

Development of Vocal and Motor Behaviours in an Infant: Preliminary Findings

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Abstract

Previous work has suggested that oral and manual systems co-emerge in a developing child which leads to the emergence of a more adult-like, precisely-timed coupling of gesture and speech (Iverson & Thelen, 1999). This study aimed to document the frequency of occurrence of vocalic and body movement gestures namely, hand, facial expression, facial movements and eye gaze in infants (using ELAN software) and to understand the emergence of vocal-motor link in a single typically developing child. The child was from a Kannada speaking family and the mother-infant dyad interactions were audio-video recorded once a month, from the 3rd to the 5th month. Results indicated that a typically developing infant is endowed with a repertoire of vocal, facial, and bodily signals and as young as 5 months there is a clear indication of strong vocal-motor linkage in expression.

Keywords

Non-verbal behaviours, vocal behaviour, motor behaviour, speech development, Case study

Introduction

Gestures constitute the nonverbal aspect of communication. Gesture is used by all when they speak, irrespective of the age, culture and social background. Gesture is not only performed with hands, but by other parts of body, such as head, face or arms. Thus, gestures are defined as manual [e.g., waving to say goodbye], facial [e.g., pouting to show displeasure], or other body movements [e.g., miming an object or person], (Capone, 2010).

McNeill (1992) documented four major characteristics of the gestures used by adults along with speech. First, although gesture and speech often convey complementary aspects of an underlying message, they do so simultaneously, temporally linked within the bounds of a single utterance. Second, when adults gesture while speaking, gestures consist primarily of hand, arm, and finger movements (manual). It is relatively uncommon for mature speakers to produce gestures that involve legs, feet or whole body (non-manual). Third, among right-handed speakers (majority of all speakers), coexpressive gestures tend to be unimanual and are produced primarily with the right hand (Kimura, 1973). Fourth, gestures and speech have a constant relationship in time, with the manual movements of gesture either slightly anticipated or occurring in synchrony with co expressive speech.

Connections between the vocal and gestural system has been suggested to be in place early in development in children. Iverson and Thelen (1999) suggested a model of vocal-motor development as an evidence for an integrated view of the origins of gesture-speech timing in infancy. This model suggests that although gesture and speech are produced in order to convey meaning, their co-production requires the ability to produce controlled, voluntary movements in

the two effector systems, namely, the vocal tract and the manual system, and to coordinate these movements in time and space.

Iverson and Thelen (1999) suggested a possible developmental progression characterized by four phases based on the model proposed. The first phase is called *initial linkages*, where hand and mouth activity are loosely coupled from birth. The second phase is *emerging control*, where there is an increase in the adaptive use of hands and mouth marked by rhythmical and sometimes coordinated activities in both manual and vocal modalities. This phase is seen from 6 to 8 months of age. The third phase is *flexible couplings*, which is characterized by the emergence of coupled but not synchronous gesture and speech from 9 to 14 months of age. The last phase called *synchronous coupling*, has adult-like precisely-timed coupling of gesture and speech and is seen from 16 to 18 months of age.

Various researchers have supported the developmental progression as suggested in the model by Iverson & Thelen (1999). Lew and Butterworth (1997) observed that when newborns bring their hands to the facial area to introduce the fingers for sucking, they open the mouth as the hand is moving towards the facial area, in anticipation of its arrival. Trevarthen (1977), followed 5 children from 2 to 6 months of age, and observed that as early as 8 to 12 weeks, hand and finger movements were synchronized with prespeech facial movements such as tongue protrusion and lip contraction. The facial movements, which were usually produced without concurrent vocalization, were accompanied by hand, foot or trunk movements. Among these, hand and arm movements, especially hand waving, finger pointing, and fingertip clasping, were found to be finely synchronized with pre speech movements.

A study on a larger scale conducted with 28 children in the age range, 9 to 15 weeks, reported that manual actions such as index finger extensions, which resemble 'pointing' co-occurred with vocalization or mouthing movements even in this young group of infants. Hand action was found to be systematically organized into sequences with other infant actions (Fogel & Hannan, 1985). They also suggested that manual actions of infants as young as 9 weeks of age may occur in relation to their facial expressions, gaze directions and vocalizations. In a similar study, among older Japanese infants studied between 5 to 9 months, increased production of rhythmical upper limb movements were reported to be related to the age of onset of reduplicated babbling (Ejiri, 1998).

Iverson and Fagan (2004) also reported an age-related increase in frequency of vocal-gestural coordination, with greater coordination in arm (specifically right arm) than leg or torso movements, and a temporal pattern similar to that of adult gesture-speech co-productions, in 6- to 9-month old infants. They also documented that rhythmic vocalizations occurred more with rhythmic manual than non-manual activity in babblers.

Need for the Study

Few studies (Trevarthen, 1977; Fogel & Hannan, 1985; Iverson & Fagan, 2004) thus, have suggested that the vocal-motor system may be linked together, either tightly or loosely, during development in infants. In the Indian context, a previous study by Veena (2010) has addressed the development and communicative functions of gestures in Kannada speaking children from the age of 8 to 18 months. This study focused on hand gestures and found that there were no differences in the age of acquisition of communicative gestures in these children when compared to those reported in other cultures. However, the pre-linguistic development of

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vocal and motor behaviours has not been given considerable focus in India and it is in this context that this study has been undertaken.

Aim of the Study

This study aimed to document the frequency of occurrence of vocalic and body gestures namely, hand, facial expression, facial movements and eye gaze and also to understand the emergence of the vocal-motor link in a typically developing infant.

Method

Participant

One typically developing female infant was included in the study. She was recorded once every month, with the first recording beginning at 3 months of age and continuing till she turned 5 months. The participant was a full term baby, had no major birth complications, and passed a hearing, visual and language screening at 3 months of age. She was from a Kannada speaking family with the mother as the primary caregiver.

Procedure

The infant and the mother were videotaped at their home, using a Sony HDR video and audio recorder. Each recording was done once a month for the duration of 1 hour, when the child was most playful and alert. The recordings were not continuous, since there were breaks when the child was fussy/ uncomfortable. The mother was instructed to talk to/ stimulate/ play with the infant as she normally would, either when the infant was lying on the floor or when placed on the lap of the mother. The videos were later edited and only those parts of the data that could be

used for the analysis was retained. The average duration of the data used for the analysis was 10 - 15 minutes for every month of recording.

Coding

All behaviours of the infant were coded using ELAN software (Lausberg & Sloetjes, 2009). The frame for the analysis was set for every second for the entire data per instance of recording. A key for coding the vocal and motor behaviours was made by the principle investigator (Appendix 1) and the same was compiled based on the review of literature (Fogel & Hannan, 1985; Oller, 1981).

Each item in the key thus developed was provided with an operational definition, in order to facilitate uniformity in the coding across coders. The coding of the samples was done by two independent coders (speech language pathologists), who were trained in the use of the coding system and the keys on a video sample of the infant who was not included in the study. The first coder (principal investigator) identified and labelled the vocal and motor behaviours exhibited by the infant in every second of the frame. The interjudge reliability check for coding was done on the sample of the 4th month. The second coder went through the annotated sample and indicated whether there was an agreement or disagreement with the annotations of the principal investigator. Later, the percentage of agreement between the coders was calculated and it was found to be 86 (N= 377) for the 4th month.

Analysis

The motor behaviours of the infant were categorized as movements of face, facial expressions, gaze, and hand movements. The vocal behaviours were categorized as vocalic,

syllabic, vegetative and periods of silence. The frequencies of occurrence of both these behaviours were calculated. The frequencies of co-occurrence of oral and gestural behaviours were also calculated by noting the different body gestures that occurred during the production of vocal behaviours as well as during those periods when the infant was silent.

Results

The results of this study are presented with regard to the two aims of the study. The first aim of the study was to document the frequency of occurrence of motor and vocal behaviours in the infant for the observation period. The percentage frequencies of occurrence for these behaviours are as shown in Table 1.

Table 1: Percentage frequencies of body gestures and vocal behaviours.

MOTOR BEHAVIOURS	MON 3	MON 4	MON 5	MOTOR BEHAVIOURS	MON 3	MON 4	MON 5
Left Hand				Right Hand			
Curl	32	30	4	Curl	31	17	3
Grasp	16	10	17	Grasp	19	20	24
Reach	1	0	20	Reach	5	1	10
Spread	12	42	37	Spread	15	34	46
Hand in Mouth	5	3	3	Hand in Mouth	0	7	10
Swing	2	4	0	Swing	2	4	0
Bang	0	0	13	Bang	0	2	2
Shake	0	0	1	Shake	0	5	0
Index finger extension	14	8	4	Index finger extension	9	8	3
Clasp	17	4	1	Clasp	19	3	1
Gaze				Facial Movement			
Gaze at person	47	31	21	Lip/Tongue Play	33	3	7
Gaze at action	23	1	0	Mouth	24	60	57
Gaze away	11	32	26	Pout	2	1	0
Gaze at object	17	33	50	Tongue Protrusion	33	36	36

Gaze track	2	3	3	Puckered Lips	8	0	0
Facial Expression				VOCAL BEHAVIOURS			
Concentration	4	11	27	Vocalic	40	47	45
Smile	8	63	55	Syllabic	11	18	16
Distress	25	0	0	Vegetative	13	11	13
Interest	63	17	18	Silence	37	24	26
Startle	0	0	0				
Frown	0	9	0				

Note: MON= month

a) Frequency of occurrence of gaze behaviours

Across the three months, there were differences seen in the occurrence of gaze behaviours between the third and the fifth month. Gaze directed towards mother (46%) was found to be more in the third month, while gaze directed towards objects (50%) was found to be frequent in the fifth month. Gaze directed towards an action (23%) was only seen in the third month and gaze directed away (30%) was seen frequently in the fourth month, while gaze track was less frequently seen across all the months.

b) Frequency of occurrence of facial movements

During the third month random lip and tongue movements (33%) at play were observed, and these were not seen in the other months. Mouthing behaviour was found to vary across the months; 24% in the third month, 60% in the fourth month and 57% in the fifth month. Pouting (2%) and puckering of lips (8%) were mostly seen in the third month. Tongue protrusions were noted throughout the months and there were minimal differences seen in the percentage of occurrence (33% in the third and 36% in the fourth and fifth months).

c) Frequency of occurrence of facial expressions

Among the facial expressions, distress (25%) was seen only in the third month, while frown (25%) was seen only in the fourth month. Interest (63%) was observed frequently in the third month. Frequency of occurrence of smile (63%) was noted to be higher in the fourth month while the occurrence of concentration (27%) was high in the fifth month.

d) Frequency of occurrence of hand movements

During the third month, curling of fingers (32%), both in right and left arms, was observed to be more frequent than the other movements. Grasp was found to be more associated with the right arm, and there was an increase in the behaviour with an increase in age (24% in fifth month). Reaching behaviour was seen more in the fifth month (20% for left and 11% for right arms respectively). Spread was also found to increase in the fourth (42% for left, and 34% for right arms respectively) and fifth (37% for left, and 50% for right arms respectively) months,

Swinging of arms was found to be high in the fourth month (4% for both right and left arms), along with hand shaking (5% for right arm). Banging was not observed in the third and fourth months, but in the fifth month it was frequently seen for the left arm (13%). Claspings of hands was seen mostly in the third month (17%) and index finger extensions (14% for left and 9% for right arms respectively) were also frequently observed in the same month. Placing the right hand in mouth was seen in the fourth (7%) and fifth (11%) months.

d) Frequency of occurrence of vocal behaviours

Across all the three months, the frequency of occurrence of vocalic utterances (48%) and vegetative sounds (12%) remained steady. It was observed that there was a slight increase in the

production of syllabic utterances with an increase in age (10% in the third month, 18% in the fourth month and 16% in the fifth month). Also, with an increase in age, it was seen that the periods wherein the infant remained silent decreased considerably from 37% in the third month to 18% in the fifth month.

The second aim of the study was to understand if there was evidence of the proposed vocal-motor synchrony in the behaviour of infant for the observation period. For the purpose of providing a comprehensive picture, the instances of the different types of behaviours were collectively considered under each of the body gestures, namely, hand, face and gaze. Thus, the percentage frequencies of the types of body gestures that co-occurred with the various vocal behaviours and during periods of silence are as shown in Figure 1.

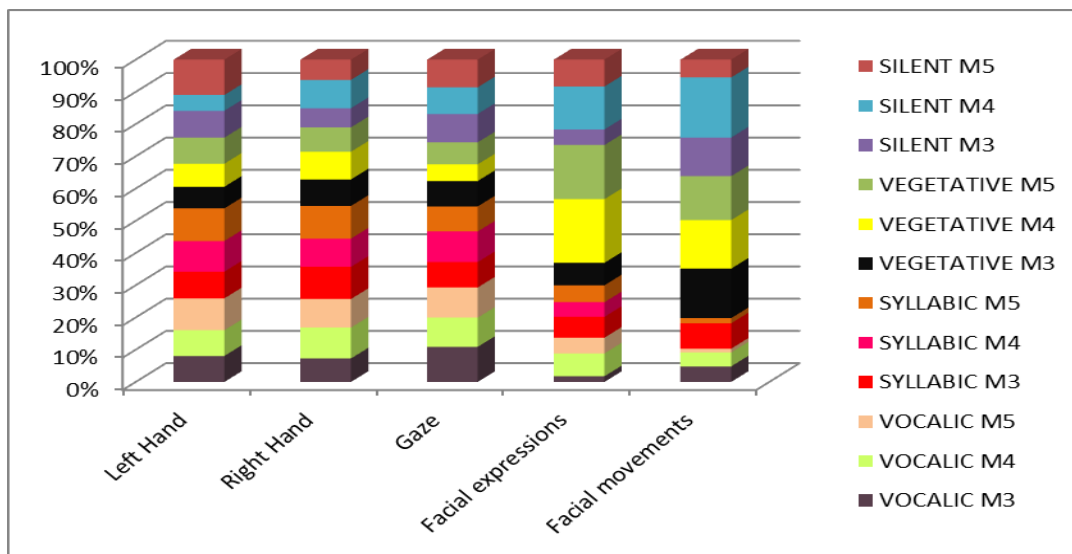


Figure 1: Percentage frequencies of co-occurrence of vocal-motor behaviours

It can be understood from figure 1 that, gestures occurred when the child was exhibiting a vocal behavior as well as when the child was silent across all the three months, although there

were some variations in the patterns seen. On comparison between left and right hand gestures, there were not many differences seen in the instances of co-occurrence. In the fifth month, left hand movements (41%) were seen frequently when the child remained silent, while the right hand movements were seen more during periods of silence in the fourth month (27%) and during syllabic utterances (31%). Facial movements occurred more when the child was silent in the fourth month (18%) as well as during vegetative productions across all months (average 15%). Facial expressions co-occurred with vegetative productions during the fourth (12%) and fifth (10%) months. Gaze behaviours seemed to occur at similar frequencies, both during vocal productions and periods of silence for all the three months (average 27%).

Discussion

The findings of this study points out that an infant as young as 3 months old demonstrates a plethora of motor and vocal behaviours. This is similar to that reported in other studies on infants from different cultural backgrounds (Trevarthen, 1977; Fogel & Hannan, 1985). The results indicate that both motor and vocal behaviours of the infant showed different patterns of occurrence across the ages which were under study. Some behaviours were only seen during certain months while some others were seen across all the months, though with varied frequencies. It was also observed that the occurrences of some behaviours reduced as the age of the child increased.

During the third month, the infant was found to engage more with the caregiver, which is evidenced in the frequent gaze directed at the caregiver as well as towards observations of the caregivers' actions. Moreover by the fifth month, gaze was directed more towards objects, which indicates that as the infant grows there is the tendency to explore and observe objects around

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his/her environment. The infant was also found to track the path of objects to which she was exposed across the three months, though it was not a very frequent behaviour, possibly due to poor neuromuscular control. It was also observed that the instances of the infant looking away from object or person were found to be less in the third month and the fifth months. But, this behaviour was found to be more in the fourth month, where there is a corresponding decrease in gaze directed at caregiver and at any object.

Hand movements were among the most frequent behaviours observed in the infant, when compared to the other motor as well as vocalic behaviours. During the third month, curling and clasping of fingers were frequently observed, and these may correspond to the quiet physiological state of very young infant, where they remain idle for longer periods of time. Index finger extensions were also seen frequently in the same month, and there was a decrease seen in this behaviour for the other months. These were observed as random movements, with neither a stimulus to trigger the act nor a specified target for the behaviour to be purposeful. Thus, these did not resemble the mature 'points' as reported in the other studies on young infants (Fogel & Hannan, 1985).

As mentioned earlier, the child showed interest in the manipulation of toys during the later months, especially in the fifth month. This was also reflected in the increased occurrence of reaching for objects, grasping objects, and spreading of fingers etc. Rhythmic behaviours such as that of banging the object on a surface of contact, swinging of arms and shaking of toys held in hand were seen more during the fourth month, but these were not as frequent as the other hand behaviours.

With regard to facial movements, in the third month random lip and tongue movements were observed and these were not seen in the other months. Similar patterns were also seen for lip pouting and lip puckering. Tongue protrusions were seen across all the months with almost similar frequencies of occurrences. These might suggest that these are very early behaviours seen in an infant, and these may pave the way for mature speech-like movements as the child develops. Mouthing behaviours, which are considered as movements that resemble speech without accompanying vocalizations, were more frequent in the fourth and fifth months.

When compared to other body gestures, namely, gaze, hand and facial movements, the instance of occurrence of facial expressions were comparatively less. Distress was most frequently seen in the third month but it did not occur in the other months. The same pattern was observed for frown, which was again only seen in the fourth month. A reason for these behaviours to occur in the younger months could be the physiological state of the infant; she was found to be very fussy. Smile was seen when the infant was paying attention to the caregiver's actions or smile, and there was an increase in the occurrence of this behaviour with age. Concentration was seen frequently in the fifth month and this was noted while the child was observing an action or while looking at an object or caregiver.

Across all the three months, vocalic utterances and vegetative sounds were produced with similar frequency. It was observed that there was a slight increase in the production of syllabic utterances with increase in age, which again coincides with a similar pattern of increase in rhythmical hand gestures. As age increased, it was seen that the periods wherein the infant remained silent decreased considerably from the third month to the fifth month. Thus, as the infant developed, there seemed to be an increase in the occurrence of mature oral productions,

namely, vocalic and syllabic utterances, and a reduction in reflexive utterances and periods of silence.

With regards to co-occurrence, both vocal and gestural movements co-occurred as early as the third month in the infant, however there were variations in the instances of co-occurrence across the months. During the third month it was observed that hand gestures (both left and right arms), gaze patterns, facial expressions and facial movements were seen during periods of silence and during vegetative productions. Even in the fourth month the same trend was noted. But during the fifth month, these body movements were seen to occur more during vocalic productions as well as periods of silence.

From the data, it was also understood that there were increased occurrences of synchronous vocal-motor behaviours, which could possibly reflect the maturity of both these systems. Motor movements such as hand gestures and gaze were seen to occur during syllabic and vocalic productions. This finding could provide evidence to an age-related increase in frequency of vocal-motor coordination as reported by Iverson and Fagan (2004). Also, the infant seemed to be in the first phase of ‘initial linkages’ from the third month of age. But, this finding has to be considered with some caution since a good percentage of motor behaviours also co-occurred during periods of silence.

There was also little evidence to support the progression to the next phase of ‘emerging control’ in the fifth month. This could be because the infant was found to exhibit fewer instances of rhythmical motor and vocal behaviours in the 5 months. Thus, the data of this study does suggest the presence of a coupled vocal-motor system, but it is not sufficient to understand the exact nature of entrainment in this coupled system.

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Conclusion

From this study it can be observed that both whole body gestures and vocalic behaviours occurred frequently in an infant as young as three months of age. It can also be understood that across the three months there are variations in the behaviours exhibited by the infant, in that, some gestures like random lip and tongue movements, are seen more at a younger age, few others, like gaze track are seen during all the three months and some behaviours, like arm banging, were more frequent when the infant was five months old. This same trend was seen even for vocal productions. Since the data in this study is limited, one cannot draw conclusions regarding the growth trends for both these motor and vocal behaviours.

Co-productions of motor and vocal behaviours were also seen from the third month of age. There were instances of facial, hand and gaze gestures co-occurring with all types of vocal productions, namely, syllabic, vocalic and vegetative productions. However, there were variations seen between the third and the fifth months. With an increase in age, there was near-synchronous occurrence of body gestures with mature oral productions (syllabic and vocalic). But again, this conclusion is guarded since these behaviours were also frequently seen during periods of silence.

Thus, it can be reasoned that a typically developing infant is endowed with a repertoire of vocal, facial, and other bodily behaviours from a very young age and one can observe evidences of a strong link between vocal and motor behaviours as they co-emerge from the third month of life.

References

1. Capone, N. C. (2010). Gesture development. In B. B. Shulman & N. C. Capone (Ed), *Language development foundations, processes, and clinical applications* (pp. 177-194). Massachusetts: Jones and Bartlett Publishers.
2. Ejiri, K. (1998). Relationship between rhythmic behaviour and canonical babbling in infant vocal development. *Phonetica*, 55, 226-237.
3. Fogel, A., & Hannan, T. E. (1985). Manual actions of nine-to fifteen-week-old human infants during face-to-face interaction with their mothers. *Child Development*, 56, 1271-1279.
4. Iverson, J. M., & Fagan, M. K. (2004). Infant vocal-motor coordination: Precursor to the gesture-speech system? *Child Development*, 75 (4), 1053-1066.
5. Iverson, J.M., & Thelen, E. (1999). Hand, mouth and brain: the dynamic emergence of speech and gesture. *Journal of Consciousness Studies*, 6 (11-12),19-40.
6. Kimura, D. (1973). Manual activity during speaking in Right-handers. *Neuropsychologia*, 11, 34-50.
7. Lausberg, H., & Sloetjes, H. (2009). Coding gestural behavior with the NEUROGES-ELAN system. *Behavior Research Methods, Instruments, & Computers*, 41(3), 841-849.
8. Lew, A. R. & Butterworth, G. (1997). The development of hand-mouth coordination in 2- to 5-month-old infants: Similarities with reaching and grasping. *Infant Behavior and Development*, 20, 59-69.
9. McNeill, D. (1992). *Hand and mind: what gestures reveal about thought*. Chicago: University of Chicago Press.

10. Oller, D. K. (1981). Infant vocalizations: Exploration and reflexivity. In R. E. Stark (Ed.), *Language behavior in infancy and early childhood* (pp. 85-104). New York: Elsevier North Holland.
11. Thelen E. (1981). Rhythmical behaviour in infancy: An ethological perspective. *Developmental Psychology*, 17, 237-257.
12. Trevarthen, C. (1977). Descriptive analyses of infant communication behaviour. In H. R. Schaffer (Ed), *Studies in Mother-Infant Interaction: The Lock Lomond Symposium*, (pp. 227-270). London: Academic Press.
13. Veena, K. D. (2010). *Development of communicative gestures and speech in children during 8-18 months* (Unpublished doctoral dissertation). Manipal University, Manipal.

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Appendix 1

Appendix 1: Operational description of vocal and motor behaviours that were studied.

Motor behaviours		
Hand movements	Curled	Fingers flexed either loosely, or in a fist
	Index finger extension	Any clear sustained extension of the index finger
	Grasp	The hands / fingers are wrapped around something other than own hands
	Clasp	Any mutual contact of hands or fingers
	Spread	All fingers fully extended or spread apart
	Swing	Vertical movement of the arm from the shoulder with no object in hand
	Shake	Vertical movement of the arm from the shoulder with an object in hand
	Bang	Movement with the hand or object held in hand makes firm contact with a surface
	Hand in mouth	All fingers or any part of hand placed in the mouth

	Toy in mouth	Child places toy held in hand in the mouth
Facial movements	Pout	Puckered
	Puckered lips	'kiss-like' mouth formation
	Mouthing	Lip, mouth or tongue movements similar to when one speaks without phonation
	Tongue protrusion	Tongue extended and placed between lips
	Lip play	Rapid and repetitive movements of lips when at play
	Tongue play	Rapid and repetitive movements of tongue when at play
Facial expression	Smile	Edges of mouth curved upwards
	Distress	Furrowed brows towards eyes and pinched face
	Frown	Mouth slightly open with edges of mouth curved downwards
	Interest	Brows slightly raised
	Concentration	Brows raised at centre of face and lowered at outer edges of face
	Startle	Rapid and sudden blinking of eyelids
Gaze	Gaze at person	Looks at mothers/caregivers/speakers face
	Gaze at object	Looks at toy or any object
	Gaze at action	Looks at the behaviour of mother/object
	Gaze away	Looks at anything other than 'person' or 'object'
	Gaze track	Visual tracking of objects
Vocal behaviours		
	Silence	Periods where the child was not vocalizing
	Vegetative productions	Includes all reflexive productions such as cry, grunt, vocal play etc.
	Vocalic productions	All vowel productions
	Syllabic productions	All combinations of vowels and consonants

Source: Fogel & Hannan, 1985; Oller, 1981

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