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The development of visual attention in deaf children in relation to mother's hearing status

Patterns of visual attention during free-play in deaf children with deaf (Dd) and hearing mothers (Dh) were compared at 9, 12 and 18 months. Dd children were more likely to look at their mother's face spontaneously than Dh children at all ages although spontaneous looking increased significantly at 18 months for both groups. The proportion of responsive looks declined at 12 months for the Dd group but not until 18 months for the Dh group. Elicited looking was more common in the Dd group and, at 12 months, a greater proportion of these looks were to the mother's face. Overall the results suggest that Dd children show greater sensitivity to the communicative significance of their mother's face in the second year of life.

Keywords: Deafness, visual attention, mother-infant interaction

Introduction

Visual attention to the mother's face is important for many aspects of an infant's development. Berger (2006) describes the face as 'a complex dynamic visual configuration' and sees attention to the face as essential for 'normal social development and the development of social cognition'. In the earliest months of life visual attention between infant and parent occurs in face-to-face dyadic interactions (Tronick, Als, & Brazelton, 1980). However, around the middle of a child's first year, face-to-face interactions decrease as the infant becomes increasingly interested in objects or events in the environment. This marks the beginning of triadic interaction involving parent, child and the environment which affords an opportunity for joint attention to the external world.

Butterworth (2001) saw this development of joint attention as 'a precondition for the acquisition and use of language....' However, the ability to co-ordinate visual attention between the environment and a communicative partner may take a child many months to master. Bakeman and Adamson (1984) found that it was not till 18 months of age that the great majority of hearing children showed evidence of such co-ordinated joint attention. Joint attention is often achieved with younger children but this primarily

occurs because adults follow the child's focus of attention (Bakeman & Adamson, 1984; Harris, 1992). Bakeman and Adamson refer to the latter case as passive joint attention, the crucial feature being that infant and adult are engaged with the same object but the infant is not engaged with the adult. In case of co-ordinated joint attention, the infant is engaged both with the object and the adult in a triadic relationship.

For young hearing children, both passive and co-ordinated joint attention can occur without the child having to look at the face of the communicative partner since the child can focus on an object or event while listening to the adult's comments. The fact that the mother labels the focus of the child's interest ensures that the 'label' has a salient nonverbal context for the child. Such 'contingent naming' allows the child to make the link between an object and its label (Barnes, Gutfreund, Satterly, & Wells; 1983; Tomasello & Todd, 1983; Harris, Jones, Brookes, and Grant, 1986; Baldwin & Markham, 1989). By contrast, for deaf children – irrespective of whether communication is sign-based or oral – both the attended object and its verbal label are perceived through the visual modality, thereby creating a potential need for a deaf child to divide attention to perceive 'contingent naming'.

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Research into the signing strategies of mothers of young deaf children – and particularly those who are deaf themselves – suggests that at least some of the potential problems of divided attention can be resolved by adaptations of signing (see Spencer and Harris 2006 for a review). For example, in order to make their signs visible to young infants, mothers may displace signs into a child's line of sight. With older infants they may wait until the child looks at them before signing (Ackermann, Kyle, Woll, & Ezra, 1990; Mohay, Luttrell, & Milton, 1991; Spencer, Bodner-Johnson, & Gutfreund, 1992; Harris, 2001). Waiting to sign until a child pauses and looks up from an activity encourages the child to make the link between that activity and the sign but the success of such a strategy relies on the child looking at the mother, especially her face. In order to gain attention, deaf mothers may actively elicit their children's visual attention by waving or tapping and are much more likely to do so than hearing mothers of deaf children. Hearing parents, on the other hand, are not always as fully aware of their deaf children's visual needs. Reports (e.g. Scroggs, 1983; Swisher, 1991) of hearing parents signing when their children were not looking are testimony to the difficulties involved in changing an ingrained and largely unconscious communication style.

While visual attention to the mother's face is essential for perceiving signs, it is also important for oral communication since deaf children pick up essential information about speech from lip movements. Many deaf mothers also use exaggerated affect when communicating with young children (Erting, Prezioso, and O'Grady-Hyne, 1990) which provides strong cues to their reactions to an event and helps to sustain the children's attention. Visual attention to the face thus lies at the heart of successful communication for all deaf children and for the perception of sign, speech and affect. The main aim of the present study was to investigate the development of patterns of visual attention in two groups of deaf infants, one with deaf mothers and the other with hearing mothers.

Much of the research into visual attention in hearing infants has focused on the development of joint attention in mother-child dyads. It has been shown by Meadow-Orlans & Spencer (1996) that the time spent in coordinated joint attention by deaf 18-month-olds with deaf parents is similar to that spent by hearing children of the same age with hearing parents. In an extended analysis of the above study, Spencer (2000) found that the time spent in coordinated joint attention was affected by the make up of the infant-mother dyad with such attention being more prolonged when mother and child have the same hearing status.

Other studies (Harris & Mohay, 1997; Harris, 2000; Harris & Chasin, 2005) have looked at the nature of children's switches of visual attention towards their mothers. Harris & Mohay (1997) divided switches of attention into one

of three mutually exclusive categories. The first of these was 'spontaneous' in that the child looked spontaneously towards the mother; the second was 'responsive' in that the child turned towards the mother in response to some action she had carried out; the third category was 'elicited' where the mother made a deliberate and successful attempt to gain the child's attention. Harris and Mohay (1997) found that deaf and hearing mothers with young deaf children differed in their use of strategies to elicit attention with deaf mothers being more proactive than hearing mothers. Spontaneous and responsive looking patterns were similar for the two groups with the latter category being the most frequent; and, in both groups, children were most likely to be able to see signs that followed spontaneous or elicited switches in attention since they typically looked at their mother's face rather than at her hands or body.

The above research has established what the patterns of visual attention towards the mother are like at 18 months of age. However, the antecedents of these patterns are not so well known. The aim of the present study was to investigate the developmental course of visual attention in the first year and a half of life. Patterns of attention at 9 and 12 months were analysed in two kinds of dyad that both included a deaf child but differed in the hearing status of the mother. These earlier patterns were then compared with those found when the same children were 18 months of age to address three specific questions: did the younger children look towards their mothers as frequently as the older children; were the general patterns seen at 18 months in the proportions of children's spontaneous, responsive and elicited attention switches the same as patterns seen when the children were younger; and did the amount of looking to the mother's face change with age? Overall it was hoped that the study would determine what changes in the children's visual attention patterns were likely to be maturational and what, if any, changes had been influenced by the mother's hearing status.

Method

Participants

Nine infant-mother dyads were included in the study. Seven of these dyads had participated in earlier longitudinal investigations looking at the development of communication and language in deaf and hearing children. Two dyads, consisting of deaf infants and their hearing mothers, had not participated in any previous study. In five of the dyads both infant and mother were deaf (Dd). The remaining four dyads, consisted of deaf infants and hearing mothers (Dh).

All the children were deaf and had been diagnosed by the time they were six months old with a hearing loss of at least 90 dB. The five deaf mothers were users of British

Sign Language (BSL) which was the main language at home. There were three boys and two girls in the Dd dyads. The remaining four mothers were hearing. All primarily used speech but varied in the amount of sign language they used with their infants. One of the mothers was able to sign before her child was born while two of the other mothers learnt some signing after they discovered their child was deaf. The fourth mother relied mainly on speech and some gesture. The children in the Dh dyads consisted of two boys and two girls.

Observation and analysis

Mothers and children were observed during free play sessions in which mothers were asked to play informally with their children. A standard set of toys was supplied but children were not restricted to playing with these. All sessions were filmed for between 15 and 40 minutes. Filming was normally continuous unless mother or child went off camera. When this occurred, the recording was resumed as quickly as possible. All the deaf/deaf dyads were filmed by a deaf researcher while the deaf/hearing dyads were filmed by a hearing researcher. Most of the recordings were made in the children's homes but some were made in a video laboratory. Comparable patterns of mother-child interaction have been found to occur in both these settings when children are in the first two years of life (Harris, 1992).

Ten continuous minutes of the video recordings made when the children were 9 and 12 months of age were analysed and compared with a similar analysis made when the children were 18 months of age. Analysis usually began 5 minutes after the start of a session. This allowed mother and child enough time to settle down and become used to the recording procedure. A later segment was sometimes used when mother or child was not fully visible in the earlier part of a recording.

The tapes were analysed to determine the number of times the children turned their visual attention towards their mothers. This followed the procedure outlined in Harris and Mohay (1997). Each look towards the mother marked the beginning of a new attentional episode. Attention switches fell into three different categories. The first was 'Spontaneous'. Here there was no maternal input and the child looked to his or her mother spontaneously. In the second 'Responsive' category the child looked towards his or her mother in response to some maternal action such as moving an object when there had been no deliberate attempt on the mother's part to gain the child's attention. The final category was 'Elicited' where the child's mother had actively sought the child's attention by e.g., tapping or waving. Failures to gain child's attention were also noted. Reliability of the coding was assessed by two independent coders. Agreement ranged between from 85% to 95% with a mean of 90.6%. Inconsistencies were resolved by re-inspection of the videotapes.

The second analysis was concerned with where the children looked. Each look to the mother was coded as a look to her face, her hands, her body or to an object she was holding. Location of the children's gaze was again coded by two independent coders. Agreement ranged between 85% and 100% with a mean of 91.9%. Any inconsistencies were resolved as above.

Results

Attentional Episodes

Table 1 shows the mean number and proportions of attentional episodes of each type that occurred during the 10-minute period of analysis. The total number of episodes showed a gradual decline across time. The decline was similar for both dyad groups though the drop at 18 months of age was more pronounced in the Dh group. A priori polynomial contrasts revealed a linear trend in the declining number of episodes that was close to significance ($F_{(1,7)} = 4.671, p = 0.067$). Correlations revealed a significant relationship between the total number of episodes at 9 and 12 months of age ($r = +.774, p < 0.05$) but no significant relationship between 12 and 18 months of age ($r = +.396, p > 0.05$).

Given the variation in total number of episodes over time, subsequent analysis was carried out on proportions of each type of episode. Table 1 shows that Responsive episodes were most frequent across all three ages and for both types of dyad. However, it can also be seen that there was a decline in the proportion of responsive episodes across time which differed for the two types of dyad. When the children were 9 months old, the proportion of responsive looking was similar in both dyad groups. When the children were a year old, responsive looking in the Dd group had declined from 68% to 48% but a comparable decline was not seen in the Dh group until 18 months of age. Comparisons of the proportions of responsive episodes across time showed a significant effect of age ($F_{(2,14)} = 6.936, p = 0.008$) and a significant effect of dyad hearing status ($F_{(1,7)} = 5.669, p < 0.05$) but no significant interaction between age and hearing status. Comparisons between the groups showed that the only significant difference occurred at 12 months of age ($F_{(1,7)} = 9.859, p = 0.016$).

Spontaneous episodes were relatively infrequent for both groups at 9 and 12 months of age but they constituted a greater proportion at 18 months when they comprised 20% of episodes. Comparisons of proportions of spontaneous looking, using a two factor mixed design analysis of variance, showed a significant effect of age ($F_{(2,14)} = 13.885, p < .001$), a non-significant effect of dyad hearing status ($F_{(1,7)} = .877, p > 0.05$) and a non-significant interaction between age and hearing status ($F_{(2,14)} = .620, p > 0.05$). A priori contrasts of between within-subject means showed a significant difference between 12 and 18 months of age

Table 1
Mean percentage (and number) of different types of episode for each age and dyad group.

Age	Dyad	Spontaneous	Responsive	Elicited	Failed	Total
9 months	Dd	8.01 (6.60)	67.72 (55.80)	10.19 (8.40)	14.08 (11.60)	(82.40)
	Dh	8.98 (7.75)	80.86 (69.75)	5.52 (4.76)	4.64 (4.00)	(86.26)
	Overall	8.45 (7.11)	73.71 (62.00)	8.06 (6.78)	9.78 (8.22)	(84.11)
12 months	Dd	7.61 (5.80)	47.51 (36.20)	22.83 (17.40)	22.051 (16.80)	(76.20)
	Dh	8.09 (6.25)	80.91 (62.50)	5.50 (4.25)	5.50 (4.25)	(77.25)
	Overall	7.83 (6.00)	62.46 (47.89)	15.08 (11.56)	14.63 (11.22)	(76.67)
18 months	Dd	18.81 (13.40)	52.25 (37.20)	17.70 (12.60)	11.24 (8.00)	(71.20)
	Dh	27.80 (16.75)	64.73 (39.00)	2.48 (1.50)	4.99 (3.00)	(60.25)
	Overall	22.45 (14.89)	57.28 (38.00)	11.56 (7.67)	8.71 (5.78)	(66.34)

($F_{(1,7)} = 18.895, p < 0.005$) but not between 9 and 12 months.

As can be seen in Table 1, deaf mothers made many more both successful and unsuccessful attempts to elicit their children's attention than the hearing mothers did. Analysis of the proportions of successfully elicited episodes revealed a significant effect of age ($F_{(2,14)} = 4.057, p < 0.05$), a significant effect of dyad hearing status ($F_{(1,7)} = 6.246, p < 0.05$) and a significant interaction between age and dyad hearing status ($F_{(2,14)} = 3.812, p < 0.05$). Further non-parametric analysis found a significant effect of dyad hearing status at both 12 months ($Z = -2.205, p = 0.027$) and 18 months ($Z = -2.449, p = 0.014$) but not at 9 months ($Z = -.498, p > 0.05$).

Significant correlations were found between the proportions of all attempts to gain attention between 9 and 12 months of age ($r = +.685, p < 0.05$), between 12 and 18 months ($r = +.899, p < 0.01$) and also between 9 and 18 months of age ($r = +.739, p < 0.05$). This suggested that the proportions of attention seeking attempts exhibited by a particular Dd dyad characterised the interaction of that dyad over time.

Locus of visual attention

Table 2 shows the locus of children's looks towards their mother for each type of episode. Given the variation in the total number of different types of episode, looking is shown as a proportion for each type of episode. It can be seen that children were most likely to look at their mother's face in spontaneous episodes. This was the case at all ages and for both groups. In responsive episodes, children were most likely to look towards an object being held by the mother. Again this was true at all three ages and for both groups. The pattern for elicited episodes varied over time

and was different for the two types of dyad.

Since it is attention to the mother's face that is most significant for the development of language and communication, the proportion of episodes in which children looked to their mother's face over time and across dyad type was compared individually for each type of episode. For spontaneous episodes, there was a significant effect of dyad type ($F_{(1,7)} = 10.32, p = 0.02$) but no significant effect of age ($F_{(2,14)} = 1.59, p = 0.24$). The age x dyad interaction was also not significant. It can be seen in Table 2 that, at each age, children in the Dd dyads showed a higher proportion of looks to the mother's face.

For Responsive episodes, there was no significant effect of age or dyad and no significant interaction reflecting the fact that the pattern of looking to the mother's face was stable over time and across dyads. By contrast, for elicited episodes, there was a highly significant effect of age ($F_{(2,14)} = 29.95, p < 0.001$) and a significant age x dyad interaction ($F_{(2,14)} = 4.16, p < 0.04$) but the main effect of dyad was not significant. Table 2 shows that this interaction arose because the children in the Dd dyads showed a marked increase in looking to the mother's face at 12 months which persisted at 18 months whereas for children of hearing mothers this increase was not evident until 18 months.

Figure 1 shows the total number of looks to the face that occurred at each age and for each type of dyad. In both groups, looking to the mother's face was greatest at 18 months but, at each age, looking was higher in the Dd dyads. Analysis of variance revealed that there was a significant effect of age ($F_{(2,14)} = 4.05, p = 0.04$). However, neither the effect of dyad type ($F_{(1,7)} = 1.52, p = 0.26$) nor the interaction ($F_{(2,14)} = 0.31, p = 0.74$) was significant.

Table 2
Percentage looks to mother's face, an object held by mother or elsewhere for each type of episode at 9, 12 and 18 months of age.

Age (Months)	Episode type	Dyad type	Face	Object	Elsewhere ¹	Total
Responsive						
9		Deaf-Deaf	20.7	70.3	9.0	100
		Deaf-Hearing	12.4	77.9	9.7	100
12		Deaf-Deaf	18.6	70.1	11.3	100
		Deaf-Hearing	13.9	74.0	12.1	100
18		Deaf-Deaf	26.5	60.1	13.4	100
		Deaf-Hearing	15.1	70.6	14.3	100
Spontaneous						
9		Deaf-Deaf	77.1	5.0	17.9	100
		Deaf-Hearing	48.1	23.1	28.8	100
12		Deaf-Deaf	86.7	13.3	0.0	100
		Deaf-Hearing	72.1	5.0	22.9	100
18		Deaf-Deaf	89.9	3.4	6.7	100
		Deaf-Hearing	80.9	9.8	9.3	100
Elicited						
9		Deaf-Deaf	6.9	44.1	49.0	100
		Deaf-Hearing	9.6	37.1	53.3	100
12		Deaf-Deaf	41.7	36.1	22.2	100
		Deaf-Hearing	8.3	76.4	15.3	100
18		Deaf-Deaf	67.9	11.7	20.4	100
		Deaf-Hearing	87.5	12.5	0	100

¹ Looks classified as elsewhere were to the mother's hands or body

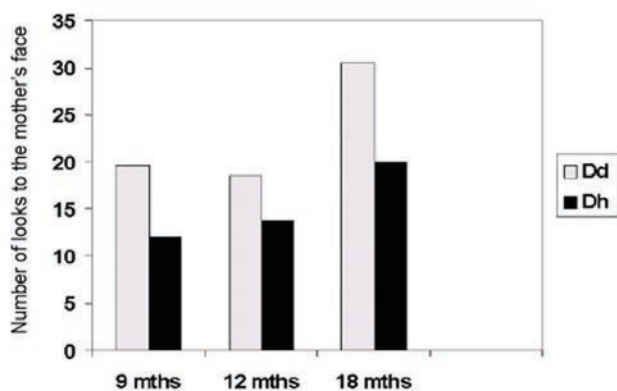


Figure 1. Total number of looks to the mother's face according to age and dyad type. Legend: Dd – deaf children and deaf mothers; Dh – deaf children and hearing mothers.

Discussion

The overall aim of this study was to examine the development of visual attention in deaf children of deaf and hearing mothers. In the introduction we posed three specific questions, the first of which concerned the total amount of looking to the mother. We found that there was an overall decline in the number of attentional episodes with a mean of just over 80 episodes at 9 months for both groups and a mean of 71 for the Dd dyads at 18 months and a mean of 60 for the Dh dyads. The fact that the number of attention switches was not affected by dyad hearing status suggests

that the reduction in episode numbers over time was, in large part, due to developmental changes in the children.

Notably, interactions became more sustained with time although, with the children's increasing independence, it often became more difficult for mothers to engage attention. The increasing role of the children in shaping the dynamic of the dyad as they moved into the second year of life is reflected in the fact there was a significant correlation in the total number of attentional episodes at 9 and 12 months but there were no correlations with the number of episodes at 18 months.

A major reason for the decline in the number of attentional episodes can be seen in the answer to the second question we asked. This concerned the relative proportions of responsive, spontaneous and elicited episodes between 12 and 18 months. Previous studies (Harris & Mohay, 1997; Harris, 2000) have shown that responsive episodes were the most frequent type of episode at 18 months of age. The present study showed that this was also true at 9 and 12 months of age. The decrease in the percentage of responsive episodes appeared to mirror the decline previously seen in the total episode numbers. Both age and dyad hearing status were shown to have a significant effect on the proportions of responsive looking with the decline following a different pattern in each dyad group. At 9 months of age, the children in the two groups did not differ in their proportions of responsive looking. By 12 months of age the proportion of responsive looking had dropped in the Dd dyads but had remained at the 9-month level in

the Dh dyads. A similar decline was not seen in the Dh children until 18 months.

One possible explanation for the earlier decline in responsive looking in the Dd dyads was the appearance of a substantial amount of elicited looking which occurred at 12 months of age in these dyads. This 'balancing' of responsive and elicited episodes may indicate that individual dyads have a characteristic and preferred rate of interaction. The general decline in responsive episodes over time suggests that the children were becoming more discriminating in the way they paid visual attention to a communicative partner. The differences between the two groups suggest that the deaf mothers were supporting this developing discrimination by beginning to shape their children's looking patterns by 12 months of age in a way that was not yet evident in the Dh dyads.

Age was also found to have a very significant effect on the proportions of spontaneous looking in both groups of deaf children. Spontaneous episodes, in which the children initiated looks towards their mothers, were relatively infrequent when the children were 9 and 12 months of age but their frequency had increased to 20% for both groups by 18 months. As this change was similar for the two groups, it is likely that the increase in spontaneous looking was due to the children's increasing maturity. Studies of hearing children (Schaffer, Collis & Parsons, 1977; Rutter & Durkin, 1987) have found that both 24-month-olds and 18 month-olds look at their mothers considerably more often than 12-month-olds.

Whereas the pattern of spontaneous looking was very similar for the two groups, the change in elicited looking was rather different. The proportion of elicited looks increased between 9 and 12 months for the Dd dyads while relatively little change was evident in the small amount of elicited looking seen in the Dh dyads over the same period. At 18 months there was still little elicited looking in the Dh dyads.

Although hearing mothers elicited much less than the deaf mothers, the deaf mothers themselves varied considerably in the amount they elicited their infants' attention. It is thought that the lack of a significant difference between the two groups at 9 months of age was due to the considerable individual variation among the Dd dyads. Successful and unsuccessful attempts to gain attention constituted over 50% of attentional episodes in one of the Dd dyads while there were no attempts to gain attention in one of the other Dd dyads. The individual variation among the dyads was also reflected in the finding of significant positive correlations in the proportions of attention-getting attempts (both successful and unsuccessful) between 9 and 12 months, 12 and 18 months and between 9 and 18 months of age. The strongest correlation occurred between 12 and 18 months. Other studies (e.g. Swisher, 2000) have found maternal eliciting behaviour to vary over time but the results of the

present study suggest that there is considerable stability in this behaviour in the second year of life.

The second part of the study focused on the development of children's attention to their mother's face. As in previous studies (Harris & Mohay, 1997; Harris & Chasin, 2005), responsive looking was most commonly to an object the mother was holding rather than to her face. This pattern was evident at all ages and for both groups. In both spontaneous and elicited episodes, there were notable differences between the children of deaf and hearing mothers. In spontaneous episodes, at 9, 12 and 18 months, the children of deaf mothers were more likely to look at their mother's face than children of hearing mothers. In elicited episodes, there was a significant developmental change which differed in the two groups. At 9 months, there was little looking to the mother's face in either group. By 12 months, children of deaf mothers showed a marked increase in the proportion of looks to the mother's face (from 7% to 42%) which was not shown by the children of hearing mothers. By 18 months, the majority of elicited looks were to the mother's face in both groups.

It should be noted that the total number of elicited looks remained relatively small especially for the children of hearing mothers so this finding should be interpreted with some caution. What is clear, however, is looking to the mother's face occurred most often in spontaneous and elicited episodes and it would appear that deaf children with deaf mothers become attuned to the importance of the mother's face at an earlier age than children of hearing mothers. It is also possible to speculate that, while the increase seen in spontaneous face looks was mainly maturational since it was not affected by dyad hearing status, the deaf mother's greater use elicitation provided their children with more opportunities to learn about the communicative importance of the face.

The final analysis compared the total number of looks to the mother's face across time. There was a significant effect of age with both groups showing the largest number of face looks at 18 month but there was no main effect of group and no group x age interaction. The total number of looks to the mother does not, however, tell the whole story about the development of visual attention. Another important aspect is the length of looks. Chasin (2005) found that deaf children of deaf mothers looked significantly longer at their mothers when they were 18 months old than did children of hearing mothers. Interestingly, this pattern mirrors the one found by Meadow-Orlans & Spencer, 1996 for more joint attention at the same age. They found that the *frequency* of bouts of joint attention did not differ between children of deaf and hearing mothers but that these bouts lasted *longer* for deaf children with deaf parents.

The general conclusion of this paper is that the children of deaf mothers were showing greater sensitivity to the communicative significance of their mothers face in that,

by 12 months, they were showing evidence of a marked attention to the face in elicited episodes which did not occur in children of hearing mothers until some months later; and, in spontaneous episodes, Dd children across the duration of the study, were more likely to look at their mother's face than those in the Dh group. However, in concluding the discussion, we would like to note that there was considerable individual variation among the dyads. For example, at 12 month, the proportion of looks to the mother's face across episodes varied from 19% to 69% for children of deaf mothers and from 12% to 36% for children of hearing mothers. This variability was also present at the earlier and younger ages and for the other measures that we report. We have also suggested that there was a consistency over time in the way that particular dyads interacted. Notably, there were correlations in the proportion of episodes in which mothers sought to gain their child's attention at different ages.

Characteristics of the interactional style of individual dyads is related to children's language development. In a recent study of the predictors of deaf children's language ability at 18 months (Spencer, Meadow-Orlans, Koester & Ludwig, 2004), a number of factors turned out to be significant. These were: children's visual behaviours (including social referencing and co-ordinated joint visual attention), the overall quality of children's behaviour during interaction, frequency of mother's signing and their rate of responding to their child's focus of attention. It was notable that the hearing status of the mother did not account for additional variance. This suggests that it is the quality of the interaction between child and mother, including the extent to which children have attuned their attention to their mother's face, which is important for the development of language.

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