during gaze at the target in both conditions appears to support the hypothesis of Jones (1996), whereby TP serves as an exploratory tool. An alternative explanation to this conclusion is that TP occurs when an infant is engaged with an object, and may correlate with sustained attention to one spatial location or object. Under this scenario, behaviour such as TP may be elicited during the extraction of information from a visual scene and thus appear during acts involving visual fixation on one location. In addition, TP would not be expected to be elicited during the processing of superficial visual information, such as the locations of objects when compared with the extraction of relatively more detailed information, such as the nature of an object in a location.

A significant correlation between infants' gazing at the still-face stimulus and the number of tongue protrusions was found. However, no relationship was evident between gazing at the manikin and the number of tongue protrusions. This suggests that the still-face condition is processed by the infants as an *ambiguous social situation*. This result supports Striano and Thoermer (2001), who suggested that gazing and TP behaviours may serve as a tool with which to probe an ambiguous situation. These behaviours may functionally relate to the attempt to communicate or to process information in an unusual social situation. Support for this interpretation is also provided by Meltzoff and Moore (1994), where it was suggested that TP or imitation of mouth gestures may be used to explore person identity even at six weeks of age.

Differences found between the *manikin* and *still-face* conditions imply that infants responded differentially to social and non-social constructs. One interpretation of these data is that infants were more interested in the social rather than the non-social context. Additional support for this notion derives from the reaching behaviours, where six month olds were shown to reach towards the stimulus more often than four month olds during the *still-face* condition but not during the *manikin* condition. This implies that the increased frequency of reaching behaviours by six-month olds in the still-face condition, when compared to infants of four months, may be due to

developing social expectations. Results from Rochat, Quierdo, and Striano (1999), support this interpretation as they showed that changes in social awareness occur around this time, with resulting changes in infant social behaviour.

A further interpretation of these results is that with increased experience of interacting with people, infants are less likely to depend on oral exploration. Rather, they utilize better and more overt behaviours in social situations in order to more effectively communicate with another person. This interpretation supports Jones (1996), who suggested that infants use new motor skills to facilitate exploration. The overall result is a decline in oral behaviours for the purposes of exploration.

With increased experience of interacting with people, the function of the infants' hands becomes more clearly differentiated. In early infancy, hands have a grasping (supporting) function and an exploratory (perceptual) function (Hatwell, 1987). By six months of age, hands may also provide a nonverbal social communicative function, with certain gestures acting as indicators of socially relevant material to others, such as whole arm waving to gain attention and finger pointing to highlight important aspects of the environment to an observer. Interestingly, Fogel and Hannan (1985) reported when infants were engaged in social interaction, the isolated extension of the index finger was observed as early as three months of age. Also, "pointing" usually was accompanied by eye and mouth movements. Franco and Butterworth (1990) found that social conditions are necessary for pointing in infants as they pointed only when there was a social partner for communication. Pointing did not occur when infants were alone with attractive objects. These studies suggest that the communicative function of hands may develop and differentiate when infants have greater experience of social interaction.

In the current study, during the still-face condition, the six month olds learned to combine visual inspection with reaching actions to probe the ambiguous social situation. The four month olds in the same condition, however, still preferred TP over reaching. During the ambiguous still-face condition, the function of reaching behaviours may be communicative. This function might be fundamentally different from its role in the manikin condition, where the behaviour is manifestly explorative. Future studies are needed to disambiguate the functional characteristics of this behaviour set. One approach could be to assess the kinematics of reaching in various conditions (e.g., Claxton, Keen, & McCarty, 2003). Such a study could assess whether communication and exploration contain different action execution properties.

The present study attempted to track changes in the early development of explorative activities. At two months, infants utilize tongue protrusions to explore an interesting object and probe an unusual social situation. At four

months, infants start to perform reaching to explore the interesting object, but respond less both with TP and reaching to an unusual social situation. At six months, infants rarely depend on oral exploration, instead they use reaching more often in both situations. These results indicate that there are significant social-cognitive changes that occur across this period in early infancy.

Even though existing literature has mainly associated tongue protrusions with imitative acts by young infants, the current study provides further support for Jones (1996) and suggests that motor development and social understanding should not be investigated in isolation. In fact, the frequency of behaviours, such as tongue protrusions, which are well within the infants' behavioural repertoire, may be a valuable tool in helping to establish what infants understand about other people and how such knowledge develops throughout early infancy.

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