PERCEPTUAL AND COGNITIVE FACTORS IN INFANT SOCIAL DEVELOPMENT

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ABSTRACT

This thesis considers infant social development from the viewpoint of the perceptual and memory capacities necessary for particular social abilities. Some social abilities, e.g. facial or voice discrimination, require visual or auditory integrity, thus the development of visual and auditory capacities are reviewed. Recognition of familiar faces and/or voices requires memory. Hence the development of memory abilities is considered. Subsequently the development of social behaviour is reviewed. After these literature reviews, three experimental studies are described. The first of these investigates the recognition of mother's voice and reports evidence of that such recognition develops during the first month of life. The second experiment considers visual recognition of the mother and differential responsivity to face-to-face and averted gaze and to different tones of voice. One month old infants did not reveal any conclusive evidence on these points. However, post-hoc analysis suggested the importance of the physical characteristics of faces in eliciting infant visual attention. Experience in these studies suggested the need for the study of more naturalistic encounters and hence a methodology for the study and analysis of naturalistic social interactions was developed. This methodology was then applied to a study of interactions between mothers and strangers with infants seen from one to eight months of age. This study revealed a surprising developmental pattern of differentiation between mother and stranger, with an unexpected period of positive responsiveness to strangers occurring at five months of age. The sequential analysis of interactions revealed evidence of a progressive development of infant receptivity to gaze, and also an exploratory analysis of receptivity to adult smiles and vocalizations suggested infants may respond to these adult behaviours. Subsequently the results of these studies are linked to other recent research.

CONTENTS.

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Chapter 1.

Introduction.

Sociability is a fundamental characteristic of humanity. Resolving how this sociability develops is thus central to an understanding of human nature. Ontogenetically research on such a topic inevitably focusses on infancy in that by the end of the infancy period the child has obviously developed a wide range of social behaviours.

These social behaviours include both productive and receptive capacities. Productive abilities are reflected in those behaviours that the infant emits which have an influence on the behaviour of others. Initially the infant may not intend such an influence, they are perlocutionary in Austin's (1962) terminology; yet nonetheless they are interpreted by others as indicative of the infant's state and hence serve a commmunicative function. Several writers e.g. Bowlby (1969) have hypothesized that certain behaviours of the infant, such as the smile, have evolved to act as releasers of affection in other humans, which would obviously foster the attachment of other humans to the infant, which would have obvious survival value for the species.

The infant also develops receptive social skills in terms of being able to respond to others. One aspect of this receptivity is the ability to respond differentially to different people; in particular, the mother. Such an ability would also have survival value for the species in that selective responsiveness to the mother will foster her attachment to the infant. Another aspect of social receptivity is the ability to respond to particular behaviours of another. Such receptivity is a prerequisite of all later communication and hence socialization.

In considering the development of the infant's responsiveness to people one has to consider the development of basic perceptual and cognitive processes within the infant, as such processes will obviously mediate the infant's perception of, memory for, and subsequent response to any person. Hence data on the development of such basic processes should aid in the interpretation of data on the development of social behaviour in infancy. This thesis aims to consider visual, auditory, and memory factors in the development of social behaviour during the first eight months of life. The infancy literature on vision is reviewed in chapter 2, audition in chapter 3, and memory in chapter 4.

Traditionally the literature on the development of basic processes and the literature on the development of social behaviours have not been integrated a great deal and where interaction has occurred it has tended to be in one direction only, viz. the literature on basic processes informing theorists on social development. However, when one considers that the infant probably encounters familiar people within his environment far more often than he encounters any materials used in the studies of perceptual and cognitive processes, it is a possibility that the behaviours shown to such people may reflect greater sophistication than that displayed to the inanimate, often unfamiliar materials used in most studies of perception and cognition. Hence it may well be the case that the data on the development of behaviour within a social context may provide information to supplement data derived from studies involving objects and hence influence our view of the infant's basic perceptual and cognitive capacities.

Social competence can be considered as the sum of the individual's social abilities. The infant's social abilities can be divided into productive abilities, i.e. those social behaviours initiated by the infant, and receptive skills i.e. those abilities involved in discriminating people and their actions. Three categories of receptive skill can be distinguished,

firstly discrimination of people from objects,
secondly discrimination of individuals,
thirdly discrimination of the behaviours of individuals.

Chapter 5 reviews the literature on these aspects of development.

Arising from these literature reviews numerous questions arise about the development of infant social behaviour. Experimental studies described in chapters 6, 7, and 9 attempt to answer some of these questions. Chapter 6 addresses itself to the question of whether the 1 month old can distinguish between individuals in the auditory mode, in particular, does the infant recognise a familiar voice. Chapter 7 is an attempt to answer the question of whether the 1 month old can distinguish people in the visual mode, and also can the 1 month old respond to 2 particular aspects of social behaviour, viz. tone of voice, and gaze direction. Chapter 8 describes a methodology for the investigation of the social abilities of infants in the context of naturalistic social interaction; and chapter 9 describes the application of this methodology to the development of social responsivity toward familiar and unfamiliar adults over the age range 1-8 months of age. Chapters 2-5 review the literature up to 1974 when experimentation started. The experiments took place over the period 1974-1978, and chapter 10 links the experimental findings with research up to 1979.

Chapter 2

Visual Abilities.

Knowledge of the development of vision aids understanding of the development of receptivity to facial-visual social signals, and hence this chapter reviews evidence on visual development.

Anatomical Data

The Eye

At birth the eyeball itself is aspherical, the sagittal diameter being greater than the vertical diameter (Mann 1964). However, as the infant develops the vertical diameter increases more rapidly than the sagittal diameter, and thus, the eyeball becomes increasingly spherical. The growth of the eyeball is quite rapid in the first two years and continues throughout childhood. Throughout its development the eye approximately doubles in size.

The Cornea.

Duke-Elder and Cook (1963) state that the cornea of the newborn is more spherical than that of the adult, and Walton (1970) has shown that the radius of curvature of the newborn cornea is about 1mm less than that of the adult. Mann (1964) states that the cornea of the newborn is both thinner and more refractive than that of the adult.

These differences would suggest that the newborn's peripheral acuity would be less than the adult's due to spherical aberration at the cornea. Also, the higher refractivity of the cornea in the newborn should compensate, somewhat, for the shortness of the eyeball.

The Lens.

Duke-Elder and Cook (1963) and Mann (1964) state that the lens of the newborn is more spherical and more refractive than the adult's lens. The greater refractivity should help to compensate for the shortness of the eyeball but the greater roundness of the infant lens may well have implications for accommodation (see section on accommodation)

The Retina.

By 7 months after conception the retina covers similar proportions, to the adult, of the eyeball inner surface, and the fovea is beginning to form (Duke-Elder and Cook 1963, Mann 1964). At birth the retina is reasonably well-developed but the macula is less mature than the rest of the retina, the cones being stumpier, comparatively few in number, and there is present a layer of ganglion, amacrine, and bipolar cells which will later disappear. By 4 months, the layer of ganglion, amacrine and bipolar cells has largely moved to the periphery, and the cones are longer and more numerous. However, Duke-Elder and Cook and Mann draw their conclusions on retinal development from the same data viz. Bach and Seefelder (1914). The postnatal section of this research involved the anatomical investigation of the eyes of three infants who died shortly after birth for unknown reasons, hence it is not known if they were developing normally. If they were of retarded development, which seems likely in that they died, then this data obviously presents an erroneous picture of the ordinary neonate's development. Therefore, we need to regard this data cautiously, but insofar as it is correct then it would indicate that marked changes in foveal activity are likely over the first 4 months of life; corresponding to the dispersion of the layer of ganglion, amacrine and bipolar cells.

The Optic Nerve.

Scammon and Armstrong (1925) have shown that the optic nerve is about two thirds of adult diameter at birth and slightly shorter in length. The rate of myelinization of the optic nerve is one of the most rapid in the nervous system. Langworthy (1933) found myelinization starting in the eighth month after conception. Nakayama (1968) has found myelinization as early as the sixth month after conception and that myelinization of the optic nerve was complete by one month after birth. This is supported by Last (1968), who found that myelinization of the optic nerve was complete by three weeks after birth. However, Duke-Elder and Cook (1963) and Walton (1970) do not find myelinization complete until four months after birth. Whatever the correct answer is, it is clear that the optic nerve is ready to function early in life, probably from birth onwards. Evidence of optic nerve function comes indirectly from studies of the functioning of the visual cortex. Obviously the fact that cortical evoked potentials in response to light stimulation exist in newborns demonstrates that the optic nerve must be functioning at some level.

The Visual Cortex.

Most of the data available on the development of the visual cortex comes from studies done by Conel (1939-1951)

Conel studied the anatomy of the cortex in infants from birth upwards, where the infants had died from some cause which was not suspected of affecting neural development. Conel presents his data by dealing separately with the newborn,the one month old, the three month old, and the six month old. The development of the visual cortex can be summarised as follows, in terms of Conel's criteria of development.

1. the width of the cortex increases
2. the density of nerve cells decreases
3. the size of nerve cells increases
4. there is an increase in the quantity and differentiation of chromophil
5. neurofibrils appear
6. nissl bodies between 1 and 3 months of age
7. there is an increase in the size and length of processes of nerve cells
8. nerve cells develop more pendunculated bulbs
9. the variscoties of nerve fibers increase
10. the size and quantity of exogenous fibers increase
11. myelinization starts between 1 and 3 months of age

The area OC develops in advance of OB which is in advance of OA. Hence it might be expected that OC would be capable of functioning at a higher level than OB and OA. However, as very little is known about the relationship between these anatomical changes and behaviour, any generalizations are made with trepidation: e.g. the appearance of nissl bodies or neurofibrils is not associated with any specific behavioural change Also, although myelinization speeds nerve impulse transmission, nerves will function before being myelinated

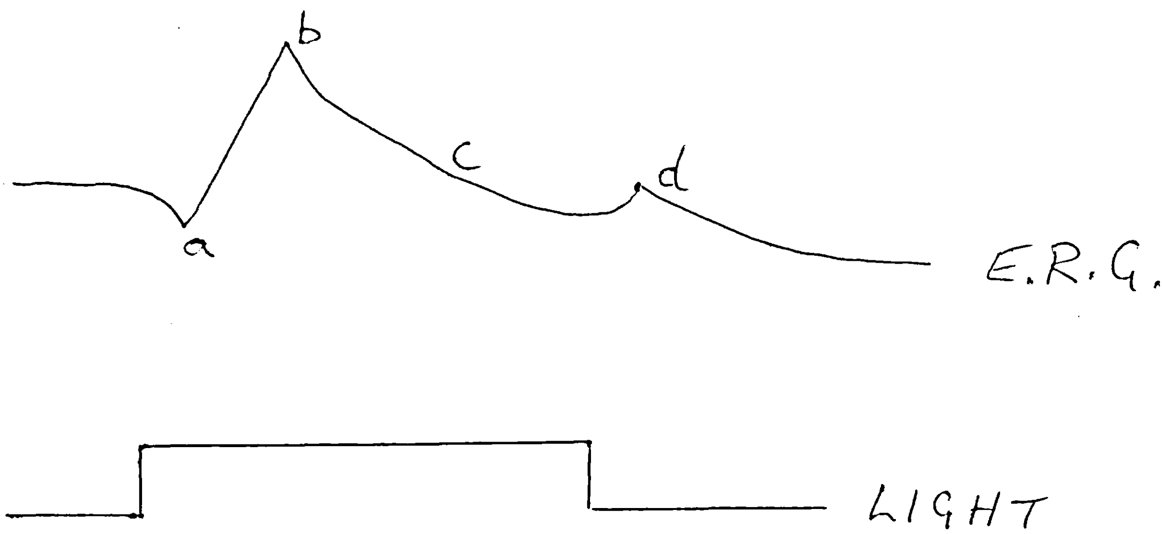
(Coghill 1929), so that the appearance of myelin between 1 and 3 months does suggest inceasing efficiency but not necessarily that the cortex only becomes functional between 1 and 3 months of age.

Physiological Data.

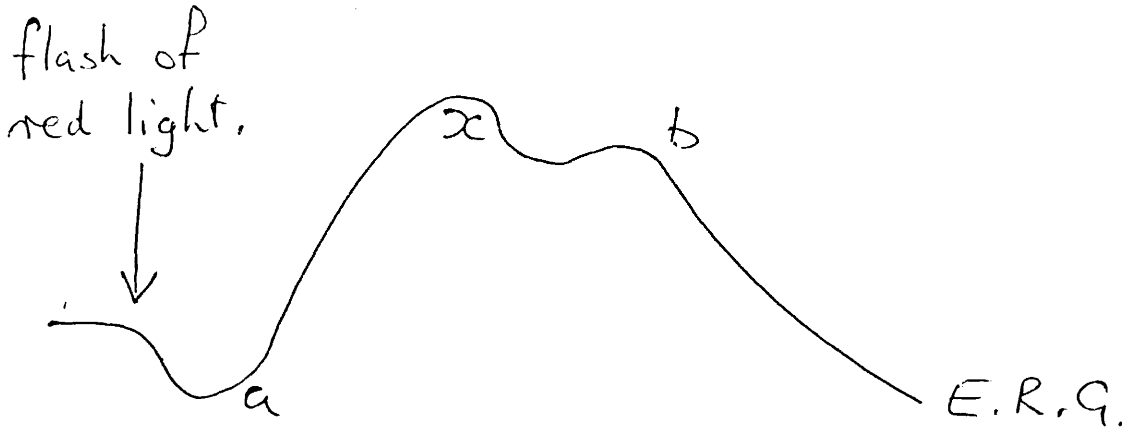
The Electroretinogram (ERG).

When stimulated by light a change in the electrical potential of the retina is produced. The ERG consists of a record of these potential changes. The potential is usually measured by an electrode attached to a contact lens, and a reference electrode on the forehead. Usually the eye is anaesthetized, the pupil dilated and the eye held open while exposed to diffuse light. To white light the adult's ERG consists of a small negative a-wave, followed by a large positive b- wave, which is succeeded by a slowly changing c-wave and at the end of the stimulus a small positive d-wave.

e.g. the ERG of a light-adapted adult to 1 second of white light.



To red light the ERG is different in form, an x-wave preceding the b-wave



Armington (1968) found that the size of these wave-forms are dependent on the intensity of stimulation, the a- and the x-waves increasing in amplitude as intensity increases. Also, amplitude varied with the size of the stimulus, the response disappearing with stimuli subtending less than 2 degrees at the retina. Armington (1966) found that the size of the b-wave varies greatly with the wavelength of the light used. These results have been confirmed by Riggs and Wootton (1972), who found that the size of the b-wave increased with duration of the stimulus up to 1 second

In comparing the results of ERG studies of adults with those of infants, it should be borne in mind that most studies of adults are done on awake adults but infants, when used in ERG studies, are usually asleep. Lodge et al. (1969) have found that the newborn's ERG shows similar patterns to that of an adult to changes of intensity of stimulation, i.e. as intensity increases, the amplitudes of the a-, b-, and x- waves increase, and the latency of the b-wave decreases. They did not use a stimulus of sufficient duration to test for a c-wave. Davson (1972) claims that the a-wave can only be recorded if the eye has cones in that species without cones (e.g. night monkey) do not show an a- wave. The full a-wave can only be recorded from inputs from fovea and periphery. On this basis, it seems that the a-wave reflects the activity of both rods and cones. Therefore, the newborn would seem to have both rods and cones functioning to some extent. The functioning of cones is supported by the observation of x-waves in newborns. The presence of the c-wave has not been adequately tested in newborns and the d-wave seems to be related to the a-wave in that their magnitudes are correlated across species, and they show maximum response to the same part of the retina.

To summarize, the data from the ERG indicates that the retina of the newborn is functional in certain respects, but it indicates very little about the visual abilities of the newborn, except that there is no raeson to believe, on the basis of ERG studies, that the infant is not capable of any form of vision.

Electrooculography.

If electrodes are placed on the skin next to the eye they will register an electrical potential. This potential is probably produced by the retina, and when the eye moves the potential changes. The electrooculogram (EOG) is a record of such potential changes consequent upon eye-movements. (It is not, as is sometimes believed, a record of potential changes in the ocular muscles.)

Electrodes are placed above and below the eye to record vertical movements and to either side to measure horizontal movements. This technique can measure movements as small as 0.5

degrees of arc and is commonly used for measuring movements 40-50 degrees from the centre of the visual field (Larson 1970) In order to relate the potential changes to eye-movements accurately, a calibratation procedure is necessary in order to calculate the degree of potential change for a given eye-movement for the individual concerned. This calibration procedure is eased by the knowledge that the relationship between EOG changes and eye-movements is linear up to about 15 degrees from the centre of the visual field. The problems associated with the EOG are that of linearity, which can be established by calibration, crosstalk between electrodes, which can usually be muted by repositioning of electrodes, the drift that occurrs in the resting potential of the EOG, which necessitates frquent recalibration, and the problem of head-movements. Trevarthen and Tursky (1969) have described an ingenious method of measuring EOG and head-movements simultaneously in infants and then estimating the change in fixation position by vector summation of eye and head-movements.

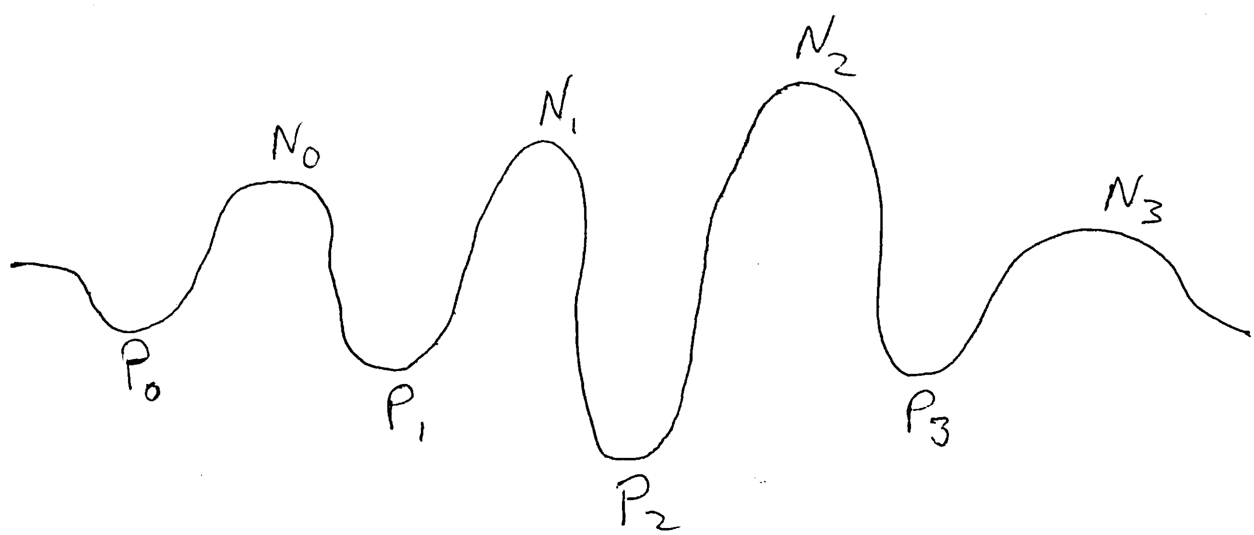
Dayton and Jones (1964) measured eye-movements in newborns and found that conjugate eye-movements frequently occurred but they are not explicit as to what proportion of eye-movements were conjugate. Similar results have been reported by Dayton et al. (1964), and Prechtl and Lenard (1967). Dayton and Jones also found that newborns were capable of tracking a target presented centrally and then moved left or right at 15 degrees per second. Tronick and Clanton (1971) used the EOG and head-movement measurement on infants 4-15 weeks of age. They describe 4 patterns of looking; 'shift', 'search', 'focal', and 'compensation' patterns. The 'shift' pattern denotes rapid movements of eye and head. The 'search' pattern is a series of saccades and fixations with slow head-movements. The 'focal' pattern consists of small saccades made when the head is still. The 'compensation' pattern is the compensatory movement of the eyes for a head movement. However, since they did not calibrate eye and head movements, it is difficult to conceive how they identified the 'compensatory' pattern. Presumably, they used this term to refer to movements of eyes and head in opposite directions and assumed that compensation was taking place. They found all the patterns in all the infants at all ages studied and they also found that saccades may be as speedy as 400 degrees per second, and that there was an increase in the amplitude of saccades with increasing age.

Bruner (1973) used the EOG to investigate eye-movements of 3-month olds watching films, while sucking a pacifier and while not doing so. Two films were used; one was an 'unconventional' film of geometric shapes moving haphazardly without appropriate perspective transformations; the second was a 'conventional' film of an Eskimo mother and child. With pacifiers the infants made similar eye-movements to either film, whereas, without pacifiers, more saccades occur to the 'unconventional' film. However,the differences between the two films were so great it is difficult to interpret what might be the cause of this difference. Moreover, as Bruner did not measure head-movements it is impossible to relate EOG records to actual patterns of looking, and, in addition, it is possible to that pacifiers affect head-movements as well as eye-movements. Hence, Bruner's claim that sucking acts as a form of buffer is hardly based on strong evidence.

These studies of infant EOG records tell us that the infant can control his gaze patterns considerably. However, they tell us little more due to the inadequate methodologies in the studies considered.

Visually Evoked Cortical Potentials

In response to visual stimulation, a change in the electrical potential of the visual cortex results. This is known as the visually evoked cortical potential (VECP or VEP). Ellingson (1967) has found that the best method of measurement is via an active electrode on the midline just above the inion, and a reference electrode on the rear of the head or earlobe. Because the VECP is weak and only just perceptible above the background EEG activity, averaging the VECP for a number of stimulus presentations is often used. Ellingson suggests an average of 10 stimulus presentations is appropriate, while this makes the VECP more apparent it also obscures information concerning response variability. The usual form of the VECP is as in the following diagram;



VECP responses show large individual differences and large differences within an individual due to state changes. The nature of the VECP is a function of these subject variables plus the following stimulus variables; intensity, colour, rate of presentation, pattern, clarity (contrast) and the retinal position.

Ellingson (1958,1960,1964) found that most newborns would show a VECP which consisted of a positive change P2 followed by a negative change N2, although some infants only showed one of these components. Ellingson (1970) reports that some newborns show up to 8 different waves in their VECPs. Ferris et al. (1967) found that some newborns showed P1 and in other infants P1 became apparent in the first 7 days. Also they found that by 2 months the infants' VECP was essentially similar to that of an adult.

Differences include infants showing a longer latency of the VECP than an adult. Latency is correlated with conceptional age and body weight (Ellingson 1968) but not with postnatal age (Umezaki and Morrell 1970). These findings suggest that latency of VECP is determined by maturity. Ellingson (1958) reported that the infant often shows a higher amplitude VECP than the adult, and this is supported by Umezaki and Morrell (1970), but this may be the result of the fact that the infants are sleeping and Barnet et al. (1968) have found similar amplitudes for infants and adults.

Harter and Suitt (1970) studied the VECP of 1 infant to checkerboard stimuli. They found that up to 35 days of age check-size did not affect VECP, but after 35 days of age, they found that the P2 component varied with check-size and that the size of the check that produced the greatest P2 response was the same as that which produced most attention in other infants. They also calculated from previous adult work that the 1 month old infant's response would correspond to an adult with an acuity of 20/500 (Snellen value) and that the infant at 3 months gave a VECP equivalent to that of an adult with an acuity of 20/250. If the results of Gorman et al. (1957), Fantz et al. (1962) and Ordy et al. (1964) are converted to Snellen notation then they give results of newborn acuity of between 20/400 and 20/800 and that infants in the third month of life yield an acuity figure of 20/200. These results show good agreement with Harter and Suitt. However, the work of Dayton et al. (1964) does not fit this pattern as their results indicate a newborn acuity of 20/150. There are good reasons for believing Dayton et al.'s results to be the most accurate (see section on OKN studies) also it should be borne in mind that a) Harter and Suitt used only 1 infant whose acuity may not have been as good as the infants in Dayton et al.'s study and b) that the calculation procedure derived from adult work by Harter and Suitt may not be applicable to infants. Hence, on this evidence, it seems that the VECP is not likely to lead to a more accurate acuity estimate than the more direct methods of Dayton et al..

Karmel et al. (1970) also found with infants of 2 to 5 months of age that the size of check which produces the greatest P2 component of the VECP is that which produces most attention in other infants. Karmel relates these findings to the amount of contour in the stimulus and shows that VECP P2 amplitude is an inverted U-function of the amount of contour in the stimulus. Karmel et al. (1974) also find that infants who show the greatest P2 response to the smallest checks (and by that criterion are 'advanced') also show a P2 response with a short latency and therefore on that criterion seem 'advanced'.

Infants differ from adults in their VECP response to flashing lights. Ellingson (1958) found that most newborns have a 1 second refractory period after a flash when they cannot show a second response, whereas adults have a refractory period of only a tenth of a second. Almost all infants will show photic driving (Ellingson 1967) but that the optimal rate changes from 2-3 Hz. in the first 2 months to 8-10 Hz. in the third month.

The interpretation of VECP studies is problematical. Firstly, there is no clear relationship between neurological functioning and the VECP; e.g. Watanabe et al. (1972) found that infants who had abnormal neurological symptoms (hyperirritability and convulsions) showed normal VECPs. Also Ellingson (1968) found that subjects with severe visual defects show a normal VECP record.

Various parts of the brain and visual pathway have been suggested as the origin of the VECP but there is no strong evidence on this. There is the further problem with infants that so many neurological developments are occurring simultaneously; it is pure speculation as to what are the causative changes for the observed developments in VECP. However, Hrbek et al. (1973) have shown that the relative maturity of the visual cortex and somatosensory cortex parallel the maturity of the corresponding evoked potentials, which does suggest that the overall maturity of the visual cortex is one contributing factor to development of VECP responses.

In conclusion, Ellingson's data does show that all the principal components of the VECP are present in the neonate. Therefore, insofar as the VECP reflects cortical functioning, we may tentatively conclude that the neonate visual cortex is functioning, and that there are marked changes in functioning as measured by the VECP in the early months of life. Hence, one might expect marked changes in visual competence as a consequence of these changes.

Behavioural Data.

Accommodation.

Evidence suggestive of accommodative capacity is provided by a study by Fantz (1963). Neonates were presented with a grating pattern paired with a homogeneous surface, and looking time at either of the pair recorded. This procedure was repeated for various grating patterns. Preferences for grating patterns over an homogeneous surface, independent of any head position preference, consistently emerged. This preference was maintained whether the viewing distance was 5, 10, or 20 inches. It might be taken that this is evidence of accommodation, however, it is perfectly feasible that a neonate may not be accommodating to the different distances but can still discern sufficient pattern from his unfocussed image to maintain a preference.

Haynes, White and Held (1965) did a study of the accommodative capacity of infants at various ages using dynamic retinoscopy. They found that in the first 2 months of life, the eye of the infant was focussed at a point approximately 7.5 inches(19cm) from the eye, and that the infant could not alter this, i.e. had no accommodative capacity. They found that accommodation began at approximately 2 months of age and reached adult levels at approximately 4 months of age. However, there are several reasons for doubting the validity of these results. Firstly, accommodation readings can only be taken when the eyes are still yet newborns move their eyes at least twice a second (Haith 1968). Secondly, Haynes et al. used a red annulus containing black dots as the stimulus for fixation, and Hershenson (1967) has pointed out that such a stimulus may not be an adequate elicitor of infant fixation, particularly as at far distances, the dots may have been too small to resolve. Haynes et al. do not state the size of the dots, hence it is difficult to evaluate this criticism. However, the whole methodology of Haynes et al. rests on the assumption that the infants were fixating the stimulus, yet they present no evidence that this was the case. If this criticism does hold then the results of this study may be due to the poor acuity of the newborn and the lack of an appropriate fixation stimulus, and that the results indicating developing accommodation may be due to developing acuity rather than accommodation.

However, this study is the best estimate currently available for the accommodative powers of the infant even if it may underestimate the infant's ability due to reasons given above.

Acuity.

Optokinetic Nystagmus (OKN) studies

If a repetitive pattern is moved in front of a subject at a constant speed, he will fixate part of the stimulus and after a short time saccade back to fixate another part of the stimulus. These responses are repeated in a rhythmic fashion and are called optokinetic nystagmus. Gorman, Cogan and Gellis (1957) presented infants, up to 6 days old, with a moving pattern of black and white bars each of which subtended an arc of 33.5 minutes at the retina. 93 of 100 infants showed the OKN response to this stimulation, thus showing that young infants had acuity at least good enough to discriminate stimuli subtending 33.5 minutes of arc at the retina (adults can discriminate stimuli subtending 1 minute of arc) which would enable them to perceive quite small patterns.

Gorman, Cogan and Gellis also presented the same infants with a pattern with bars subtending 11.1 minutes of arc and did not find an OKN response regularly. However, one might question their methodology insofar as it may limit the sensitivity of acuity assessment. Firstly, the presence of an OKN response was made by an observer, who did not have a very clear view of the infant's eyes, and also they do not quote observer reliability figures. Secondly, EOG records are a more reliable method of judging OKN responses than observers. Thirdly, the movement of the stimulus was provided by a handcrank, and hence the movement may have been unsteady, eliciting an unstable OKN response. Fourthly, presentation of the narrow stripe pattern always preceded the wider stripe pattern and hence there is the possibility of order effects in their data.

Dayton, Jones, Aiu, Rawson, Steele and Rose (1964) also used the OKN technique to investigate acuity. They tested 39 full-term infants from 8 hours to 8 days old, using stripe patterns which subtended 7.5, 14.9 and 22.3 minutes of arc at the retina. Movement of the patterns was provided by an electric motor and the speed of movement controlled to 16+-2 degrees per second. The duration of the stimuli was 8 seconds, rather than 90 seconds as in Gorman et al. (1957), thus reducing the possibility of fatigue. Recording of the OKN response was accomplished via EOG records. Of the 39 subjects only 18 yielded usable records. 7 subjects being eliminated by technical problems, and 14 gave no evidence of an OKN response to any target. Of the subjects that showed OKN responses,

9 showed OKN responses to all stimuli used,

5 " " " " 14.9 and 22.3 stimuli only

4 " " " " 22.3 stimulus only.

Thus, this experiment demonstrates that some infants, in the first 8 days of life, can discriminate lines of 7.5 minutes visual angle.

Ordy, Latanick, Samorajski and Massopust (1964) used a similar methodology to Gorman et al. (1957) to investigate acuity in children over the first 5 months of life. They found 2 week old infants showed OKN responses to stripes of 20-40 minutes of arc. This is a similar result to Gorman et al.'s but is subject to the same criticisms as that study. It seems that the better acuity figures found in Dayton et al.'s experiment reflect their more sensitive stimulus presentation and measuring techniques.

A problem with the OKN method of establishing acuity is that infants' hyperopia and lack of accommodation may lead to the stimuli not being properly focussed on the retina. Hyperopia is very common in young infants according to Cook and Glasscock (1951), and the young infant has no accommodative capacity until 2 months of age according to Haynes et al. (1965) and until this age the infants lens is fixed such that only stimuli 7.5 inches are in focus. None of the OKN studies used this distance so that they may well have underestimated infant visual acuity because the stimuli would not have been in focus for the infants. Also, in adults the measurement of acuity by OKN techniques is not as sensitive as behavioural techniques (Reinicke and Cogan 1958). However, Fantz, Ordy and Udelf (1962) used OKN and fixation- preference techniques to establish acuity in infants 1-22 weeks of age and found that OKN techniques were more sensitive for the first 2 months and after that fixation-preference was the more sensitive. However, the fixation-preference technique is itself subject to a number of criticisms (see next section) and hence one may still question the OKN technique of measuring visual acuity.

In summary, OKN studies have yielded figures for infant acuity which establish that <u>some</u> infants have acuity sufficient to discriminate stripes of 7.5 minutes visual angle. However, due to the limitations in the methodologies used, e.g. not presenting stimuli at the appropriate ditance for infants to focus, one cannot accept the results of OKN studies as giving the lowest estimate of visual acuity.

Preference studies

Fantz, Ordy and Udelf (1962) used the visual preference technique to investigate acuity in infants 4 days to 1 month old. They found preference for stripes over homogeneous fields with stripes of 40 minutes visual angle or greater (equivalent to 1.5 cycles per degree or Snellen acuity 20/400). They also found similar results with OKN techniques. Stimuli were presented at 5, 10, and 20 inches were little effect of distance and from this the investigators conclude that the infants are accommodating in this range (see section on accommodation pp. Haynes, White and Held 1965).

Miranda (1970) has used the same technique for preterm and term newborns and found that they would respond to stripes equivalent to 1 degree of visual angle (0.5 cycles per degree, 20/600). Teller et al. (1974) have used a modified fixation preference technique to test acuity. They presented striped and plain stimuli to infants 42 days to 6months old. An observer, viewing through a peephole between the 2 stimuli, judges which position the striped stimulus is in. The observer makes the judgement on the basis of eye and head movements of the infant and does not use corneal reflections. The results of this experiment indicate that 2 month old infants respond to stripes equivalent to 2 cycles/degree and that there was a gradual improvement in acuity up to 6 momths of age when an acuity figure of 3.75 cycles/degree was usual. These results are in broad agreement with those of Fantz et al. (1962)

Using a similar technique to Teller et al. (1974), Atkinson, Braddick and Braddick (1974) studied the acuity of 1 infant between 50 and 62 days of age. They presented sinusoidal gratings paired with a grey surface of equal luminance. Sometimes the gratings were moving and sometimes stationary but flashing. They found that this infant responded to gratings of 8 cycles/degree (7.5 minutes of arc) which is higher than previous acuity figures derived from preference studies. This may reflect the use of flashing and moving gratings, which may be more effective elicitors of infant attention, and also the fact that the presentation distance was within the theoretical accommodation range of the infant.

In comparing the results of studies of visual acuity, it appears that OKN studies may attribute the infant with better acuity than visual preference studies. This may reflect the inherent limitations of preference studies i.e. lack of preference does not necessarily indicate lack of discrimination, or it may reflect the fact that moving stimuli are used in OKN studies. This latter possibility is supported by the results of Atkinson, Braddick and Braddick (1974) who find better acuity estimates than usual for the preference technique, when they presented flashing and moving stimuli. It may be that acuity for stationary and moving stimuli are not directly comparable

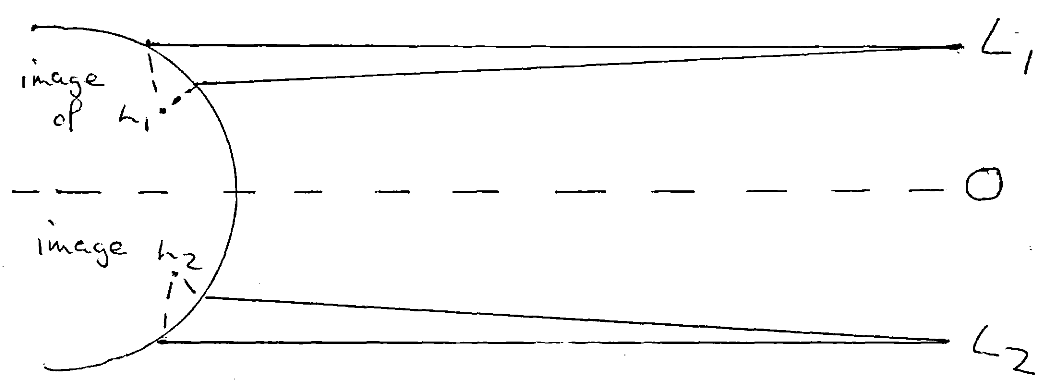
Form Perception.

Research on form percption has been largely concerned with 2 types of information on infant responsivity to pattern. The first of these is the nature of infant scanning patterns as measured by the corneal reflection technique; and the second is the basis for infant visual preferences between patterns. A little effort has been devoted to the study of gestalten in infant perception, and much research has looked at special aspects of pattern perception e.g. familiarity and facelikeness. These latter two aspects are dealt with in later chapters.

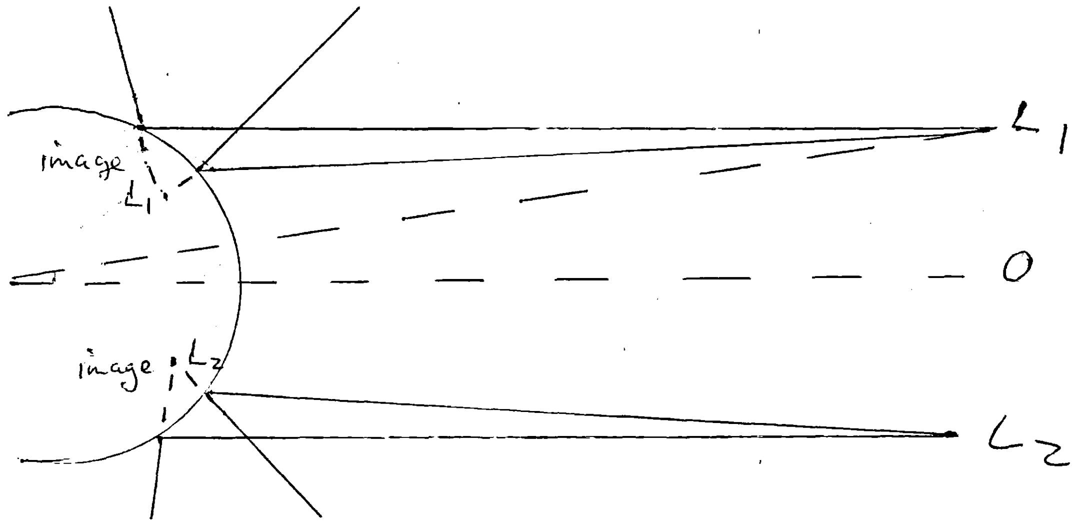
Infant Visual Scanning.

Corneal reflection technique.

The cornea of the eye acts as a convex mirror in that a proportion of incident light is reflected from the cornea. This fact is utilised in the corneal reflection technique which uses this reflected light as a means of estimating the infant's direction of gaze.

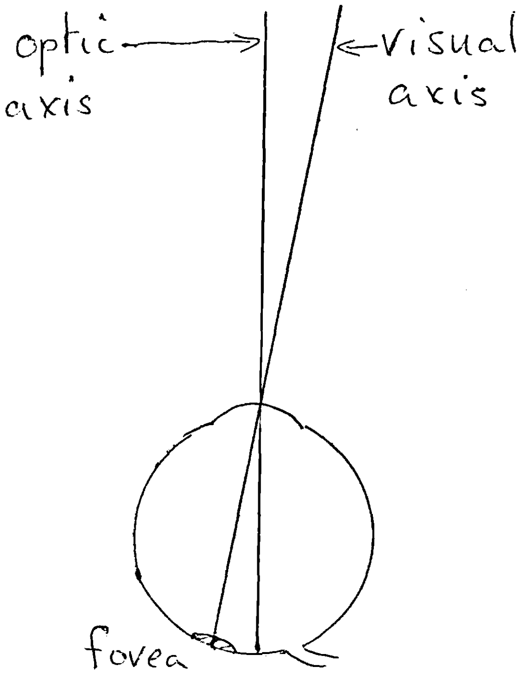


If O is positioned between 2 lights L1 and L2, and the subject looks at O then to O the images of L1 and L2 will appear equidistant from the centre of the pupil. However, when the subject looks toward L1 then the image of L1 will appear to be nearer the centre of the pupil than the image of L2.



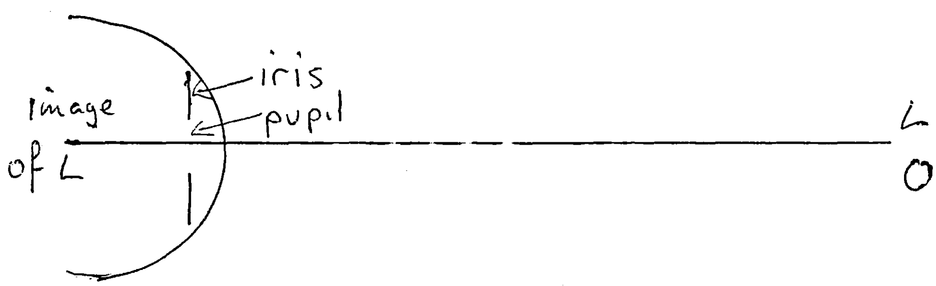
Now, these observations may be made by a live observer but the changes in fixation are often too quick for such an observer to be accurate. Therefore, a photographic record of the eye is usually used, to measure infant fixations in the following way.

The infant views a figure on a screen, behind which is a film camera (or CCTV camera) which photographs one eye of the infant. Infra-red light sources are also positioned behind the screen, and the camera provides a record of the reflection of the infra-red lights from the cornea of the infant's eye. By measuring the distance from these infra-red reflections to the centre of the pupil, the fixation point of the infant on the screen may be determined. The usual procedure using this technique is to take that point on the target, whose image coincides with the centre of the pupil, as the fixation point. Slater and Findley (1972), however, point out sources of error in this procedure. Firstly, the visual axis is not coincident with the optic axis.

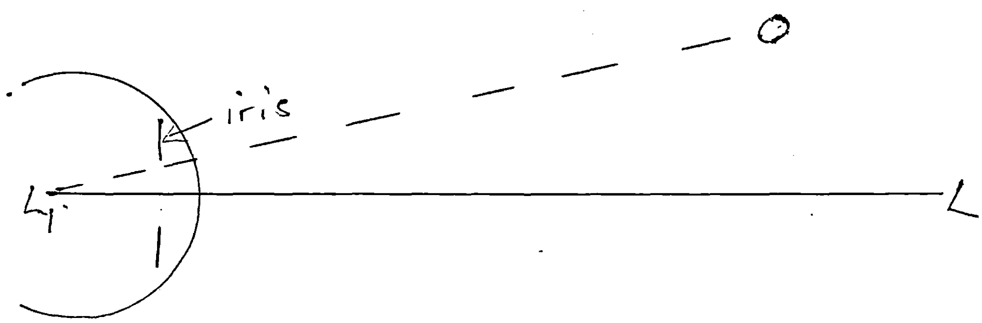


The procedure of taking the point of the target whose reflection is on the centre of the pupil assumes correspondence of visual and optic axes, hence this procedure will give errors dependent on the displacement of visual and optic axes.

Secondly, Slater and Findley point out the error involved in projective distortion.



The virtual image of the light L is produced behind the pupil. If the light and observer are coincident then this is not a problem. However, as the light and observer are, in practice, separated then the projection of the image of the light as if it were in the same plane as the pupil leads to a parallax error.



The position of the light image appears displaced on the pupil toward the observer, as compared with the position it would have if it were formed on the pupil.

Thirdly, Slater and Findley point out that the corneal reflection technique relies on formulae which do not hold true when the image is not near the optic axis. There is an error introduced herein that fixations will be displaced more from the midline the farther the stimulus is from the midline.

Taking these points together, Slater and Findley argue that the 'off-contour' looking reported by investigators using the corneal reflection technique, may in fact be 'on-contour', but that it appears 'off-contour' because of these errors. Similarly, the lack of convergence reported by Wickelgren (1967) may be a result of these errors.

Wickelgren (1967,1969) has used this technlque to investigate how well the infant coordinates both eyes. It was found that newborns show frequent conjugate eye-movements in that the eyes move in the same direction at the same time. However, the newborns' eyes were found to be rarely convergent in that the right looked to the right of the visual field and the left looked at the left of the visual field. Slater and Findley (1972a) suggest that this apparent lack of convergence may be an artefact of taking the visual axis as coincident with the optic axis. Slater and Findley suggest that if the newborn is converging then one would expect the pupil centres to be oriented 16 degrees apart, and therefore the eyes would appear to be diverging by 16 degrees according to the criteria used by Wickelgren. Hence, it would appear possible that the newborns in Wickelgren's study may have shown convergent eye-movements more often than Wickelgren reports. However, some of the divergences reported by Wickelgren are greater than the expected divergence calculated by Slater and Findley, and whether these may also be artefactual or the result of actual lack of convergence is problematical.

Much research using corneal reflection has looked at responsiveness to various angles and contours. Salapatek and Kessen (1966) found that the newborn will scan a blank field in all directions but horizontal eye-movements predominate, and when presented with a triangle the newborn typically concentrates fixations on a single feature of the stimulus, usually an angle

Nelson and Kessen (1969) found that closed figures including angles, like triangles, attracted more newborn attention than just angles alone, even though most attention in the closed figures was to angles. Also they found that figures made up of sides alone did not elicit any fixations. Thus, it does seem that the angle of a closed figure is the most effective elicitor of newborn visual attention and Kessen, Salapatek and Haith (1972) found vertical edges more effective than horizontal edges.

Salapatek (1969)found a similar pattern of fixation on a limited part of the stimulus in 1 month olds, even if the stimulus was complex and irregular. However, 2 month olds scanned all parts of the figure with fewer and longer fixations. In this study, Salapatek also used figures within figures, and found that 1 month olds fixated on the external contour mostly, whereas 2 month olds fixated the internal contour most often. This result was not an artefact of the infant's fixation capabilities in that both 1 and 2 month olds would look at either figure when presented on its own.

In line with these findings with geometric forms, Bergman, Haith and Mann (1971) found a similar phenomenom when infants looked at faces. 5 week old infants looked at the perimeter such as the hairline or chin, while 7 week olds did look more often than 5 week olds at internal features of the face. Donnee (1973) found a similar pattern and in addition 10 week olds returned to looking at the perimeter.

Generally, the results of studies using the corneal reflection technique stand despite the criticisms by Slater and Findley. The possible exception being the work by Wickelgren claiming to show non-convergence, which may be an artefactual result of failing to take account of the errors outlined by Slater and Findley with infants who may have been showing convergence. However, the work of Slater and Findley does suggest that much of the apparent 'off-contour' looking found in these studies may be 'on-contour', but this does not alter the nature of the conclusions to be reached from these studies.

The conclusions that can be drawn from these studies are that newborns show perception of some elements of form e.g. angles, and that there are developmental changes in their scanning patterns which suggest a change in the nature of the perception of form between 1 and 2 months of age in terms of an increasing ability to take account of the internal features of a stimulus. Also, there is a development of the ability to scan many aspects of the pattern presented rather than being 'captured' by one element of the pattern which may be a sign that the infant is moving from perception of parts to perception of a whole form. The fact that infants in these studies initially sees the point of the target that is fixated initially peripherally, demonstrates that peripheral vision is functional, and also the fact that a stimulus selected is held in central vision does suggest that central vision is more sensitive than peripheral vision, although the extent of the development of the macula is unknown because the error variation inherent in these techniques is greater than the size of the macula, hence it is impossible to say whether any given point of the stimulus is focussed on the macula or not.

A general point one might make on these corneal reflection studies is that the infants used as subjects have all been on their backs in the experiments. Now there is evidence that infants in this position are not as alert as when in a more upright position (Prechtl quoted in Bower 1974). In particular, there does seem to be an increase in the amount of scanning that the infant does when upright. Therefore, the scan patterns generated in these experiments may not be representative of the perceptual processes of the infant when fully alert.

Infant form perception as revealed by preference studies.

Stirnimann (1944) held up plain and patterned cards to infants 1-14 days old. The infants looked more at the patterned cards than at the plain cards. Fantz (1958) followed up this early study and used a paired presentation procedure to evaluate infant preference. Stimuli would be presented on either side of the infant's visual midline and preference was determined by recording and comparing the times the infant spent looking at either of a pair of patterns. Presentation positions were counterbalanced. Fantz found that 1-6 week old infants preferred red and white checkerboards to a plain red square. In 1961 Fantz reported that infants 2-3 months old preferred black and white patterns (face, bull's eye, and newsprint) to plain red, yellow or white stimuli; and in 1963 Fantz reported similar results for newborns. These early studies confound colour and brightness with pattern differences, however, Fantz controlled for these in subsequent studies and Fantz (1965) found that neonates preferred black and white checkerboards to plain grey squares of equivalent brightness. Using similar techniques, Spears (1964) presented 4 month old infants with stimuli varying in colour and/or shape and found that shape preceded colour as a basis for preference, if a pair of stimuli varied in both colour and form. These early studies demonstrated clearly that there was at least some element of form perception from birth. Later research has gone on to look at the nature of these form preferences in terms of whether they are based on the complexity of the stimulus or the amount of contour in a stimulus.

Complexity and contour

Berlyne (1958) found that 3-9 month old infants preferred to look at patterns with the greatest amount of contour. This finding led to the suggestion that infants are responding on the basis of stimulus 'complexity'. Hershenson (1964) found that 2-4 day old infants preferred the least complex stimulus where complexity referred to the number of checks in a checkerboard. 2x2, 4x4, and 12x12 checkerboards were used. Thomas (1965) used the judgment of students to order stimuli in terms of complexity and presented the stimuli to infants 2-26 weeks of age and found a tendency for the older infants to prefer the more 'complex' stimuli.

Hershenson, Munsinger and Kessen (1965) showed newborns stimuli varying in the number of angles and found that fixation time was an inverted U function of number of angles, figures with 10 angles being preferred over figures with 5 or 20 angles.

Fantz (1966) using schematic faces varying in number of elements found that infants varying in age from newborns to 6 month olds all preferred the most complex of the schematic faces. Perhaps these results reflect not 'complexity' preferences but preferences based upon experience of 'faces'.

The situation up to this time seemed confused with different researchers using different materials, and different age subjects coming up with very different results. Brennan, Ames and Moore (1966) did a study which illuminated this topic somewhat in that they found that 'complexity' preferences were age-related. They found that:
3 week olds preferred 2x2 checkerboards
8 week olds preferred 8x8 checkerboards and
14 week olds preferred 24x24 checkerboards.
Spears (1966) could find no complexity preferences by 4 month olds for 5 polygons, however, his figures were all simple and may have been too simple to elicit preferences from 4 month olds.

McCall and Kagan (1967) have found that 4 month olds did not show any regular preferences between figures containing 5, 10, or 20 angles, but that their preferences could be explained as an inverted U function of the amount of contour in the figures. Cohen (1969) showed

2-6 month old infants a light that was stationary, or that changed amongst 4, 8 or 16 positions. His subjects preferred the light that changed amongst 4 positions which could be interpreted as a preference for intermediate complexity.

At this juncture there is evidence of age-related preferences in 'complexity', but no clear concept of 'complexity' exists. Karmel (1969a) found that the preferences of 68-148 day old infants could be best explained as an inverted U function of the amount of contour in the figure, regardless of whether the contour was random or redundant. This finding supports the earlier finding of McCall and Kagan (1967). Also this finding was supported by Karmel (1969b) who found that 13 and 20 week olds showed preferences amongst random and redundant check patterns, which were consistent with an inverted U function of the amount of contour. Karmel also calculated that the data of Brennan, Ames and Moore (1966) and Hershenson (1964) fitted the same conceptual model well. McCall and Melson (1970) found that fixation was a function of contour length in arrangements of squares varying in regularity, further supporting Karmel's proposition.

Moffett (1969) looked at the effect of 2 variables on the visual preferences of 10-19 week olds. She found that one major determinant of preference was amount of contour, but also that when contour was equated that the number of separate parts formed by crossing of lines was also an important determinant. Thus it would seem that more than just contour was important in determining preference, possibly the number of angles was also important, in that as the number of crossings increase so do the number of angles.

Greenberg and O'Donnell (1972) investigated visual preferences in 6 and 11 week old children for

a) patterns of dots varying in complexity

b) patterns of checks varying in complexity and

c) patterns of stripes varying in complexity.

In each case the 11 week olds preferred more complex patterns than the 6 week olds.The amount of contour was equated across the 3 types of pattern, but there was a main pattern type effect, and interaction effects occurred involving pattern type. Therefore, Greenberg and O'Donnell argue that contour per unit area is not the sole determinant of infant visual preferences They interpret their results as supporting the proposition that infants will prefer that level of complexity which gives rise to an optimal level of stimulation, which will be age dependent. Karmel (1974) argues that Greenberg and O'Donnell have not calculated the degree of contour appropriately for their stimuli and that when the amount of contour is recalculated then the preference data of Greenberg and O'Donnell can be accounted for on the basis of contour effects alone.

There are some general points one could make about research on infant form perception. With regard to the corneal reflection technique the assumption appears to be that the infant perceives form via a series of foveal fixations. Such an approach ignores the role of peripheral vision in perception and peripheral vision is functional in infancy as shown by Harris and MacFarlane (1974). Not all of a form can be on the fovea at any point in time yet the form is perceived, in adults at least, as a whole. Hence scanning of elements is not necessary for form perception. Indeed it is the wholeness or unity of features which gives a form distinctive characteristics. Thus the corneal reflection studies only inform about the infant's abilities at perceiving 'elements' such as angles and contour which might go together to make up a form.

The preference studies have largely been concerned with one particular aspect of form perception; i.e. the relative importance of complexity or contour in determining visual preference. Such a concern stems from the nature of the experimental materials used, in that, in almost all of the infant's (or adult's) visual experience the 2 aspects of stimulation are inextricably combined. Also, of course, the preference studies are laden with the problem that non-preference does not imply non-discrimination, and infants may well discriminate patterns or particular objects but not have consistent preference (as indexed by fixation time).

Possibly more could be learnt about the development of the infant's form perception abilities if the infant's responsivity were measured to stimuli of more ecological relevance than checkerboards or triangles. Perhaps these stimuli are of such low 'interest' to the infant that his attention to them is inconsistent; hence conflicting results in different studies.

Chapter 3

Auditory Abilities

The auditory abilities of an infant mediate any receptivity to the vocalizations of others. Therefore comprehension of the development of auditory abilities may illuminate the development of such receptivity, and hence this chapter reviews the evidence on the development of auditory abilities.

Anatomical Data.

The Ear.

Arey (1965) describes the structures of the outer, middle and inner ear as being totally differentiated by the sixth fetal month. Elliott and Elliott (1964) suggest that a reason for the precocious development of this area of the anatomy may be in order to provide the fetus with information as to its position in space. This information would be provided by the semi-circular canals of the inner ear. They suggest that fetal kicking is a response to disturbances of bodily position sensed via the semi-circular canals and that the kicking has the function of restoring the fetus to its optimal position. Another reason to consider is that the fetus is subjected to auditory stimulation, and there is evidence that the development of sensory pathways is influenced by sensory stimulation (Riesen 1961, Blakemore and Cooper 1970). Possibly the auditory stimulation that the fetus receives is a catalyst to the development of the auditory pathways.

Auditory Nerves.

Falkner (1966) states that myelinization of the auditory nerves commences at the sixth fetal month.

Auditory Cortex.

Again nearly all the information available on cortical development comes from Conel. Hence this data should be considered with the reservations mentioned earlier (see section on visual cortex chapter 2.). The same criteria of development are used with respect to the development of the temporal cortex as were used with the occipital cortex. A similar pattern of development as measured by Conel's criteria emerges for the temporal cortex as for the occipital cortex and area TC is more advanced in its development than any other part of the temporal cortex.

However, when we consider the significance of these findings for behavioural development we are left with the same problems mentioned when discussing the data on the occipital cortex viz. that as very little is known about the relationship between the anatomical changes described by Conel and behaviour predictions about behavioural consequences are speculative

Wada (1969) studied the brains of a few newborns who happened to die at, or shortly after, birth and he reports that the temporal cortex of the left hemisphere is larger than the temporal cortex of the right hemisphere. Witelson and Pallie (1973) report similar findings and also that the hemispheric difference is more pronounced for females. As the left hemisphere usually becomes the anatomical location of linguistic functions later in life, possibly this hemisphere difference reported by Wada is a preadaption of the infant for later linguistic behaviour.

Methods of studying auditory function.

Electrophysiological Methods.

Electroencephalography.

As with studies of visual functioning, electroencephalograms can be used with newborns as the electroencephalogram does show veral components of evoked response to auditory stimulation.

Autonomic measurements.

Measurements of autonomic activity are frequently used as indices of auditory reactivity. The most commonly used measures being heart rate and respiration rate, but other measures such as electromyography are also occasionally used.

Behavioural techniques.

Several behavioural techniques have been used to study infant auditory perception. These include measurement of changes in general bodily activity (responsivity), changes in the orienting reflex, and conditioning techniques, particularly using the sucking response.

As auditory analogues of visual fixation, tracking and scanning cannot readily be measured, the behavioural techniques for auditory research are more limited than those for visual research. Therefore, auditory research in infancy relies heavily on autonomic techniques and measures of general changes in bodily activity (responsivity). Another consequence is that auditory research is not tied so closely to the state of the infant, as these measures can be applied in a variety of infant states. Nevertheless, one should not forget the importance of state in determining infant behaviour, and the effects of state on autonomic and general bodily activity are particularly important.

Ashton (1971) specifically studied the relationship between state and auditory reactivity in the neonate and found that state was a crucial determinant of auditory reactivity, most response to auditory stimulation being when the infant was in a quiet alert state (state 4 Prechtl classification). Hence, the state of the infants involved needs to be taken into account in evaluating any study of infant audition.

The relationship between state and hearing is not a one-way process, indeed the relationship between any behaviour, particularly perception, and state is always a two-way interaction. What the infant hears may well affect its state; Birns et al. (1966) and Brackbill et al. (1966) both demonstrate that an infants state can be changed by what it hears; in these cases playing sounds to neonates calmed them. Hence, state changes consequent upon hearing sounds also may be informative as to auditory abilities.

Rather than considering the literature on infant audition in terms of the methodologies employed, it is more appropriate to consider the literature in terms of what information is given on infant auditory abilities. This can be justified as, in visual research, different methodologies ask different questions about the infant's abilities, whereas in auditory research, different methodologies often are used to investigate the same problem.

When can the infant hear?.

Several studies report that fetuses show responsiveness to a variety of sounds including pure tones (Bench 1968, Bench and Vass 1970, and Murphy and Smyth 1962). Spelt (1948) reports classical conditioning of fetal movements with repeated auditory stimulation of the mother's abdomen.

Also Eisenberg et al. (1964) and Eisenberg et al. (1966) both report that prematures show a similar reponsivity to auditory stimulation to full-term infants. Hence, it seems safe to conclude that the infant can hear from birth. However, having said this it should be noted that there may be present considerable 'fluid' in the ear of the infant after birth and this may attenuate the infant's hearing to some degree.

Amplitude discrimination.

Steinscheider et al. (1966) measured cardiac activity and general motor activity to presentations of white noise at varying intensity levels from 55db. to 100db.. It was found that both cardiac responses and general responsivity were a direct function of loudness. Some infants responded to the full range of sounds, while some only showed an apparent response to stimuli of 70db. and above. This difference may well be due to the presence of 'fluid' in the neonatal ear mentioned earlier. Similar results were found by

Steinscheider (1968) using both cardiac and repiratory measures of autonomic reactivity to auditory stimulation, both showing increases in rate directly related to loudness. Also Kearsley (1973) reports differences in the orienting reaction of neonates to sounds differing in amplitude.

Barnet and Goodwin (1965) measured the average evoked potential to clicks of varying loudness. They found that the P2 component of the average evoked potential increased as the loudness of the click increased.

Thus, there exists EEG, autonomic and behavioural data that the newborn is responsive to amplitude differences in hearing.

Frequency discrimination.

An early investigator who noted the infant's differential responsivity to frequencies was Dearborn (1910) who noted that high notes on a piano were apparently more disturbing than low notes to a young infant. An experimental study to investigate this ability was carried out by Kasatkin and Levikova (1935) who played a musical tone before feeding the infant with a bottle. By one month of age, a conditioned response had formed in some infants such that they started sucking upon hearing the musical tone, yet without being given the bottle. This conditioned reponse generalized initially so that the infants would show the response to bells as well as the musical tone. The earliest instance of stimulus generalization was at 2 months and

14 days when the infant would produce the sucking response upon hearing the original musical tone, but not other sounds. Up to 3 months of age differentiation of musical tones as close as 11.5 musical tones was possible, and by 4 months of age this was reduced to 5.5 musical tones. While this study is useful as an early indication of infant discrimination, the conditioning did take a long time to become established, and obviously the tests of musical tone differentiation could not take place until the conditioning had been established. Hence the developmental trend revealed in these results may reflect the methodology rather than the infant's abilities.

Russian interest in this field was continued by Bronshtein and Petrova (1967) who used inhibition of sucking as an index of the orienting reflex in neonates. They produced a tone on an organ pipe to a neonate and the neonate would orient as indicated by his inhibition of sucking. This procedure was repeated in a habituation paradigm until the orienting reflex habituated, as indicated by the infant continuing to suck. At this point the tone was changed , amd this produced recovery of the orienting reflex, i.e. the infant again inhibited his sucking. Thus , this study indicates frequency discrimination in neonates, as does a study by Eisenberg et al. (1964) who found differential bodily activity to different sound frequencies. Kearsley (1973) found differences in the orienting reaction to stimuli of 250, 500, 1000, and 2000 Hz.

Hutt et al. (1968) recorded neonatal electromyographic activity and autonomic avtivity to sine wave and square wave sounds at various frequencies and also to a female voice. They found that the greatest reactivity was produced by low frequency square waves. The square waves were produced by playing an electrical square wave signal through a loudspeaker system. Bench (1973) points out that this produces an auditory signal with a characteristic fundamental frequency but also containing considerable energy in surrounding frequencies; i.e. the signal has bandwidth and spans a range of frequencies. Hence one could interpret these results as patterned sounds produce more response than pure tones (sine wave stimuli). Within this categorisation, patterned sound, and pure tones, those stimuli which had fundamental frequencies within the range of the fundamentals of the human voice, elicited the strongest responses. Hutt et al. argue that these results are consonant with a proposition that the infant will be most responsive to those stimuli which produce most excitation of the basilar membrane. These will be stimuli with the greatest bandwidth, and lowest fundamental frequency. They suggest that it would be useful for the neonate to function in this way as it would enable differentiation of broad bands of sound, and would allow the infant to discriminate biologically relevant bands, such as the human voice.

Lenard et al. (1969) followed this up by reporting on an EEG study of neonates using a similar range of stimuli. Differential evoked response avtivity was found depending on the frequency of the sound. However, the pattern of reactivity as measured by the average evoked potentials did not coincide with the pattern previously revealed by Hutt et al. (1968) using electromyograms and autonomic measures. Hence they conclude that the proposition previously put forward i.e. the greater the basilar membrane activity the greater the response, was too simple and that probably a more complex mechanism was at work.

While the relationship between infant reactivity and the frequency characteristics of sound are still a matter of debate, the literature does provide EEG, autonomic and behavioural data of neonatal frequency discrimination. Some studies also indicate that the bandwidth of sounds may be a crucial factor in determining the magnitude of neonatal response.

Temporal characteristics of sound.

These include duration, repetition, rhythm, and the rise and fall time of sound.

Duration.

Clifton et al. (1968) measured heart rate responses of neonates to square wave stimuli and found that the relationship between heart rate change and duration was an inverted U-function over the time period 2 to 30 seconds, in that as the duration of the stimuli increased up to 10 seconds duration, heart rate changes became greater but further increases in duration produced progressively less heart rate change. Ling (1972) presented stimuli in the duration range 50 milliseconds to 1 second and measured changes in bodily activity. The longer the duration of the stimuli the greater the responsivity of the infants.

Repetition.

Eisenberg et al. (1966) found that the bodily avtivity of neonates showed an habituation pattern to repeated sounds. A similar habituation pattern of the orienting reflex of neonated was found by Bronshtein and Petrova (1967) with repeatedly presented sounds.

Rhythm.

Studies of rhythm have used stimuli which may be considered to have some biological significance and will be considered later.

Rise and fall times.

Rise-time refers to the time between the onset of a sound and when it reaches its full intensity. Similarly, fall-time refera to the time the sound takes to reduce from its full intensity to zero. Such times for many commonly occurring sounds are usually small (of the order of milliseconds) and are significant in that they are integral to aspects of speech perception.

Goodman et al. (1964) measured the average evoked potential to sounds of varying rise-times. They found that the AER in neonates was systematically related to the rise-time. Also Kearsley (1973) has found that the nature of the orienting reaction of neonates differed with stimuli varying in rise-time between 0, 10, 500, 1000 and 2000 milliseconds.

Overall, the available data indicates that from birth onwards the unfant discriminates the temporal characteristics of sound, and, in particular, seems to be responsive to rise-time which is important for speech perception.

Biologically significant sounds.

Rhythmic sounds.

Salk (1962) played recordings of heartbeats (72 beats/minute at 75db) to a group of 102 newly-born infants in a maternity ward for 4 consecutive days. He found that these infants cried less often and showed a higher average weight gain than a control group of 112 infants who had the same conditions, including food intake, but who did not hear the heartbeats. Salk suggested that these effects were due to the infant becoming 'imprinted' in the womb to the maternal heartbeat, and subsequently the heartbeat calmed them.

Brackbill et al. (1966) attempted a further test of this proposition. They subjected neonates to 1 of 4 conditions; no sound, heartbeat recordings, metronome beats or a voice singing a lullaby. She found that there was more crying, more motor activity, higher heart rate and less regular respiration in the no sound group of infants than the rest. However, Brackbill concludes that sound produces a calming effect on neonates but that the heartbeat has no special significance.

However, while it seems that Salk was wrong to claim special significance for the heartbeat, and that his results could be due to the extra sound his experimental group receives, it should be noted that Brackbill's sounds all contain rhythm. Therefore, it is a possibility that it is rhythmic sound rather than just sound which has such calming effects on infants.

Condon and Sander (1974) investigated the infants response to speech. They filmed infants while somebody talked to them and then analyzed the film frame by frame in terms of the relationship of infant movements and rhythms in the speech pattern. They claim that much of the infant's movements coincided with rhythms in the speech being heard by the infant. This finding suggests that the infant is particularly sensitive to the rhythms of speech. However, when one looks at the range of rhythms within the speech signal, rhythms within words, within phrases, within clauses, within sentences, and between sentences, it becomes apparent that almost any movement of the infant would fit within this rhythmic structure somewhere. Hence, it is suggested that this finding does not indicate specific infant receptivity to speech rhythms.

The human voice.

Studying neonates, Hutt et al. (1968) report that electromyographic activity, autonomic activity and general bodily activity are greater to sounds where the fundamental frequency falls within the range of fundamental frequencies for the human voice. Similarly, Lenard et al. (1969) find parallel findings in an analysis of evoked potentials to similar stimuli. Hence, this data is suggestive of particular sensitivity to the frequency range of the human voice.

Simner (1971) found that neonates were more likely to cry when they could hear another newborn's cry than if they heard either noise of similar intensity or silence.

Speech perception studies.

Further evidence as to the receptivity of the infant to the human voice comes from studies of the infant's speech perception. Routh (1969) selectively rewarded either consonants or vowels for 2 to 7 month old infants and found that these infants demonstrated an ability to distinguish vowels from consonants.

A more specific aspect of speech perception is the ability to discriminate voice onset time (VOT) appropriately. Voice onset time is the time between the release of air pressure and the subsequent pulsing of the vocal cords. For voiceless consonants this is short i.e. approximately 100 milliseconds. Now one can artificially produce a range of sounds having VOT varying gradually. In adult discrimination of such stimuli it is found that discrimination along a dimension of varying VOT is of a categorical nature. They cannot discriminate stimuli differing in VOT by 20 milliseconds if both stimuli have VOTs less than 25 milliseconds or if they both have VOTs more than 25 milliseconds. However, they can discriminate such

VOT differences where the difference crosses a natural phoneme boundary i.e. around 25 milliseconds. Adults, therefore, perceive sounds from a constantly varying VOT dimension as either voiced or voiceless. They perceive only two categories along this dimension.

Eimas et al. (1971) used a contingent sucking technique to investigate the ability of 1 and 4 month olds to discriminate stimuli along this VOT dimension ('ba' and 'pa'). The infants heard a sound upon sucking, which either remained the same or changed after 20% response decrement. When the change corresponded to crossing a phoneme boundary, the infants showed significant response recovery. Whereas, no change, or a change of equal magnitude within a phoneme's boundaries did not produce response recovery. Hence, it appears that infants as young as 1 month discriminate the VOT dimension in a categorical manner corresponding to the ability of the the human vocal apparatus to produce sounds along this dimension. This evidence strongly suggests that the infant is innately preadapted to perceive specifically linguistic distinctions. With similar age infants, Trehub and Rabinovitch (1972) produced similar findings for other artificial sounds varying in VOT and, using the same technique, demonstrated discrimination of the natural consonants 'd' and 't', thus demonstrating that these findings are not artefactual to the artificial stimuli used.

Another linguistic distinction which corresponds to a categorization of a continuously varying physical dimension is the distinction between 'place contrasts', an example being the distinction between 'b' and 'g'. Place contrasts correspond to the position of energy transitions along the frequency continuum. Moffitt (1971) used a habituation-recovery paradigm with heart-rate change as the index response to investigate discrimination of the natural sounds 'bah' and 'gah' with 5 to 6 month old infants and found evidence of discrimination. However, these results merely demonstrate discrimination between a pair of phonemes but do not demonstrate that perception of the relevant dimension is categorical. In order to do this, discrimination of changes within phoneme boundaries needs to be compared with discrimination of similar changes across phoneme boundaries. Morse (1972) did this using the technique of Eimas et al. (1971) with 2 month olds. He found that infants perceive 'place contrasts' in a categorical manner, showing response recovery to changes across phoneme boundaries, but no response recovery to no change or changes of similar magnitude within phoneme boundaries. Morse also investigated in this study the 2 month old's ability to discriminate 'ba-' from 'ba+' i.e. falling intonation from rising intonation and he did find such discrimination.

Trehub (1973) has used the technique of Eimas et al. (1971) to investigate vowel discrimination and frequency discrimination. She found that response recovery occurred to natural voice vowel changes but not to stimuli that differed only in frequency. These results firstly suggest that the infant's phoneme discrimination abilities also apply to vowels, but not necessarily that vowel perception is categorical in the manner that VOT and place contrast perception appears to be. Secondly, the failure to find discrimination of frequencies, which other studies have found, demonstrates that non-recovery of habituated behaviour does not necessarily indicate non-discrimination. However, the fact that such recovery happened to linguistic contrasts and not non-linguistic contrasts does suggest that linguistic features may have some primacy for the infant.

Overall, these studies of the infant's speech perception abilities do strongly suggest that the infant is born with a predispositio;n for linguistic perceptions on the auditory mode. An alternative explanation is that these abililties do not reflect genetic programming of behaviour but that the infant in his early days is influenced by the fact that much of his auditory experience is linguistic and hence his auditory analyzers become selectively "tuned" for linguistic distinctions. Such an argument would parallel the findings of Blakemore and Cooper (1970) who find evidence of rapid environmental modifications of the visual analyzers of the newborn cat. One might extend this argument into considering the possibility that the prenatal auditory experience of infants may predispose them to attend to linguistic rather than non-linguistic distinctions. Tschanz (1968) has found that prenatal experience does influence recognition of parental calls in guillemots. However, this explanation would require that the attenuation of the auditory environment produced by the mother's body did not mask the auditory stimulation of the infant to such an extent that linguistic distinctions became indistinguishable. Regardless of which interpretation one places on such findings these studies do show that considerable auditory processing abilities are present from 1 month of age onwards and possibly from birth.

Auditory-visual integration.

One aspect of the integration of information from auditory and visual modalities is the ability to integrate spatial information. Piaget (1953) investigated this problem by making noises out of the sight of his son, Laurent. He concludes that initially Laurent looks around trying to find the source of the sound and it is not until the third month that Laurent looks in the appropriate direction when a sound is made. Piaget argues that the early visual search of the infant on hearing a sound reflects his attempts to actively assimilate the environment.

Chun, Pawsat and Forster (1960) in a cross-sectional study, found that sound localization was well-established by 6 months of age. However, they did find occasional instances of such localization at earlier ages. There have also been several casual references in the literature to neonates orienting to the source of a sound (e.g. Froeshels and Beebe 1946). Wertheimer (1961) carried out an interesting study of such integration in one neonate within minutes of birth. He made click sounds beside an ear of neonate and observed any subsequent head-turning. This procedure was repeated 22 times and in the majority of cases, the head turn was in the appropriate direction.

This finding could indicate an innate ability to link auditory space perception with visual space perception. Turkewitz et al. (1966) found similar results to Wertheimer with moderate intensity sounds, but they also found that neonates will usually turn away from (rather than toward) sounds of high intensity. They suggest that such behaviour reflects innate auditory-oculomotor integration rather than innate auditory-visual perception integration. This proposition is strengthened by their finding that appropriate eye-movemeants take place to sound when the eyes are closed, and hence it is unlikely that the eye-movements are equivalent to those in visual search.

A different approach to sound localization was adopted by Leventhal and Lipsitt (1964), who repeatedly made a sound beside one ear of a neonate, and produced habituation. However, upon changing the ear stimulated, recovery of responsivity occurred, thus indicating that neonates can distinguish which ear is most intensely stimulated. However, again such a finding need not indicate any spatial awareness by the infant.

A rather different approach was undertaken by Aronson and Rosenbloom (1971) who recorded the behaviour of 1 month olds while their mother was talking in front of them. The mother's voice, however, was relayed via 2 speakers on either side of the infant. In 1 condition, the speakers were 'balanced' so that the mother's voice appeared to be coming from the mother who was sat in front of the infant. While in other conditions the voice appeared to be coming from the side of the infant; i.e. the auditory direction of the mother did not coincide with her visual direction. Aronson and Rosenbloom report that the incidence of tongue protusions on this latter condition was greater than in the more natural condition, where the voice comes from the same direction as the mother is seen. They consider that this greater incidence of tongue protusions indicates distress to a violation of a learned expectation that the mother's voice should come from where the mother appears visually. Thus, they argue their data reveal the integration of auditory and visual spatial information by 1 month olds. McGurk and Lewis (1974) have taken this study to task on the following points:

1. The 'unnatural' condition always follows the 'natural'. Hence greater distress could be due to fatigue.

2. Aronson and Rosenbloom discard infants who showed any distress at the beginning of the experiment; thus greatly reducing the chances of state changes in the opposite direction to that hypothesized.

3. The stereo presentation of sound is not an exact equivalent of unidirectional sound.

4. The index of distress viz. tongue protusion has never been validated as a measure of distress.

McGurk and Lewis also attempt to replicate Aronson and Rosenbloom's findings, by having a mother talk to an infant with the voice being relayed from a speaker, in the same direction as the mother, or to the left or to the right. They found no evidence of increased distress when the auditory and visual directions of the mother were dissociated. The only indication auditory localization was in terms of appropriate head-turning at 4 and 7 months of age. Therefore, it seems that Aronson and Rosenbloom's conclusions are not justified by the evidence. It is interesting to note that Wertheimer (1961) and Brazelton (1973) find evidence of appropriate head-turning to sounds from the side in neonates, yet Griffiths (1954), Bayley (1969) and McGurk and Lewis do not find such behaviour until 4 months of age or older. It appears that this aspect of auditory spatial perception is present only as an unstable response until 4 months of age. Possibly it is a response which appears in the neonate, to disappear and then reappear in later infancy as Bower (1974) has described for other infant behaviours. However, such appropriate head-turning could be at the reflex level as argued earlier and does not necessarily indicate the integration of auditory spatial perception and visual spatial perception.

Cohen (1974) has looked at another dimension of auditory visual integration. She had mothers and strangers talking to infants so that mother's voice (MV) could be paired with either mother's face (MF) or stranger's face (SF), and the stranger's voice (SV) could be paired with either mother's or stranger's face. She subjected 5 month olds and 8 month olds to these 4 conditions, MFMV, MFSV, SFSV, SFMV. She finds no discrimination in 5 month olds but 8 month old girls showed shorter initial visual fixations to discrepant conditions (MFSV AND SFMV) than to normal conditions (MFMV and SFSV). Hence this study indicates that 8 month old girls can recognise the mother's face and the mother's voice and relate these visual and auditory perceptions. However, in order to demonstrate auditory-visual integration in this manner, the infant must be able to recognise the mother's voice, the mother's face and then relate these 2 learnt perceptions, and have sufficient preference for familiar pairings to unfamiliar pairings to demonstrate differential behaviour. It is possible that infants are capable of auditory-visual integration, but either

a). have not learnt mother's face

or b). have not learnt mother's voice

or c). have not learnt to connect face and voice

or d). do not have a behavioural preference for appropriate combinations of faces and voices. Therefore, it is perfectly possible that auditory-visual integration could be possible for infants less than 8 months old.

To summarize auditory-visual integration is present by 8 months of age, may well be present before this age and auditory space perception in terms of appropriate head-turning is present before this age.

Chapter 4.

Memory Abilities.

One aspect of social development in the first year of life is the development of differential behaviour to familiar and unfamiliar people. Besides the visual and auditory abilties previously reviewed such behaviour involves memory, as does the development of other social abilities. There are various reports indicating memory in infants from a variety of sources e.g. Levy's (1960) report on infants' memory of inoculation. However, almost all evidence relating to memory processes derive from experimental studies using visual and auditory materials. This chapter is concerned with such evidence.

Visual Memory.

The most common laboratory procedures for the investigation of infant visual memory are

a). the single stimulus presentation habituation/recovery paradigm.

b). the paired-comparison paradigm.

c). the operant conditioning paradigm.

Information about visual memory may be gleaned from other areas of investigation such as the study of imitation or attachment behaviours and these will be dealt with in later sections. This section concerns itself with the use of laboratory procedures involving the above techniques in the investigation of visual memory for inanimate stimuli.

Description of the Paradigms.

a). Habituation.

In this technique a stimulus is presented a number of times. A decrease in response may be regarded as either a function of fatigue or of a memory process. In order to separate these two explanations it is usual to present a novel stimulus after either a set number of trials, or when a set level of habituation has occurred. If the response recovers to the novel stimulus, this is taken as indicating that memory processes are causing the response decrement and recovery and not fatigue. The reasoning being that if fatigue were causing response decrement then the decrement should continue with the novel stimulus, and if recovery occurs to the novel stimulus this indicates that the infant distinguishes a difference between the novel stimulus and a 'memory' of the familiar stimulus.

b). Paired- comparison Paradigm.

The second experimental paradigm used is the paired comparison procedure where two stimuli are presented for a number of trials, and then a novel stimulus introduced on one side of a pair and then on the other side of the pair. If fixation of the novel stimulus increases as compared with the familiar stimulus then memory of the familiar stimulus is indicated.

In the habituation paradigm the response measured may be visual fixation, heart rate, suppression of sucking, or any response which is affected by visual stimuli. Whereas in the paired-comparison paradigm only visual fixation is used as a response.

c). Operant Conditioning.

This technique involves the conditioning of a response contingent upon a particular visual stimulus. If the infant makes the appropriate response (e.g. visual fixation) to the appropriate stimulus, reinforcement follows (e.g. social reinforcement of E smiling, talking or shaking rattle). If the infant learns to respond more often to the appropriate stimulus than other stimuli, then the infant must have learnt to recognise the appropriate stimulus and hence have visual memory.

Experimental studies.

Bronshtein, Antonova, Kamenetoskaya and Sytova (1958) studied habituation to a bright light using as a response measure, suppression of sucking. They found in neonates that suppression of sucking decreased with continued presentation of the bright light. However, they did not test for recovery of response upon presentation of a novel stimulus, hence fatigue cannot be ruled out as an explanation. Haith (1966) did a similar study with neonates and found greater suppression of sucking to a moving than to a stationary light, but no evidence of habituation was found. Similarly, Haith, Kessen and Collins (1969) failed to find habituation of suppression of sucking to a moving light in 2-4 month olds.

Another study by Lewis, Bartels, Fadel and Campbell (1966) presented infants aged 3-18 months old with four 30 second trials of either a stationary or a moving blinking light followed by a fifth trial with the different type of light. The inter-trial interval was 30 seconds. Response decrements for visual fixation and heart rate were found over the first four trials; the older the infant the quicker the the decrease. However, no evidence of recovery was found on the fifth trial so that the response decrement may well have been due to fatigue. Lewis, Goldberg and Rausch (1968) found similar results in a similar experiment.

The studies using suppression of sucking to stationary or changing lights do not provide any convincing evidence of memory processes.

Other studies have used changing lights as stimuli but have used other response measures such as visual fixation and heart rate. Kagan and Lewis (1965) presented to 24 week old infants a blinking light that was either stationary, moving horizontally or that described asquare helix pattern. The inter-trial interval was 12 seconds. There was a reduction in fixation times over trials and also a reduction in heart rate deceleration. They also found similar results with pictures of faces, a toy bear, a bottle, a bull's eye and a checkerboard. However, they did not test for recovery of response Cohen (1969) also investigated habituation to a moving, blinking light, but he only measured visual fixations and used 20 habituation trials with 5 second inter-trial intervals. There was a response decrement over trials with 5 month olds showing more rapid decrease than 3 month olds. An additional group of infants did not receive the first 15 trials, but were in the laboratory situation, and only received the last 5 trials. The responses of this group to the last 5 trials was equivalent to the responses of the other infants to the first 5 trials. Cohen argues that this indicates that the response decrement is due to exposure to the light and not fatigue. However, there was no test for response recovery to a novel stimulus and hence fatigue cannot be ruled out as this study confounds treatment effects with possible subject differences. Therefore this study cannot be taken as strong evidence of habiuation even though that is the most likely reason for such results.

Overall, the research on habituation to changing lights using suppression of sucking, visual fixation or heart rate change has not produced strong evidence of memory processes. This may well be due to the methodological inadequacies of the various studies.

Fantz (1964) used a paired-comparison methodology to present magazine photographs to infants 1-6 months old . One of the photographs remained constant wheras the other changed from trial to trial. Fantz found that there was decreasing fixation of the familiar and incrasing fixation of the novel stimuli as trials progressed for infants over 2 months of age. But there was no apparent discrimination of the familiar from novel by infants less than 2 months of age. Hence, this study demonstrates visual memory in infants from 2 months of age onwards.

Paired presentations were also used by Saayman, Ames and Moffett (1964) to investigate visual memory in 3 month olds. They used as stimuli red and black circles and crosses. After a 4.5 minute familiarization period with one of the stimuli, the familiar and a novel stimulus varying in colour or form or both colour and form were presented to the infant simultaneously. Fixation times were greater for the novel form only when it varied in both colour and form from the familiar. This result suggests that infants can show memory for both colour and form.

An operant paradigm was used by Bower (1966) with infants 8-20 weeks old. They were conditioned to make a head turn to a disk containing a cross and two dots. After conditioning, the infants were tested to see if they would generalize the response to the disk, the cross and the dots separately presented and also their response to the original stimulus was tested. Bower argued that if the subjects memorized the original stimlus as separate components, the number of responses to the original stimulus should equal the sum of the responses to each separate component; whereas, if they had memorized the original stimulus as a compound of the components, it should elicit more responses than the sum of the responses to the separate components. Bower interprets his results as indicating that infants up to 16 weks of age memorize components separately, whereas, 20 week olds memorized the stimulus as a compound of components.

Long habituation periods were used by McCall and Kagan (1967), who exposed infants to a pattern for 20-30 minutes a day, 4-6 times a week, for 4 weeks. At 4 months of age, the infants were shown the familiar stimulus and 3 stimuli varying in discrepancy (according to adult judgments) from the familiar figure. Female infants showed greater heart rate deceleration to the novel patterns than to the familiar. In addition, they found that females showed greatest heart rate deceleration to those stimuli most discrepant from the familiar stimulus. Thus this study suggests that the development of visual memory may proceed differently in males and females and that a determinant of the magnitude of the novelty response will be the degree of discrepancy between the familiar and the novel stimuli.

Meyers and Cantor (1966) measured the visual fixations and heart rate of 5 month olds while preenting pictures of objects in a habituation experiment. There was no response decrement for fixation times, but with the last trials of the habituation series, males showed increased heart rate deceleration, whereas females showed decreased heart rate deceleration. Hence, while there is some suggestive evidence of the effect of familiarity, the results do not support other studies which have found clear response decrement and hence evidence of visual memory. Meyers and Cantor (1967) found that 6 month old males showed greater deceleration of heart rate to novel than to familiar pictures. These two studies, while not giving any clear evidence of memory, do suggest that habituation and recovery may proceed differently in male and female infants. However, these results differ from those of McCall and Kagan (1967) in that males showed the greater novelty response. This difference may be due to different ages of the infants involved.

Caron and Caron (1968) found that 3.5 month old infants would show habituation of visual fixation to a repeatedly presented stimulus abd recovery of fixation on presentation of a novel stimulus. However, they also found that response decrement was greater for simple stimuli than for complex stimuli. Caron and Caron (1969) found similar results with 2 month olds but noted that girls showed greater response decrement than boys. Hence, when considering the results of habituation experiments, the response decrement will be a function of complexity as well as familiarity, and also the course of response decrement may show sex differences. The sex differences reported here parallel the findings of McCall and Kagan (1967) with 4 month old infants.

McCall and Melson (1969) recorded first fixation times and heart rate of 5.5 month old infants during familiarisation trials and to novel stimuli of varying discrepancy. They found that response decrement occurred but that the recovery of response to the novel stimulus depended on the level of discrepancy of the novel stimulus from the familiar stimulus; novel stimuli of small discrepancy eliciting greater heart rate deceleration than novel stimuli of larger discrepancy. Indeed, significant recovery of heart rate deceleration only occurred with the novel stimulus of small discrepancy from the familiar. This result may seem to conflict with the results of McCall and Kagan (1967) where they found deceleration of heart rate was greater with larger discrepancy. However, this difference may be a function of the subjects used and the familiarization times used.

Using an operant paradigm with 14 week olds, Watson (1969) found that visual fixation of 1 of 2 targets was conditioned more thoroughly by visual reinforcement (a schematic face) than auditory reinforcement (a soft tone) for boys, whereas for girls auditory reinforcement was more effective than visual reinforcement. For operant conditioning to proceed in this experiment, the infant must have had visual memory. The sex difference reported may reflect differences in the salience of the auditory and visual reinforcement used in the study, or differences in the development of auditory-visual associations. Watson did a similar experment with 10 week olds, where reinforcement was either visual, auditory or auditory and visual combined. Females showed learning when reinforcement was auditory or auditory and visual combined, but not when it was visual only. Males did not show learning under any condition. Thus, this study supports the view that infants over 2 months have visual memory.

A problem with the habituation experiments so far mentioned investigating infant visual memory is that they have not counterbalanced the stimuli used as familiar and novel items. Hence, it is a possibility that any increased response noted to a novel stimulus may be due to the inherent properties of that stimulus quite apart from its novelty. An experiment by Pancratz and Cohen (1970) however, has tested this possibility with 4 month old infants using a habituation procedure, and measuring visual fixations. The stimuli used were a red square, a green circle, a blue triangle and a yellow rod. The choice of which was the familiar stimulus was random, and the other 3 stimuli were used as novel stimuli. Clear habituation and recovery occurred for males but not for females. The sex differences found in this study conflict with reports by McCall and Kagan (1967), and Caron and Caron (1969), while they support the findings of Meyers and Cantor (1967), who also report stronger novelty responses for boys than for girls.

Fagan (1970) measured fixation times to a pair of stimuli, one novel, one fimiliar, in 3-6 month olds. He found greater attention to the novel stimulus thus indicating recognition of the familiar stimulus and he also found that this recognition was still present even after a 2 hour delay since familiarization trials. Hence, it would seem that the recognition memory of 3-6 month old infants may be more than short-term.

A comparison of techniques is provided by McGurk (1970) who investigated the perception of orientation with infants 6-26 weeks old. Firstly, infants were subjected to a visual preference technique, being presented simultaneously with a stimulus in the upright position and the same stimulus presented at 180 degrees to the upright. Secondly, infants were subjected to an habituation technique where they were exposed to a stimulus for familiarization trials and then presented with the same stimulus rotated through 180 degrees. Thirdly, a paired-comparison technique was used wherein subjects were exposed to an identical pair of stimuli in the same orientation, for a familiarization period, and then 1 of the pair was rotated through 180 degrees and the stimulus pair represented.

In all cases visual fixations were recorded. McGurk found no evidence of discrimination of orientation in the visual preference technique. However, in both the habituation and paired-comparison techniques, discrimination of the novel orientation occurred; thus demonstrating a disadvantage of the visual preference technique. This study also gives evidence that infants as young as 6 weeks may show visual memory.

Schaffer and Parry (1970) looked at the novelty response of 5-13 month old infants. These infants all showed habituation of visual fixation to an increasingly familiar stimulus and recovery of visual fixation to a novel stimulus. However, those infants less than 7 months did not show any modification of manipulation responses as well. This finding suggests that up to approximately 7 months of age visual and manipulative responses are independent, whereas around 7 months a developmental change takes place whereby manipulation responses are integrated with visual responses.

The habituation procedure was used by Friedman, Nagy and Carpenter (1970) who found that newborns would show a decrement of visual fixation times to repeated presentations of either a 2x2 or 12x12 checkerboard. They found that males showed greater decrement to the 2x2 than to the 12x12 checkerboard, and that females showed greater response decrement to the 12x12 than to the 2x2 checkerboard. However, as no novel stimulus was presented the results of this study may indicate fatigue rather than visual memory.

Another similar study by Friedman and Carpenter (1971) found similar sex differences. Also they found that older newborns (mean age 78 hours) showed greater response decrement than younger newborns (mean age 38 hours). However, again there was no presentation of a novel stimulus to test for response recovery, hence the results may well be due to fatigue rather than visual memory.

Friedman (1972a) presented newborns either with the same stimulus over 8 trials or with 8 trials with 8 different stimuli, 1 in each trial. Both groups showed decrement of visual fixation across trials, and the group who saw the same stimulus showed greater response decrement. However, this group was not shown a novel stimulus for response recovery, and it is possible, if unlikely, that the differences in amount of decrement between groups reflect individual differences in fatigue rather than implying visual memory.

Friedman (1972b) measured visual fixation in newborns while they were presented with 8 trials of the same stimulus and then on the ninth trial either the same stimulus or a novel stimulus. The stimuli were checkerboards and were counterbalanced. Response decrement occurred over the first 8 trials and recovery occurred to the novel but not to the familiar stimulus. These results do indicate visual memory rather than fatigue and this experiment is notable as the only experiment to find evidence of visual memory in newborns.

For these experiments by Friedman and his collaborators, subjects were randomly selected from those newborns in a hospital nursery, who were alert and awake at the time of observation. Now such newborns are not a random sample of newborns in that many newborns will not be alert and/or awake at the time of observation. Such newborns are likely to be those who are alert and awake more often than other newborns. In addition, in these experiments there is a high drop-out rate for subjects due to fussing or lack of alertness. In the Friedman (1972b) study only 40 out of 90 selected newborns completed the experiment. Hence, this study provides evidence of visual memory in a particular sample of newborns. It may well be the case that the habituation and recovery found in this experiment may not be found with newborns in general, and that the subjects in this study are those who are most likely to show visual memory, possibly their increased alertness being related to advanced visual system development.

Continuing their investigations into the role of discrepancy in influencing the novelty response McCall and Kagan (1970) investigated the hypothesis that those subjects who showed most habituation should show most response to discrepancies. They showed 4 month olds standard (s) and discrepant (d) stimuli in the following format

sssssdsssdsssdsss

They classified their subjects into

short lookers---only look at the first 5 stimulus briefly

quick habituators---definite response decrement over first 5 stimuli
slow habituators---little or no response decrement over first 5 stimuli
They found that short lookers and quick habituators showed recovery of looking to discrepant stimuli, but slow habituators did not. These results are not surprising in that the slow habituators did not habituate at all to the standard, but they do indicate the importance of individual differences in habituation studies and that the results obtained can depend crucially on the subjects selected.

Another study using long-term familiarization was reported by Greenberg, Uzgiris and Hunt (1970), who exposed infants to a mobile for 30 minutes/day for 1 month and at 2 months of age the infants showed a preference for the familiar over a novel stimulus. 2 and 4 weeks later after additional familiarization, preference changed to a novel stimulus. Therefore this study indicates that a developmental change is occurring around 2 months of age leading to changes in preference between novel and familiar stimuli.

Weizmann, Cohen and Pratt (1971) exposed 4 week old infants to a mobile hanging over their cots for 30 minutes/day for 4 weeks. They were then presented with the familiar and a novel mobile in a paired-comparison procedure at 6 and 8 weeks of age. At 6 weeks of age, they preferred to look at the familiar whereas at 8 weeks of age they preferred to look at the novel mobile. These results indicate visual memory at 6 and 8 weeks and that attention may well show a developmental change between 6 and 8 weeks of age in terms of the relative attractiveness of familiar and novel stimuli. It is also noteworthy that the tests occurred between 12 and 24 hours after the last familiarization period, hence the memory demonstrated here is comparatively long term.

This study and that of Greenberg et al. (1970) strongly suggest that infants of less than 2 months demonstrate visual memory via a familiarity preference whereas infants of 2 months and older demonstrate visual memory via a novelty preference. This developmental change may account for the failure of earlier studies e.g. Fantz (1964) to find any evidence of visual memory in infants of less than 2 months in that these studies were looking for an increase in response to the novel stimulus.

Confirming evidence that infants of less than 2 months have visual memory is provided by a study by McKenzie and Day (1971a), who used social reinforcement (E smiling, praising, shaking rattle) to instrumentally condition visual fixation response to particular stimuli. They successfully achieved this with 6-12 week old infants. This result could be due to visual memory, or possibly to proprioceptive memory, in that the visual response depended on a head turn to left or right. However, another experiment by McKenzie and Day (1971b) with 7-12 week olds compared the visual preference technique and an operant conditioning technique in testing discrimination of vertical and horizontal lines. The visual preference technique did not demonstrate discrimination whereas the operant conditioning technique did. This result demonstrates the greater sensitivity of operant conditioning procedures in certain instances, and also demonstrates that visual memory is operating in the operant conditioning procedure, in that the discrimination needed visual perception and not just position perception.

Cohen et al. (1971) investigated the relative role of colour and form in visual memory with 4 month olds. They used 4 stimuli, a red circle, a green circle, a red triangle and a green triangle, one of which was used in habituation trials for a quarter of the subjects, and the other were then presented on three consecutive novelty trials. Habituation and recovery from habituation to the novel stimuli both occurred. i.e. A novelty response occurred if either colour or form changed, however the novelty response was greatest if both colour and form changed. This result closely parallels that of Saayman et al. (1964), who only found a novelty preference in a paired comparison experiment if both colour and form changed. Also, it was noted that females showed less habituation than males, which was also found by Pancratz and Cohen (1970), but not by Caron and Caron (1969), who found greater habituation by females.

The long-term nature of infant memory and also the operation of interference effects in infant memory are demonstrated in a series of experiments by Fagan. Fagan (1971) used a paired preference procedure to demonstrate a novelty response in 5 month olds. The novelty response occurred immediately after the familiarisation procedure and after a delay of over 6 minutes; thus confirming that the infants visual memory is more than short-term. Fagan (1973) continued this research with stimuli such as black and white patterns, photographs of faces and three-dimensional face masks. He found that black and white patterns showed novelty effects up to 48 hours after familiarisation, photographs of faces showed novelty effects up to 2 weeks after familarisation, but that three-dimensional face masks were forgotten 3 hours after familiarisation. Fagan suggests that this forgetting of face masks could be due to interference effects in that infants would have had much experience with faces in the natural environment. This interpretation is supported by his finding that memory of photographs of faces would show the effects of interference 3 hours after familiarisation if the interfering stimuli (inverted face photographs) were presented immediately after familiarisation (no interference effects were noted if the inverted photographs were presented immediately before testing for a novelty response). These experiments by Fagan clearly indicate that visual memory is long-term, and supports similar findings by Weizmann et al. (1971) who found evidence of memories 24 hours after familiariation.

Parry (1972) reports on a study of habituation and recovery of visual fixation and manipulation responses in infants 44-54 weeks old. The infants were presented with a wooden disc with dots on for six 20-second trials and on trial 7 they were presented with another wooden disc with a different pattern of dots. This experiment was conducted in the home for half of the subjects and in the laboratory for the other subjects. In both home and laboratory, novelty responses occurred, but greater visual attention and greater manipulative latency occurred to the familiarised stimulus (trials 1-6) in the home than in the laboratory. This study brings out the importance of context in considering the results of this type of experiment.

A habituation experiment by Wetherford and Cohen (1973) using 6-12 week old infants, found signifant habituation and novelty responses in 10-12 week olds but not in 6-8 week olds. However, some suggestive evidence of a familiarisation preferdnce was found, which would be compatible with findings of Weitzmann et al. (1971) and Greenberg et al. (1970).

Cohen (1973) followed up the research of Cohen et al. (1971) investigating the relative roles of colour and form in visual memory. They presented 4 month olds with alternating trials of a red circle and a green triangle and then divided subjects into 3 groups, who were presented with 1 of 3 test conditions,

either the same 2 stimuli	group 1
or 2 totally different stimuli e.g a blue square,	group 2
or stimuli of same colour and form but rearranged e.g. red triangle, green circle	group 3

Only group 2 showed increased fixation times in the test. Groups 1 and 3 showed similar responses in the test, and this result suggests that infants store information about stimuli separately as components, rather than as a compound memory of the total stimulus. i.e. that infants store information in terms of colour and in terms of form but not as particular compounds (arrangements) of colour and form.

It was also found that males showed more habituation than females which supports the findings of Cohen et al. (1971) and Pancratz and Cohen (1970) but not Caron and Caron (1969) who found greater habituation by females.

Cornell and Strauss (1973) also looked at the question of whether infants memorize stimuli as components or compounds. They presented 4 month olds with a cross and a circle separately habituation trials , and then presented a compound of familiar components (e.g. a cross embedded in a circle) or a compound of novel components (e.g. a triangle overlapping a square). They found that only males showed a novelty response and that occurred only to the compound of novel components. This result supports Cohen (1973) in the view that infants store information separately as components but do not remember the compounds of those components, otherwise the novelty response should have occurred to the novel compound of familiar components.

McCall (1973) followed up the research into the role of discrepancy by giving long-term familiarisation to 3.5-5 month olds and then testing for responses to various stimuli. Firstly, spontaneous attention to 4 stimuli was established. One of the stimuli was then presented to an infant in the home for approximately 15 minutes a day most days, while the infant was alert, for 2 weeks. After this time, the infant's attention to the familiar and 3 discrepant stimuli was measured. The pattern of results is complex. Older females showed an appoximate inverted U-function relating change in attention time and discrepancy, i.e. the greatest increase in attention time occurred to the stimulus of moderate discrepancy, and was less for the least and most discrepant stimuli. Younger females showed an approximate U-shaped function relating change in attention to discrepancy. Males showed results roughly the opposite of females. In addition to these trends, it was noted that those infants who appeared to have shown a response decrement in the home, showed more attention to the discrepant than to the familiar stimuli, whereas those infants who appeared not to have shown a response decrement in the home, showed less attention to moderately discrepant than to familiar stimuli. Possibly this indicates that the complex pattern of results reflects differing levels of habituation occurring, some subjects habituating more than others, and that this causes the differences in response to discrepancy. However, these results do not allow any clear conclusions to be drawn relating attention time and discrepancy.

A study which provides less confusing results was reported by McCall, Hogarty, Hamilton, and Vincent (1973) who presented a horizontal or vertical arrow to 12-18 week olds until they looked 3 seconds or less. They then presented various rotations of the arrow corresponding to various discrepancies from the familiar stimulus. They found that rapid habituators gave results which fitted an inverted U-function relating discrepancy and attention, whereas slow habituators showed most attention to the most discrepant. While these results are less complex than those of McCall (1973), possibly due to the introduction of a habituation criterion, They still do not allow any firm conclusions to be drawn on the relationship between discrepancy and attention, other than that individual differences such as speed of habituation are modulating influences.

Caron, Caron, Caldwell and Weiss (1973) used the habituation paradigm to investigate perception of facial attribues in 4-5 month olds. They habituated subjects to a distorted schematic face (subjects had to look at least 18 seconds (ex 30) on the first trial and show at least 25% response decrement over the habituation trials in order to be included in the study). Subjects then were shown slides of abstract art and they showed response recovery (subjects had to look at least 18 seconds (ex 30) at 4 of the slides). Subjects were then shown a regular schematic face. The experimenters argue that the more important a facial attribute, the less facelike its distortion would be, and hence there would be longer fixation time to the regular face. At 4 months the results indicated that the eyes had more salience than the mouth, and that the head outline was more salient than the inner face. By 5 months, the mouth had become as salient as the eyes and the inner face as salient as the outline. The conclusions drawn in this study assume that a monotonic relationship relates attention and perceived distortions (or discrepancies). However, While some evidence for this assumption exists (e.g. McCall and Kagan 1967) evidence for other relationships between attention and discrepancy also exists (e.g. McCall 1973). Also, the experimenters used several criteria in selecting subjects, such that those who showed most habituation and most response recovery were used in the data analysis. Now, this type of subject who McCall et al. (1973) call fast habituators, has been found to show an inverted U relationship relating attention to discrepancy, hence it seems quite likely that Caron et al. may have made an erroneous assumption on the relationship between attention and discrepancy and hence the interpretation of their results is problematical, and their conclusions not necessarily justified.

Another experiment on memory for faces was conducted by Cornell (1974). He showed paired presentations of face photographs to 19 and 23 week olds, and visual fixation was recorded. During a familiarisation period, infants were put into 3 groups who were presented with either

a). different faces of the same sex

or b). different poses of the same face

or c). repeated exposure to one face

Then all infants were presented with a male and female face simultaneously. 19 week olds did not show any reliable novelty response, while 23 week olds showed a reliable novelty response in all conditions. During the familiarisation period, the 23 week olds showed habituation in conditions b). and c). but not condition a). Now in that condition a). did not show any habituation but did show a novelty response, this indicates that learning can take place without any apparent habituation. Also, the result that infants did show habituation in condition b). indicates that infants can extract information from invariant features of differing stimuli; because each pose of the same face was different yet the infant apparently could still perceive the sameness between the photographs. Such a capacity is obviously important in the natural leaning situation.

Summary.

Many studies have shown that infants older than 2 months of age show visual memory. There is consistent evidence that the failure to find any indication of infants younger than 2 months may be due to a developmental change whereby infants younger than 2 months show a familiarity preference whereas infants older than 2 months show a novelty preference (c.f. Weizmann et al. 1971). Also, there exists some evidence which may indicate visual memory in some neonates (Friedman 1972b) but no other investigators have corroborated this finding yet.

The visual memory demonstrated in these studies seems to be long-term and open to interference effects (c.f. Fagan 1973). Also, infant visual memory seems to store information about stimuli as separate components rather than as compounds of components up to 4 months of age (c.f. studies by Cohen 1973 and Cornell and Strauss 1973) and possibly as compounds of components by 5 months of age (c.f. Bower 1966).

Individual differences complicate the interpretation of studies of visual memory in that infants who are slow or fast habituators may show differing patterns of results (c.f. McCall et al.1973). Evidence for sex differences also exists. Some investigators have found that females habituate more quickly than males, some investigators have found the opposite, while some have found no sex difference at all.

The evidence on the role of discrepancy on attention is confused, and the only safe conclusions to be drawn are that discrepancy does affect attention but that individual differences (e.g. fast vs. slow habituators McCall et al. 1973) and also possibly type of stimulus material (in that studies with differing results have often used different types of materials and different types of discrepancy) are crucial modifying influences.

Auditory Memory.

Three main kinds of paradigms provide evidence of auditory memory capacities in infants. These are classical conditioning, operant conditioning, and habituation paradigms.

Classical conditioning.

In this paradigm an auditory stimulus is the conditioned stimulus. If a conditioned response is established, then obviously memory for the auditory stimulus is implicated.

Operant conditioning.

If auditory stimulation is used as a reinforcement and a change in the respondent behaviour ensues, then again memory for the auditory stimulus is implied.

Habituation.

Repeated auditory stimulation should produce a decrement in response to indicate habituation. True habituation, rather than fatigue, is indicated if response recovery occurs (dishabituation) to a novel sound. Sokolov (1963) and Jeffery and Cohen (1971) maintain that short-term memory capacity is a prerequisite of habituation. Therefore, if habituation and dishabituation occur; then short-term memory is indicated.

Empirical studies.

Classical conditioning.

Early studies by Marquis (1931) with neonates and Kasatkin and Levikova (1935) with 1 month olds reported classical conditioning with sound as the conditioned stimulus. Some later studies have reported similar findings e.g. Kaye (1965) and Connolly and Stratton (1969) with neonates. However, some studies in the sixties failed to find evidence of such conditioning e.g. Lintz et al. (1967) with 2 month olds, and Fitzgerald et al. (1967) with 1-3 month olds. Moreover, Sameroff (1971) in a detailed review of these studies, strongly criticizes the available evidence on both methodological and theoretical grounds. The criticisms generally involve lack of appropriate control groups and lack of replication of results. Hence, there is considerable doubt about the reliability of conclusions from such evidence. A more recent study by Clifton (1974) found that newborns show anticipatory changes in heart rate in a classical conditioning paradigm with sound as the conditioned stimulus. Clifton recognizes that his results do not provide adequate evidence for proposing that classical conditioning was occurring. However, the anticipatory change in heart rate does indicate some form of memory process and as sound was the conditioned stimulus, this is evidence of auditory memory in the neonate.

Hence, there is suggestive evidence of auditory memory in a number of reports involving classical conditioning. However, the problems associated with these studies are such that firm conclusions are not yet possible.

Operant conditioning.

Todd and Palmer (1968) used a voice as reinforcer to produce operant conditioning of vocalizations in 3 month olds. Similarly Millar (1972) has used auditory feedback in 4-7 month olds to produce operant conditioning of manipulation responses.

Several other studies e.g. Routh (1969) and Ramey and Ourth (1971) have used auditory stimulation as part of 'social reinforcement' but as this also contains visual and tactile components, it is impossible to include such studies as evidence for auditory memory.

Habituation.

Bronshtein and Petrova (1967) report habituation of suppression of sucking in neonates, with repeated auditory stimulation and dishabiuation upon changing the tone of the sound. Bridger (1962) reports similar results while measuring the heart rate and body startle components of the orienting reflex. Bartoshuk (1962) also found limited habituation of heart rate responses to repeated auditory stimulation but did not test for dishabituation. While Keen (1964) found partial habituation of neonatal heart rate but did not find dishabituation to a sound of different frequency. Clifton, Graham and

Hatton (1968), Graham, Clifton and Hatton (1968) and Moreau et al. (1970) find similar results but they did not test for dishabituation.

Habituation to the spatial characteristics of sound was tested by Wertheimer (1961) who found habituation of head-turning to clicks from the side in a neonate. Leventhal and Lipsitt (1964) found similar results with neonates and they also found recovery of the response upon changing the ear stimulated.

However the above studies on habituation all lack adequate controls for possible state changes in the subjects across trials. Hence, the pattern of results reported could in large measure be due to state changes rather than habituation. Only when dishabituation has been tested and reliably found can habituation be said to have occurred. Some of the above studies did not test for dishabituation and those studies that did altered both the amplitude and the frequency of the sound hence it is not known what dimensions of the stimulus are the basis for the habituation and dishabituation.

McCall and Melson (1970) expanded their research on discrepancy to auditory processing. They gave 5.5 month olds 4,8 or 12 presentations of a sequence of tones, and then the infants were presented with a discrepant sequence. They found recovery of heart rate responsivity with the discrepant stimulus, and the greater the prior familiarization the greater the response recovery. This study is novel in finding evidence for memory of particular patterns of auditory stimulation rather than memory for gross physical features of stimulation.

Continuing research with neonates, Stratton (1970) found habituation and dishabiuation of heart rate to auditory stimulation and Stratton and Connolly (1973) produced habituation of heart rate in neonates and then produced dishabituation if

either 1) the intensity changed.

or 2) the frequency changed.

or 3) a stimulus was omitted: i.e. rhythm changed

This indicates processing and memory for these three separate dimensions of sound.

Habituation and dishabituation of heart rate to auditory stimulation has also been found in 3, 6 and 12 month olds (Lewis 1971 and Horowitz 1972).

Using the average evoked response (AER) of the EEG, Weber (1972) failed to find habituation in 3.5-4.5 month oldsto repeated auditory stimulation. However, Dorman and Hoffman (1973) did find habituation in 2.5-3.5 month olds. Unfortunately, they did not test for dishabituation.

The interpretation of the results from habituation studies is confused by the many instances of methodological flaws im experiments. However, enough adequately controlled experiments have found evidence of habituation and dishabituation to auditory stimulation that auditory memory is reliably indicated from the neonatal period onwards. Such memory capacity would seem to include the physical aspects of amplitude, frequency and temporal characteristics and also the patterning of sequences at least by 5.5 months of age.

The studies reported so far only indicate auditory memory for short periods of time. More long term memory is indicated by studies of recognition of mother's voice. Wolff (1963) finds evidence of such recognition as young as 5 weeks of age. However, as the comparison voices were all male, this study may only indicate pitch discrimination. Turnure (1971) found more mouthing to mother's voice than to a female stranger's voice in 3 month olds. These studies are discussed in more detail in chapter 5. Such studies indicate the possibility of long term auditory memory from as young as 3 months of age.

Overall, there is evidence of short term memory for the physical dimensions of amplitude, frequency and the rhythm of sound from the neonatal period onwards. Also, evidence exists for short term memory for patterning of sounds from 5.5 months onwards although this has not been tested in a laboratory setting for younger ages. The only evidence of more long term memory comes from studies of recognition of the mother's voice.

Chapter 5.

Social Skills in Early Infancy.

Previous chapters have considered the development of basic sensory and memory capacities; this chapter reviews the evidence on the development of social abilities during infancy. The social or communication skills of the infant can be considered to be either productive or receptive; productive referring to those behaviours emitted by the infant that have potential social or communicative function, and receptive skills being the abilities of the infant to respond to the behaviours of others. Another categorization is in terms of the perceptual modes involved, in particular social skills mediated by either visual or auditory perception are being considered. Visual social skills usually involve face perception and are mediated by the facial-visual channel. Auditory social skills usually involve voice perception and are mediated by the vocal-auditory channel.

Productive social or communication skills.

In a sense all the behaviours of the infant could be said to be communicative in that they are potentially able to affect the behaviours of others. However, particular behaviours are seen to be more potent in this respect than the rest of the infant's repertoire. Within the facial-visual channel such behaviours would include overall facial expressions, the smile, gaze or looking, mouthing, and frowning. Whereas the vocal-auditory channel would include the cry, and non-cry vocalizations.

Bowlby (1969) has hypothesized that the human species has evolved such that infant behaviours which enhance the likelihood of the proximity of other species members are favoured by evolutionary pressures. Hence infants show a series of characteristic behaviours in that they are effective in maintaining the proximity of other humans. Bowlby has further drawn the distinction between those behaviours which act as signals to other humans, such as smiling and vocalizing, and those behaviours such as grasping and sucking which directly bring the infant into contact with others. It is the class of behaviours which might be considered as signalling systems that the following section's concern. These might be regarded as the infant's capacity for productive communication. However, there another side to social development, the capacity for reception of others' behaviours, and Bowlby plays scant attention to this aspect of development. This side of social development is considered later in this chapter and is the subject of much of the following chapters.

Facial Expression

Darwin (1872) refers to 6 facial expressions of emotion in the first ysar of life. These are pleasure, amusement, discomfort, anger, fear, and affection. Pleasure is signalled by the presence of a smile but other facial components may include a wrinkled nose, and eyes "swimming" or looking through partly closed lids, and Darwin firsts observes this in the second month. Amusement is signalled by the laugh and Darwin first noticed this at 3.5 months of age. Discomfort is signalled by the cry, other facial components being closed eyes, frowning, and retracted lips, but the frown may occur in isolation and Darwin referred to a frown at 8 days of age. Anger was noticed by Darwin in his son at 4 months of age and was inferred from a red face, a scream of rage, frowning, lip protusion and respiration changes. Darwin noticed 2 types of fear; firstly as starting to a sudden sound which occurred very early in infancy, and secondly, at 2.5 months Darwin walked backwards toward his son and stood motionless, which caused the infant to look very grave and Darwin said that he would have cried had Darwin not turned around, which caused the infant to relax and smile. Affection was inferred by Darwin by Darwin at 45 days of age when his son smiled at a person.

Bridges (1932) put forward a theoretical scheme of emotional devopment where initially the infant is only capable of general excitement, which soon differentiates into distress and pleasure. Later in infancy distress differentiates into other negative emotions such as fear and anger and pleasure differentiates into other positive emotions such as affection and amusement.

Watson (1919), however, maintained that there were 3 emotions present at birth viz. love, anger and fear and that other emotions developed out of these 3. However, these theories depend on subjective interpretation of infant behaviour and Sherman (1927) found that raters could not reliably distinguish emotion from infant facial expressions without knowing the situation of the infant. Hence, interpretation of such expressions is highly subjective and situation dependent; e.g. Bridges did not recognise disgust in an infant until 5 months of age whereas Peiper (1963) interprets a grimace at an unpleasant taste on the fist as disgust. This discrepancy could reflect different viewpoints or merely the fact that Bridges did not test reactions to unpleasant tastes.

The laugh.

In a laugh the corners of the mouth are pulled back and up; showing the teeth, and raising the cheeks. The eyebrows are smooth and the eyes may appear 'bright' behind partly closed lids while a characteristic vocalization is made. Darwin (1877) recorded a laugh in his infant at 3.5 months of age whereas Preyer (1888) recorded a laugh at 23 days. Dennis and Dennis (1937) give a median age for the first laugh as 9 weeks of age, from a review of baby biographies. However, Wolff (1969) reports some infants "chuckling" at 1 month of age to being tickled, whereas Sroufe and Wunsch (1972) did not find unambiguous laughter until after 4 months of age, when tickling was the most effective elicitor; from 7 months auditory and tactile stimulation became the most effective elicitor, and by 10 months of age social, visual and auditory stimulation was most effective.

Smiling.

Early investigators (e.g. Darwin 1877, Washburn 1929) agree that most infants smile by 2 months of age. Dennis and Dennis (1937) in their review of baby biographies put the median age of the first smile at 6 weeks of age and Soderling (1959) put the median age at 3-4 weeks of age. Watson (1925) however, reported that smiling could be obtained shortly after birth by tickling and patting the infant. This finding has not been replicated, but Wolff (1963) has reported that smiles can occur during irregular sleep or drowsiness. These early smiles seem to reflect endogeneous state changes and are not controlled by exogeneous factors as the smiles reported by other investigators, who were concerned with the 'social' smile, which occurs while the infant is looking at a person and which Wolff says is most easily elicited in the early months by a high pitched voice. It is an open question whether it is the person as such which elicits the smile or as Ahrens (1954) has suggested particular characteristics of people such as the two-eye gestalt, which elicits the 'social' smile. Ahrens, influenced by ethological work, draws the comparison between the smile and the 'gaping' response of many infant birds, and suggests that the two-eye gestalt may be a 'sign-stimulus' similar in function to the red-tip of the herring-gull's bill. Several investigators have used differential smiling as an index of discrimination between the mother and a stranger. Polak, Emde and Spitz (1964b) have also used the smile as an index of depth perception and found that from 2 months 20 days, but not before, more smiling occurred to a real face than to a photograph; thus indicating that the infants discriminated between a 3-dimensional visual stimulus and its 2-dimensional representation.

The finding that blind, deaf and blind-deaf infants all smile indicates that smiling is an innate response, and Gray (1958) has suggested that it is the human equivalent of the imprinting response of precocial birds. Piaget (1953) has suggested that the smile indicates "recognitory assimilation" when an external stimulus is matched with an internal schema. Zelazo and Komer (1971) tested this hypothesis with 20 male infants 12-15 weeks old. Stimuli of low, medium and high visual and auditory complexity were presented; each stimulus for 8 consecutive 8 second trials. This procedure was repeated the next day. Smiling gradually increased to a peak over trials and then declined. Zelazo and Komer argue that their results support the "recognitory assimilation" hypothesis in that the gradual increase in smiling would reflect the growing recognition, and that afterwards additional presentations did not lead to further assimilation and hence smiling declined. Tautermannova (1973) found a similar decline in smiling to repeated presentation of a person. It is possible that the smile may reflect "recognitory assimilation" but this may not be the only function of the smile. It may be used as an instrumental response as reported by Wahler (1967), who found that 3 month olds would smile more when reinforced by their mothers talking, smiling and touching them. As well as acting as instrumental responses, smiles and vocalizations may be the reaction to the perception of a contingency, as reported by Watson (1973) for 2 month olds. Watson suggests that humans elicit smiles and vocalizations from infants because they regularly provide stimulation contingent upon the infant's behaviour. This idea has links with Piaget's notion of 'recognitory assimilation'.

It therefore appears that smiles may occur from birth but initially reflect endogeneous changes within the infant (Emde and Harmon 1972) whereas around 6 weeks of age the smile becomes influenced by exogeneous factors and may reflect the infant's pleasure and/or recognition, or be used as an instrumental response, and from this time on, if not before, is a potent form of communication for the infant.

Looking.

Robson (1967) reports that some mothers felt strong affection when their infants looked at them. Infant looking has been used by a number of investigators, such as Fantz, to indicate infant preferences, and some investigators have used differential looking to mother and stranger as an index of recognition of the mother e.g. Carpenter (1974). Schaffer (1974) reports that mothers synchronize their direction of gaze to that of the infant. Thus, looking is a communicative behaviour which can influence others and which can inform us of the cognitive and/or emotional state of the infant.

Mouthing.

Mouth movements are commonly observed in infants at all ages, sometimes they are related to hunger, but often they will occur when the infant is not hungry. Such mouthing may be related to the infant's state of arousal, and hence is potentially communicative to others. Aronson and Rosenbloom (1971) used mouthing as an indication of state of arousal. Mouth movements are a form of behaviour that the infant has good control over from birth and hence are one of the few behaviours the infant can use to influence others. As an example of the infant's control Zazzo (1957) reports that imitation of one type of mouth movement viz. tongue protusion can occur in the first month of life. However, while this study indicates that the infant shows good control of mouth musculature the lack of adequate control comparisons throws doubt on the claim that imitation is demonstrated.

Trevarthen (1974) refers to mouth movements in a social context as "prespeech" as he believes that they are the precursors of speech and he describes how prespeech and facial and bodily gestures are coordinated in mother-infant interaction so that the behaviours of mother and infant mesh together. To what extent this is the result of the mother adapting to the infant's behaviour or vice versa is an open question. It seems likely that initially the mother controls this meshing of behaviours, but that as the infant matures, then it is possible that the infant enters into control of the interactions.

Trevarthen regards the early mouthing without vocalizations as precursors of later speech and describes how they are associated with particular breathing patterns and often accompanied by hand gestures. He further claims that such prespeech is a characteristic of an infant's behaviour to people rather than to objects indicating the infant's social awareness and adaptation.

The frown.

Frowning as a drawing together of the eyebrows causing a furrow, occurs as part of the cry-face of the infant when distressed. However, the frown does occur as a specific facial expression on its own, from the neonatal period onwards. What the frown signifies is an open question but it certainly is part of the infant's repertoire of productive communication skills. The frown has been used as an index of infant reactivity by both Carpenter (1973) and McGurk and Lewis (1974).

Crying.

This is a communicative behaviour that the infant can use from birth onwards and which seems impossible to ignore. At first there do not seem to be any tears present; Dennis and Dennis (1937) in a review of baby biographies found that the median age for the first tears was 5 weeks of age. However, Darwin (1877) reported that tears could be elicited from the first day of life if the eyes were touched. Also Wolff (1966) reported tears on the first day of life. Wolff (1969) in a detailed study of the infant cry finds that early crying is initially endogeneous, being elicited by bodily distress such as pain, hunger or discomfort. Wolff reports that the cry differs in form depending on the cause of the infant's distress and he distinguishes a rhythmical cry, a pain cry, a hunger cry and a frustration cry (the differences being in terms of the cry-rest respiration cycle); and he also reports that mothers can distinguish between and react nost appropriately to these different cries, thus they do function as separate communications. Bernal (1972) in a study of infant-mother pairs in the first ten days of life finds that few mothers consciously use the type of cry as a determinant of their response. However, it is possible that they respond to the type of cry without being conscious of doing so.

Later the cry may be controlled by exogeneous factors as in the fear of strangers response. Ainsworth (1963) found that Ganda infants may cry differentially when held by a stranger as young as 8 weeks of age and commonly at 12 weeks of age. Another cause of exogeneous crying is as an instrumental response to elicit attention from an adult. On this last point there is little systematic evidence although there are parents' reports in abundance and Wolff's mothers suggest that their babies may use a cry instrumentally from as young as 3 weeks of age.

Non-cry vocalizations.

The earliest sounds the infant makes are various forms of cry considered in the previous section. Nakazima (1962,1970) found that non-cry vocalizations started around 1 month of age and initially consist mostly of a-like sounds sometimes paired with y-, x-, k-, or g-like sounds. The variety of sounds increased up to 6 months of age when a number of different vowel and consonant-type sounds may be produced. From 6 months of age onwards repetitive babbling may be produced such as babababababa . Up to 9 months of age Nakazima regards these utterances as non-communicative and as examples of circular reactions and secondary circular reactions. From 9 months on vocal imitation was observed by Nakazima and also some indications of comprehension and Nakazima suggests that from this age the child's vocalizations may commence to be communicative. Wolff (1969) claims that 6-8 week olds show a type of imitation in that an infant may alter his vocalizations to become more like those of another.

Lewis (1959) on the basis of his research into language acquisition postulates 3 stages of infant vocalizations

1) 3-4 months - infant increases vocalizations on hearing others vocalize

2) subsequently vocalizations decrease due to the infant's increased attention and realization that speech has meaning.
3) about 10 months infant again responds to speech with increased vocalizations.

Other studies (e.g. Rheingold et al. (1959), Weisberg (1963)) have shown that , at least from 3 months of age , infant vocalizations can be influenced by reinforcement and Haugan and McIntyre (1972) compared food, tactile stimulation and vocal imitation as reinforcers of vocalizations in infants 3-6 months old. They found that vocal imitation was the most effective reinforcer, thus supporting the proposition that infants are receptive to the vocalizations of others. This is also supported by evidence from Wolff (1969) who found that 6-8 week old infants vocalized more to a talking adult than to silent one. Similar findings are reported by Bloom (1974) for 3 month olds. Webster (1969) and Webster, Steinhardt and Senter (1972) present evidence that the infant's vocalizations are influenced by the phonemic and pitch structure of the adult vocalizations (see section on non-segmental phonology)

Receptive Social Abilities.

Primarily receptive social abilities are mediated visually in the facial-visual channel or aurally in the vocal-auditory channel, this chapter will firstly consider the visually mediated abilities and then those mediated aurally. Any behaviour of an adult is potentially communicative in the sense that it may affect the behaviour of the infant. It is very difficult to establish if an infant is receptive to any behaviour. However, one method one may use is to see if the infant's behaviour is altered by a particular behaviour of another.

Facial Expressions.

An early study by Buhler and Hetzer (1928) on 90 infants 3-11 months old recorded whether their rections were positive or negative to a smiling face and an angry face. They found that infants discriminated between these expressions by 5 months of age. (They also found similar results for affectionate and angry voices, where the voice was not accompanied by a face.) Buhler and Hetzer also presented the infants with threatening and affectionate arm/body gestures and these were discriminated by the 8 month olds but not by the younger infants. However, a later study by Spitz and Wolf (1946) who presented 2-6 month olds with 'terror' and 'pleasant' expressions on the experimenters face and on masks found that the infants' reactions were generally positive and there was no apparent discrimination

Ahrens (1954) presented infants with drawings of facial expressions and found some suggestive evidence that 5 month olds could discriminate between crying, laughing and neutral expressions and that 8 month olds were distressed by a drawing of a frowning face.

A recent study by Wilcox and Clayton (1968) measured infants visual fixations to moving and still pictures of smiling, frowning and neutral expressions, and found no evidence of discrimination.

Possibly this failure to find discrimination was a result of only using fixation as a response measure when it may not have been appropriate. Charlesworth and Kreutzer (1973) measured visual attention, activity level and emotional response from video-tapes of infants aged 4-10 months old who saw and heard live facial and vocal expressions of anger, happiness, sadness and neutrality. Infants 6 months and older did discriminate between these expressions in terms of attention and emotional response. However, it is not clear from this study whether the face, voice, posture or a combination was discriminated by the infants.

From these studies it seems likely that by 6 months of age infants can discriminate some facial and vocal expressions and that shortly afterwards they are receptive to gestures but these conclusions can only be tentative in view of the pattern of the evidence.

Another source of information on infants' receptivenes to facial (and vocal) expression comes from studies if imitation in that discrimination of a behaviour must precede its imitation.Zazzo (1957) and Maratos (1973) report that infants will imitate tongue protusions within the first month of life. However, infants of this age do protude their tongues often and the frequency may be related to arousal as claimed by Aronson and Rosenbloom (1971). Therefore the incidence of tongue protusion during a period of equivalent stimulation and arousal should be compared with the incidence of tongue protusion in the imitation test period before any conclusion is reached. Unfortunately, these studies do not contain adequate controls in this respect and hence are suspect.

Piaget (1953) reports imitation of lip movements at 8 months, and Buhler and Hetzer (1928) report imitation of mouth and brow movements in the fifth and sixth months. Concerning vocal imitation Piaget reports imitation of crying in the first few days of life yet this could be merely the infants crying to unpleasant sounds. Bridges (1932) reports that 10 month olds will imitate other children's laughter and other noises.

Hence we see that the imitation studies give a similar pattern of results to the other studies leading to a tentative conclusion that towards the end of the first half year of life infants are responsive to variety of facial and vocal expressions.

Looking; Direction of Gaze.

From the earlier section on looking as a productive skill, it is clear that the direction of an infant's gaze is an important communication from the infant to another. What is the relevance of another's gaze to the infant? Allyn (1972) removed facial features from an adult with make-up and found that the removal of the eyes had most effect on infants. Bloom (1974) found that social stimulation increased the vocalizations of 3 month olds, when E was wearing spectacles with clear lenses, or lenses with photographs of eyes (direct looking or averted) but not when the spectacles contained opaque lenses. She concluded from this study that eyes elicit, or, are a catalyst for eliciting infant vocalizations, but the no eyes condition of this experiment is obviously an incongruous experience for the infants and it is likely that this incongruity supressed vocalizations rather than eyes eliciting vocalizations. Nevertheless, this study does suggest the importance of eyes to infants.

Stern (1974) has approached one aspect of the question, viz. does an infant notice whether the mother is looking at him or not, via a microanalysis of mother-infant interaction. Play sessions between 3.5-4 month old infants and their mothers were video-taped. The looking behaviour of the mother and infant were analyzed in terms of 0.6 second segments and the probability of the infant initiating looking at the mother in time segment x when the mother has looked at him in time segment x-1 (A) is compared with the probability of the infant initiating looking at the mother when the mother has not looked at the infant in segment x-1 (B).

If A=B then the infant is not apparently discriminating whether the mother looks at him or not. However, if A is not equal to B then this is an indication that such discrimination is taking place. To put it another way if the infant starts to look at the mother more often when she looks at him than when she does not look at him then this indicates that the infant is receptive to the mother's gaze. For a discussion of the methodological problems of Stern's technique see chapter 8.

Responses of infants to the human face.

One aspect of infant social responsivity in the visual modality is responsivity to faces. An early study by Kaila (1932) found that infants showed an increase in smiling to a face-like pattern as they aged, and that this smiling peaked at 20 weeks of age, and that occluding the eyes decreased smiling. Spitz and Wolf (1946) found similar results with a real face, and also if 1 eye were covered up this stopped smiles. Thus the eyes seem to be important to the infants perception of faces. Spitz and Wolf put a mask on a person's face which showed the eyes and tongue protuding and infants smiled to this. There was similar responsiveness to a nodding doll but not to toys. They concluded that the eye configuration and movement were crucial elements in infant facial perception up to 6 months of age. Ambrose (1961) found similar patterns of smiling with institution-reared infants but home-reared showed an earlier peak in smiling at 14 weeks. Thus experiential factors also seem important. Ambrose reasons that these results are indicative of recognition of mother's face. This is discussed in the section on recognition of the mother.

Ahrens (1954) investigated the necessary stimulus elements needed to elicit smiling at various ages. From his results it seemingly emerges that perception of the face develops in a regular fashion: dot and eye configurations initially being distinguished and later, toward 5 months of age, the mouth becomes important, and later the face is perceived as a whole. After this comes discrimination of expressions and individual faces. Note , however, that the primary index of infant responsivity is the smile. The possibility exists that such a developmental pattern is more dependent on the functional development of the smile than upon face perception.

Research on face perception as in most areas of infant visual perception took on a new dimension with the findings of Fantz on visual selectivity between visual forms. Fantz (1961) found that a schematic face and a scrambled face were fixated more than less complex patterns in infants 4 days to 6 months old. Fantz reports a marginal preference for the schematic face over the scrambled face but he does not report whether this slight fixation difference is statistically significant. This finding led to speculation that infants may have an innate preference for face-like stimuli. This speculation was fostered by Fantz's (1963) report that neonates fixated a schematic face more than a bull's eye, newsprint or homogeneous circles. However, Hershenson (1964) found that neonates did not show any difference in looking to facial photographs, schematic or scrambled faces.

Koopman and Ames (1968) found that infants showed no preference between symmetrical arrangements of facial features and suggest that Fantz's finding may reflect a preference for symmetry, as the schematic face is symmetrical and the scrambled assymmetrical. Alternatively, these findings can be explained in terms of complexity and/or contrast preferences, without the need to invoke preference for faces. This point is supported by subsequent findings. While Wolff

(1963) found that a face alone would elicit smiling in 4-5 week olds, Salzen (1963) found that other stimuli with high brightness contrasts would elicit as much smiling as faces in 7-8 week olds, and Thomas (1965) found that 2-4 week olds would fixate a checkerboard more than a schematic face. Other researchers have also been unable to substantiate Fantz's initial findings on preferences for schematic faces. Lewis (1965) did not find a preference for schematic over scrambled faces until infants were 6 months old, and Fantz and Nevis (1967) did not find such a preference until infants were 5 months old.

However, Fitzgerald (1968) using pupil dilation as an index of autonomic arousal to stimuli, found that 1 month old but not 2 month old infants showed greater pupil dilation to real faces than to checkerboards or a triangle.

One interpretation of these studies is that face-likeness is not an important determinant of infant responsivity and that findings which apparently show preferences for faces can be explained by complexity or contrast preferences. One problem with separating face-likeness from complexity is that the configuration of elements within a display is itself a contribution to the complexity of a stimulus and hence the scrambled face is not a perfect control for the complexity of a schematic face. An alternative comparison would be to compare a facial stimulus with its inversion, thus controlling also for the effect of element configuration on complexity. Watson (1966) presented infants with real and schematic faces at various orientations and by 14 weeks of age the upright orientation elicited most smiling.

Another aspect of face perception concerns the features to which infants are responding. Kaila, Spitz and Wolf and Ahrens all maintain it is the eyes to which infants initially respond. Lewis's (1965) finding of more smiling in 3 month olds to a photograph of a real face than a photograph of a cyclopean face supports this view. Further support comes from Kagan et al. (1966) who found that 3-dimensional forms with eyes elicited more smiling in 4 month old infants than similar forms without eyes. This strategy of studying the importance of facial features by their deletion was adopted by Allyn (1972) who deleted facial features from real faces by make-up and found that 5 month old infants were least attentive to faces without eyes. Caron et al. (1973) adopted a similar strategy with 2-dimensional stmuli by showing infants repeated presentations of a distorted face and then recording fixation time to a subsequently presented schematic face. The reasoning behind this approach was that the more distorted the face, the less face-like it would appear to the infant and hence the greater the recovery in looking to the schematic face. At 4 months of age, the eyes were the most salient feature and the head outline was more salient than inner features. However, by 5 months of age, the mouth had become as salient as the eyes and also the inner features had become as salient as the head outline.

Using the corneal reflection technique, Bergman, Haith and Mann (1971) found that 1 month olds scanned the perimeter of facial forms i.e. fixated hairline and facial outline, whereas 2 month olds also fixated internal features. Donnee (1973) found similar results but in addition that 2.5 month olds would return to scanning the periphery of facial forms.

One problem with the use of schematic faces is that they are 2-dimensional and responses to 3-dimensional faces may be different. Polak, Emde and Spitz (1964) found that as infants approached 3 months of age a smiling preference for real faces over photographs emerged. Also Kagan et al. (1966) found greater fixation and smiling to 3-dimensional than to 2-dimensional faces. Such findings may reflect an emerging preference for solid forms or a preference for a more real face as the infant's schema increasingly approximates reality. This latter possibility is supported by Lewis (1965) and Wilcox (1969) who found that photographs elicited more looking than drawings of faces in 3-4 month olds; and with 3-dimensional stimuli by Carpenter et al. (1970) who presented 2-7 week old infants with the mother's face, a manikin head, and an abstract form. Infants showed differential looking to all the stimuli; and using the same stimuli, Carpenter (1974b) reports that adding movement further increases attention. These studies imply that infants do react differently to facial stimuli depending on how closely they approximate reality. Hence it may well be that the processes that apply to the perception of schematic and unnatural faces may not be the same processes which apply in the natural environment.

It appears that early reports of an innate preference for face-like stimuli are not supported by later evidence. Attention to the face in early infancy does seem to be a function of the complexity and contrast of the face, and the degree of reality of the facial stimuli becoming important as the infant's experience accumulates. This point is illustrated by a comparison of 2 studies; Haaf and Bell (1967) presented stimuli varying in facial resemblance and complexity to 18 week old infants and found that looking time was related to facial resemblance. However, Haaf (1974) with 5 and 10 week olds found that looking times were related to complexity and not facial resemblance.

With respect to facial features, limited research on scanning patterns suuggests that the facial outline is attended initially, and that later the inner features such as eyes are attended. These findings may well reflect the fact that these are high contrast areas of the face. However, as stated earlier, such conclusions are derived largely from studies which use schematic and/or unnatural facial stimuli, and to the extent that the infant can discriminate such stimuli from real faces, the behavioural processes produced by such stimuli may not reflect behaviour to faces in the natural environment.

It should be borne in mind that during the first 4 months of life there are substantial changes in the accommodative ability and acuity of infants and these will interact with the changing nature of the infant's schema of a face to determine responses. It may well be that the face provides a degree of gross contour and contrast that is discriminable by the newborn infant's immature visual system, and is appropriate for attracting attention, as the infant's visual capacities develop finer detail will become discriminable and hence provide novel stimulation. In this way the face may maintain an attractive degree of novelty throughout the period of the development of visual abilities.

Responses of infants to the mother's face.

For most infants the most frequently encountered visual stimulus is probably the mother; and in particular the mother's face. Therefore, one might expect that the mother's face will be the first aspect of the environment of which the infant forms a visual memory. On this basis Preyer (1888) suggests that the first visual memories of the infant are formed between the third and sixth month of life and certainly by 30 weeks of age. His evidence for this conclusion was that he noted that it was during this time that his own child, and others he observed, showed different responses to strange people and also strange environments. Darwin (1877) had also noted that his own son first showed a sign of recognizing a person by showing more affection to a particular person i.e. smiling at them more often than at other people.

The findings of these baby diarists were confirmed by later more systematic studies. Bridges (1932) not only noticed that the infant, by 6 months of age, distinguished between familiar and strange people, but, that around 7 months of age the infant might show an apparent fear of a strange person. Shirley (1933) confirmed these findings. Bayley (1932), in administering developmental scales to infants, noted that the causes of crying showed developmental changes. In particular, she noted that crying as a response to strangeness of place or person started at 2 months of age in some infants and became very common by 6-7 months of age. This study is of interest in that it is the first study to put the origins of visual memory as young as 2 months of age.

The apparent unanimity of these early studies is broken by a report by Buhler (1935) on 60 infants seen in the first year of life. She did not notice a consistent fear of strangers until the end of the first year. However, she did note that at 6 months of age, an unfamiliar grimace or hat on a familiar person will frighten an infant. Also, she found that 5 month olds will show an apparent fear of a familiar person seen in profile even though the infant is happy when presented with the full face. This is one of the first studies to describe fear of a distortion of a familiar object i.e. incongruity. This evidence is support for a proposition put forward by Hebb (1946) that a major determinant of acquired fears is that the feared object is incongruent with the schema of a familiar object, and that this incongruity is the cause of the fear.

Spitz and Wolf (1946) followed up the earlier study by Washburn (1929) on the smiling responses of infants to adults. In the first six months infants smiled indiscriminately at all adults, but after this smiles to strangers decreased rapidly. Spitz and Wolf also examined the infant's responses to a 'terror face' and a pleasant facial expression and they did not find any differentiation. However, they did find that infants would stop looking at a persons face if 1 eye was covered up. In addition, they found that if the experimenter (E) put on a mask containing 2 eyes and protuded his tongue, infants would smile as frequently as to an ordinary face, up to 6 months of age. These infants also responded similarly to a life-size puppet that nodded but not to toys. Spitz and Wolf conclude from these experiments that infants do not understand facial expressions, and that infants up to 6 months of age react not to the face as a whole but to elements such as the 2 eye configuration and motion. From these observations, Spitz (1950) put forward a theory that the infant first develops memory capacity around 6 months of age as part of the development of an ego, and that 'stranger anxiety' seen initially at 6 months of age and peaking at 8 months of age is due to the infant distinguishing that the stranger is not the mother and is then anxious as he conceives of the loss of the mother. Note that this explanation is not compatible with already existing studies indicating discrimination before 6 months of age, e.g. Bayley (1932). Szekely (1954) pointed out that as the infant shows fear of the stranger even if on the mother's lap, then the explanation in terms of fear of loss of the mother is unlikely. In addition, as the fear is not apparent if the stranger turns his back toward the infant then it appears that it is the stranger's face which instigates the fear. Spitz (1955) rejects this argument of Szekely claiming that most infants will not show fear of the stranger when in the mother's lap. However, Benjamin (1961) found that infants will often show a fear of strangers when the mother is present and hence gives empirical support to Szekely's critique of Spitz's proposition. This finding was confirmed by Morgan and Ricciuti (1969). Szekely suggested that the 2 eye configuration is an innate releaser of fear for humans and that the fear of the stranger is due to the innate fear of the 2 eye and forehead gestalt. However, it is not very clear from Szekely's exposition why familiar people do not evoke this fear. He suggests that the experience with familiar people enables this innate fear to be overcome in some mysterious way. Freedman (1961) points out that as a model of a face will not elicit a fear response Szekely's proposition is unlikely.

Further evidence that a visual memory of the mother is formed in advance of the 'stranger anxiety' comes from Griffiths (1954). In standardizing infant developmental scales she found that recognition of the mother occurred around 2 months of age and that 'stranger anxiety' occurred around 8 months of age. The usefulness of this finding is reduced, however, by the lack of an adequate definition index, which Griffiths takes to be smiling and attending to the mother.

Gray (1958) put forward the idea that the smiling response of the infant may be the human equivalent of the following response indicating imprinting in precocial birds such as the duckling. If this were so then the strategy followed earlier by Spitz and Wolf of taking the smile as the primary index for discrimination of familiar from unfamiliar would be appropriate. Ambrose (1960) also followed this strategy. He studied the pattern of smiling to a stranger's face in home-reared infants seen from 6-30 weeks of age in a longitudinal study, and also in institution infants aged 8-30 weeks in a cross-sectional study. He found a steady increase in the frequency of smiling to the stranger's face up to 11-14 weeks of age for home-reared, and 17-20 weeks of age for institution infants. Thereafter the smiling response to the stranger's face declined. Polak, Emde and Spitz (1964a) confirmed this developmental pattern in a similar experiment. Ambrose concludes that the decline in response strength of smiling "points unmistakably" to the infant discriminating between the stranger's face and the face of the mother-figure; hence, placing the onset of face recognition at 11-14 weeks for home-reared and 17-20 weeks of age for institution infants. However, this conclusion is unwarranted because no testing of smiling to a familiar face occurred. Indeed, if a familiar face had been presented in a similar way i.e. expressionless with no feedback contingent on the infant's responses, it is possible that a similar decline would have occurred due to the extinction of the smiling response with no reinforcement. This possibility becomes more likely in view of the fact that in this study of home-reared infants, where the experimenter was seen weekly by the infants, the decline in smiling continues even though the experimenter is presumably becoming more familiar.

This interpretation is supported by Watson (1966) who presented a stranger's face and the mother's face to infants and got a decline in the smiling response from 13-14 weeks of age for mother and stranger. Therefore, this developmental pattern is unlikely to be the result of the onset of discrimination between familiar and unfamiliar faces. The faces in Watson's study were smiling but still and unresponsive and this may have led to extinction of the smiling response as there was no reinforcement of the infant's smile. Another explanation might be that a still, unresponsive face is becoming incongruent with the infant's developing schema of what faces are, in that in his normal experience he will not have encountered still or unresponsive faces. Watson also presented faces at 90 and 180 degrees to the vertical and those faces were ineffective in eliciting smiles. He argues that in the normal care-taking situation much face presentation takes place at 90 degrees to the vertical, therefore the development of the smiling response is unrelated to primary need reduction. Gewirtz (1965) also found that smiling to a stranger increased to a peak at 4 months of age for home-reared infants and at 5 months for institution infants. Thereafter smiling declined, but there was no abrupt decline corresponding to '8 months anxiety'.

Ethological influences are shown by Freedman (1961) who suggested that the infant's fear of strangers is the homologue of the flight response of many animals. Freedman also makes a point, without giving any evidence, that is potentially significant, when he observes that infants in the second half year of life show a greater fear of strange adults than of strange children. If this were so, then it would indicate that the stranger reaction is not a reaction to strangeness in itself.

Ainsworth (1963) in a study of 26 Ganda infants, delineated 12 separate behaviours which were elicited differentially by the mother or a stranger in the first year of life. These behaviours could therefore be used as indications of the infants recognition of and growing attachment toward the mother. The results of this study were as follows:

1.Differential crying.

This was observed in 1 infant at 8 weeks of age but commonly by 12 weeks of age.

2.Differential smiling.

This was first noticed in a 9 week old but regularly observed by 32 weeks of age.

3.Differential vocalizations.

This was first noticed in a 20 weekold infant.

4.Visual-motor orientation toward the mother.

This was first noticed in an 18 week old.

5.Crying when mother leaves.

This first occurred with a 15 week old but was observed regularly by 25 weeks of age.

6.Following.

This was regularly observed as soon as a baby could crawl.

7.Scrambling:-climbing over and exploring mother.

Commonly this was observed by 30 weeks of age.

8.Burying face in the lap.

The youngest infant to show this was 22 weeks old and was commonly seen by 30 weeks of age.

9.Using the mother as a base for exploration.

Earliest 28 weeks but often by 33 weeks of age.

10.Clinging: usually associated with fear.

Earliest 25 weeks but not earlier.

11.Lifting arms in greeting.

This was seen at 21 weeks but not earlier.

12.Clapping hands in greeting.

Not earlier than 32 weeks of age.

Here we see examples of differential responsiveness long before the 'fear of strangers' and also differential behaviour is seen as young as 8 weeks of age. Thus we see that when a wider selection of infant behaviours are used as criteria then we find indications of recognition of mother rather earlier than studies which have used a limited response range. These findings of Ainsworth support those of Bayley (1932) and Griffiths (1954) who also found recognition of the mother to occur as young as 8 weeks of age. It is noteworthy that Ainsworth did not observe any infants younger than 8 weeks of age and it is possible that using a wide range of behaviours she may have found evidence of recognition even earlier.

These studies (Ainsworth, Bayley, and Griffiths) all record recognition of mother earlier than other investigators and above all used naturalistic situations where recognition of the mother may be via any one of several modalities e.g. recognition of face, voice or smell. Now Wolff (1963) found that in a study of 8 infants seen regularly over the first 5 weeks of life that auditory selectivity occurred before visual selectivity. By the second week of life, the human voice seemed to be the most efficient elicitor of smiling, and it was only by the third week of life that visual stimuli affected the probability of a smile when a nodding head and voice was more effective than voice alone. By the fourth week, infants seemed to show an increased alertness to faces and would often smile to a face alone. By the fifth week, the mother's voice more consistently elicited the infant's smile than the experimenter's or the father's.

Also, the mother's voice elicited vocalizations more effectively than the experimenter's, whether paired with mother's or experimenter's face. This finding indicates that auditory learning may precede visual learning, and that the infant may recognise the mother's voice by this age, but this is not a necessary conclusion in that both E and the father were male and the infant may have been responding to their deeper voices. However, these findings do indicate that the early recognition claimed by Ainsworth and others may be auditory rather than visual.

Tennes and Lampl (1964) studied 19 infants from 3-23 weeks of age, and they found that 'stranger anxiety' occurred before and separately to 'separation anxiety'. This is further evidence that 'stranger anxiety' is not due to fear of object loss and hence Spitz's theory of the nature of 'stranger anxiety' is untenable in view of the evidence.Tennes and Lampl found that 8 of their infants had shown signs of 'stranger anxiety' as early as 3 months of age, and that a further 8 by 7 months of age. This is rather younger than other investigators and may reflect methodological variations between studies.

A longitudinal study by Schaffer and Emerson (1964) of infants in the first 18 months of life, found that 15% of the infants showed a fear of strangers by 6 months of age and the majority by 8 months of age. It was also noted that the onset of this fear occurred about 1 month after the age when the infant could no longer be comforted by a stranger in the mother's absence. This implies that the recognition of the mother is at least 1 month prior to the onset of the fear of strangers.

Schaffer (1966) studied 36 infants from 6 weeks to 18 months of age. Each infant was seen at 4 weekly intervals when a female stranger entered the infant's visual field, smiled and talked to the infant and then approached the infant to culminate with touching and picking up the infant. Between 13 and 19 weeks of age, a lag in smiling to the stranger occurred while the mother still received immediate smiling. Fear of the stranger appeared earliest at 25 weeks of age but the average age was 36 weeks of age. The fear reaction usually did not occur until the stranger touched the infant. Schaffer concludes from these results that as the infants demonstrate discrimination between familiar and unfamiliar persons considerably earlier than the fear response, then incongruity alone is not a sufficient condition for the fear response. Also, sight alone of the stranger was inadequate to elicit fear and usually touch was necessary before fear of the stranger was unequivocal.

Yarrow (1967) presented infants from 1 month upwards with visual and auditory, inanimate and animate stimuli, the mother's face and voice and a stranger's face and voice (friendly and neutral tones of voice).The responses measured were:

1.changes in activity level
2.approach and withdrawal movements
3.facial expressions
4.vocalizations

and there were 3 dimensions to each response

a.latency

b.duration

c.intensity

In addition the mother's report on the following situations were elicited:

reactions to mother and stranger when distressed,

reactions to stranger in mother's absence and presence

reactions to stranger in familiar and unfamiliar situations

reactions upon separation from the mother

reactions upon reunion with the mother

Yarrow found that by 1 month of age infants preferred animate to inanimate stimulation. Passive selective attention to the mother was shown by

38% of infants at 1 month of age

81% of infants by 3 months of age

100% of infants by 5 months of age

There was a progressive increase in stranger anxiety to reach a peak at 8 months of age, but even by this age less than half of the infants had shown this reaction. Separation anxiety increased steadily from 3 months of age. From these results, Yarrow distinguishes 5 different social response patterns.

1. social awareness; discrimination of animate from inanimate
2. recognition of mother
3. differentiation of stranger
4. stranger anxiety
5. developing a confidence relationship with the mother, entailing

expectations of maternal responsiveness to infant.

In this study, the responses measured are briefly outlined and the results briefly described. It is never clear upon which responses any given result is dependent, e.g. if 38% of infants show passive selective attention to the mother at 1 month of age, which responses of those measured (activity level, approach/withdrawal, facial expressions, vocalizations) correspond to passive selective attention. Hence it is difficult to evaluate this study or relate its findings to those of others. However, it is worth noting that this study indicates recognition of the mother by 1 month of age, which is rather earlier than most studies in this area.

Some of Yarrow's results are not compatible with the findings of Morgan and Ricciuti (1969) who did a cross-sectional study of infants 4-13 months of age. Infants were presented with a male and female stranger, when on the mother's lap and when in a feeding chair 4 feet from the mother. In some approaches the stranger touched the baby before retreating and in other approaches he played 'peek-a-boo' before retreating. Infants were also presented with distorted and realistic masks. The responses measured were facial expressions, vocalizations and visual and motor activity which were rated on scales from very positive affect (+2) to very negative affect (-2). The results indicated that the younger infants showed generally positive responses and that as the infants got older there were more negative responses. They did not find a peak period for negative responses corresponding to 8 months anxiety as Spitz and Yarrow found. In this study, sober staring was scored as showing neutral affect, whereas some investigators e.g. Ambrose (1963) have suggested that this may be an early sign of fear. However, even when sober staring is coded as a negative reaction, the general pattern of Morgan and Ricciuti's results remains the same. There was a high correlation between the reaction to the 2 strangers (r=0.70); however the female did receive slightly more positive reactions than the male, but as there was only 1 male and female stranger it is difficult to generalize on this point other than that the individual characteristics of the stranger may well be important in determining an infant's reactions.

The stranger's behaviour was important, in that as the stranger approached, younger infants became more positive whereas older infants became more negative and also where the infant touched the infant more negative reactions occurred than if the stranger played 'peek-a-boo'. Any account of 'stranger reactions' must take account of stranger's behaviour. The masks generally elicited positive responses even from those infants who showed stranger anxiety. This may have been due to the masks being presented on sticks and hence not seen as persons in that Franus (1962) presented masks on people and did find a fear reaction.

Morgan and Ricciuti did not find any relationship between any previous experience variables and reactions to a stranger, however, this might be due to the homogeneity of their sample. Collard (1968) found that first-borns and widely-spaced later-borns did show more hesitancy in the presence of a stranger, than did other later-borns. This suggests that the extent of previous experience with others may be influential in determining reactions to unfamiliar people.

Scarr and Salapatek (1970) looked at the relationship between cognitive development (as measured by object-permanence and means-end scores) and various fears in a cross-sectional study of 91 infants 2-23 months of age. Infants of 7-9 months commonly showed a fear of strangers but not younger infants. This fear increased in likelihood with age and was related to a fear of masks on people as found by Franus (1962). Scarr and Salapatek did not find any relationship between their measures of cognitive development and fear of strangers once age variance was removed. Therefore, these results do not support Schaffer's (1966, 1971) proposition that object permanence is a prerequisite of fear of strangers. However, as the tests used in this study measure differing levels of object permanence, it is possible that there is a low level of object permanence necessary for a fear of strangers but which all infants show by 7-9 months of age when Scarr and Salapatek first notice fear of strangers. A more adequate test of Schaffer's proposition would be a longitudinal study of infants which looked at the development of stages of object permanence and fear of strangers, to see if any particular level of object permanence regularly precedes the development of fear of strangers.

Bronson (1972) recorded on videotape the reactions of 32 infants to strange people and objects at 3, 4, 6.5 and 9 months of age. The tapes were analyzed on an affect scale, where smiling indicated pleasure and frowning, crying or crawling away indicated wariness. Strange objects elicited little wariness at any age; whereas there was an increase in wariness to strangers with increasing age. Wariness to a stranger was present by 4 months of age for nearly half the sample. This finding is at odds with some other studies who have not found consistent indications of wariness (or fear) until the second half year of life. Bronson points out however, that these studies (e.g. Morgan and Ricciuti 1969, Scarr and Salapatek 1970, Schaffer 1966) have only used short periods of proximity to the stranger (approximately 10 seconds) whereas those studies which have used longer periods have found wariness earlier (e.g. Bronson 1972, Tennes and Lampl 1964). Hence it appears that wariness of the stranger may well occur by 4 months of age if sufficient exposure occurrs. Therefore, Bronson argues there is no need to account for the delay between discrimination of the familiar and wariness of the strange,as the two phenomena are concurrent Thus, it follows that the explanation of wariness of strangers is that it is due to the perception of 'incongruence' between strange and familiar people. This explanation rests on the assumption that recognition of familiar people does not occur prior to the onset of fear of strangers, yet there are studies which consistently find recognition of the mother precedes any fear or wariness of the stranger. The differences between the positions of Schaffer and Bronson can be seen as revolving around the meanings of either a) wariness

or b) discrimination of familiar and unfamiliar people.

Considering the term wariness, several investigators have noted that a difference in infants' responsiveness occurs in the first half year of life, infants showing more responsiveness to mother than to a stranger. Some regard this as neutral affect toward strangers (e.g. Scarr and Salapatek, Schaffer) whereas others (e.g. Bronson) interpret it as negative affect or wariness. (Bronson implicitly recognises this by the use of the term wariness rather than fear.).

Considering the phrase recognition between familiar and unfamiliar people, researchers on human memory have always made the distinction between 2 retrieval processes; recognition and recall. Schaffer uses this distinction in accounting for the delay between recognition of the mother and the later fear of strangers, in that the latter requires the developmentally later recall of mother in her absence in order for the incongruence of the stranger to be perceived. Bronson, however, only accepts discrimination of familiar and unfamiliar people if there is negative affect shown to the stranger; and hence recall must have taken place for the incongruence to be perceived and result in negative affect.

Carpenter (1973a, 1973b, 1974) reports on a study of infants seen from 2-7 weeks of age. Infants were sat in an infant seat in an observation chamber, and presented with a person's still face, a face plus mother's recorded voice, and a face plus female stranger's recorded voice. The face was sometimes the mother and sometimes a female stranger, who moved their lips to the voices. Thus there were 6 conditions:

mother's face MF

mother's face and voice MFMV

mother's face and stranger's voice MFSV

stranger's face SF

stranger's face and voice SFSV

stranger's face mother's voice SFMV

Each trial lasted 30 seconds, with 30-60 seconds inter-trial interval. The behaviours recorded by 2 observers viewing through slots either side of the face were, looking at face, peripheral looking (face in peripheral vision), looking away (face out of vision entirely), eyes closed, and fussing. Also noted were instances of smiles, vocalizations, frowns, hiccups and yawns.

The results of this study indicated that infants from as young as 2 weeks of age would spend more time looking at their mother than at the stranger; thus indicating recognition of the mother. Now this finding if correct would indicate the need to revise considerably the prevailing view of when an infant can first visually recognise the mother, and also would have implications for the interpretation of research on infant visual memory, where only the research of Friedman indicates any visual memory at such a young age.

The infants used in this study were a highly selected sample, having been seen as newborns and selected as being amongst the most visually attentive and most often awake of newborns on a matermity ward. Hence, it might be expected that these infants might show visual recognition of the mother in advance of their peers as they are likely to have more visual experience of her, being awake and attentive more often. However, there are limitations to this study which mitigate against the ready acceptance of these findings. Firstly, the observers who recorded infants looking behaviour knew which face was before the infant, and hence it is a possibility that unconscious bias in coding may have influenced the results. Secondly, there was only 1 stranger used in this study, and hence it is possible that any discrimination made by the infant reflect a response to the physical characteristics of that stranger rather than a response to her unfamiliarity. Thus there are doubts about the validity of these findings.

Receptivity to the human voice.

Now turning to the auditory modality, social receptive skills revolve around the infant's receptivity to voices.

Receptivity to speech characteristics

An early study by Hetzer and Tudor-Hart (cited in Buhler 1933) recorded smiling in 126 infants aged 1 day to 5 months old, when presented with a variety of auditory stimuli. Smiling occurred almost exclusively to voices. Also Wolff (1963) reports that voices elicit smiling at an earlier age than faces.

When considering the infant's receptivity to voices, we need to consider 2 aspects of the sound structure of speech. These aspects are segmental phonology and non-segmental phonology. Segmental phonology is the description of an utterance in terms of phonemes. Non-segmental phonology is the description of those sound variations not reducible to phonemes and includes intonation, rhythm, prosodic features and other paralinguistic features. Writers vary in how they use these various terms but intonation is generally taken to include variation in tone, pitch-range, loudness, rhythm and speed; prosodic features include stress, pitch and timing. Note there is overlap in the use of these terms.

Segmental Phonological Receptivity.

Webster (1969) recorded the vocalizations of 4-6 month old infants under conditions of

1) no vocal stimulation (baseline)

2) 5 minutes of vowel sounds

3) 5 minutes of consonant sounds.

When stimulated with vowels the proportion of vowel-like sounds produced by the infant was smaller than in the baseline period, and when stimulated with consonant sounds, the proportion of consonant-like sounds produced by the infant also was smaller than in the baseline period. This study suggests that infants of 6 months of age may be receptive of some phonemic distinctions and this proposition is further supported by the work of investigators such as Eimas et al. (1971) who have found evidence of discrimination between certain phonemes on the basis of voice onset time (VOT) and place contrasts. This work on speech perception is discussed more fully in chapter 4.

Condon and Sander (1974) investigated the movements of neonates when listening to speech. They examine the movements and speech frame by frame from a sound film record giving resolution down to 1/48th of a second. From an analysis of changes in all infant bodily movements and changes between phonemes, syllables and words, they claim that changes in infant bodily movement are synchronized with changes between phonemes, syllables and words in speech. This suggests that the neonate is innately programmed to respond to the microrhythms of speech. In order to adequately evaluate this work, it is necessary to know the accuracy of the decisions as to which frames are transition points. The time periods between transistions of phonemes are so small that an inaccuracy of even 1 frame would be sufficient to destroy the synchrony between speech and movement, and hence a synchronous pattern is crucially dependent on the judgment of which frame is a transition point, and without knowledge of the reliability and margin of error of such judgments, evaluations of this work can only be tentative. Unfortunately Condon and Sander do not supply this information. Also, the control in this study consists of an analysis of the synchrony between the movements of an infant who hears nothing, and, speech. This is inadequate as a control as an infant not talked to is likely to show different types of movement, particularly if as Trevarthen (1974) claims, infants show different patterns of activity to people than to objects. A necessary control would be to compare the synchrony between the movements of an infant who is talked to, and the speech of another adult who is not talking to that infant: coders being 'blind' as to which adults and infants were interacting. Condon and Sander did not do this.

In summary infants from as young as 1 month display considerable discrimination aurally and seem to be able to discriminate at least some phonemes. Possibly they respond to the rhythm of phonemes, syllables and words but the evidence is inadequate on this point.

Non-segmental Phonological Receptivity.

As with facial expression some evidence comes from studies of emotional reaction to vocal expression and some from studies of imitation.

Vocal expression.

Again the early baby biographers give some of the first documented evidence of infant abilities. e.g. Champneys (1881) records his child imitating intonation from 9 months of age.

Buhler and Hetzer (1928) presented infants with angry and affectionate voices with the speaker behind a screen and found that infants 5 months and older displayed discrimination in terms of their emotional reactions. Buhler (1933) later claims that infants as young as 2 months old may react to tone of voice.

Imitation studies such as Bridges (1932) report older ages for receptivity to tone of voice. Bridges found 10 month olds would imitate the sounds of others, and although Piaget (1953) reports imitation of crying in the first days of life this could be a reaction to an unpleasant stimulus. Lewis (1951) presents evidence of 7 month olds imitating the stress and pitch of utterances. Whereas Wolff (1969) claims that an infant of 1-2 months old may imitate adult pitch if it is in his repertoire.

Webster, Steinhardt and Senter (1972) recorded the vocalizations of 7 month olds when hearing vowels spoken with high or low pitch and when not vocally stimulated (baseline). Significant changes in the fundamental frequency of infant vocalizations occurred from baseline to high-pitch-stimulus periods. This study is consistent with the findings of other studies which have found 7 month olds receptive to pitch, such as Kaplan and Kaplan (1971) who found and increase in heart rate and orientation upon changing intonation in 8 month olds but not 4 month olds. However Culp and Boyd (1974) find dishabituation of visual attention when the voice paired with a visual stimulus changes intonation from 'hard' to 'soft' in 9 week old infants.

Responses of infants to the mother's voice.

Laroche and Tcheng (1963) report differential smiling to tge mother's voice as opposed to that of a stranger at 4 months of age . However this early discrimination then disapppeared and did not reappear until 11 months of age. Friedlander (1968) looked at the preferences of 3 infant boys 11-15 months old to the human voice. He found that they appeared to discriminate the mother's voice from that of a stranger in terms of consistently preferring the mother's voice to other forms of auditory feedback. They also differentiated between voice inflection but the pattern of results were individualistic. Turnure (1971) looked at infant responsivity in 6 boys and 5 girls to the voice of the mother and a female stranger and the earliest indication that she found of recognition of the mother's voice was at 3 months of age when more mouthing occurred to the mother's voice. Tulkin (1973) finds that middle class 10 month olds are more likely to show differentiation of mother's from stranger's voice than working class infants. He interprets this as indicating the effects of differential experience to language.

Two studies, Boyd (1974) and Laub and McCluskey (1974) both report evidence of dishabituation of looking to visual stimuli when the auditory stimulus paired with the visual stimulus is changed from a stranger's voice to the mother's voice. In both cases voice discrimination is implied, for Boyd at 9 weeks of age and for Laub and McCluskey at 10-11 weeks of age. However, neither study necessarily implies recognition of mother's voice in that the infant's could have been responding to a change in stimulation which could have been between 2 strangers. Only if a greater dishabituation to the mother than to a stranger is demonstrated is recognition of the mother's voice implied.

To summarize there is weak evidence of recognition of mother's voice as young as 3-4 months of age. Other reports suggest possible earlier discrimination amongst voices without showing recognition of the mother's voice.

Chapter 6.

A Study of Infant Voice Recognition.

Introduction

From the evidence reviewed in chapter 3 it would seem likely that reception of social signals in the auditory mode would occur early in infancy. Neonatal studies of auditory localization (see page 56) reflect the power of auditory stimulation in obtaining infant attention. Various studies (see page 44) show that the neonate is particularly responsive to the frequency range of the human voice, and to patterned sounds. Several studies (e.g. Eimas et al. 1971) have found that infants can make very fine discriminations involving phonemic contrasts. Hence, auditory abilities are well-developed early in infancy.

A common category of frequent auditory stimulation for most infants is the mother's voice. Hence, the mother's voice provides the earliest opportunity for auditory learning for many infants. The available evidence on recognition of mother's voice is discussed in detail in chapter 5. The earliest indication of recognition of mother's voice comes from Turnure (1971) who found more mouthing to the mother's voice than to a female stranger's voice in 3 month olds but not in older infants. A study claiming recognition at 5 weeks can be interpreted as showing pitch discrimination in that the strangers were male.

Note: The experiment described in this chapter was carried out jointly by the author and M. Mills; the author being concerned with the technique described as a test of recognition of the mother's voice and M. Mills being concerned with the development of contingent sucking.

Therefore it would seem appropriate to test for recognition of the mother's voice as one of the earliest examples of a receptive social skill. The work on linguistic distinctions suggests that infants as young as 1 month of age have the perceptual capacities for voice discrimination, and while short-term memory has been found in infants this young, the evidence of long-term memory has not been adequately investigated. For these reasons and because it was easy to contact mothers of 1 month olds, it was decided to investigate recognition of mother's voice in 1 month olds.

The testing of auditory discrimination in young infants presents considerable methodological problems. However, one response over which infants have complete control is sucking, and this fact has been utilised in the development of a contingent sucking technique by a number of studies. Siqueland et al. (1969) and Kalnins and Bruner (1973) have both trained infants to use sucking as an operant to change visual stimulation, and Eimas et al. (1971) utilised the contingent sucking technique to investigate phonemic discrimination. Thus, it was decided to test the hypothesis that 1 month old infants can discriminate their mother's voice from a stranger's voice.

Design

Infants were assigned to one of three groups

	0-1 minutes	2-7 minutes	8-10 minutes	11-13 min
group 1	base-line sucking	1st SV cs	MV cs	2nd SV cs
group 2	base-line sucking	1st SV cs	2nd SV cs	MV cs
group 3	base-line sucking	1st SV ncs	Mv ncs	2nd SV ncs

cs= contingent upon sucking; ncs= non-contingent upon sucking

The first minute enabled the pen recorder to be appropriately calibrated for each infant.

Assignment to groups 1 and 2 was random, whereas assignment to group 3 did not occur until several subjects had been through the experiment. This characteristic was to enable collection of data from experimental groups which could be used by a computer program to generate a non-contingent schedule for auditory reinforcement which matched the contingent schedules (groups 1 and 2) extremely closely.

Comparison of the last 2 3-minute periods of groups 1 and 2 would reveal any difference in sucking produced by the mother's and stranger's voices. Groups 1 and 2 had these periods counterbalanced to control for possible order effects. Comparison of groups 1 and 3 was intended to reveal whether the contingent nature of stimulation was critical in determining the results.

Subjects

Subjects were recruited from health visitors in the Camden area. All infants were aged between 20 and 30 days of age, and were clinically normal.

Apparatus

A blind teat was connected by a M.R.D. pressure transducer to a pen recorder, and a light under a translucent screen which illuminated a written page in front of the voice provider. The infant seat supported the infant at approximately 45 degrees to the horizontal, and was separated from the adult by a curtain. The adult and infant sat side by side, separated by approximately 3 feet. In front of the infant seat there was an abstract picture so that the infant's visual environment was controlled but not distressingly bereft of stimulation. A Dawes sound-level meter was used to approximately equate mother's and stranger's voices.

Procedure

When an infant and mother first entered the laboratory, the experimental procedure was outlined to the mother. Then the mother was asked to read the script (taken from a Beatrix Potter book) as if she were speaking to the baby, and her loudness level measured with the sound-level meter. (All strangers were female and of similar age to the mothers to approximately equate gross physical features such as pitch.) The 2nd stranger then practiced matching that loudness level. It would have been more efficient to have matched loudness levels using taped voices; however, taping a voice alters its characteristics slightly, and it was thought possible that the infant might recognise the unnaturalness of the voice. Therefore, it was decided to use live voices throughout the experiment.

Infants were tested when quiet and alert (Prechtl state 4) as it was believed that this was the most appropriate state for sensory discrimination tasks. Testing took place midway between feeds to minimise the affect of the infant's prandial condition. The infant was placed in the infant seat and the blind teat offered. When the infant started sucking (5mm of water pressure regarded as minimum suck), recording commenced. The pen recorder recorded both sucking and time and the prevailing contingencies were marked on the paper record. Changeovers in conditions occurred in the first pause in sucking following the designated time criterion.

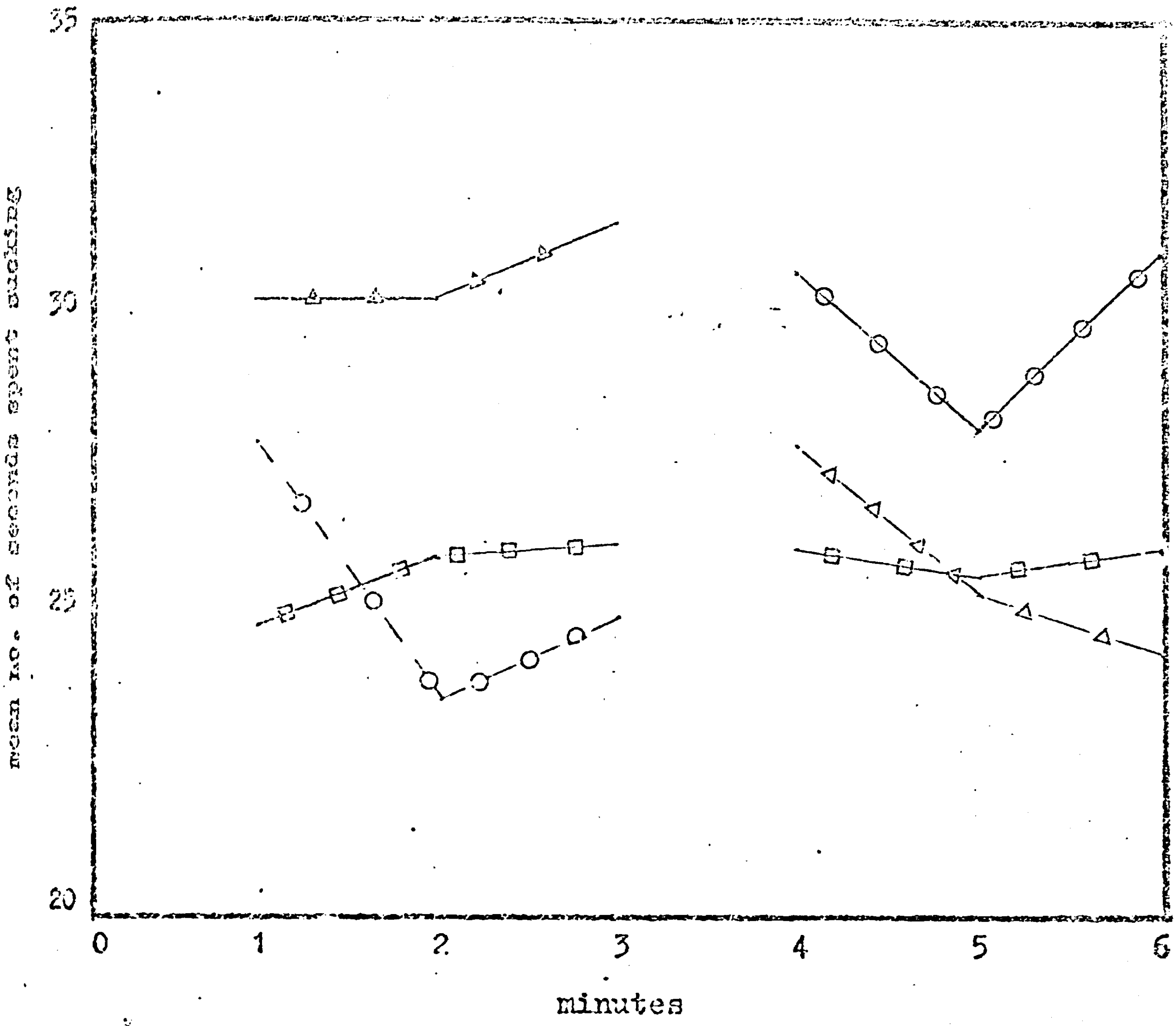
Results

For comparisons of differential responsivity to mother and stranger only the last 6 minutes of the session are considered. A 3(group) x 2(mother or stranger) repeated measures analysis of variance was carried out on the mean time spent sucking per minute. This analysis of variance revealed a significant effect for the voice (mother or stranger) $p \leq 0.001$ and a significant interaction between groups and voice $p \leq 0.05$. These results are due to the greater sucking to the mother's voice than to the stranger's voice for groups 1 and 2 but not for group 3. These effects are illustrated in fig. 6(1).

A similar analysis of number of sucks per minute revealed the same pattern: i.e. more sucks to mother than stranger $p \leq 0.001$. This was almost inevitable, given the above result, as the time for each individual suck stays roughly constant.

A similar analysis for mean length of sucking burst revealed that the burst length was greater to mother $p \leq 0.025$. Also, the pause between bursts was less for mother than stranger $p \leq 0.01$.

These results can be summarized as infants show ing more sucking to mother than stranger by increasing burst length and decreasing pause length to a greater extent when the mother's voice is contingent upon sucking. These results hold for groups 1 and 2 but not group 3.



COMPARISON OF MEAN TIME SPENT SUCKING TO MOTHER AND STRANGER.

sucking to mother.......... ————

sucking to stranger.......– – – –

△ --Group 1.
○ --GROUP 2.
□ - GROUP 3 (non - contingent)

Conclusions

The results of this experiment indicate that infants of 1 month of age are capable of discriminating their mother's voice from a female stranger's voice. The fact that group 3 infants showed no such discrimination suggests that the contingent nature of the voice was important in increasing sucking, and that sucking did not increase due to increased arousal produced by the mother's voice. This suggests that group 1 and 2 infants increased their sucking in order to hear the mother's voice, and hence suggests intentionality. However, there are alternative explanations for this effect.

1. Infants may have experienced increased arousal on hearing the mother's voice, and that the arousal produced an increase in the behaviour in which the infant was currently engaged. For group 1 and 2 infants this would cause an increase in sucking, whereas for group 3 infants sometimes they would be sucking and sometimes not sucking when a voice occurred hence no increase in sucking would be expected.

2. Sucking affects an infant's state, and infants change state very quickly, possibly while sucking the infants were more receptive to auditory stimulation and hence more susceptible to being aroused by it, which in turn would produce increased sucking to mother's voice for group 1 and 2 infants but not group 3 infants.

Whichever of the above explanations is accurate, the conclusion that 1 month old infants can recognise their mother's voice still holds. What dimensions of the voice form the basis for the recognition is not known. It may be some simple physical features such as a characteristic frequency of the voice or it may a more complex patterning of features to which the infant is responding. Regardless of these considerations, this study demonstrates that the perceptual and memory capacities of 1 month old infants are such that they will be able to have learnt and display recognition of the mother's voice.

Chapter 7.

Further investigation of social abilities of 1 month old infants.

Introduction.

In considering the infant's capacities for differentiating people, it can be seen from chapter 5 that the work of Carpenter (1974) stands out in indicating earlier visual recognition of the mother than other studies on this topic. Indeed, the speed of recognition indicated by this study would require considerable revision of currently accepted viewpoints on visual, memory, and social development in infancy. However, there are methodological considerations which suggest alternative explanations of the results of this study. These are discussed in chapter 5. The doubts raised about this potentially important finding require resolution. It was decided therefore to test visual recognition of the mother in early infancy by means which do not have the methodological drawbacks of the Carpenter (1974) study.

If the conclusions of the Carpenter (1974) study are valid then infants are rapidly able of visual discrimination of individuals. If a 2 week old infant can recognise a particular person then the question is raised as to when can the infant visually discriminate behaviours of a person. One potentially important behaviour requiring visual processing is discrimination of gaze. The simplest aspect of gaze discrimination, and also a relevant one for social development, would be discrimination of whether a person is in face-to-face gaze with one or is gazing in some other direction. Hence, it was decided to also test infant's capacity for such a discrimination. Auditory abilities are well developed in early infancy as reviewed in chapter 3, and the experiment described in chapter 6 demonstrates recognition of mother's voice in 1 month old infants. Following from this experiment it would be appropriate to consider other receptive communicative abilities of infants. In particular, if infants can discriminate voices, can they also discriminate different tones of the same voice? Therefore, a test of tone of voice discrimination was included in the next experiment.

Design.

The experiment was based on a

2(sex) x 2(mother or stranger) x 5(voice or gaze condition)

factorial design where the 5 voice and gaze conditions were;

face alone no voice
face and neutral voice
face and affectionate voice
face averted 45 degrees no voice
face averted 45 degrees affectionate voice

In that both mother(M) and stranger(S) provided these various combinations, there were 10 conditions in all. All subjects experienced all 10 conditions. The order of presentation was randomized with the restriction that no more than 2 successive presentations were by the same adult, (or were of no voice conditions). This was done to avoid possible habituation effects on infant responsiveness.

Subjects.

Potential subjects were introduced by health visitors in the Camden area, and a visit would be made to the home to explain the experiment and to request participation. 42 subjects were recruited. It was not possible to analyze the data from all subjects in that malfunctioning in the video equipment degraded the recordings of some subjects such that the data was unusable and some infants were disregarded due to inapprpriate state. The data from 16 males and 15 females were used in the analysis of results. All subjects were in the age range 24-35 days of age.

Apparatus.

The observation chamber (see fig. 7(1)) in which infants were to sit was based upon that used by Carpenter (1974). It was modified to facilitate video-recording of the upper half of the infant, by a widening of the stimulus presentation aperture, and the provision of an infra-red light source.

The Link camera used was fitted with a silicon diode tube to facilitate low light level recording. Recording was made on an Ampex 1 inch video-recorder which was in a separate room. A stopwatch was

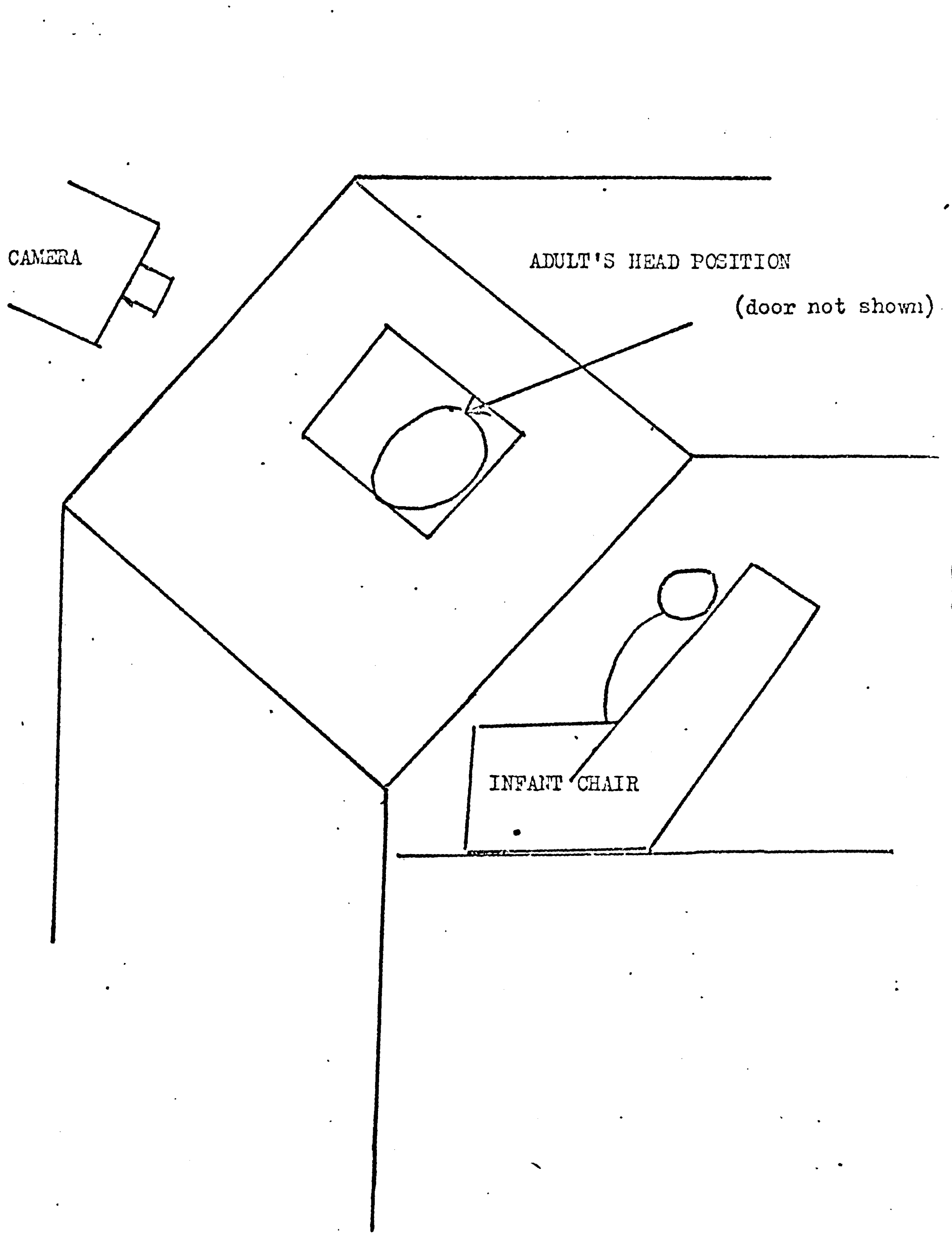


DIAGRAM OF THE OBSERVATION CHAMBER AND CAMERA (SCHEMATIC)

Fig. 7(1)

used to time stimulus presentations. A Rustrak event recorder was used for scoring of video-tapes.

Procedure.

Mothers and infants were driven to the laboratory from their homes in order to avoid transport problems. When a mother and infant arrived at the laboratory, firstly the mother was shown the apparatus, then reminded of the procedure, and practiced in the presentation of face and voice. When the infant was in a quiet alert state (Prechtl state 4), he/she would be placed in the infant seat and the recording apparatus activated. When the infant was looking forward at the lights on the inside of the aperture door, the aperture door was opened and the first stimulus presentation would begin. After more than 30 seconds had elapsed the 'stimulus' withdrew to a signal (tap on shoulder) and closed the door. After an inter-stimulus gap of at least 10 seconds, the next stimulus started. If a subject started fretting or seemed uncomfortable then the procedure was suspended until the infant again in a calm state.

If possible, a session would be completed on the initial visit, by repeating stimuli where the infant had not been in a quiet, alert state. However, sometimes this required that mother and baby return on another day, when the experiment would be repeated in full. If a subject did not complete all experimental conditions then that subject was excluded from the results. Data from 5 subjects was rejected due to lack of appropriate state, and 6 subjects were excluded due to equipment failure.

Collection of validation data.

After the 10 experimental stimuli had been presented, and if the subject was still in a quiet alert state, the experimenter would present himself as a stimulus to the infant. The experimenter would say when the infant was and was not looking at him. This may be repeated several times if the infant maintained a quiet, alert state. The purpose of these latter presentations were to provide a means of checking the validity of the judgments on infant looking made from the video-tape.

Sessions might last from 30 minutes up to 2 hours depending on the cooperativeness of the infant. Such variation would tend to increase the variance of the results but would not have any directional influence.

Scoring of video-tapes.

When the video-tape was replayed the sound was turned off, except when scoring vocalizations, to avoid any knowledge by the scorer as to the identity of the 'stimuli'. For this reason vocalizations were always scored last. Each video-tape was played through once for each the event recorder. The record charts from the event recorder were then scored by measurement with a ruler. Results were matched with particular stimuli after all scoring had been finished.

Looking.

When a session was replayed, if the infant appeared to be looking at the right-hand edge of the monitor screen, this was scored as looking at the 'stimulus'. Looking at the cimera, above, below or in any position other than the area immediately adjacent to the right-hand edge of the monitor was not scored as looking.

Validity of looking measure.

This was derived from scoring the 'validity stimuli' from vision only, as usual, and then scoring the same stmuli from the sound track i.e. E saying "looking" or "not looking". The total duration, and number of looks of the sets of scores were then used in a product-moment correlation, to derive a measure of validity of the scoring of looking. These correlations were 0.97 for total duration, and 0.93 for number of looks. The raw scores for the validity series are in appendix 2(1).

Vocalizations.

Any vocalization made by the infant except crying was scored as a vocalization. Pilot work had found that any further differentiation could not be reliably maintained.

Smiles.

An upward and outward movement of the mouth corners was scored as a smile. Again pilot work had found that further differentiation e.g. 'half smile' vs. 'full smile' could not be reliably maintained.

Mouthing.

All mouth movements made by the infant, were as mouthing, regardless of whether the tongue was involved or not. Some investigators have used a finer discrimination e.g. Aronson and Rosenbloom (1971) only scored mouth movement involving the tongue. Pilot work showed that such discrimination could not be reliably maintained.

Frowns.

When an infant drew together the eyebrows causing a furrow this was scored as a frown.

Reliability of scoring.

The reliability of the scoring technique was assessed by scoring 2 sessions by 2 observers independently, and then correlating (Pearson product-moment correlation) the aspect of the behaviour that was to be used in the analysis of the results, somtimes this was a duration score, sometimes a frequency score. The reliabilities are in the following table. The raw scores in appendix 2(2).

duration of looking	0.96
frequency of looks	0.92
first look	0.98
frequency of vocalizations	0.95
frequency of smiles	1.00
duration of frowning	0.89
duration of mouthing	0.93

Results.

Look data.

This was analyzed firstly in terms of the total duration of looking at each stimulus. It was firstly necessary to check on the appropriateness of parametric statistics in terms of whether it fits the assumptions of parametric statistics.

1. Normality of data.

Histograms of each stimulus for each sex were constructed and inspected. An example histogram is in appendix 2(3). They appeared to be truncated normal distributions which was probably a result of restricting the stimulus duration to 30 seconds. The hypothesis that such data were not from a normal distribution with the same mean and standard deviation as the sample was tested by the Kolmogorov-Smirnov test. The results are presented in the following table

SEX	STIMULUS	PROBABILITY	SIGNIFICANCE
male	MF	0.994	n.s.
male	MFMV	0.752	n.s.
male	MFMVA	0.986	n.s.
male	MFAV	0.823	n.s.
male	MAVA	0.951	n.s.
male	SF	0.940	n.s.
male	SFSV	0.863	n.s.
male	SFSVA	0.880	n.s.
male	SFAV	0.411	n.s.
male	SAVA	0.872	n.s.
female	MF	0.917	n.s.
female	MFMV	0.677	n.s.
female	MFMVA	0.902	n.s.
female	MFAV	0.981	n.s.
female	MAVA	0.605	n.s.
female	SF	0.685	n.s.
female	SFSV	0.528	n.s.
female	SFSVA	0.807	n.s.
female	SFAV	0.842	n.s.
female	SAVA	0.923	n.s.

It was therefore concluded that the data was a sufficient approximation to a normal distribution to use parametric statistics.

2. Is the data in different groups or conditions of approximately equal variance. For each stimulus, the null hypothesis of equal variances between sexes can be tested by the F test, and the results

are in the following table.

STIMULUS	RATIO OF VARIANCES	SIGNIFICANCE
MF	1.13	n.s.
MFMV	1.06	n.s.
MFMVA	1.02	n.s.
MFAV	2.02	n.s.
MFMVAVA	1.37	n.s.
SF	2.02	n.s.
SFSV	1.09	n.s.
SFSVA	3.77	L.T. 0.05
SFAV	1.12	n.s.
SFSVAVA	2.05	n.s.

The significant F test for SFSVA means that any effect involving sex would need to be treated cautiously.

The BMD P2V program for analysis of variance with repeated measures includes a test of the hypothesis of symmetrical distribution of the repeated measures and this served to check the similarity of variances of stimulus conditions within sexes.

On the basis of these results it seemed appropriate to use parametric statistics, therefore the total duration of looking was analyzed in a

2(sex) x 2(mother or stranger) x 5(face and voice conditions) repeated measures analysis of variance using the BMD P2V program.

summary table is shown below.

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F RATIO	PROB
mean	108177.0000	1	108177.0000	689.3208	0.000
sex	158.1027	1	158.1027	1.0075	0.324
error	4551.0497	29	156.9327		
adult	1.4136	1	1.4136	0.0206	0.887
ad. x sex	195.4770	1	195.4770	2.8513	0.102
error	1987.8559	29	68.5468		
face/vo	267.5106	4	66.8776	1.5901	0.182
f/v x sex	251.1883	4	62.7971	1.4931	0.209
error	4878.7374	116	42.0581		
ad. x f/v	82.8292	4	20.7073	0.3899	0.815
ad. x f/v x sex	143.2958	4	35.8240	0.6747	0.611
error	6159.4486	116	53.0987		

Thus the analysis of total duration of looking reveals no significant results.

<u>Number of looks.</u>

Histograms for number of looks for each sex were constructed an example is in appendix 2(3). They appear to be normal distributions and the null hypothesis that this data is derived from a normal distribution was tested with the Kolmogorov-Smirnov test. The results presented below indicate acceptance of the null hypothesis.

SEX	STIMULUS	PROBABILITY	SIGNIFICANCE
male	MF	0.460	n.s.
male	MFMV	0.800	n.s.
male	MFMVA	0.819	n.s.
male	MFAV	0.210	n.s.
male	MAVA	0.232	n.s.
male	SF	0.688	n.s.
male	SFSV	0.878	n.s.
male	SFSVA	0.423	n.s.
male	SFAV	0.731	n.s.
male	SAVA	0.305	n.s.

female	MF	0.455	n.s.
female	MFMV	0.518	n.s.
female	MFMVA	0.142	n.s.
female	MFAV	0.797	n.s.
female	MAVA	0.632	n.s.
female	SF	0.259	n.s.
female	SFSV	0.501	n.s.
female	SFSVA	0.508	n.s.
female	SFAV	0.388	n.s.
female	SAVA	0.861	n.s.

To test for the equality of variances of the different sex groups data an F test was carried out for each stimulus. Results are shown below indicating acceptance of the null hypothesis that the data are derived from distributions with equal variances.

STIMULUS	RATIO OF VARIANCES	SIGNIFICANCE
MF	1.62	n.s.
MFMV	1.39	n.s.
MFMVA	2.05	n.s.
MFAV	1.64	n.s.
MFMVAVA	2.10	n.s.
SF	1.28	n.s.
SFSV	1.35	n.s.
SFSVA	1.47	n.s.
SFAV	1.64	n.s.
SFSVAVA	1.32	n.s.

The BMD P2V program for analysis with repeated measures was again used to analyse this data. Again the similarity of variances within sexes was included in this analysis. The summary table for the analysis of variance is presented below.

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F RATIO	PROB
mean	2462.3147	1	2462.3147	248.6086	0.000
sex	14.1213	1	14.1213	1.4258	0.242
error	287.2271	29	9.9044		
adult	1.3000	1	1.3000	0.6818	0.416
ad. x sex	0.0226	1	0.0226	0.0119	0.914
error	55.2871	29	1.9065		
face/vo	3.3582	4	0.8396	0.3073	0.873
f/v x sex	14.0.679	4	3.5170	1.2871	0.279
error	316.9708	116	2.7325		
ad. x f/v	14.3596	4	3.5899	1.9846	0.101
ad.x f/v x sex	15.9596	4	3.9899	2.2058	0.073
error	209.8275	116	1.8089		

Thus this data reveals no significant differences.

First look.

A commonly used index in studies recording visual fixation is the duration of the first look.

An example histogram for the first look data is presented in appendix 2(3). It is clearly not normal, having a pronounced positive skew. Therefore the first look data was transformed by taking the log of the first look score +1 i.e.log(first look +1). An example of the histograms for the transformed data is presented in appendix 2(3). The null hypothesis that the data is derived from a normal distribution was tested by the Kolmogorov-Smirnov test with the following results.

SEX	STIMULUS	PROBABILITY	SIGNIFICANCE
male	MF	0.995	n.s.
male	MFMV	0.742	n.s.
male	MFMVA	0.979	n.s.
male	MFAV	0.478	n.s.
male	MAVA	0.893	n.s.
male	SF	0.956	n.s.
male	SFSV	0.773	n.s.
male	SFSVA	0.469	n.s.
male	SFAV	0.998	n.s.
male	SAVA	0.969	n.s.
female	MF	0.988	n.s.
female	MFMV	0.827	n.s.
female	MFMVA	0.895	n.s.
female	MFAV	0.945	n.s.
female	MAVA	0.814	n.s.
female	SF	0.746	n.s.
female	SFSV	0.984	n.s.
female	SFSVA	0.443	n.s.
female	SFAV	0.637	n.s.
female	SAVA	0.821	n.s.

Thus the null hypothesis was accepted.

The equality of variances for sexes for each stimulus was tested by the F test; results below indicate that the data are derived from distributions with equal variances.

STIMULUS	RATIO OF VARIANCES	SIGNIFICANCE
MF	2.32	n.s.
MFMV	1.33	n.s.
MFMVA	1.24	n.s.
MFAV	1.52	n.s.
MFMVAVA	1.33	n.s.
SF	1.33	n.s.
SFSV	1.12	n.s.
SFSVA	1.11	n.s.
SFAV	1.23	n.s.
SFSVAVA	1.44	n.s.

The BMD P2V program for analysis of variance with repeated measures gave the following summary table.

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F RATIO	PROB
mean	1205.28670	1	1205.28670	782.63730	0.000
sex	1.42494	1	1.42494	0.92526	0.344
error	44.66093	29	1.54003		
adult	2.49447	1	2.49447	4.64448	0.040
ad. x sex	0.23847	1	0.23847	0.44401	0.510
error	15.57540	29	0.53708		
face/vo	2.89709	4	0.72427	1.08868	0.365
f/v x sex	1.70780	4	0.42695	0.64176	0.634
error	77.17182	116	0.66527		
ad. x f/v	3.039994	4	0.76000	0.91450	0.458
ad.xf/vxsex	0.71986	4	0.17996	0.21655	0.929
error	96.40144	116	0.83105		

Thus there is a marginally significant result (p LT 0.040 1-tailed) for the effect of the adult (mother or stranger).

<u>Mouthing.</u>

An example histogram is presented in appendix 2(3).The histograms suggest normality which was tested by the Kolmogorov-Smirnov test results below:

SEX	STIMULUS	PROBABILITY	SIGNIFICANCE
male	MF	0.394	n.s.
male	MFMV	0.752	n.s.
male	MFMVA	0.986	n.s.
male	MFAV	0.823	n.s.
male	MAVA	0.951	n.s.
male	SF	0.940	n.s.
male	SFSV	0.863	n.s.
male	SFSVA	0.880	n.s.
male	SFAV	0.411	n.s.
male	SAVA	0.872	n.s.

female	MF	0.917	n.s.
female	MFMV	0.677	n.s.
female	MFMVA	0.902	n.s.
female	MFAV	0.981	n.s.
female	MAVA	0.605	n.s.
female	SF	0.685	n.s.
female	SFSV	0.528	n.s.
female	SFSVA	0.807	n.s.
female	SFAV	0.842	n.s.
female	SAVA	0.923	n.s.

Thus the data may be assumed to be normally distributed.

The equality of variances between sexes for each stimulus was tested by the F test and the results below indicate that the null hypothesis of equal variances may be accepted.

STIMULUS	RATIO OF VARIANCES	SIGNIFICANCE
MF	1.24	n.s.
MFMV	1.10	n.s.
MFMVA	1.81	n.s.
MFAV	1.82	n.s.
MFMVAVA	1.08	n.s.
SF	1.98	n.s.
SFSV	1.79	n.s.
SFSVA	1.67	n.s.
SFAV	1.80	n.s.
SFSVAVA	3.24	L.T. 0.02

The significant effect for SFSVAVA means that any sex effect must be considered with caution.

The BMD P2V program for analysis of variance with repeated measures was carried out and the summary table is below.

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F RATIO	PROB
mean	24362.9720	1	24362.9720	234.0005	0.000
sex	298.3887	1	298.3887	2.8660	0.101
error	3019.3362	29	104.1150		
adult	0.7878	1	0.7878	0.0325	0.858
ad. x sex	7.5786	1	7.5786	0.3126	0.580
error	703.0486	29	24.2428		
face/vo	63.3325	4	15.8331	0.6277	0.644
f/v x sex	101.3237	4	25.3309	1.0042	0.408
error	2926.0486	116	25.2246		
ad. x f/v	63.4993	4	15.8748	0.6629	0.619
ad.x f/v x sex	58.9246	4	14.7311	0.6152	0.653
error	2777.7691	116	23.9463		

There are no significant differences revealed by this analysis.

Vocalizations.

Vocalizations were usually very short in duration therefore the frequency of vocalizations only was analysed. The histograms (example in appendix 2(3)) reveal that the data is non-normal. Therefore non-parametric statistics should be used. The data was analysed separately for each sex by a Wilcoxon matched-pairs signed ranks test for each comparison which bore upon the hypotheses. There are 10 experimental conditions for each subject. Therefore there are 9 degrees of freedom for the conditions, and thus up to 9 contrasts amongst conditions are allowable.

The 9 orthogonal contrasts chosen are shown below in terms of the weighting given to each condition's score in the calculation of the Wilcoxon statistic.

COMPARISON	MF	MFMV	MFMVA	MFAV	MAVA	SF	SFSV	SFSVA	SFAV	SAVA
mother v stranger	1	1	1	1	1	-1	-1	-1	-1	-1
voice v no voice	+3	-2	-2	+3	-2	+3	-2	-2	+3	-2
affection v neutral	0	+2	-1	0	-1	0	+2	-1	0	-1
averted v not averted (with voice)	0	-1	-1	0	+2	0	-1	-1	0	+2
averted v not averted (no voice)	-1	0	0	+1	0	-1	0	0	+1	0
INTERACTIONS										
voice x M or S interaction	+3	-2	-2	+3	-2	-3	+2	+2	-3	+2
aff/neutral x M or S int.	0	+2	-1	0	-1	0	-2	+1	0	+1
av/not av. x M or S int.	0	-1	-1	0	+2	0	+1	+1	0	-2
av/not av (no voice) x M or S int.	-1	0	0	+1	0	+1	0	0	-1	0

X

SEX	COMPARISON	N	T	PROB
MALE	mother vs stranger	11	26.5	n.s.
MALE	voice vs no voice	14	23.0	n.s.
MALE	affectionate vs neutral voice	12	12.0	n.s.
MALE	averted face vs not averted (voice)	9	20.5	n.s.
MALE	averted face vs not averted (no voice)	11	9.0	LT 0.025
MALE	voice/no voice x M or S int.	13	24.0	n.s.
MALE	affection/neutral x M or S int.	12	25.0	n.s.
MALE	averted/not av(voice) x M or S int.	10	6.0	LT 0.025
MALE	averted/not av(no voice) x M or S int.	12	21.5	n.s.

SEX	COMPARISON	N	T	PROB
FEMALE	mother vs stranger	9	14.0	n.s.
FEMALE	voice vs no voice	13	30.5	n.s.
FEMALE	affectionate vs neutral voice	11	22.5	n.s.
FEMALE	averted face vs not averted (voice)	11	18.0	n.s.
FEMALE	averted face vs not averted (no voice)	10	29.0	n.s.
FEMALE	voice/no voice x M or S int.	13	32.0	n.s.
FEMALE	affection/neutral x M or S int.	13	37.5	n.s.
FEMALE	averted/not av(voice) x M or S int.	11	22.5	n.s.
FEMALE	averted/not av(no voice) x M or S int.	10	26.0	n.s.

For males only, there is an indication that the infants may be distinguishing the face to face position from the averted face condition, when not accompanied by a voice. The face to face condition evoking more vocalizations than the face averted condition. Also there is an indication of interaction between averted/not averted(with voice) and the adult (M or S). These differences imply that the face to face condition is differentiated from the face averted condition and the interaction with adult when the voice is present (but not with voice absent) supports the proposition that the adult's voices are differentiated.

Females show no significant differences.

<u>Frowning.</u>

Frowning is analyzed in terms of duration of occurrence. The histograms (example in appendix 2(3)) show that this data is non-normal, therefore non-parametric statistics are appropriate. The Wilcoxon matched pairs signed ranks test results are below. Scores are weighted as for vocalizations.

SEX	COMPARISON	N	T	PROB
MALE	mother vs stranger	13	34.0	n.s.
MALE	voice vs no voice	12	31.0	n.s.
MALE	affectionate vs neutral voice	9	7.0	n.s.
MALE	averted face vs not averted (voice)	9	22.0	n.s.
MALE	averted face vs not averted (no voice)	12	38.5	n.s.
MALE	voice/no voice x M or S int.	13	46.0	n.s.
MALE	affection/neutral x M or S int.	9	22.0	n.s.
MALE	averted/not av(voice) x M or S int.	9	16.0	n.s.
MALE	averted/not av(no voice) x M or S int.	10	19.0	n.s.

SEX	COMPARISON	N	T	PROB
FEMALE	mother vs stranger	9	13.0	n.s.
FEMALE	voice vs no voice	9	13.0	n.s.
FEMALE	affectionate vs neutral voice	5	00.0	n.s.
FEMALE	averted face vs not averted (voice)	5	6.0	n.s.
FEMALE	averted face vs not averted (no voice)	9	10.5	n.s.
FEMALE	voice/no voice x M or S int.	9	20.0	n.s.
FEMALE	affection/neutral x M or S int.	5	3.0	n.s.
FEMALE	averted/not av(voice) x M or S int.	5	6.0	n.s.
FEMALE	averted/not av(no voice) x M or S int.	9	18.5	n.s.

These results reveal no significant differences.

Smiles.

Smiles occurred rarely and in order to have enough data to carry out statistical analysis it was necessary to sum data over sexes and conditions. Such a procedure results in non-orthogonal contrasts but is necessary to undertake meaningful comparisons and is unlikely to bias the results. Wilcoxon results are below.

COMPARISON	N	T	PROB
ALL MOTHER vs ALL STRANGER	8	13.5	n.s.
ALL FACE ALONE vs ALL FACE AND VOICE	9	1.0	LT 0.01
ALL FACE AVERTED vs ALL FACE TO FACE	9	0.0	LT 0.01
ALL AFFECTIONATE VOICE vs ALL NEUTRAL VOICE	9	28.0	n.s.

These results indicate differentiation of conditions on the basis of whether a voice is present and also on the basis of direction of gaze.The face alone evoked more smiles than face+voice conditions and the face-to-face conditions evoked more smiles than the face averted conditions. Possibly this latter result reflects the greater smiling to a 2-eye gestalt reported by Ahrens (1954).

Post-hoc analysis.

In the collection of the validation data it was noticed that the experimenter attracted more attention than either the mother or stranger. The experimenter was a dark-haired male with a beard and hence his face consisted of dark hair, light forehead, dark eyes, light cheeks, dark beard; i.e. a stimulus full of contrast. This suggested the possibility that contrast may be a critical factor in attracting the infant's attention. Therefore it was decided to reanalyze the looking data with a recategorization of adults into darker-haired vs. lighter-haired as this would approximate a more contrast vs. less contrast comparison. The results for the BMD P2VS program are given below

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F RATIO	PROB
mean	108177.000	1	108177.000	689.32	0.000
sex	158.1027	1	158.1027	1.01	0.324
error	4551.0497	29	156.9328		
adult	688.6882	1	688.6882	13.47	0.001
ad. x sex	7.0240	1	7.0240	0.14	0.714
error	1482.9194	29	51.1351		
face/vo	267.5106	4	66.8771	1.59	0.182
f/v x sex	251.1883	4	62.7971	1.49	0.209
error	4878.7374	116	42.0581		
ad. x f/v	109.2186	4	27.3046	0.52	0.722
ad.xf/v xsex	161.8020	4	40.4505	0.77	0.548
error	6108.7734	116	52.6618		

The significant effect for adult is due to the greater looking to the darker-haired adult than to the lighter-haired adult. No other comparisons were significant.

Conclusions.

The large number of comparisons carried out in the analyses of the results will tend to capitalize on the likelihood of significant results due to chance factors. Therefore, one needs to interpret the results with caution, particularly where the significance levels are marginal. With respect to the hypotheses posed at the beginning of the experiment, one comparison directly supports the hypothesis of mother-stranger discrimination by 1 month-olds. This is the finding of longer first fixations to the mother than to the stranger. This result is significant at the 0.04 level (1-tailed). None of the other mother-stranger comparisons produce significant results. Therefore, it would be rash to use this marginal significance level as justification for accepting the hypothesis of mother-stranger discrimination.

With regard to the hypothesis of tone of voice discrimination, there is no evidence to support this hypothesis. It should be noted at this point that this experiment probably did not constitute a good test of this hypothesis in that, while initially adults would discriminate their tone of voice, such were the demand characteristics of interacting with infants that adults seemed to slip into using an affectionate tone of voice in all voice conditions.

Concerning the third hypothesis of differentiation of the face-to-face conditions from the face averted conditions. This is supported by three sources. Firstly, for males but not for females, the comparison between the vocalizations evoked by the face-to-face and face averted conditions (no voice) reveals a significant difference. Secondly, again for males only, there is a significant interaction in vocalizations between the face-to-face/face averted conditions (+voice) and the adult. Thirdly, the comparison of smiles evoked by all face-to-face vs. all face averted conditions again indicates a significant difference. Here the hypothesis is supported by more than one source of evidence, and while each comparison alone would be weak evidence, together they indicate that it would be justified to reject the null hypothesis of no differentiation between face-to-face and face averted conditions.

The post-hoc analysis of the looking data with a recategorization of adults as darker-haired or lighter-haired with its significant main effect for adult suggests that the contrast of the face is important in determining infant attention. This result also suggests another interpretation of the Carpenter (1973,1974) data in that the stranger used in that study was fair-haired and hence would be of low contrast and hence would attract little attention. Thus the apparent mother-stranger discrimination in this study may well reflect differential responsivity to faces differing in contrast value.

The results of the post-hoc analysis indicate that an important determinant of infant attention to faces in the first month of life is the physical characteristics of the face. The contrast value of a face would seem to be a major reason for infant visual attention. Hence, in explaining patterns of infant visual attention to faces such factors need to be taken into account.

Chapter 8.

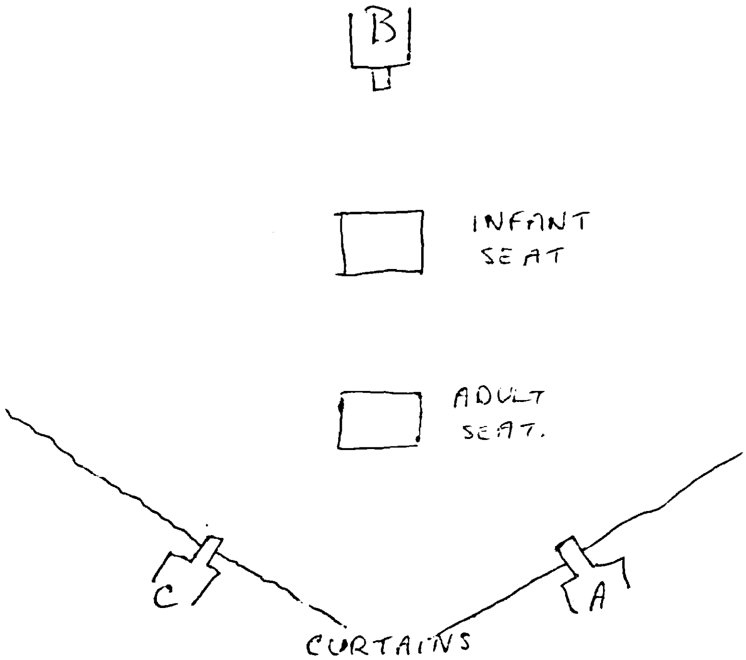
The development of a methodology for the analysis of adult-infant interaction.

In presenting social stimuli in a pre-set manner, infant responses are measured in terms of gross frequency or duration or derivatives thereof. There are limitations to such an approach. In particular, the infant in a naturalistic situation may show patterns of response which do not appear in non-naturalistic situations. One aspect of this in volves the analysis of sequences of behaviour. Particular infant behaviours may be more likely when a particular adult behaviour is already occurring. In order to evaluate such responsiveness a method of sequential analysis is necessary. Therefore it was decided to develop a methodology which allows for the recording of naturalistic social interactions in a manner which allowed a sequential analysis of the behaviour changes occurring in the interaction.

The 2 experiments earlier described have taken place in the laboratory and have presented social stimuli in a contrived manner, obviously not similar to the situations in which stimuli would naturally occur. This was required by the particular methodologies involved. Now the 2 experiments so far conducted lead to the conclusion that infants are learning about the social stimuli in their natural environment, certainly in the auditory modality and possibly in the visual modality. Therefore it is possible that the infants may learn enough to discriminate naturalistic situations from the laboratory situations so far described and as a result react differently toward the social stimuli than they would in the naturalistic situation. Now to the extent that the infant shows greater differentiation of response to social stimuli this may aid the investigation, however it is quite likely that the infant may show less differentiation of response in the non-naturalistic than in naturalistic surroundings. In view of this latter possibility it was decided to conduct the next study in a manner which allowed a closer approximation to naturalistic situations in which the infant might display his response repertoire to other people.

Several investigators (e.g. Stern (1974) and Brazelton et.al.(1974)) have reported on the video-recording of mother-infant interaction in a manner which allows the infant's responses to be measured while encountering people in a close approximation to a naturalistic situation. Therefore, it was decided to video-record infant behaviour while the infant was responding to other people. If the adult interacting with the infant were similarly video-recorded, then the infant's responsivity not only to particular adults, but to particular behaviours of an adult may be recorded. This would require temporal coordination of the video records of infant and adult. There are 2 ways to do this. One way is to record the adult with the same camera as that used on the infant via a mirror arrangement. A second way is to record the adult on a second camera and record the 2 camera images on the same tape using a video mixer. Pilot work indicated that this second technique gave information which was more accurately codable, and hence this technique was chosen.

In video taping infants one needs to minimise the possibility of the video-taping itself altering the behaviour of the infant. One concern is the positiong of the cameras. It was found that positioning cameras behind drawn curtains so that only the lens protruded was very successful and infants very rarely attended to the cameras. The camera positions can be seen in the following diagram.



Stern (1974) found that estimation of infant gaze direction was difficult from video records, This is true, and Stern's idea of live observers who code the gaze behaviours of the participants by operating lights visible to a camera was used. Lights were put on the back of the infant seat so that they were not visible to the infant but were visible to camera B. One light corresponded to the infant looking at the adult , and the other light corresponded to the adult looking at the infant. Pilot sessions quickly revealed that the judgment of adult looking at infant was extremely reliable from the video record and the use of the live observer to code adult gaze was dispensed with.

With this arrangement of cameras one could observe reliably the following infant behaviours:

infant looks left

" " at adult

" " right

" mouths

" smiles

" frowns

" vocalizes

and the following adult behaviours:

adult looks left

" " at infant

" " right

" points

" vocalizes

" smiles

Finer discriminations of infant behaviour led to unreliability as did altering the speed of playback. Adult behaviour generally posed few problems in coding, other adult behaviours were observed in pilot sessions e.g. frowning, tongue protusion, various forms of imitation, but they were infrequent in occurrence and it was decide to restrict the field to the behaviours above.

Some investigators kinescope tapes onto film and analyse the film frame by frame, or view the video-tape at slow speed. This technique is extremely time consuming and involves expensive equipment which was not available. Also, sometimes the interpretation of behaviours can be problematical if viewing is done at slow speed or via stopped frames e.g. what looks like a smile at normal speed can appear as a series of grimaces when viewed at slow speed. An alternative is to view the tape at ordinary speed and code the behaviours at that speed. This involves a number of coders being available at the same time, in order to obtain simultaneous records of all behaviours to be coded. It was found that the best assignment of coders was that

one coder did all infant looking behaviours

" " – infant mouths and smiles

" " – infant frowns and vocalizes

" " – all adult looking and pointing

" " – adult vocalizes and smiles

This combination of coding tasks did not result in any deterioration over the situation where only 1 coder coded 1 behaviour.

Once the behaviours to be coded and method of coding was established, it was necessary to establish a recording technique for the coded data. Computer analysis would enable far greater data loads to be handled therefore a computer readable method was desirable. For this a Digitronix Super 8 data logger was used.

This method of coding has the inherent disadvantage that the coding is contaminated by the coder's reaction time. This reaction time is of the order of 0.5 second and hence is not likely to corrupt the data very much. However, it was necessary to ensure that such errors were kept to a minimum. Hence a fast sampling time of 0.08 seconds for each behaviour was chosen on the data logger.

Coding of video records.

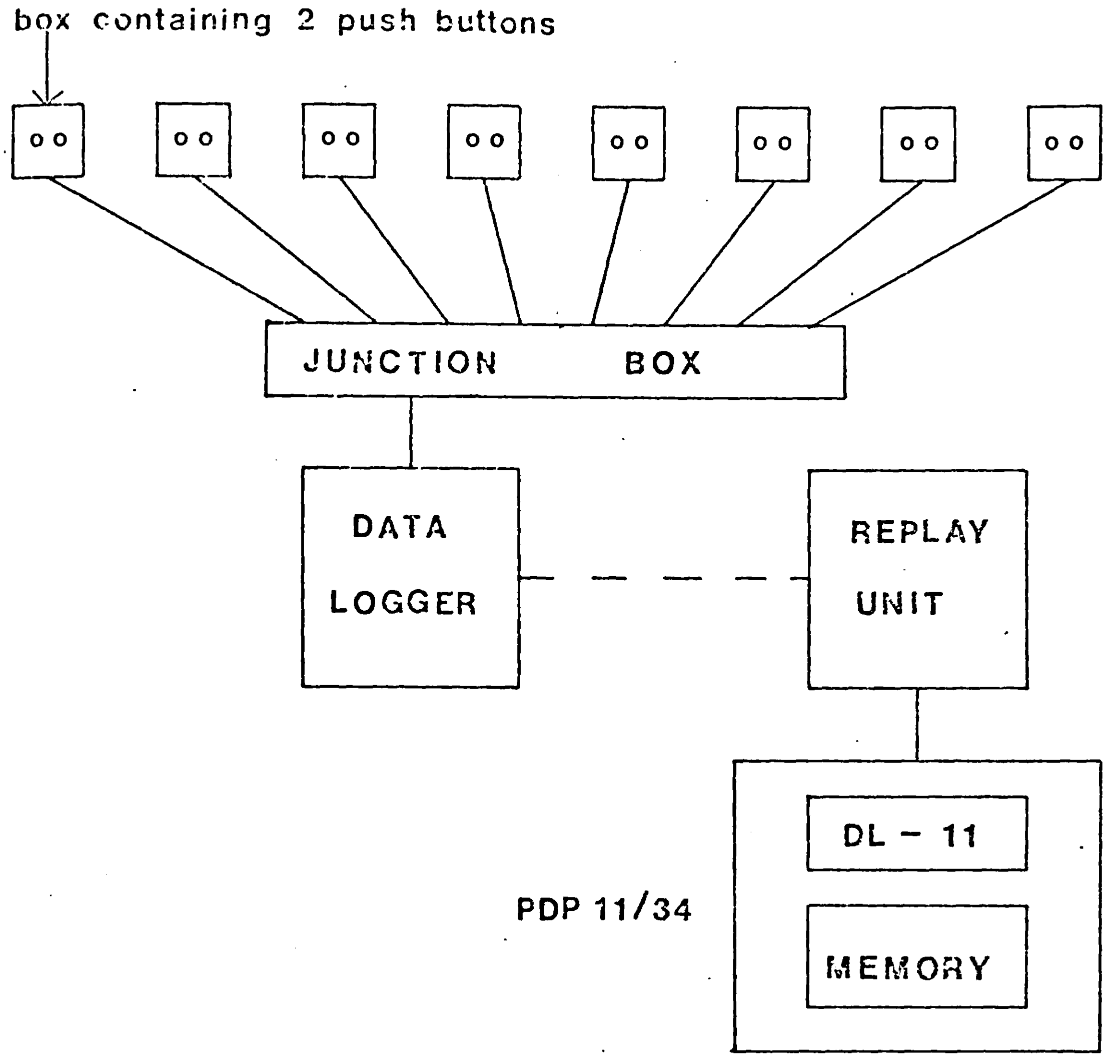
Observing the playback of the video recordings were coders, who pressed a separate push-button for each behaviour to be coded. While a behaviour was occurring the corresponding button was depressed, and while it was not occurring the corresponding button was not depressed. The number of behaviours, and hence buttons, with which any coder has to cope may vary, depending on the particular behaviours concerned. The coder's activity was recorded on special mechanism (SM) cassettes with a Digitronix Super 8 data logger, which entered a specific voltage every 0.08 seconds on each of its 8 channels. For the purposes of this study, the push-buttons were grouped in pairs such that

0.1	volts	corresponded	to	neither	button	depressed
0.3	1st	"	"	"	"	"
0.5	2nd	"	"	"	"	"
0.7	both	"	"	"	"	"

In this way it was possible to record 16 behaviours on the 8 available channels. The 16 options were used as follows:

1. data inappropriate for analysis due to fretting or euipment failure
2.) these channels used to
3.) code who adult was
4. infant looks left
5. " " at adult
6. " " right
7. " mouths
8. " smiles
9. " frowns
10 " vocalize
11. adult look left
12. " " at infant
13. " " right
14. " point
15. " vocalize
16 " smile

After an interaction had been coded in this way on to a cassette, the cassette was played via a Digitronix Dataforce ADR2 replay unit into a PDP 11/34 computer. The output from the replay unit was interfaced via a single line asynchronous serial interface of a DL-11 board, into the computer's buffer memory. Figure 8(2) represents the information flow from coders to computers. A program called CASCOP.MAC was written in MACRO-11 to enable the data to be read from the cassette into the buffer and thence into storage. (CASCOP.MAC is shown in appendix 3(1)). Once the data was in the computer it was necessary to transform the voltages into the on/offs of the 16 behaviour channels. A program called CASPV1.MAC was written in MACRO-11 to perform this task (CASPV1.MAC is in appendix 3(2)). Once the data was stored in the form of 16 behaviour channels, data analysis of the occurrence of behaviours within sessions could begin. A program FID.FOR was written in FORTRAN to perform this task.



Representation of information flow in transformation of coder's activity into a computer file.

Fig. 8(2)

However, it was discovered that the computer core needed to perform the analyses desired exceeded the limits of the PDP 11/34. Therefore, the data was transfered from the PDP 11/34 to a DEC 10/50 computer. Luckily a program to do this already existed so that the author was spared this task. However, once the data was on the DEC 10/50 the program for analysing the data had to be rewritten due to differences in the versions of FORTRAN used by the 2 computers.
(This program INTAC.F4 is shown in appendix 3(3)). INTAC.F4 analysed each session by adult involved. For a particular adult-infant interaction INTAC.F4 made 2 kinds of calculation:

1. Calculations on individual behaviours.

For each behaviour
- frequency of occurrence
- duration of each occurrence
- total duration of occurrence
- % of time behaviour was occurring

2. Calculations based on pairs of behaviours.

For each pair of behaviours a X^2 adjusted by the Altham technique (method 2 in following section r=25 observations = 2 seconds) is calculated. Also the interaction between the onset of each behaviour with every other behaviour is tested by the application of the binomial test as described in method 8 in the following section. The same binomial analysis is repeated for the interaction between the offset of each behaviour with every other behaviour.

The analysis of dyadic interactions.

Consider the interaction between individuals, if we designate I as infant and A as adult,

and I- as infant not responding I+ as infant responding.

and A- as adult not responding and A+ as adult responding we have 4 possible dyadic states:

I-A-, I-A+, I+A- and I+A+

Analysis of co-occurrences of behaviours.

These states can be ordered into a 2 x 2 contingency table as follows

	A-	A+
I-		
I+		

Method 1.

If the data is sampled then the frequency of each state can be entered into the contingency table and a X^2 test undertaken as a test of the independence of states of I and states of A.

However, in such a contingency table, the entries consist of instances in a particular state. Now, given that a state exists at time T-1 by far the most likely occurrence at time T is the same state. Hence the entries of any cell of such a contingency table are correlated. This violates the assumption of independent sampling of the X^2 test and will lead to inflated X^2 values.

One way out of this problem is to sample at intervals large enough that successive samples can be regarded as independent. Such an interval would of necessity be large enough that a change in behaviour could occur in the interval and hence transitions in the data may well be missed. Thus such a solution is likely to reduce the usefulness of the data collected.

Method 2.

An alternative solution is provided by Altham (1979) who has discussed this problem of correlated observations in contingency tables of this type in some depth. She provides a mathematical demonstration that one method of adjusting the X^2 value obtained from such contingency tables is to divide the X^2 value by (2r - 1) where r is the number of observations that would intervene between independent samples

She does not discuss how r might be estimated by this is certainly a viable approach to the problem.

Method 3.

Another approach to such a problem has been suggested by Bakeman (1978). Bakeman's method can be best illustrated by quoting his own example, which is based on data collected by Brown, Bakeman, et. al. (1975). Bakeman (1978) p. 70.

"One fairly typical infant, for example, had his eyes open 53.7% of the time overall but 66.3% of the time when feeding. But is this sufficient to establish "feeding/eyes open" as a behavioral pattern? An index is needed to guage whether behaviours coincide more or less frequently than their simple probabilities would predict. Such an index would facilitate comparisons of coincidences within a subject or between subjects. Behavior patterns could be defined as those coincidences whose index exceeds some arbitrary decision rule value. An index that we and others have found useful is the binomial test z score, $z = (x-NP)/\sqrt{NPQ}$.

For the case of the above infant, numbers used to compute the 2 score for the probability of eyes open given feeding were as follows:

x = observed joint frequency of feeding and eyes open (533)

NP = predicted joint frequency (frequency of feeding N = 834, probability of eyes open P = 0.537), and NPQ = the variance of the difference between predicted and observed (834x0.537x0.463).

In this case, z= 7.29. (The frequencies refer to the number of time intervals in which the behaviour or behaviours occurred. Given the lack of independence between successive time intervals of an observation, it seems best to treat the z score solely as an index rather than assigning p values to it. Hereafter, it is referred to as the z index.) Since we had decided that an index in excess of 2 would be sufficient to establish an individual behaviour pattern, here we concluded that "feeding/eyes open" was indeed a behaviour pattern for this infant."

However, the value of N derives from the number of observations that occur during feeding. Hence it is dependent on the frequency of sampling. If, for example, sampling were a tenth of the rate used in this example then N = 83 and x = 53 (rounding to whole numbers)

and $$z = \frac{53 - (83 \times 0.537)}{\sqrt{83 \times 0.537 \times 0.463}} \simeq 1.86$$

Whereas, if the sampling rate were ten times as frequent as in Bakeman's example,

then, N = 8340 , x = 5330

and $$z = \frac{5330 - (8340 \times 0.537)}{\sqrt{8349 \times 0.537 \times 0.463}} \simeq 18.7$$

Thus, one can see that the value of z is dependent on the sampling rate and is proportional to the square root of the sampling rate. Hence, one might find apparently significant z scores which are an artefact of the sampling rate used.

Bakeman apparently recognises this problem in part by his statement "Given the lack of independence between successive time intervals in which the behaviour or behaviours occurred, it seems best to treat the z score as an index rather than assigning p values to it."

However, the heavy dependence of z on the sampling rate used (illustrated above) makes such an index of dubious value.

Such approaches test the null hypothesis of independence between the behaviours concerned, and such a hypothesis may be rejected either as a consequence of the infant being influenced by the adult's behaviour or vice versa. Approaches which take account of the kinds of transitions that occur between states are more appropriate for deciding if the dependence observed between a pair of behaviours is due to the sensitivity of a particular member of the dyad.

Analysis of state transitions.

Each state can change to any other state so that there are 16 possible transitions.

	State at time T			
State at time T-1	I-A-	I-A+	I+A-	I+A+
I-A-	1	5	9	13
I-A+	2	6	10	14
I+A-	3	7	11	15
I+A+	4	8	12	16

From the data, the frequencies of each type of transition are counted, and the transition probability of each type of transition can be calculated.

Comparing the transitions

I-A- → I+A-

and

I-A+ → I+A+,

if the infant's behaviour is independent of the adult's behaviour then the probabilities of these transitions should be equal. Therefore, a comparison of these transition probabilities provides a method of testing the null hypothesis of independence between the onset of the infant's behaviour and adult behaviour, and the alternative hypothesis that the onset of the infant's behaviour is influenced by adult behaviour.

Method 4

One method of doing this involves the derivation of a 2 x 2 contingency table of the following form.

	Initial state A-	Initial state A+
I- → I+	No. of transitions of type 9, 13	10, 14
I- → I-	1, 5	2, 6

Transitions 10 and 13 refer to the infant and adult changing state simultaneously. Such occurrences are so rare that they are never observed. Hence the contingency table would reduce to

	Initial state A-	Initial state A+
I- → I+	No. of transitions of type 9	14
I- → I-	1, 5	2, 6

Application of X^2 test to such a contingency table would provide a test of the null hypothesis of independence of onset of infant behaviour and adult behaviour.

However, transitions 1 and 6 refer to the participants staying in the same state. Now, given that a state exists at time T-1 by far the most common event at time T will be maintenance of the same state. Therefore, the observations which contribute to the frequencies of transitions 1 and 6 will be highly correlated. This violates the assumption of independent sampling and will lead to distorted X^2 values. An example of this approach is provided by Stern (1974) who sampled dyadic states every 0.6 seconds which would cause successive samples to be correlated. Thus it would appear that Stern's analyses of his data, which apparently used X^2 tests of this type, will suffer from this fault. A reanalysis of some of Stern's (1974) data is provided later in the chapter to illustrate this point.

Method 5.

In order to overcome the problem of correlated observations where the same state is maintained, one might reconsitute the null hypothesis to be tested as

p (I-A+ $\Rightarrow$ I+A+: given that a change in state occurs)

= p (I-A- $\Rightarrow$I+A-: given that a change in state occurs)

This would result in a contingency table of the following form

	Initial state A-	Initial state A+
I- I+	No. of transitions of type 9	14
I- I-	5	2

However, transitions 5 and 2 are produced by changes in the adult's behaviour. Therefore, the resulting X^2 test would be a test of the null hypothesis that state changes are as likely to be by changes in infant behaviour as adult behaviour: i.e. a totally different hypothesis from that initially desired. Hence this approach is not viable.

Method 6

As discussed earlier, Altham (1979) has produced a method for adjusting X^2 values derived from contingency tables which consist of correlated observations. However, her approach applies to the case where all the cells of the contingency table include correlated observations. The contingency table involved here

	Initial state A-	Initial state A+
I- I+	No. of transitions of type 9,	10
I- I-	1, 5	2, 6

consists of cells where the upper cells refer to events separated in time and which can be regarded an independent, whereas the lower cells contain observations (transitions 1 and 6) successively sampled and hence correlated in the manner already described. i.e. Altham's technique applies to the case

correlated observation	correlated observation
correlated observation	correlated observation

whereas this case is

uncorrelated observations	uncorrelated observations
correlated observation	correlated observation

Now, one might be able to modify the Altham technique to apply to this case, but the Altham technique is not immediately applicable. Hence, at the moment this approach is not viable.

<u>Method 7</u>

The z - score approach discussed earlier could also be applied to the comparison of transitional probabilities.

In the formula

$$z = \frac{x - NP}{\sqrt{NPQ}}$$

x = observed number of transitions

N = number of opportunities for the transition to be observed

and P = overall probability of occurrence of the transition.

Q = 1 - P

However, this approach would be heavily influenced by the sampling rate used, as discussed earlier, hence the usefulness of this technique is dubious.

In analysing sequences of dyadic behaviour in terms of states, it is necessary to sample at a speed which is faster than a behaviour may change, otherwise one may miss a behavioural change. In sampling this frequently it is usually inevitable that successive samples will be correlated, leading to the faults mentioned earlier in several of the methods discussed.

A way out of this dilemma is to sample frequently enough to ensure that all behaviour changes are recorded but not to allow the sampling rate to influence the statistical comparison of probabilities. An appropriate treatment follows.

Method 8

Transition 14 can only occur from the state I-A+. Similarly, transition 9 can only occur from state I-A-.

Now if

a = freqency of transition 14

and b = frequency of transition 9

then a+b = total number of onsets of I i.e. I- $\to$ I+

and (time in I-A+) + (time in I-A-) is the total time period in which these onsets may occur.

Now if the null hypothesis is that the onsets of I are independent of states of A then the only influence on the probability of an onset will be the opportunities for its occurrence.

Therefore a should be proportional to (time in I-A+)

and b should be proportional to (time in I-A-)

Hence the expected probability of a occurences out of a total of a +b onsets, will be

$$\frac{\text{(time in I-A+)}}{\text{(time in I-A+) + (time in I-A-)}}$$

Using this expected probability in a binomial expansion will enable the calculation of the exact probability

of a occurrences of transition 14

and b occurrences of transition 9

Reanalysis of Stern (1974) data using method 8

Stern (1974) presents enough information on 1 of his subjects A1 (shown in fig.8(10)) to enable a reanalysis of this subject's data using method 8.

For infant A1, Stern's analysis, using a form of chi-square (method 4) finds that

p(I+M-→I-M-) is greater than p(I+M+→I-M+)

X^2=49.71, p= less than 0.000001

Using method 8;

number of transitions I+M- $\rightarrow$ I-M- =10

number of transitions I+M+ $\rightarrow$ I-M+ =207

time in (I+M-) =15+3+3 =21 observation units

time in (I+M+) =208+1765+14 =1987 observation units

therefore, expected probability of any (I+M- $\rightarrow$ I-M-) offset is

$$\frac{\text{time in (I+M-)}}{\text{time in (I+M-) + time in (I+M+)}} = \frac{21}{21+1987}$$

therefore expected probability =0.0105

Using the binomial expansion,

the probability of 10 or more transitions (I+M-) is 0.000117

Thus using method 8 this comparison is still very significant, but Stern's probability value ($\ll 0.000001$) is approximately 20 times less than this more accurate probabilty value.

Comparing p(I-M+ $\rightarrow$ I-M-) with p(I+M+ $\rightarrow$ I+M-)

Stern's result $X^2=14.59$, p 0.000124

Using method 8,

a=41, b=15, N=41+15=56,

Expected probability=0.5592

thus the probability of 41 or more transitions (I-M+ $\rightarrow$ I-M-) is 0.00584

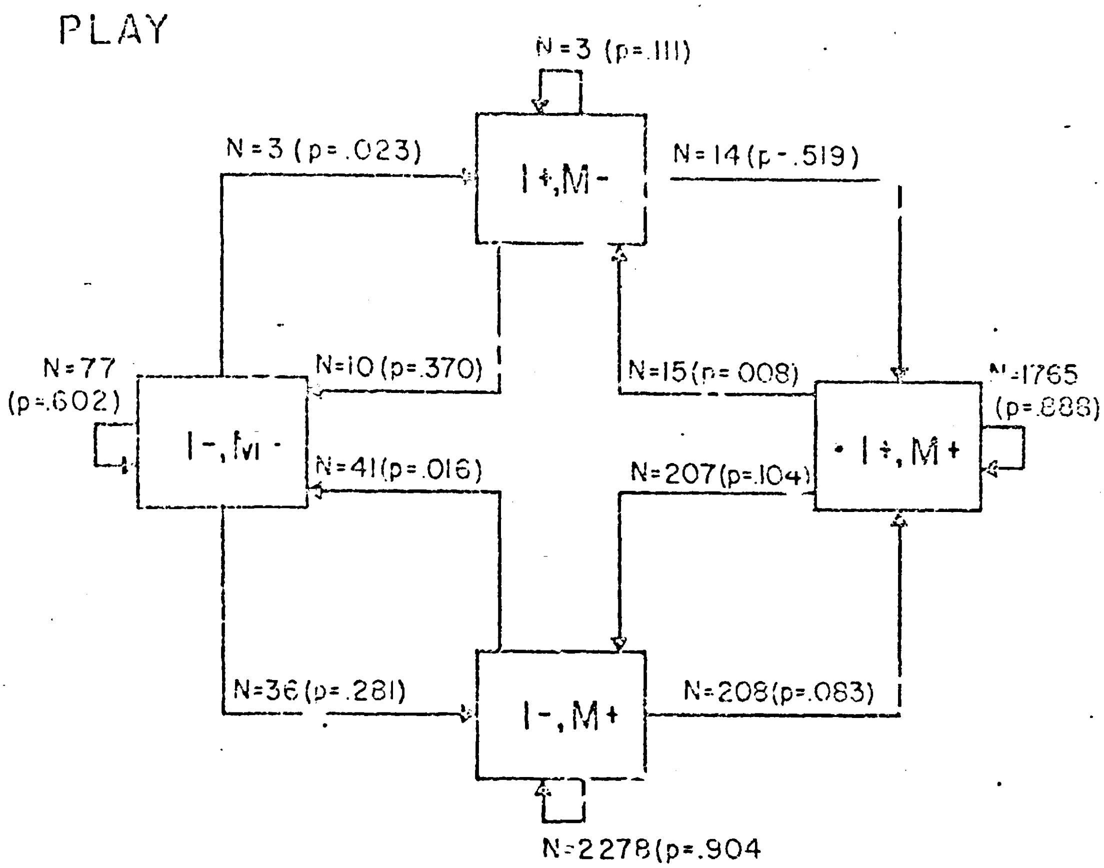


FIGURE 4. A dyadic state transition diagram for all play sessions between Twin A1 and her mother. Sampling every 0.6 seconds, the number and probability of transition from each dyadic state to any other dyadic state including itself is shown.

Fig. 8(10)
(From Stern 1974)

Comparing p(I-M+ $\rightarrow$ I+M+) with p(I-M- $\rightarrow$ I+M-)

Stern's result X^2=15.88, p $\simeq$ 0.00007

Using method 8,

a=208, b=3, N=211,

Expected probability=0.9517

thus the probability of 3 or more transitions (I-M+ $\rightarrow$ I+M+) is 0.00787 and Stern's result is approximately 100 times less.

Thus it is seen that Stern's data for infant A1 does show significant results for the above comparisons, however, the X^2 method used overestimates the 'accurate' significance levels by a factor of 50 to 200.

Chapter 9.

Infant Social Receptivity Over the First 8 Months.

The study described in this chapter is concerned with the development of the infant's receptivity to the social environment over the period 1-8 months of age. The methodology used has been described in the previous chapter. The aspects of social receptivity investigated are

a) the development of differential responsivity to people viz. mother and female stranger over the period 1-8 months of age.

b) the infant's responsivity to particular acts of another; and the methodology employed allows the investigation of such responsivity to gaze, vocalizations and smiles of another.

From the experiment described in chapter 7 it was not possible to support Carpenter's (1973,1974) reports of visual discrimination of the mother from a stranger in the first month of life. Neither did it appear that the infant was responding differentially to tone of voice, but for the reasons given in the conclusion to this experiment it probably did not constitute a good test of such discrimination. However, it did appear that infants responded to the direction of gaze in the simple sense of behaving differently (differential smiles, vocalizations) to an averted face than to a face not averted. Now Stern (1974) also reports responsivity to direction of gaze in 3.5 month olds and this aspect of social responsivity merits further investigation.

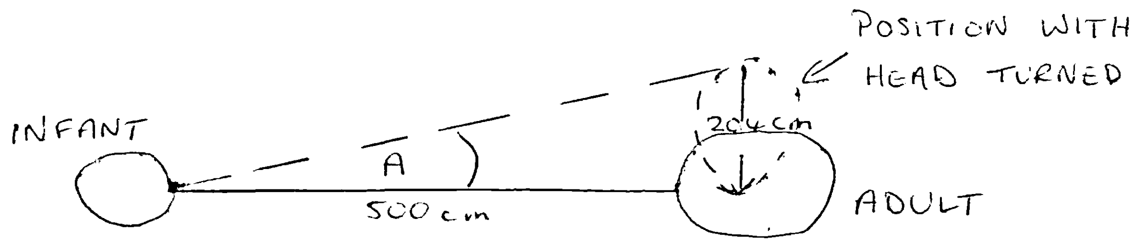
Returning to the question of mother-stranger discrimination, the evidence available as reviewed in chapter 5 indicates discrimination sometime in the first 3 months, developing sometimes to the 'stranger reaction' sometime after 6 months of age. Schaffer (1971) has suggested that the development between the earlier discrimination and the later fear reaction may be accounted for in terms of the infant's developing cognitive capacity, in particular, the infant being only capable of recognition memory in the early months and later being capable of recall, and the development of recall of the mother's face is a prerequisite of the 'stranger reaction'. However, when one considers the available evidence on the course of infant responsivity to mother and stranger in the period between early discrimination and later 'stranger reaction', there is a paucity of detail and this period is ill understood. Hence the next study is concerned with the development of responsiveness to the mother and a female stranger over the period 1-8 months of age. Also, the discrimination of particular social behaviours of the adult are investigated.

One of the social behaviours investigated is gaze. Now the experiment described in chapter 7 indicated sensitivity to gaze in 1 month olds. It was desired to substantiate this finding in more naturalistic conditions, which allowed the infant not only the opportunity to respond to a gaze direction of itself, but also to respond to changes in gaze direction. Another aspect of gaze discrimination is the ability to use the gaze of another as a referent to the environment, and one way to do this is to use another's gaze to guide one's own gaze. Scaife and Bruner (1975) report on a study of the ability of 2-14 month old infants to follow another's line of regard. An experimenter would engage the attention of an infant and then look silently to the side for 7 seconds. A 'positive' response was scored if the infant looked to the same side within the 7 seconds . 2 trials were given, 1 to either side, and direction of infant's gaze scored from a video-record. They give the following table to summarize their results.

AGE	No. of infants	% showing positive response
2-4	10	30
5-7	13	38.5
8-10	6	66.5
11-14	5	100

This obviously shows a developmental trend but why no attempt was made to estimate which infants were responding above chance levels is puzzling. In order to determine whether infants were following other's line of regard, one would need to know the incidence of such head-turning in the absence of the experimenter's lead. This incidence was apparently not recorded. Collis (1977) has suggested a means of estimating such a figure. Scaife and Bruner report that 80% of 'negative' trials were non-responses. Therefore there is a 1:4 ratio of responses:non-responses. Collis then assumes that infants were equally likely to look left and right giving a 1:1:4 ratio of correct:incorrect:non-response i.e. a 1 in 6 likelihood of 'correct' responses by chance. In 2 trials there would be a $(5/6)^2=0.694$ probability of 2 incorrect responses and hence a probability of 0.306 of at least 1 response being 'correct'.

These figures would suggest that in Scaife and Bruner's study the 2-7 month olds were operating at chance levels and infants 8 months and older are doing significantly better than chance. Scaife and Bruner report that infants would look anywhere from about 20 degrees to 90 degrees away from the mid-line. In their experiment the experimenter was seated in front of the infant, eyes at the same level, about 0.5 metres away. In similar pilot work of the author adults in looking at some object to the side often moved their head such that the tip of the nose is displaced by as much as 8 inches (204 cm) horizontally from its position when the adult is gazing at the infant. The following diagram represents the geometry of such movements.



From this diagram tan A = 204/500. Therefore A= 22 degrees (to the nearest degree), and hence the infant may displace his line of regard by 22 degrees and still be looking at the adult i.e. not following the adult's line of regard. Thus it may be that some of the reported 'positive' responses in this study may not be 'positive' and thus this report may overestimate the incidence of 'positive' responses. In particular, infants could appear to turn to follow gaze for other reasons than actually using another's gaze to direct their own gaze. Specifically, following the displacement of other's turned face could appear as gaze following in their study. One way to overcome these problems is to record if the infant is looking at the adult when the adult's gaze is to the side. Thus, although the infant's gaze may change direction as the other's face is turned to the side, if the infant were still looking at other's face this would be recorded. However, even when this is done, if the adult also points as he changes gaze direction, the movement of the hand in peripheral vision may attract the infant's attention and hence produce apparent gaze following. The resolution of this uncertainty would require more accurate estimation of the infant's direction of gaze than is feasible with the methodology envisaged. Therefore, this study restricts itself to questions of

a) whether the infant differentially responds to averted gaze and face-to-face gaze

b) whether the infant shows appropriate gaze alteration when the adult gazes and points to the side.

c) whether the infant shows appropriate gaze alteration when the adult gazes (but not points) to the side.

Affirmative answers to b) but not c) would indicate that the pointing hand is the object of attention rather than that part of the environment indicated by the gaze direction: whereas an affirmative answer to c) would indicate that gaze direction is being used as a referent.

Other social signals which commonly form part of the social environment of infants are vocalizations and smiles. While studies of the infant's use of smiles and vocalizations are common, there has been little interest in the infant's receptive capacities to the smile or vocalization of another (apart from speech perception studies). The literature reviewed in chapter 5 reveals only a suggestion of responsivity to smiling at 5 months of age.

To summarize the next study is an attempt to answer the following questions

1. What is the nature of the infant's differential responsivity to mother and female stranger over the age range 1-8 months? In order to control for the possibility of the strangers differing in some aspects other than familiarity from the mothers, a stranger was the mother of another infant in the study, whenever circumstances would allow.

2. Can infants, in this age range, respond to gaze?

a) in terms of differentiating direct gaze from averted gaze, the hypothesis being that infants will gaze more at an adult who is looking at them than an adult who is not.

b) in terms of using gaze as a referent. The hypothesis was that infants will turn to follow another's gaze.

3. Do infants demonstrate differential responsiveness to the presence and absence of another's smile?

4. Do infants demonstrate differential responsiveness to the presence and absence of another's vocalizations?

The methodology employed is described in chapter 8.

Subjects.

8 male and 5 female infants recruited via health visitors in Hertfordshire. All infants were clinically normal. The following sessions were missed from the analysis due either to illness or equipment failure.

MONTH	INFANTS WITH MISSING SESSION
1	4, 12, 13
2	13
3	none
4	none
5	1, 2
6	5,
7	5, 6
8	6

Design.

Each subject to be recorded in interaction with the mother and a stranger once a month from 1 to 8 months of age.

Procedure.

The interaction sessions took place in a CCTV studio which had been converted so that infants could be video-taped in interaction with others while sitting in an infant seat. The methodology employed is described in chapter 8.

Infants and mothers were brought to the studio, and allowed to adapt to the surroundings before recording started. As far as circumstances would allow 2 or more mother - infant pairs would be brought to the studio at the same time so that a mother could act as a stranger for another I. This also served to make the recordings more of a social occasion for the mothers which fostered cooperation. On the few occasions when this was not possible, a stranger who was experienced with infants was used, in order to allow a closer matching of the behavioural characteristics of the mother and stranger.

When an infant was in a quiet alert state (Prechtl state 4) he would be put in the infant seat and allowed to get used to it for a few minutes. Then recordings of interactions would begin. Whether the first interaction was with mother or stranger was randomized. For all infants interactions were recorded with the mother and a female stranger. The length of interactions varied from as little as 48 seconds up to 9 minutes, most interactions being in the range 2-4 minutes in duration. Infants tended to have shorter interactions in the first 2 months. It was impossible to prescribe time limits for interactions without interupting the flow of the interaction and possibly corrupting the information collected. When the experimenter judged that the state of the interaction was appropriate for a change, the adults would change places and a new interaction begin.

If infants cried or seemed uncomfortable recording was suspended and the infant comforted. If the infant returned to a quiet alert state then the recording could continue. However, somtimes the infant would be too upset or fall asleep and in these circumstances, the session would need to be restarted on another day. Occasionally, this required several visits by an infant in order to collect one session of data. Conversely during several sessions infants seemed happy to continue to interact with people after the interactions with mother and stranger had taken place and in these circumstances additional data on interactions with a second (and sometimes third) stranger, sometimes male, sometimes female, would be collected.

It was desired that the interactions proceed in a good approximation to naturally occurring interactions, however pilot work indicated that an adult very rarely averted her gaze when the infant was looking at her. This may be a function of the 'demand characteristics' of the situation . Therefore, in describing the purpose of the study to the adults involved it was mentioned that the infant's response to changes in gaze was to be investigated and therefore they were requested to look to either side occasionally when the infant was looking at them. As adults gazed to the side when infants did not look at them anyway, this instruction resulted in adult gaze aversion both when the infant was in face-to-face gaze and when not. Adults were asked to avert gaze to a piece of furniture requiring a change from face-to-face gaze of approximately 80 degrees. Scaife and Bruner (1975) found no evidence of appropriate following of gaze in the early months of infancy. Therefore, it was decided not to include pointing as an adult behaviour until 4 months of age. From this age on adults were requested to direct their gaze to the side, while the infant looked at them, sometimes with pointing and sometimes without pointing. Apart from these instructions about gaze adults were asked to interact with the infant as if they were at home with their own child.

Results

Differential responsivity to mother and female stranger.

It was necessary to convert the behavioural observations to proportional or percentage data in order to allow for the differing times that infants interacted with the various adults . Such data will tend to be non-normal at the extremes due to the limitations on the range of the data. Much of the data for all behaviours is near the extremes of the range. Therefore, it was decided to apply non-parametric statistics. The comparison for differential responsivity to mother and female stranger is made by the Wilcoxon statistic. In order to try to separate the effects of the adults' voices and faces in determining attention the look data is analyzed separately for total duration ,when adult is talking, and when adult is not talking.

One month olds.

% duration data.

Comparison	N	T	Prob.
look to mother (total) vs stranger (total)	10	21.0	n.s.
look to mother (talking) vs stranger (talking)	10	19.0	n.s.
look to mother (not talk)vs stranger (not talk)	10	17.0	n.s.
mouthing mother vs stranger	9	22.0	n.s.
smiling mother vs stranger	6	10.0	n.s.
frowning mother vs stranger	5	4.0	n.s.
vocalizing mother vs stranger	10	29.0	n.s.

Frequencies per minute

Comparison	N	T	Prob.	
look to mother (total) vs stranger (total)	10	25.0	n.s.	
mouthing mother vs stranger	10	13.0	n.s.	
smiles mother vs stranger	6	10.0	n.s.	
frowns mother vs stranger	6	11.0	n.s.	
vocalizations mother vs stranger	10	31.0	n.s.	

Thus there are no significant comparisons at one month of age.

Two month olds.

% duration data.

Comparison	N	T	Prob.	
look to mother (total) vs stranger (total)	12	31.0	n.s.	
look to mother (talking) vs stranger (talking)	12	26.0	n.s.	
look to mother (not talk)vs stranger (not talk)	12	28.0	n.s.	
mouthing mother vs stranger	12	9.0	L.T.	0.02.
smiling mother vs stranger	11	10.0	L.T.	0.05.
frowning mother vs stranger	11	31.0	n.s.	
vocalizing mother vs stranger	12	36.0	n.s.	

Frequencies per minute

Comparison	N	T	Prob.	
look to mother (total) vs stranger (total)	12	40.0	n.s.	
mouthing mother vs stranger	12	12.0	L.T.	0.05.
smiles mother vs stranger	11	9.0	L.T.	0.05.
frowns mother vs stranger	11	33.0	n.s.	
vocalizations mother vs stranger	12	25.0	n.s.	

Both mouthing and smiles are significantly greater to the mother than to the stranger both in terms of percentage duration and frequencies per minute.

Three month olds.

Comparison	N	T	Prob.
look to mother (total) vs stranger (total)	13	45.0	n.s.
look to mother (talking) vs stranger (talking)	13	51.0	n.s.
look to mother (not talk)vs stranger (not talk)	13	45.0	n.s.
mouthing mother vs stranger	13	24.0	n.s.
smiling mother vs stranger	13	22.0	n.s.
frowning mother vs stranger	8	8.0	n.s.
vocalizing mother vs stranger	13	38.0	n.s.

Frequencies per minute

Comparison	N	T	Prob.
look to mother (total) vs stranger (total)	13	19.0	n.s.
mouthing mother vs stranger	13	27.0	n.s.
smiles mother vs stranger	13	36.0	n.s.
frowns mother vs stranger	8	7.0	n.s.
vocalizations mother vs stranger	13	36.0	n.s.

Thus there are no significant comparisons at three months of age.

Four month olds.

Comparison	N	T	Prob.
look to mother (total) vs stranger (total)	13	28.0	n.s.
look to mother (talking) vs stranger (talking)	13	25.0	n.s.
look to mother (not talk)vs stranger (not talk)	13	24.0	n.s.
mouthing mother vs stranger	13	29.0	n.s.
smiling mother vs stranger	13	35.0	n.s.
frowning mother vs stranger	9	19.0	n.s.
vocalizing mother vs stranger	13	39.0	n.s.

Frequencies per minute

Comparison	N	T	Prob.
look to mother (total) vs stranger (total)	13	34.0	n.s.
mouthing mother vs stranger	13	29.0	n.s.
smiles mother vs stranger	12	29.0	n.s.
frowns mother vs stranger	9	13.0	n.s.
vocalizations mother vs stranger	13	38.0	n.s.

Thus there are no significant comparisons at four months of age.

Five month olds.

Comparison	N	T	Prob.
look to mother (total) vs stranger (total)	11	4.0	L.T. 0.01
look to mother (talking) vs stranger (talking)	11	6.0	L.T. 0.02
look to mother (not talk)vs stranger (not talk)	11	9.0	L.T. 0.05
mouthing mother vs stranger	11	31.0	n.s.
smiling mother vs stranger	9	12.0	n.s.
frowning mother vs stranger	4	1.0	n.s.
vocalizing mother vs stranger	9	22.0	n.s.

Frequencies per minute

Comparison	N	T	Prob.
look to mother (total) vs stranger (total)	11	39.0	n.s.
mouthing mother vs stranger	11	33.0	n.s.
smiles mother vs stranger	10	8.0	L.T. 0.05
frowns mother vs stranger	4	1.0	n.s.
vocalizations mother vs stranger	9	26.0	n.s.

Thus there were significant differences in terms of duration of looking to mother and stranger (whether talking or not) and these were due to greater looking to the stranger than to the mother. There was also differentiation in the frequency of smiles, again smiling being more likely to the stranger than to the mother.

Six month olds.

Comparison	N	T	Prob.
look to mother (total) vs stranger (total)	12	27.0	n.s.
look to mother (talking) vs stranger (talking)	12	25.0	n.s.
look to mother (not talk)vs stranger (not talk)	12	20.0	n.s.
mouthing mother vs stranger	11	29.5	n.s.
smiling mother vs stranger	11	11.0	=0.05
frowning mother vs stranger	7	11.5	n.s.
vocalizing mother vs stranger	10	19.0	n.s.

Frequencies per minute

Comparison	N	T	Prob.
look to mother (total) vs stranger (total)	12	43.0	n.s.
mouthing mother vs stranger	12	35.0	n.s.
smiles mother vs stranger	11	10.0	L.T. 0.05
frowns mother vs stranger	7	11.0	n.s.
vocalizations mother vs stranger	11	24.0	n.s.

For both duration and frequency data, there was more smiling to the stranger than to the mother.

Seven month olds.

Comparison	N	T	Prob.
look to mother (total) vs stranger (total)	11	6.0	L.T. 0.02
look to mother (talking) vs stranger (talking)	11	13.0	n.s.
look to mother (not talk)vs stranger (not talk)	11	10.0	L.T. 0.05
mouthing mother vs stranger	10	16.0	n.s.
smiling mother vs stranger	8	6.0	n.s.
frowning mother vs stranger	8	18.0	n.s.
vocalizing mother vs stranger	11	17.0	n.s.

Frequencies per minute

Comparison	N	T	Prob.
look to mother (total) vs stranger (total)	11	09.0	L.T. 0.05
mouthing mother vs stranger	10	18.0	n.s.
smiles mother vs stranger	8	5.0	n.s.
frowns mother vs stranger	8	17.0	n.s.
vocalizations mother vs stranger	11	15.0	n.s.

For duration data, there was significantly more looking to the stranger; and this was true for total looking and looking while the adult was not talking, the comparison for when the adult is talking is almost significant. For the frequency data, there were significantly more smiles also to the stranger.

Eight month olds.

Comparison	N	T	Prob.
look to mother (total) vs stranger (total)	12	19.0	n.s.
look to mother (talking) vs stranger (talking)	12	17.0	n.s.
look to mother (not talk)vs stranger (not talk)	12	29.0	n.s.
mouthing mother vs stranger	12	30.0	n.s.
smiling mother vs stranger	11	25.0	n.s.
frowning mother vs stranger	9	16.0	n.s.
vocalizing mother vs stranger	12	39.0	n.s.

Frequencies per minute

Comparison	N	T	Prob.
look to mother (total) vs stranger (total)	12	28.0	n.s.
mouthing mother vs stranger	12	41.0	n.s.
smiles mother vs stranger	11	27.0	n.s.
frowns mother vs stranger	9	14.0	n.s.
vocalizations mother vs stranger	12	34.0	n.s.

Thus there are no significant comparisons at eight months of age.

The patterns of differential responsiveness revealed by these results are markedly different from what might be expected from much previous research. These results indicate some differential responsiveness at 2 months of age in terms of more mouthing and smiling to the mother and stranger. Differential responsiveness then disappears to reemerge at 5 months of age. At 5 months of age, there was more looking and smiling to the stranger than to the mother. This emergence of a period of more positive social responsiveness to the stranger than to the mother was most marked. Many mothers in the study commented on the change in infant behaviour themselves. Mothers often referred to the infants being "bored with mum". At 6 months of age this positive responsiveness to the stranger was reflected in more smiling to the stranger than to the mother, and at 7 months of age in terms of more looking to the stranger. Such positive responsiveness to the stranger, which is so contrary to previous studies, suggests that much thinking in terms of fearful 'stranger reactions' may be inappropriate. Perhaps such studies of responsivity to strangers have used methodologies which predispose to negative reactions.

Responsivity to the behaviours of others.

Results here are presented for each subject individually as the method of interactional analysis is designed for intra-individual analysis. If an infant behaviour is influenced by an adult behaviour then this might manifest itself in 3 ways

1) the probability of the onset of the behaviour may occur more often than might be expected by chance, when the adult behaviour is occurring or not occurring.
2) The same may occur for the offset of an infant behaviour.
3) the lack of independence of the 2 behaviours may be reflected in a significant X^2. However, in this particular case, the significant X^2 may reflect the adult being influenced by the infant. Therefore, in this presentation where the concern is with the infant's receptivity to the adult's behaviour only the results based on the onsets and offsets of infant behaviour are considered.

Results are based on the calculation of the chance probability of the observed pattern of behaviours by the use of the binomial expansion as described in chapter 8. Results are in the following form.

ADULT	INFANT BEH. onsets	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	la	la	29	24	0.9456	0.9958	0.0189

This means that there were 24 onsets of infant behaviour la while adult behaviour la was occurring out of a total of 29 onsets. The chance probability of 24 or more is 0.9958, and the chance probability of 24 or less is 0.0189. Thus both the probabilities of the observed being on the high or low side of the chance distribution are being simultaneously calculated, and therefore the probabilities are equivalent to a 1-tailed significance test. This is appropriate for some comparisons of gaze behaviour where directional hypotheses have been stated, and for these comparisons the conventional significance level of p=0.05 will be used. For other comparisons where non-directional hypotheses apply, 2-tailed significance levels are appropriate and the significance level of p=0.025 (=2-tailed significance levelof 0.05) is used.

In order to simplify presentation only significant results are presented. The interactional analysis is perfomed for each adult separately.

For these results the following abbreviations are used

FOR BEHAVIOURS

la	looking at the other person
lr	looking to the right (infant's right)
ll	looking to the left (infant's left)
lrp	looking to right and pointing
llp	looking to the left and pointing
lra	looking to the right in total pointing and not pointing
lla	looking the left in total pointing and not pointing
m	mouthing
s	smiling
f	frowning
v	vocalizing
so	smiling but not vocalizing
st	all smiling
vo	vocalizing but not smiling
vt	all vocalizing
sv	smiling and vocalizing

FOR ADULTS

m	mother
fs	female stranger

Results are correct to 4 decimal places.

Each session included interactions with the mother and a female stranger. For many sessions there were additional interactions with a second female stranger and a male stranger, but these interactions do not uniformly appear. Hence the analysis is focussed on the interactions of each infant with the mother and a female stranger in that data on these interactions are uniformly available across sessions. (The results of the analyses for the interactions with other people are included in appendix 5.)

Infants may differ in terms of which behaviour reflects their receptivity to changes in the environment. In order to accommodate this possibility in a study which would use a new method of intra-individual analysis, several behaviours of the infants were recorded. In practice any one infant may only manifest a few of the behaviours which were potentially measurable. However, as it was not possible to say, in advance, which behaviours would be exhibited by the infant, the possibility of recording a range of infant behaviours was maintained. 7 infant behaviours are potentially recordable, and the method of analysis tests for statistically significant deviations from chance for the onset and offset of each behaviour. Thus significant results may well occur due to chance alone. The likelihood of such chance results would be overestimated by the assumption that all behaviours are used for each interaction; i.e. for any interaction, out of the 7 infant behaviours which are potentially measurable, only 2,3 or 4 may actually occur, and if a behavior does not occur then it cannot be a potential source of significant results whether due to 'real' effects or chance factors. Thus the actual number of comparisons carried out in the analysis of an interaction will depend on the number of behaviours which actually occurred in that interaction. As interactions will differ in this respect it would be difficult to specify a general rule in evaluating the number of significant results one might expect by chance factors alone. However as a large number of comparisons are carried out in the analysis of an interaction, the possibility that any significant result may reflect chance occurrence needs to be considered. Hence in interpreting the results consistency in the pattern of significant relationships should be found before drawing conclusions.

GAZE

From previous research outlined in the introduction to this chapter the following hypotheses are to be tested. Can infants respond to another's gaze?

a) in terms of differentiating direct gaze from averted gaze, the hypothesis being that infants will gaze more at an adult who is looking at them than an adult who is not.

b) in terms of using gaze as a referent, the hypothesis being that infants will turn to follow another's gaze.

These hypotheses involve changes in infant gaze patterns. To accommodate the possibility that infants may reflect their receptivity in terms of other behaviours significant results are also presented for the other behaviours which could be measured.

The result are presented numerically, and for the one month old infants the results are repeated in words, in order to facilitate the reader's understanding of the numerical format.

One month olds.

Infant 7.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
fs	onsets						
	m	11	11	1	0.0021	0.0226	0.9998

This result indicates that the infant started to mouth when the adult was looking left and that the chance probability of this occurring was 0.0226.

Infant 8.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
fs	onsets						
	lr	la	19	16	0.9677	0.9971	0.0221
m	onsets						
	la	la	58	57	0.9042	0.0208	0.9971
m	offsets						
	lr	la	25	25	0.8622	0.0246	1.0000

For the interaction with the stranger; the expected probability of the infant starting to look right while the adult was looking at the infant was 0.9677. There were 19 such onsets in total and 16 occurred while the adult was looking at the infant. The chance probability of 16 or less such onsets was 0.0221. Thus the infant was less likely to start to look right when the adult was looking at the infant.
For the interaction with the mother; the expected probability of the infant starting to look at the adult while the adult was looking at the infant was 0.9042. There were 58 such onsets in total and 57 occurred while tha adult was looking at the infant. The chance probability of 57 or more such onsets was 0.0208. Thus the infant was more likely to start to look at the adult when the adult was looking at him.

Also for the interaction with the mother; The expected probability of the infant stopping to look right while the adult was looking at him was 0.8622. There were 25 such offsets and all 25 occurred while the adult was looking at the infant. The chance probabilty of this pattern was 0.0246. Thus the infant was more likely to stop looking right when the adult was looking at the infant.
This pattern of results is consistent with the hypothesis that the infant is responsive to the distinction between face-to-face gaze and averted gaze.

At 1 month of age the majority of the infants do not show any significant results at all. One infant (7) shows a significant result for mouthing unsupported by any other significant relationship. Infant 8 shows a consistent pattern suggesting that he is responsive to the distinction between another's averted and face-to-face gaze. Thus, while we might reject the null hypothesis of no differential responsivity for infant 8 we would accept the null hypothesis for one month olds in general.

Two month olds.

Infant 2.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	lr	lr	22	2	0.0076	0.0122	0.9994
	lr	la	22	20	0.9862	0.9967	0.0364
	offsets						
	la	lr	31	3	0.0061	0.0009	1.0000
	la	la	31	27	0.9878	1.0000	0.0005

For the interaction with the mother infant 2 is significantly likely to look right when the adult looks right and is unlikely to look right when the adult looks face-to-face. Conversely the infant is more likely to stop looking face-to-face when the adult looks right and less likely to stop looks face-to-face when the adult looks face-to-face. This pattern of results is consistent with both hypotheses on infant responsiveness to another's gaze.

Infant 11.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	ll	la	24	21	0.9687	0.9938	0.0381
	ll	ll	24	2	0.0146	0.0473	0.9950

These are marginally significant results of consistent with discriminating face-to-face gaze from averted gaze and appropriate gaze following to the left.

Again, at two months of age, the majority of infants do not show any significant results. Only infant 2 shows a strong indication of responsivity to the gaze of another and infant 11 shows marginally significant results, thus in general two month olds apparently respond in accordance with the null hypothesis of no responsivity to another's gaze.

Three month olds.

Infant 2

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
fs	onsets						
	m	ll	22	1	0.0004	0.0072	1.0000

For the stranger this infant started to mouth when the adult looked left and the chance probability of this was 0.0072.

Infant 3.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
fs	onsets						
	s	la	13	9	0.9332	0.9989	0.0087

This infant is less likely to start a smile when the stranger is looking at the infant, i.e. the infant is more likely to smile to the adult's averted gaze.

Infant 4.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	la	lr	14	0	0.1979	1.0000	0.0456
	la	la	14	14	0.8021	0.0456	1.0000

For the mother infant 4 is less likely to start looks face-to-face when the adult looks right and is more likely to looks face-to-face when the adult is looking at him; i.e. this infant is acting according to the hypothesis of differentiation of averted gaze from face-to-face gaze.

Infant 5.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	ll	ll	4	1	0.0127	0.0497	0.9991

For the mother this infant looked left once when the adult looked left and the chance probability of this was 0.0497.

Infant 7.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	offsets						
	la	la	18	15	0.9625	0.9960	0.0282

Infant 7 is less likely to stop looking at the adult if the adult looks at the infant.

Infant 9.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	la	la	29	24	0.9456	0.9958	0.0189
	offsets						
	la	la	28	24	0.9724	0.9991	0.0070
	lr	la	14	11	0.9703	0.9994	0.0075
fs	onsets						
	la	la	12	10	0.9847	0.9993	0.0140
	m	lr	9	1	0.0020	0.0181	0.9999

Infant 9 is less likely to look at the adult if the adult is looking at the infant. This is likely to be due to the infant taking quick looks in the same direction as the adult when the adult looks to the side, and returning to look at the adult while the adult is still looking to the side. This will have the effect that there will be onsets of looks at the adult when the adult is looking away and give this pattern of results.

Infant 11.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	offsets						
	la	lr	47	3	0.0130	0.0234	0.9964

This infant is more likely to stop looking at the adult when the adult looks right, which is consistent with the hypothesis of discrimination of face-to-face gaze from averted gaze.

Infant 13.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	offsets						
	lr	lr	19	2	0.0046	0.0035	0.9999
	lr	la	19	17	0.9892	0.9989	0.0178

Infant 13 is more likely to stop looking right when the mother looks right and less likely to stop looking right when the mother looks at the infant.

At three months of age there is a marked jump in the number of infants who show some significant results indicating the possibility of responsivity to another's gaze. For 6 infants the behaviours which show differential response are gaze behaviours, for another 2 infants it is mouthing or smiling. Thus it appears likely that this is an age when such responsivity may be possible for many infants.

Four month olds.

Infant 1.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
fs	onsets						
	ll	llp	4	2	0.0341	0.0163	0.9994

This infant shows appropriate gaze following when the adult looks the left and points.

Infant 2.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	f	ll	11	3	0.0274	0.0029	0.9998

This infant is more likely to start frowning when the mother looks to the left.

Infant 4.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
fs	onsets						
	lr	lrp	11	2	0.0073	0.0028	0.9999
	offsets						
	la	lrp	14	2	0.0074	0.0048	0.9999

This infant is likely to show appropriate gaze following to the right if the stranger points.

Infant 6.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	s	la	2	1	0.9955	1.0000	0.0089

This infant started only 1 of 2 smiles when the mother was looking at the infant, i.e. started 1 smile when the adult was not looking which had only a 0.0089 chance probability.

Infant 11.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
fs	onsets						
	ll	la	2	1	0.9819	0.9987	0.0358
	ll	ll	2	1	0.0024	0.0048	1.0
	s	lr	4	1	0.0016	0.0064	1.0
	offsets						
	la	la	10	5	0.8099	0.9951	0.0267

This infant is less likely to look left when the stranger is looking at him and is more likely to look left when the stranger looks left. The infant shows this appropriate gaze following without the adult pointing. Also the infant is less likely to stop looking at the stranger when she is looking at the infant.

Infant 12.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	lr	lra	7	2	0.0447	0.0361	0.9973
fs	onsets						
	lr	lrp	15	1	0.0025	0.0375	0.9993

For the interaction with the mother the infant is more likely to look right if the adult looks right (pointing and not pointing). For the interaction with the stranger the infant shows appropriate gaze following to the right without the stranger pointing.

At four months of age significant results indicating responsivity to adult gaze patterns regularly appear, and there are several instances indicating appropriate gaze following.

Five month olds.

Infant 3.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
fs	onsets						
	lr	lrp	6	2	0.0165	0.0039	0.9999
	ll	llp	16	2	0.0151	0.0238	0.9983
	offsets						
	la	la	20	15	0.9223	0.9967	0.0103
	la	llp	20	3	0.0293	0.0197	0.9976

This infant shows appropriate gaze following to the left and to the right when the stranger points.

Infant 4.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
fs	offsets						
	la	la	19	18	0.7396	0.0249	0.9968

This infant is more likely to stop looking at the stranger when the stranger looks at him; i.e. the opposite to the hypothesized relationship.

Infant 6.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	lr	la	13	10	0.9903	1.0	0.0002
	lr	llp	13	1	0.0016	0.0209	0.9998
	offsets						
	la	la	12	10	0.9885	0.9997	0.0081
	la	llp	12	1	0.0019	0.0228	0.9998

This infant is likely to look to the side when the adult looks to the side but not necessarily the same side; i.e. the infant seemingly differentiates averted gaze from face-to-face gaze without showing appropriate gaze following.

Infant 7.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	lr	lr	13	1	0.0015	0.0190	0.9998
	ll	ll	9	1	0.0023	0.0209	0.9998

This infant shows appropriate gaze following to the left and right without the adult pointing.

Infant 8.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	lr	la	7	3	0.8626	0.9992	0.0088
m2	onsets						
	lr	lrp	5	1	0.0075	0.0370	0.9994
fs	onsets						
	lr	lrp	2	1	0.0139	0.0277	0.9998

This infant shows results consistent with appropriate gaze following to the right when the adult points.

Infant 9.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	ll	ll	5	1	0.0061	0.0302	0.9996
	ll	lrp	5	1	0.0031	0.0152	0.9999

This infant tends to look left whatever direction the mother looks.

Infant 12.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	ll	la	13	10	0.9357	0.9924	0.0467
	ll	llp	13	2	0.0082	0.0049	0.9999
fs	onsets						
	la	ll	15	3	0.0447	0.0271	0.9963
	la	la	15	10	0.9350	0.9998	0.0020
	lr	lr	4	1	0.0055	0.0219	0.9998

These results indicate appropriate gaze following to the left if the mother points and appropriate gaze following to the left and right for the stranger without pointing.

Infant 13.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	la	la	12	9	0.9685	0.9991	0.0055
	la	ll	12	2	0.0155	0.0143	0.9993
	offsets						
	lr	la	10	7	0.9558	0.9994	0.0082

The infant is less likely to look at the mother when she looks at the infant and is more likely to look at the mother when she looks left; and the infant is less likely to stop looking right when the mother looks at the infant. This pattern of results indicates sensitivity to the distinction between averted gaze and face-to-face gaze but the pattern of looking by the infant is the opposite to that hypothesized. This pattern of results can occur if the infant looks to the side when the adult looks to the side and then the infant returns to look at the adult while the adult is still looking to the side.

Again, at five months of age, there are frequent results indicating responsivity to adult gaze patterns and some appropriate gaze following.

Six month olds.

Infant 1.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	ll	llp	15	1	0.0016	0.0234	0.9997
	lr	lrp	9	2	0.0104	0.0037	0.9999

This infant shows appropriate gaze following to the left and right if the mother points.

Infant 2.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	ll	llp	26	2	0.0088	0.0218	0.9985

This infant shows appropriate gaze following when the adult looks the left and points.

Infant 3.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	lr	la	18	11	0.8557	0.9979	0.0096
	ll	lra	18	1	0.3164	0.9989	0.0099
	lr	lrp	18	3	0.0328	0.0199	0.9976
fs	onsets						
	lr	la	16	10	0.8335	0.9900	0.0376
	ll	llp	7	2	0.0483	0.0416	0.9966
	s	ll	12	1	0.0008	0.0100	1.0
	offsets						
	lr	lr	16	2	0.0135	0.0194	0.9988
	lr	la	16	11	0.8990	0.9965	0.0177

To the mother the infant is less likely to looks right when the adult looks at the infant, the infant is less likely to look left when the adult looks right and shows appropriate gaze following when the adult looks right and points. To the stranger the infant is less likely to look right when the stranger looks at the infant, and is likely to show appropriate gaze following when the stranger looks left. Also the infant starts a smile when the adult is looking left when the chance probability is 0.01. The infant is more likely to stop looking right when adult looks right and is less likely to look right when the stranger looks at the infant.

Infant 6.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	lr	lrp	6	1	0.0008	0.0046	1.0
	la	lrp	15	1	0.0025	0.0362	0.9994
fs	onsetrs						
	lr	lrp	8	3	0.0102	0.0001	1.0
	offsets						
	la	lrp	17	3	0.0189	0.0038	0.9998
	la	la	17	11	0.9213	0.9998	0.0014

This infant shows appropriate gaze following if the adult points to the right.

Infant 7.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
fs	onsets						
	lr	lrp	14	2	0.0050	0.0020	1.0
	offsets						
	la	lrp	19	2	0.0057	0.0052	0.9998

This infant shows appropriate gaze following to the right if the adult points.

Infant 8.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	lr	lr	6	2	0.0114	0.0019	1.0
	offsets						
	la	lr	12	2	0.0136	0.0111	0.9995
	lr	la	5	5	0.4755	0.0243	1.0
	v	la	14	10	0.9265	0.9976	0.0161

This infant shows appropriate gaze following without the adult pointing to the right and also is less likely to vocalize when then adult is in face-to-face gaze than when the adult looks to the side.

Infant 9.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	lr	lrp	28	1	0.0006	0.0174	0.9999
	m	lrp	34	3	0.0114	0.0068	0.9994
	offsets						
	la	lrp	35	1	0.0010	0.0343	0.9994
fs	onsets						
	lr	la	15	10	0.8939	0.9969	0.0162
	lr	lrp	15	4	0.0076	0.0	1.0
	v	la	40	39	0.8547	0.0146	0.9981
	offsets						
	la	lrp	26	4	0.0080	0.0001	1.0
	la	la	26	19	0.8931	0.9955	0.0168

This infant shows appropriate gaze following to the right if the mother or stranger points.

Infant 10.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
fs	onsets						
	lr	lrp	10	0	0.3015	1.0	0.0276
	lr	la	10	10	0.6527	0.0140	1.0
	offsets						
	la	lrp	10	0	0.3911	1.0	0.0070
	la	la	10	10	0.5495	0.0025	1.0

This infant shows significant results in the opposite direction to that hypothesized, which while not supporting the hypotheses as stated does suggest the possibility of sensitivity of some form to the other's gaze..

Infant 11.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
fs	onsets						
	v	ll	2	2	0.1084	0.0117	1.0

This infant started to vocalize twice, both times when the stranger was looking left and the chance probability of this was 0.0117.

Infant 12.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	lr	lr	7	2	0.0217	0.0092	0.9997

This results indicate appropriate gaze following to the right without the mother pointing.

Infant 13.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
fs	onsets						
	ll	llp	8	2	0.0092	0.0023	1.0
	offsets						
	la	la	14	9	0.8962	0.9984	0.0099
	la	lr	14	2	0.0248	0.0458	0.9955
	la	llp	14	2	0.0124	0.0126	0.9994

This infant shows appropriate gaze following to the left if the adult points.

At six months of age, only one infant tested at this age did not show any significant results in responsivity to adult gaze and there are many examples of appropriate gaze following.

Seven month olds.

Infant 1.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
fs	onsets						
	lr	lrp	19	4	0.0167	0.0002	1.0
	ll	llp	8	1	0.0036	0.0286	0.9996
	offsets						
	la	lrp	25	3	0.0185	0.0107	0.9989
	lr	lrp	21	1	0.2309	0.9960	0.0294

This infant shows appropriate gaze following to the left and to the right if the adult points.

Infant 3.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	offsets						
	la	ll	9	2	0.0281	0.0250	0.9984
fs	onsets						
	la	la	10	7	0.9480	0.9989	0.0122

These results indicate sensitivity to adult's gaze but not appropriate gaze following.

Infant 9.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
fs	onsets						
	lr	lra	19	2	0.0174	0.0428	0.9958
	ll	la	15	11	0.9153	0.9937	0.0328
	lr	la	19	14	0.9391	0.9993	0.0047
	ll	llp	15	3	0.0076	0.0002	1.0
	offsets						
	la	lra	31	3	0.0182	0.0185	0.9977
	la	lla	31	3	0.0065	0.0011	1.0
	la	la	31	23	0.9539	1.0	0.0001

This infant shows appropriate gaze following to the left and to the right if the adult points.

Infant 10.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	lr	la	7	4	0.9246	0.9991	0.0119
	lr	lrp	7	1	0.0044	0.0306	0.9996
	offsets						
	ll	lr	10	1	0.0019	0.0193	0.9998

This infant shows appropriate gaze following to the right if the adult points and the offset of looking left if adult looks right suggests peripheral vision is important in this ability.

Infant 11.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	v	la	15	4	0.6146	0.9987	0.0067
	offsets						
	m	la	25	13	0.2037	0.0004	0.9999

This infant is less likely to start vocalizing and more likely to stop mouthing when the adult is in face-to-face gaze.

Infant 13.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	lr	lr	8	2	0.0059	0.0010	0.9999
	lr	lrp	8	1	0.0018	0.0175	1.0
	lr	la	8	5	0.9858	1.0	0.0002
	offsets						
	la	lr	13	2	0.0091	0.0061	0.9998
	la	lrp	13	1	0.0027	0.0350	0.9993
	la	la	13	10	0.9799	0.9999	0.0020

This infant shows appropriate gaze following to the right if the adult points and without pointing.

At seven months of age there are many results indicating appropriate gaze following.

Eight month olds.

Infant 1.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
fs	offsets						
	la	lrp	3	1	0.0061	0.0183	0.9999

This infant is more likely to stop looking at the adult when the adult looks to the right and points.

Infant 2.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	ll	lla	12	4	0.1099	0.0350	0.9935
	offsets						
	ll	la	12	4	0.7349	0.9994	0.0042

The likelihood of the infant looking left when the mother looks left (adding those instances where she points and not points) is statistically significant.

Infant 3.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
fs	onsets						
	ll	llp	3	1	0.0163	0.0482	0.9992

This infant shows an instance of appropriate gaze following when the adult looks the left and points.

Infant 4.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	la	la	19	9	0.9186	1.0	0.0
	la	lrp	19	4	0.0369	0.0046	0.9995
	lr	lra	17	3	0.0356	0.0210	0.9974
	offsets						
	lr	lrp	16	4	0.0529	0.0085	0.9989
	lr	la	16	12	0.9371	0.9976	0.0155

This infant shows appropriate gaze following to the right if the adult points.

Infant 5.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	ll	ll	2	1	0.0134	0.0266	0.9998
	offsets						
	ll	ll	2	0	0.8229	1.0	0.0314

This infant shows appropriate gaze following to the left without the mother pointing.

Infant 7.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
fs	offsets						
	la	la	28	24	0.9729	0.9991	0.0066

This infant is less likely to look at the stranger when she is looking at the infant.

Infant 8.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	lr	lrp	11	1	0.0035	0.0379	0.9993
	offsets						
	ll	lrp	13	1	0.0009	0.0120	0.9999
fs	onsets						
	lr	lrp	3	2	0.0511	0.0076	0.9999
	la	la	4	4	0.4100	0.0283	1.0
	lr	la	3	1	0.9129	0.9993	0.0214
	offsets						
	la	lrp	4	2	0.0531	0.0158	0.9994

This infant shows appropriate gaze following to the right if the adult points and the offset data suggest peripheral vision is playing an important part in the infant's reactivity.

Infant 9.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	lr	lr	15	3	0.0080	0.0002	1.0
	lr	lrp	15	1	0.0016	0.0238	0.9997
	lr	la	15	11	0.9546	0.9996	0.0039
	offsets						
	la	la	32	27	0.9689	0.9996	0.0029
	la	lr	32	3	0.0141	0.0103	0.9990
fs	onsets						
	ll	llp	3	1	0.0067	0.0020	0.9999
	offsets						
	ll	llp	3	1	0.0123	0.0365	0.9993

This infant shows appropriate gaze following to the left and to the right if the adult points and to the right without pointing.

Infant 12.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	lr	lr	11	3	0.0354	0.0059	0.9996
	lr	la	11	7	0.9321	0.9995	0.0048
	offsets						
	la	lr	27	4	0.0436	0.0285	0.9943

This infant shows appropriate gaze following to the right without pointing.

Infant 13.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
fs	onsets						
	lr	lrp	3	1	0.0058	0.0172	0.9999

This infant shows appropriate gaze following to the right if the adult points.

At eight months of age only two infants show no significant results and the majority of the infants show significant results indicative of appropriate gaze following.

The results reported above are supported by the results of interactional analyses performed for the interactions between infants and other strangers and for the overall interaction between an infant and all others. These results are presented in appendix 5.

Smiles and vocalizations.

With regard to infant receptivity to the smiles or vocalizations of others, the background literature does not suggest specific hypotheses concerning infant responsivity. Hence the analysis of infant behaviour changes to adult smiles and vocalizations is exploratory. However, when recording interactions it became apparent that smiles and vocalizations interacted in the adult's behaviour. A smile or a vocalization may well occur alone but often the adult would hold a smiling face while vocalizing and in this case the vocalization was often highly inflected. It would be considerably simpler to just analyse responses to smiles and and then to vocalizations separately, but for the reason above the analysis of reactivity to smiles and vocalizations looked at reactivity to

vocalizations (total)	vt
vocalizations alone	vo
smiles (total)	st
smiles alone	so
smiles and vocalizations	sv

To summarize the results on smiles and vocalizations before presenting the figures, the evidence suggests that infants may be responsive to the presence of adult vocalizations and smiles from 1 month of age onwards.

One month olds.

Infant 1.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	ll	vo	5	0	0.5351	1.0	0.0217
	offsets						
	lr	vo	4	0	0.6818	1.0	0.0102

Infant 2.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	m	sv	14	1	0.0017	0.0232	0.9997
fs	onsets						
	m	sv	13	3	0.0339	0.0086	0.9993
	offsets						
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Infant 3.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
fs	onsets						
	la	vt	6	0	0.4867	1.0	0.0183

Infant 5.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
fs	onsets						
	f	st	14	8	0.2575	0.0124	0.9973
	v	so	2	2	0.1057	0.0112	1.0

Infant 8.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	f	vt	11	10	0.5440	0.0126	0.9988
fs	onsets						
	la	vt	28	22	0.4624	0.0005	0.9999

Infant 9.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	f	vo	17	8	0.2194	0.0191	0.9950
fs	onsets						
	v	vo	8	1	0.6075	0.9994	0.0025
	lr	so	3	1	0.0016	0.0048	1.0
	m	so	4	1	0.0018	0.0072	1.0
	offsets						
	la	sv	11	0	0.4324	1.0	0.0020

Infant 10.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	la	sv	30	9	0.1081	0.0034	0.9992
	m	so	14	8	0.1905	0.0017	0.9997
	offsets						
	ll	sv	24	8	0.0972	0.0014	0.9997

Infant 11.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	offsets						
	la	vt	12	4	0.6871	0.9976	0.0125
fs	onsets						
	m	st	19	14	0.3977	0.0029	0.9994

Two month olds.

Infant 1.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	ll	so	8	4	0.1014	0.0053	0.9995
	offsets						
	la	vo	7	6	0.4207	0.0248	0.9977
fs	onsets						
	v	sv	20	8	0.1890	0.0234	0.9932
	offsets						
	la	vo	13	0	0.2564	1.0	0.0212

Infant 2.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	la	st	30	11	0.1340	0.0012	0.9997
	lr	st	22	6	0.50712	0.9929	0.0225
	offsets						
	la	st	31	10	0.5196	0.9917	0.0214
	lr	st	22	6	0.0964	0.0154	0.9964

Infant 3.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	lr	vo	11	0	0.3162	1.0	0.0153
	offsets						
	la	vt	18	2	0.3516	0.9956	0.0229
	lr	sv	12	2	0.0134	0.0109	0.9995
	m	sv	28	4	0.0360	0.0173	0.9970
fs	offsets						
	lr	st	14	6	0.1647	0.0181	0.9962

Infant 4.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	offsets						
	lr	st	14	7	0.2278	0.0235	0.9943

Infant 5.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	la	sv	9	4	0.1337	0.0230	0.9966
	m	sv	9	7	0.1789	0.0002	1.0
fs	onsets						
	la	sv	14	6	0.1094	0.0024	0.9997
	s	st	6	5	0.2574	0.0053	0.9997
	la	vo	14	2	0.4406	0.9965	0.0207
	offsets						
	ll	st	12	5	0.1235	0.0107	0.9983

Infant 6.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	lr	vo	8	0	0.4126	1.0	0.0142
fs	onsets						
	la	vo	14	1	0.4002	0.9992	0.0081
	lr	vo	10	0	0.3633	1.0	0.0110
	la	sv	14	9	0.1989	0.0004	1.0
	lr	sv	10	7	0.3559	0.0286	0.9946
	offsets						
	lr	sv	10	8	0.3688	0.0070	0.9992

Infant 7.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	offsets						
	la	vo	8	2	0.6585	0.9970	0.0223

Infant 8.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	s	vt	6	6	0.4335	0.0066	1.0
fs	onsets						
	s	st	5	4	0.2335	0.0121	0.9993

Infant 9.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	ll	sv	20	10	0.7285	0.9922	0.0247
	offsets						
	la	sv	26	13	0.7436	0.9980	0.0066
fs	onsets						
	ll	sv	18	4	0.5511	0.9990	0.0048
	offsets						
	la	sv	19	4	0.5616	0.9996	0.0020

Infant 10.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	f	vo	2	2	0.1516	0.0230	1.0
	offsets						
	v	st	27	19	0.8690	0.9943	0.0191

Infant 11.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
fs	onsets						
	v	vo	42	9	0.0893	0.0106	0.9967
	offsets						
	la	vt	19	4	0.4567	0.9934	0.0245
	m	vo	13	9	0.3779	0.0217	0.9952

Infant 13.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	offsets						
	f	vo	11	11	0.6733	0.0129	1.0

Three month olds.

Infant 1.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	s	vt	10	9	0.5053	0.0117	0.9989
fs	onsets						
	s	sv	15	6	0.1580	0.0214	0.9951

Infant 2.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	s	st	7	5	0.2517	0.0133	0.9986
	lr	vo	47	28	0.3968	0.0046	0.9981
	f	sv	29	1	0.1930	0.9980	0.0158
fs	onsets						
	m	vt	21	11	0.7949	0.9988	0.0049
	la	vo	39	11	0.4855	0.9974	0.0071
	la	sv	39	12	0.1620	0.0174	0.9934
	f	sv	33	1	0.2355	0.9999	0.0016
	v	sv	36	4	0.2814	0.9963	0.0131
	offsets						
	v	vt	37	29	0.6160	0.0237	0.9967
	lr	vo	37	10	0.4857	0.9978	0.0063
	lr	sv	37	12	0.1594	0.0099	0.9966

Infant 3.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	f	vo	5	3	0.1163	0.0131	0.9992
	s	vt	3	3	0.2659	0.0188	1.0
	la	so	7	1	0.0020	0.0136	0.9999
fs	onsets						
	la	sv	10	5	0.1818	0.0222	0.9961
	s	sv	12	7	0.1623	0.0011	0.9999
	v	sv	20	14	0.4072	0.0029	0.9980

Infant 4.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	m	sv	7	6	0.3878	0.0159	0.9987

Infant 5.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	m	so	13	8	0.2956	0.0166	0.9964
	lr	sv	6	0	0.4653	1.0	0.0234

Infant 6.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	f	st	8	0	0.4126	1.0	0.0142

Infant 7.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	la	st	47	26	0.3819	0.0127	0.9943
	v	so	20	8	0.1512	0.0062	0.9986
	offsets						
	la	vo	46	13	0.2342	0.0126	0.9946
fs	onsets						
	la	so	18	6	0.1322	0.0240	0.9941
	s	sv	3	3	0.2718	0.0201	1.0
	offsets						
	la	vo	18	2	0.3524	0.9957	0.0225

Infant 9.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	la	vo	27	7	0.5084	0.9977	0.0076
	offsets						
	ll	vo	15	3	0.5753	0.9994	0.0035
fs	onset						
	la	vt	11	9	0.4694	0.0204	0.9967

Infant 10.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	s	vt	7	6	0.4108	0.0218	0.9980
	offsets						
	m	st	51	25	0.2439	0.0001	0.9964

Infant 11

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	lr	vt	35	8	0.4213	0.9949	0.0141
	lr	st	35	0	0.1304	1.000	0.0075
	offsets						
	m	sv	42	0	0.0852	1.0	0.0237
fs	onsets						
	la	vt	25	4	0.3672	0.9939	0.0215
	lr	vo	11	5	0.1116	0.0045	0.9995
	offsets						
	la	vo	24	7	0.1013	0.0080	0.9982

Infant 12.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	lr	vt	5	1	0.7362	0.9987	0.0191
	la	vo	7	1	0.6341	0.9991	0.0115
	la	sv	7	4	0.1517	0.0126	0.9987
	offsets						
	ll	sv	2	2	0.1450	0.0210	1.0

Infant 13.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	s	vt	17	15	0.6226	0.0195	0.9964
	f	st	41	3	0.2129	0.9961	0.0155
	offsets						
	la	vt	31	25	0.5911	0.0097	0.9970
fs	onsets						
	ll	vo	16	1	0.3133	0.9976	0.0203
	lr	vo	11	0	0.3237	1.0	0.0135
	ll	so	16	8	0.1251	0.0003	1.0
	la	so	27	9	0.6640	0.9999	0.0005
	s	so	38	0	0.2123	1.0	0.0001
	la	sv	27	11	0.1435	0.0007	0.9998
	s	sv	38	24	0.3393	0.0002	0.9999
	offsets						
	la	vo	27	1	0.3514	1.0	0.0001
	s	vo	38	10	0.1045	0.0047	0.9987
	la	so	27	9	0.0605	0.0	1.0
	lr	sv	11	5	0.1032	0.0032	0.9996
	s	sv	38	27	0.8955	1.0	0.0

Four month olds.

Infant 1.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	m	so	7	4	0.1600	0.0152	0.9983

Infant 2.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	v	vt	19	4	0.5096	0.9983	0.0077
	la	sv	10	4	0.0852	0.0073	0.9992

Infant 5

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	offsets						
	la	so	9	7	0.3291	0.0077	0.9991

Infant 6.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	m	vt	5	2	0.9024	0.9996	0.0080
fs	onsets						
	s	vt	11	11	0.6465	0.0082	1.0
	offsets						
	la	so	6	4	0.2146	0.0219	0.9978

Infant 9.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	lr	st	4	3	0.1792	0.0199	0.9990
	m	st	7	4	0.1671	0.0178	0.9980
fs	onsets						
	la	st	12	6	0.1762	0.0104	0.9982

Infant 11.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	m	vt	13	9	0.3766	0.0212	0.9953
fs	onsets						
	m	st	3	3	0.2662	0.0189	1.0

Infant 12.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	ll	st	8	7	0.4219	0.0120	0.9990
	la	st	12	9	0.4071	0.0174	0.9967
	offsets						
	s	so	2	2	0.1149	0.0132	1.0
fs	offsets						
	lr	vo	15	11	0.3569	0./0034	0.9994

Infant 13.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
fs	onsets						
	lr	so	16	5	0.0961	0.0111	0.9981
	m	so	6	3	0.1044	0.0178	0.9985

Five month olds.

Infant 4.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	offsets						
	lr	vt	12	12	0.7086	0.0160	1.0
fs	onsets						
	m	st	29	21	0.5021	0.0128	0.9957
	s	so	10	5	0.1298	0.0053	0.9994
	offsets						
	m	st	30	24	0.5972	0.0162	0.9947

Infant 6.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	lr	vo	2	0	0.8602	1.0	0.0195
	m	vt	10	10	0.5674	0.0035	1.0
	offsets						
	m	vt	9	3	0.7030	0.9960	0.0238

Infant 7.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	ll	so	9	4	0.1205	0.0161	0.9979

Infant 8.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	m	so	25	0	0.1476	1.0	0.0184
	s	sv	13	8	0.3133	0.0238	0.9944

Infant 11.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	la	vt	17	12	0.4045	0.0117	0.9972

Infant 12.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
fs	offsets						
	lr	so	4	3	0.0232	0.0470	0.9915

Infant 13.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	lr	st	11	3	0.6709	0.9989	0.0081
	ll	sv	13	5	0.1295	0.0191	0.9964
rs	onsets						
	la	sv	2	2	0.1397	0.0195	1.0

Six month olds

Infant 3.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	v	vo	13	1	0.3824	0.9981	0.0172
fs	onsets						
	s	sv	7	3	0.0193	0.0003	1.0
	m	vt	21	9	0.6820	0.9957	0.0143
	ll	vo	6	6	0.4510	0.0084	1.0
	offsets						
	lr	vt	9	9	0.6476	0.0200	1.0

Infant 4.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	v	sv	18	7	0.1728	0.0249	0.9933

Infant 6.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	la	vo	14	11	0.4090	0.0048	0.9992
	ll	st	14	3	0.0438	0.0212	0.9974
	s	st	6	4	0.1395	0.0045	0.9997

Infant 7.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	lr	st	9	3	0.0660	0.0179	0.9982
	offsets						
	lr	st	8	0	0.4649	1.0	0.0167
	v	vt	6	4	0.0928	0.0010	1.0
fs	onsets						
	lr	so	27	3	0.2989	0.9948	0.0208

Infant 8.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	la	vo	17	16	0.6578	0.0080	0.9992
	offsets						
	s	sv	8	0	0.4046	1.0	0.0158
fs	onsets						
	lr	sv	7	5	0.2819	0.0220	0.9973

Infant 9.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	ll	st	20	0	0.2654	1.0	0.0021
	offsets						
	la	st	35	5	0.3390	0.9976	0.0083
fs	onsets						
	lr	st	15	0	0.2367	1.0	0.0174

Infant 10.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	la	sv	9	7	0.3354	0.0086	0.9990
	offsets						
	lr	vt	10	10	0.6740	0.0193	1.0
fs	onsets						
	s	sv	12	7	0.1906	0.0029	0.9996

Infant 12.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	s	vo	4	0	0.6832	1.0	0.0101
	s	st	4	4	0.3092	0.0091	1.0
	ll	sv	5	4	0.2732	0.0218	0.9985
	offsets						
	v	st	4	2	0.9429	0.9993	0.0181
	v	vo	4	2	0.0571	0.0181	0.9993
fs	onsets						
	lr	vo	12	11	0.5172	0.0045	0.9996
	s	vo	6	2	0.7779	0.9974	0.0247
	lr	sv	12	0	0.4610	1.0	0.0006
	s	sv	6	4	0.2048	0.0185	0.9982

Infant 13.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	m	st	14	0	0.2471	1.0	0.0188

Seven month olds.

Infant 1.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	m	st	3	0	0.8325	1.0	0.0047
	v	sv	23	6	0.0921	0.0156	0.9963
	offsets						
	la	vo	15	0	0.7055	1.0	0.0
fs	offsets						
	la	vt	25	16	0.4095	0.0169	0.9942

Infant 8.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	offsets						
	ll	vo	3	0	0.7200	1.0	0.0220
fs	onsets						
	v	st	7	6	0.3833	0.0149	0.9988

Infant 9.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	lr	st	19	3	0.4108	0.9958	0.0184
	v	st	10	7	0.3433	0.0233	0.9958

Infant 10.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	offsets						
	la	sv	11	2	0.5338	0.9969	0.0194
fs	onsets						
	lr	so	7	3	0.0645	0.0077	0.9995
	s	so	3	2	0.0690	0.0136	0.9997
	offsets						
	la	so	15	6	0.1586	0.0218	0.9950

Infant 12.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	lr	so	5	3	0.0803	0.0046	0.9998

Infant 13.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	offsets						
	m	vt	14	6	0.9979	0.9979	0.0102
	f	st	6	2	0.0173	0.0043	0.9999
fs	onsets						
	ll	sv	1	1	0.0175	0.0175	1.0

Eight month olds.

Infant 1.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	s	sv	5	2	0.0396	0.0145	0.9994
	offsets						
	m	vo	10	2	0.5595	0.9962	0.0237

Infant 2.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
fs	onsets						
	v	sv	2	2	0.0891	0.0079	1.0

Infant 3.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	offsets						
	ll	so	7	1	0.0034	0.0235	0.9998
fs	onsets						
	m	vo	13	1	0.4831	0.9998	0.0025
	s	so	7	3	0.0610	0.0066	0.9996

Infant 7.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
fs	onsets						
	lr	vo	17	16	0.6420	0.0055	0.9995

Infant 10.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	lr	vt	10	7	0.9681	0.9998	0.0037
	offsets						
	lr	vt	10	10	0.6906	0.0247	1.0

Infant 11.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	m	so	8	4	0.1234	0.0107	0.9988
fs	offsets						
	lr	st	9	0	0.3501	1.0	0.0207
	la	sv	10	1	0.4467	0.9973	0.0244

Infant 12.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	m	vt	39	1	0.1551	0.9986	0.0114
	offsets						
	la	st	27	17	0.8094	0.9924	0.0222
fs	onsets						
	lr	vt	8	6	0.3198	0.0158	0.9980

Infant 13.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
m	onsets						
	s	so	1	1	0.0109	0.0109	1.0

The results reported above are supported by the analyses of interactions between the infants and other strangers and the overall interactional analysis reported in appendix 5.

<u>Conclusions.</u>

With respect to mother stranger discrimination there is evidence of such discrimination at 2 months of age in terms of more mouthing and smiling to the mother. It is not possible to say if this discrimination is based upon auditory or visual sensitivity. However, since the experiment in chapter 6 provides evidence of auditory discrimination at 1 month and this experiment did not find differentiation in terms of mouthing or smiling at 1 month this suggests the possibility that this discrimination is the result of the emergence of visual recognition of the mother. Obviously this is not a firm conclusion but a possible explanation for the pattern of results.

By 5 months of age there appears to have been a distinct change in the nature of infant responsivity to a stranger in that there is more looking to the stranger whether the adults are talking or not, hence the discrimination is visually based. At 6 months this increased responsiveness to the stranger reflects itself in more smiling to the stranger and at 7 months again in terms of more looking. At 8 months this differentiation of response to the mother and stranger disappears. As stated earlier these results indicating positive responsiveness to a stranger by infants 5 to 7 months of age is not to be expected from much previous research. Probably such differences between the findings reported here and previous research reflects methodological differences. Possibly the presentation of a non-interactive looming stranger (as in previous studies reviewed in chapter 5) is the reason for the frequent reports of negative reactions to strangers in previous studies.

This study was the first application of a novel form of interactional analysis which allowed for the sequential analysis of dyadic interaction. The results of this study indicate that this is a viable form of analysis worthy of further application. Indeed, if this technique were to be applied to infant-adult interaction where all of an infant's appropriate time involved an interaction with one person (rather than 2 or more), then the interaction would be considerably longer and hence contain more data. Thus the analysis of responsivity to other's behaviour would be more potent.

In this study, when considering the results on the individual's responsivity to the behaviour of others, the large number of comparisons might be thought to capitalize on the possibility of significant results due to chance alone. However, the statistical procedures have been designed to take account of chance factors on an individual basis, however the large number of comparisons could lead to spurious significant results due to chance alone. Hence the need to take account of the patterning in the results. If significant results were occurring due to chance factors alone then one would expect far more significant results for responsiveness to gaze in the early months. Also one would expect a higher incidence of significant results divorced from the hypothesized relationships for gaze behaviour. The actual results indicate a marked developmental pattern for responsivity to other's gaze which is consistent with the stated hypotheses.

Considering responsivity to gaze there is little evidence that infants can discriminate face-to-face gaze from averted gaze as young as 1 month of age. Only 1 infant shows moderate evidence of such discrimination. There is a marked increase in responsivity to gaze at 3 months of age. By 4 months of age 12 of the 13 infants in the study had shown significant differential responding to face-to face gaze and averted gaze in at least one month's recording. Almost always this reflects itself in the pattern reported by Stern (1974) i.e. the infant being more likely to look at the adult when the adult looks at the infant or in terms of being more likely to look away if the adult is not looking at the infant. However, occasionally the infant will show his receptivity by another behaviour e.g. smiling. Although, almost always, the behaviour that shows a differential change dependent on adult gaze is, as hypothesized, some aspect of the infant's gaze.

There is ample evidence of appropriate gaze following when the adult points, and there is an increase in the incidence of appropriate gaze following up to 6 months of age. By 6 months of age all but one of the infants have shown at least 1 session with significant following of gaze with or without pointing. Although such gaze following is more common when the adult points, there are instances of infants showing appropriate gaze following when the adult does not point. The incidence of appropriate gaze following shows a marked increase over the period 4 to 6 months of age.

As specific hypotheses regarding the pattern of differential responsivity to smiles and vocalizations were not made the results need to be interpreted cautiously. Responsivity to vocalizations and the smile appear frequently from 1 month of age upwards. It was attempted to separate the effects of the adult's smile and vocalizations, and sometimes significant results for the smile alone or the vocalizations alone do occur. Often, however, receptivity to smiles and vocalizations is revealed by significant differentiation of response to either total smiles, total vocalizations, or to the combination of smile and vocalization. In these circumstances it is difficult to decide which is the adult behaviour eliciting the differential response. Whether such results are due to the smiles, the vocalizations, or a simple addition of the effects of the smile and vocalization or whether it reflects some unique characteristic of that particular combination is difficult to say. However, it was apparent in recording that this combination usually involved highly inflected speech and hence vocalizations with a smile may be particularly potent. In order to resolve this question one needs to collect data from infants in interaction with one adult for longer periods as would be possible in a study which did not include the dimension of differential responsivity to different people. In such a case more data on an interaction would strengthen the signal-to-noise ratio of the analysis and possibly produce more definite conclusions.

Different infants show their responsivity to the vocalization and the smile in different ways. The most common pattern was for infants to indicate receptivity to adult smiles and vocalizations in terms of gaze behaviours, however some infants reflect their receptivity in terms of changes in mouthing, others in terms of frowns, vocalizations or smiles, reflecting the individual's style of behaviour. Indeed this is a strength of intra-individual analysis that one can pick out an individual pattern of behaviour which might be lost in the combination of group data.

Chapter 10.

General discussion.

The finding of recognition of mother's voice is one of the few pieces of evidence available on such early memory processes as well as being very important with respect to social development. The efficacy of the methodology employed in chapter 6. is supported by a study by Milewski and Siqueland (1975) who demonstrated short term memory in 1 month olds for visual elements of colour and form, and also by Milewski (1979) who used the same methodology to show short term memory for the configuration of forms in 3 month olds.

Mehler et al. (1976) and Mehler et al. (1978) did a very similar study to that described in chapter 6. They found similar results but only if the mother's voice was inflected and not if the mother's voice was monotonic. The most likely explanation of their results is that the mother's voice monotone was a strange stimulus for the infants.

The reinforcing nature of speech has also been demonstrated by Trehub and Chang (1977) who compared the effects of

1) speech contingent upon sucking
2) withdrawal of speech contingent upon sucking
3) speech noncontingent
4) no speech

and found that only condition 1 produced an increase in sucking rate for 5-15 week old infants.

The finding of Mehler et al. that infants differentiate between inflected and monotone speech has also been found by Jones-Molfese (1977) who found that infants from 3-14 weeks of age showed clear preferences between inflected, monotone and scrambled speech.

One question is whether infants respond to simple physical characteristics or whether they can respond to patterning in such discriminations. Chang and Trehub (1977) found dishabituation on changing the temporal sequences of a set of tones in 5 month olds which suggests responsivity to patterning.

Such early responsivity to speech is consistent with the findings of early responsivity to phonemic distinctions reviewed in chapter 3. and further work which supports the idea of specialization of the auditory system for speech stimuli comes from Molfese and Molfese (1979), who found that the newborn AER of the left hemisphere only was responsive to changes in the second formant transition. Similar hemispheric specialization is suggested by Glanville et al. (1977) who found that differential dishabituation to music and speech dependent upon which ear was stimulated in 3 month olds. Evidence for environmental influence on such specialization comes from Eilers et al. (1979) who tested 6-8 month olds from Spanish and English environments, on VOT distinctions characteristic of Spanish and English. Infants from Spanish environments could perform both sets of discrimination whereas the infants from the English environment could only differentiate the VOT contrasts characteristic of English.

With respect to the visual discrimination of the mother, the experiment described in chapter 7 failed to find any support for Carpenter's (1974) claim of visual recognition of the mother in the first month of life. The experiment in chapter 9 did find evidence of discrimination at 2 months of age which disappeared at 3 and 4 months to reappear at 5, 6 and 7 months of age, only to disappear at 8 months of age. The discrimination revealed at 2 months of age may be due to visual or auditory discrimination, whereas that at 5 months of age is almost certainly due to visual discrimination in that greater looking to the stranger occurred even in those periods when the adults were not talking. Selective responding in 2 week olds to the smell of the mother's breast pad has been reported by Russell (1976) and in 6 day olds by MacFarlane (1975), but it would seem unlikely that in the situations involved in these experiments that smell would be a cue for discrimination: firstly because of the distances involved and secondly because the altered behaviour of the infants would not affect their receptivity to any possible odour.

The finding of differentiation at 2 months of age is supported by Barrera and Maurer (1978) who found discrimination of photographs of mother and stranger in 3 month olds. Such a finding would require infants having the ability to transfer visual learning from real faces to photographs, an ability shown by 5.5 month olds tested by Dirks and Gibson (1977). Further support for this interpretation of the results as due to visual recognition comes from Watson et al. (1979) who found that 14 and 20 week old girls but not boys smiled more to a familiar than an unfamiliar face. Such a finding appears in conflict with the finding of the experiment in chapter 9 of greater responsivity to the stranger at 5 months of age. However, Watson et al.'s stranger was a bearded bespectacled male and hence this difference is probably due to the difference in the characteristics of the stranger used.

The lack of differentiation of response found for 3-4 month old infants was similarly found by Blehar et al. (1977) with 6-15 week olds, who did not show any differentiation to the mother or a visitor except in terms of 'bouncing'. Such a lack of differentiation at 3-4 month of age and the positive responsivity to the stranger at 5 months of age is at odds with Bronson's (1972,1978) reports of aversive reactions in infants from 3 months of age upwards, but such a finding is in line with a range of findings reviewed by Rheingold and Eckerman (1974) where they dispute the notion of the normality of the 'stranger reaction' from 6 months of age upwards. The results of the experiment in chapter 9 certainly show no evidence of a 'stranger reaction', but the study was concerned with the responses of infants when calm and alert, and when infants became irritable recording ceased. Therefore, the results may not reflect the 'stranger reaction' as the methodology employed precluded its observation. However, there were 2 occasions, both at 7 months of age, when irritable infants showed an apparent 'stranger reaction', outside of the recording situation. Skarin (1977) also found negative responsiveness to the stranger rare at 6 months of age but common at 11 months of age.

Delack and Fowlow (1978) found more vocalizations occurred to the mother than a stranger from 1 month of age onwards, but the situations in which the infant encountered the people differed considerably and the results could be due to uncontrolled situational variables.

The lack of negative responsivenes to a stranger at 5 months is mirrored in the results of Waters et al. (1975) who found that most 5 month olds did not show any signs of wariness and were positively responsive to the stranger, even though the stranger did not interact in a contingent manner or smile at the infant. It was not until after 8 months of age that many infants showed signs of fear to the stranger. The findings of increased positive responsivity to the stranger at 5 months of age supports a viewpoint which regards the discrimination process and the fear reaction as separate effects developing separately. Indeed, the increase in responsivity to the stranger in a naturalistic interactional encounter (not the usual procedure for studies of mother stranger discrimination) is suggestive of infants becoming 'bored' with the mother and showing interest in the novelty of the stranger. This was the subjective impression of participants in the study. Such an interpretation is consistent with the findings of Campos et al. (1975) of deceleratory heart rate change to the stranger at 5 months of age (associated with attentiveness) and acceleratory changes at 9 months of age (associated with distress).

Greenberg et al. (1973) find more positive responses to child than adult strangers in 8-10 month olds and Weinraub and Putney (1978) find a significant effect of viewing height on responses to a stranger. Strangers who tower over the infant elicited more distress in 9-12 month olds. They put forward a proposition that infants have an innate predisposition to behave negatively to 'towering' stimuli which if true may be related to the positive responsiveness found in the experiment in chapter 9 where the stranger was at the same level as the infant.

From the preceding it is seen that the results of positive responsivity to strangers reported in chapter 9. are not without support from other investigations. Such findings do raise the need to question the traditional view of the development of responsiveness to strangers. It was a characteristic of many earlier studies, e.g. Morgan and Ricciuti (1969), Bronson (1972), to present the stranger to the infant in a stereotyped manner. The pre-set nature of the stranger's approach precludes contingent responsiveness by the stranger which is probably incongruous withe infant's previous experience with people. Such an incongruity with previous experience is unlikely to lead to positive social responsiveness and may well lead to negative emotional responses. Also the stranger approached so that he loomed up on the infant, which again might lead, of itself, to negative reactions.

The results reported in this thesis of early discrimination, around 2 months of age, and later positive responsiveness to strangers, are supported by other research. Such results do strongly indicate that the dicrimination process (mother from stranger) proceeds separately from any development of a fear response. Thus Bronson's theory on such development which links the discrimination process and fear responses is strongly contradicted both by the results in this thesis and by other work reported in this chapter.

Maurer and Salapatek (1976) used the corneal reflection technique to investigate fixation of the mother's, and male and female stranger's faces. They found that 1 month olds looked less at the mother than at the strangers' faces suggesting visual recognition of the mother. Further they find that 1 month olds largely look at the edge of the stimulus, when they look at all, which is only a small percentage of the time. Therefore, they suggest that the infant's recognition of the mother is on the basis of outline. Such conclusions are not supported by the last experiment, and possibly the discrepancy in the methodologies is the cause, with possibly the corneal reflection technique more appropriate for visual discrimination investigations.

Field (1979) found that 3 month olds showed less looking and greater heart rate change to their mother than to a doll, which she interprets as showing that the infants look less when highly aroused. A similar relationship between looking and heart rate change was reported by Waters et al. (1975). The lesser looking to the mother may reflect recognition or discrimination of the 'reality' of the faces, which is supported by Haaf's studies (Haaf and Brown 1976, Haaf 1977) showing a change between 10 and 15 weeks of age such that at 10 weeks of age complexity determines infant attention whereas at 15 weeks of age face-likeness becomes a salient characteristic. Yet Thomas and Jones-Molfese (1977) find that infants as young as 5 weeks of age discriminate photographs of faces from schematic faces. Possibly such discrimination reflects complexity preferences. If Haaf's proposition were true then possibly the importance of face-likeness reflects a change in the pattern of infant attention as reported by Milewski (1976) who found that 3 month olds would attend the internal features of a visual stimulus but the 1month olds did not, both ages attended the external features. Similar findings with faces are reported by Maurer and Salapatek (1976). Attention to internal features would seem to be an important aspect of developing a schema for a face.

Yin (1970) found that right-posterior lesions affect face recognition to a greater extent than other lesions, and led him to hypothesize a specific mechanism for face perception. If this is correct, then the infancy literature suggests that such a mechanism may become functional around 3 months of age.

Considering the infant's receptivity to the behaviour of others, this thesis reports on the development and application of a new approach to interactional analysis. The division of the infant's "appropriate state time" between 2 or more interactions may tend to dilute the signal-to noise ratio' of the results. Perhaps a more suitable strategy would be to investigate receptivity to other's behaviour in one prolonged interaction which would contain more data for analysis. Nevertheless the studies reported here do find positive indications of infant receptivity to other's behaviour.

Two experiments reported in this thesis find evidence of responsivity in some infants as young as 1 month of age to the orientation of the face. Watson et al. (1979) find differentiation of facial orientations in 14 and 20 week olds but in their study the orientations were upright and horizontal, not, as in this thesis, face-to-face and looking to the side. However, Stern (1974) shows similar discrimination in 3.5 month olds. The studies reported here support Stern's conclusions, and indicate that differential responsiveness increases markedly at 3 months of age suggesting that such discrimination occurs around 3 months of age. The last study also finds evidence that infants from 1 month of age will react to the presence or absence of vocalizations and smiles in another. However the conclusions reached here should be considered tentative as the study was exploratory in this respect. Such responsivity is obviously an important consideration in the social development of the infant in that the existence of such responsivity will foster the communication of others with the infant thus increasing his social experience. Possibly such early responsivity to gaze direction reflects the disruption of the two-eye gestalt (when face is averted) which Ahrens and others have emphasized in infant facial perception. Beside the fact of receptivity to such behaviours, the nature of the infant's reactions should be considered.

The pattern of response to gaze shows a development from differentiation of face-to-face gaze from averted gaze to appropriate following of gaze. All but one infants in the study showed some appropriate gaze following by 6 months of age. Several infants show such responsiveness when the adult is not pointing, although such responsivity is more common if the adult points. This may be due to hand action in the infant's peripheral vision attracting the infant's attention in the appropriate direction. Several findings of active peripheral vision from early infancy exist e.g. Maurer and Lewis (1979) and Lewis et al. (1978).

This finding of appropriate gaze following is supported by a study by Churcher and Scaife (1979) who found that 9 out of 10 infants showed 'simple appropriate' gaze following by 22 weeks of age i.e. turning to look to the same side as the other even if not in exactly the same location. Also Butterworth (1979) reports that 6 month olds will follow another's gaze to the side. Do these findings imply that the infant is using the gaze of another as a referent. One can interpret those results where the infant shows appropriate gaze following when other points as due to the infant being attracted by the moving hand, or this may reflect some particular salience of such a gesture. But this will not explain appropriate gaze following when no pointing occurrs. One non-referential mechanism that might be functioning is imitation, i.e. the infant imitates the head movements of the other. Then we have the referential explanation, i.e. the infant infers that the change in the other's behaviour reflects some aspect of the environment. Considering the imitation explanation; such imitation might be spontaneous or brought about by a process of operant learning whereby adult attention to the infant increases if the infant shows such a response. Possibly the imitative mechanism develops into the referential mechanism in that the response is firstly established by imitation either spontaneous or reinforced, and subsequently the infant encounters interesting aspects of the environment. Such consequences are reinforcing of themselves and would serve to sustain appropriate gaze following.

With respect to the evidence revealed here on the infant's receptivity to the smiling and vocalizing of others. The evidence suggests the possibility that such receptivity is present from 1 month of age and suggests that this is an area for future research using the intra-individual analysis described in this thesis. The patterns of response to smiles and vocalizations seem highly individualistic with little clear pattern emerging. They do not reduce to imitation.

Stern et al. (1975) distinguish between 2 styles of interaction; alternation and coaction. With regard to vocalizations, Anderson et al. (1977) find that the typical 3 month old shows coaction, being more likely to vocalize when the mother is vocalizing. Similar results are reported by Vietze et al. (1978). However, such styles of interaction are likely to be highly situation dependent, and hence the results found may be more likely to reflect the situation than a developmental pattern. If, for example, the other vocalizes often, the infant vocalizations may well be elicited by the other's vocalizations. However, if other does not vocalize often, the infant may vocalize in order to elicit the other's vocalizations. In other words the infant vocalizations may be elicited by other and coaction occurrs, or, the infant's vocalizations may initiate other's vocalizations and alternation occur. In this study, (taking all results both from chapter 9. and appendix 5.), of the 19 instances where the infant's vocalization were significantly altered by the other's vocalizations, 10 instances correspond to vocalization in alternation, and 9 correspond to vocalization in unison. Schaffer et al. (1977) find alternation of vocalizations the most common pattern in 1 year olds.

In considering the development of the infant's receptivity to others, the people who interact with the infant have an important role to play. Brazelton et al. (1974) describe how mothers interpret the infant's actions intentionally, which ensures regularities in adult responses to an infant. Collis and Schaffer (1975) have shown how adults allow the infant to control the focus of joint attention, and Schaffer and Crook (1978) show how mothers time their directives to fit into the (predicted) flow of infant actions. Stern et al. (1977) emphasize the importance of the adult's elaboration of behaviour, (exaggerating gestures, frequent repetition) in providing the infant with an appropriate environment to learn social skills. Ryan (1976) found that a rising contour, characterized mother's speech more often when the infant's attention was on the same object, hence providing an additional cue for joint reference. Such parental adjustments to infant characteristics are probably crucial in the development of receptivity to social cues.

In providing such adjustment, the predictability of infant behaviour is important and Brazelton et al. (1974) find that mother-infant interactions are characterized by cycles of arousal, which probably aid in parental adjustment. Fogel (1977) has found cycles of attention and activity with one infant between 6 and 13 weeks of age, and that the mother tended to frame her behaviour around the acts of the infant. However, the statistical analysis of this study is corrupted by the use of correlated observations in a X^2 test as discussed in chapter 8. Hence the results are not reliable. Part of the predictability of an infant's behaviour is its cyclicity. Perhaps such cyclicity has evolved to aid communication. It is interesting to note that humans are the only mammals to show burst-pause cycling in sucking patterns (Wolff 1968), and Kaye (1977) has argued that such cyclicity allows sucking to be integrated into a communicative frame work.

A deal of evidence is provided in this thesis regarding receptivity in infants to others and their behaviours. The development of such skills provides a foundation for later communication development, and is probably fostered by particular characteristics of parental behaviour. Investigators should bear in mind that such skills are likely to be highly situation-dependent and thus patterns of response may differ markedly in differing investigations. Similarly, individual responsivity may vary extensively in infants and hence an intra-individual analysis may be the most appropriate approach and such an approach would merit further application.

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<u>Appendices.</u>

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Recognition of mother's voice in early infancy

CERTAIN characteristics of the human voice at normal levels have a great influence on the neonate[1], and infants 1 month old can detect fine differences in speech-like sounds[2,3]. This enables a selective response to take place when the child meets adults. From birth, babies will turn towards the source of a sound, and this orientation to a voice helps them to learn about faces. We have also observed that infants are more interested in their mother's face when she is talking.

A mother's voice is a frequent and relatively unchanging event in the young infant's auditory world, and its early recognition has important consequences for the developing bond between mother and child. We report here a study which is the first designed to discover whether normal, 3-week-old infants from intact families can recognise their mother's voice. Successful recognition, we believe, is likely to aid communication.

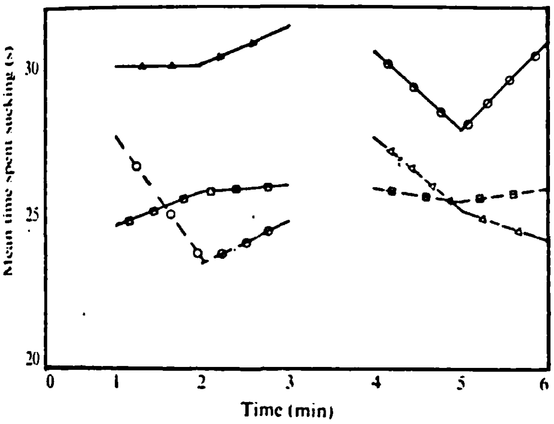

Fig. 1 Contrast effect for voice of mother (————) and stranger (— — —) measured in mean time per minute spent sucking. △, Group I; ○, group II; □, group III (non-contingent). Interaction of voices and group scheduling was significant ($P = < 0.05$) as confirmed by analysis of variance, with repeated measure.

We allowed the infants to control the auditory feedback they received (for instance, a mother's voice) by sucking on a teat to turn on the auditory stimulus. This technique, successfully employed by Siqueland *et al.*[4] and Bruner[5], may be used to find out what infants prefer to hear. (Operant conditioning of non-nutritive sucking has been demonstrated in neonates by Stern et al.[6]) If a change in the way the infant sucks is shown to be dependent on whether it can hear the mother's voice or that of a stranger, it would indicate recognition of the mother's voice.

Babies 20–30 d old, and midway between feeds, were placed, when alert (Prechtl's Stage IV[7]), in an infant seat behind a screen. A blind teat placed in the mouth connected to a pressure transducer, and a light behind a transparent reading panel turned on when the infant sucked normally and alerted the mother to read. (A normal suck was 5 mm of water pressure.) Each baby heard mother's voice live and that of a female stranger equated for loudness, but saw no one. Strangers varied from baby to baby to avoid responses being due to the characteristics of one particular voice.

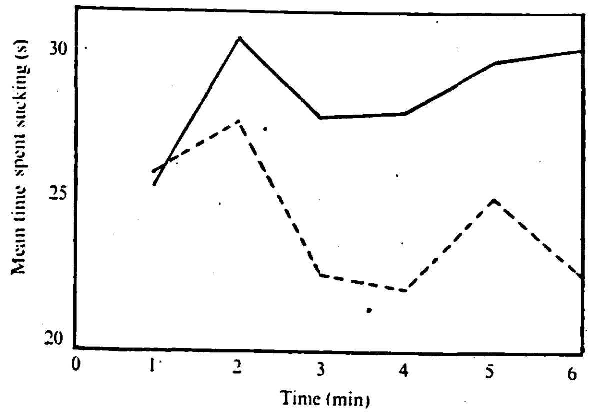

Fig. 2 Mean time spent sucking per minute during training for the contingent groups 1 and 2 combined (————) and non-contingent group (— — —). The groups and minutes interaction as confirmed by analysis of variance was significant ($P = < 0.05$) as was the linear component of the interaction trend analysis ($P = < 0.01$).

The procedure began with 1 min of sucking (baseline), and a 6 min training period followed during which the infant had a prolonged opportunity to learn the contingency between sucking and voice, and to integrate response and feedback. Data on discrimination between voices came from two further 3 min periods during which sucking produced the mother's and then the stranger's voice or *vice versa* (see Table 1).

The results for the voice presentation show that time spent sucking per minute and number of sucks per minute were greater ($P = < 0.001$ in both cases) when mother's voice was contingent on sucking. The duration of sucking for all groups is plotted in Fig. 1. No difference was recorded in the non-contingent group. Thus, the possibility of mother's voice increasing the arousal level of the infant would not account for the reported increase in sucking activity since the feedback-matching control effectively differentiates between stimulus and operant control of behaviour. Great variability in the duration of bursts of sucking in the first minute that mother's voice was available is consistent with the view that the mother's voice was initially responded to in the control group.

Non-nutritive or 'comfort' sucking typically has a rhythmic pattern in which bursts of sucking are regularly interspersed with pauses in activity. Babies could have achieved the increase in total time spent sucking when the mother's voice was available by a number of different strategies. In the event, for the mother's voice, mean burst length increased ($P = < 0.025$) and mean pause length shortened ($P = < 0.01$) as confirmed by analysis of variance. It is interesting that regulation of the sucking pattern was both systematic across contingent groups and an appropriate modification of behaviour if the mother's voice was to be found attractive.

Effects under contingent and non-contingent scheduling during the training period are plotted in Fig 2. Analysis indicates that infants were learning to produce a reward—that of a complex auditory feedback as a result of their behaviour. Only future investigation can establish whether it is sensitivity to the contingencies inherent in the present task, or the processing of correlated information that is being demonstrated by these young infants.

Table 1 Babies discrimination between voices

Schedule		Contingency training	Voice discrimination	
Group 1 (n = 16 mean age 24 d, s.d. 2.6)	Base line sucking only	First stranger's voice contingent on sucking	Mother's voice contingent on sucking	Second stranger's voice contingent on sucking
Group 2 (n = 16, mean age 24 d, s.d. 2.6)	Base line sucking only	First stranger's voice contingent on sucking	Second stranger's voice contingent on sucking	Mother's voice contingent on sucking
Group 3 (n = 16, mean age 24 d, s.d. 2.2)	Base line sucking only	First stranger's voice controlled by non-contingent schedule	Mother's voice controlled by non-contingent schedule	Second stranger's voice controlled by non-contingent schedule
Time (min)	0–1	2–7 (inclusive)	8–10 (inclusive)	11–13 (inclusive)

A non-contingent control with the same order of voice presentation as group 1 was achieved by equating total duration of feedback experienced by babies in group 1 on an individual subject basis. Schedules were generated by a computer program from the group data.

Babies will expend greater effort, it seems, to hear a familiar voice. Our findings suggest that infants have already learnt some characteristics of their mother's voice, although we are not in a position to say which aspect they may be recognising. Nevertheless, successful discrimination of mother's voice is occurring before they are a month old.

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Appendix 2(1).

Validity data relevant to chapter 7.

Duration of Looking		Number of Looks	
Without sound	With sound	Without sound	With sound
15.6	10.1	2	2
10.9	9.9	5	4
38.0	38.0	1	1
3.6	4.0	1	1
19.6	17.6	6	7
15.7	16.2	5	5
25.4	25.0	3	3
24.6	25.6	2	3
21.2	21.2	1	1
21.5	23.6	1	2
29.2	25.4	2	1

$r = 0.97$

$r = 0.93$

Appendix 2(2).

Reliability data relevant to chapter 7.

Duration of look		First Fixation		Number of Looks	
1st coder	2nd coder	1st coder	2nd coder	1st coder	2nd coder
19.0	23.8	17.9	18.1	2	2
7.1	14.3	2.2	2.4	2	2
20.1	20.5	1.5	1.5	6	5
12.6	13.5	11.9	12.5	1	2
18.0	19.0	2.0	5.9	3	4
11.0	11.1	1.5	1.7	4	4
24.3	24.5	1.0	1.0	2	2
30.0	30.0	30.0	30.0	2	1
30.0	30.0	30.0	30.0	2	1
26.1	28.5	2.4	2.0	2	2
23.6	19.6	3.6	0.5	1	1
24.1	24.0	10.8	12.0	3	3
9.8	9.0	8.4	1.3	7	5
11.0	15.0	1.8	2.0	5	4
6.1	5.5	3.1	3.0	2	2
15.0	15.0	0.4	0.4	8	6
9.2	8.5	0.5	0.2	8	6
2.0	2.6	2.0	2.6	3	3
22.1	24.8	18.1	19.6	3	3
6.4	6.6	1.0	1.1	2	2
r = 0.96		r = 0.98		r = 0.92	

Appendix 2(3).

Histograms for

duration of looking

number of looks

first fixation

log (first fixation + 1)

duration of mouthing

frequency of vocalizations

duration of frowning

frequency of smiles

In each case the stimulus stranger's face SF is used as the example.

```
      ***** HISTOGRAM FOR VARIABLE: SF     *****
40.00 +
      I
      I
      I
      I
30.00 +
      I
      I            IXXXXXI
      I            IXXXXXI
      I            IXXXXXI
20.00 +            IXXXXXI
      I            IXXXXXI
      I            IXXXXXI
      I            IXXXXXI
      I IXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXI
10.00 + IXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXI
      I IXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXI
      I IXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXI
      I IXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXI
      I IXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXI
      --+-----+-----+-----+-----+-----+-----+-----+-----+
        ^  2  ^  2  ^  4  ^  2  ^  2  ^  2  ^  1  ^  1  ^
        ^     ^     ^     ^     ^     ^     ^     ^     ^
        ^    2.50   ^    7.50   ^    12.5   ^    17.5   ^
       .000        5.00        10.0        15.0        20.0
```

Duration of looking.

```
          ***** HISTOGRAM FOR VARIABLE: SF     *****
50.00 + IXXXXXI
      I IXXXXXI
      I IXXXXXI
      I IXXXXXI
      I IXXXXXI
37.50 + IXXXXXI
      I IXXXXXI
      I IXXXXXI
      I IXXXXXI
      I IXXXXXI
25.00 + IXXXXXI
      I IXXXXXI
      I IXXXXXIXXXXXI
      I IXXXXXIXXXXXI
      I IXXXXXIXXXXXI
12.50 + IXXXXXIXXXXXIXXXXXI                  IXXXXXI
      I IXXXXXIXXXXXIXXXXXI                  IXXXXXI
      I IXXXXXIXXXXXIXXXXXIXXXXXI            IXXXXXI
      I IXXXXXIXXXXXIXXXXXIXXXXXI            IXXXXXI
      I IXXXXXIXXXXXIXXXXXIXXXXXI            IXXXXXI
      --+-----+-----+-----+-----+-----+-----+
        ^  8  ^  3  ^  2  ^  1  ^  0  ^  2  ^
        ^     ^     ^     ^     ^     ^     ^

        ^   5.20    ^   15.2    ^   25.2    ^
       .200        10.2        20.2        30.2
```

Number of looks.

```
         ***** HISTOGRAM FOR VARIABLE: SF     *****
40.00 +
      I
      I
      I
      I IXXXXXI           IXXXXXI
30.00 + IXXXXXI           IXXXXXI
      I IXXXXXI           IXXXXXI
      I IXXXXXI           IXXXXXI
      I IXXXXXI           IXXXXXI
      I IXXXXXI           IXXXXXI
20.00 + IXXXXXI           IXXXXXI
      I IXXXXXIXXXXXI     IXXXXXI
      I IXXXXXIXXXXXI     IXXXXXI
      I IXXXXXIXXXXXI     IXXXXXI
      I IXXXXXIXXXXXIXXXXXIXXXXXI
10.00 + IXXXXXIXXXXXIXXXXXIXXXXXI
      I IXXXXXIXXXXXIXXXXXIXXXXXI
      I IXXXXXIXXXXXIXXXXXIXXXXXI     IXXXXXI
      I IXXXXXIXXXXXIXXXXXIXXXXXI     IXXXXXI
      I IXXXXXIXXXXXIXXXXXIXXXXXI     IXXXXXI
      --+-----+-----+-----+-----+-----+-----+
        ^  5  ^  3  ^  2  ^  5  ^  0  ^  1  ^
        ^     ^     ^     ^     ^     ^     ^
        ^    2.00   ^    4.00   ^    6.00   ^
       1.00        3.00        5.00        7.00
```

First fixation.

```
          ***** HISTOGRAM FOR VARIABLE: LSF    *****
 20.00 +
       I       IXXXXXIXXXXXIXXXXXI
       I       IXXXXXIXXXXXIXXXXXI
       I       IXXXXXIXXXXXIXXXXXI
       I       IXXXXXIXXXXXIXXXXXI
 15.00 +       IXXXXXIXXXXXIXXXXXI
       I       IXXXXXIXXXXXIXXXXXI
       I IXXXXXIXXXXXIXXXXXIXXXXXIXXXXXI      IXXXXXI
       I IXXXXXIXXXXXIXXXXXIXXXXXIXXXXXI      IXXXXXI
       I IXXXXXIXXXXXIXXXXXIXXXXXIXXXXXI      IXXXXXI
 10.00 + IXXXXXIXXXXXIXXXXXIXXXXXIXXXXXI      IXXXXXI
       I IXXXXXIXXXXXIXXXXXIXXXXXIXXXXXI      IXXXXXI
       I IXXXXXIXXXXXIXXXXXIXXXXXIXXXXXI      IXXXXXI
       I IXXXXXIXXXXXIXXXXXIXXXXXIXXXXXI      IXXXXXI
       I IXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXI
  5.00 + IXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXI
       I IXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXI
       I IXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXI
       I IXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXI
       I IXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXI
       --+-----+-----+-----+-----+-----+-----+-----+
         ^  2  ^  3  ^  3  ^  3  ^  2  ^  1  ^  2  ^
         ^     ^     ^     ^     ^     ^     ^     ^

         ^   .682    ^    1.68   ^    2.68   ^    3.68
       .182        1.18        2.18        3.18
```

Log (first fixation + 1)

```
          ***** HISTOGRAM FOR VARIABLE: SF     *****
40.00 +
      I
      I
      I
      I                   IXXXXXI
30.00 +                   IXXXXXI
      I                   IXXXXXI
      I                   IXXXXXI
      I                   IXXXXXI
      I                   IXXXXXI
20.00 +                   IXXXXXI
      I IXXXXXI     IXXXXXIXXXXXI
      I IXXXXXI     IXXXXXIXXXXXI
      I IXXXXXI     IXXXXXIXXXXXI
      I IXXXXXI     IXXXXXIXXXXXIXXXXXIXXXXXI
10.00 + IXXXXXI     IXXXXXIXXXXXIXXXXXIXXXXXI
      I IXXXXXI     IXXXXXIXXXXXIXXXXXIXXXXXI
      I IXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXI
      I IXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXI
      I IXXXXXIXXXXXIXXXXXIXXXXXIXXXXXIXXXXXI
      --+-----+-----+-----+-----+-----+-----+
        ^  3  ^  1  ^  3  ^  5  ^  2  ^  2  ^
        ^     ^     ^     ^     ^     ^     ^
        ^   7.40    ^   17.4    ^   27.4    ^
       2.40        12.4        22.4        32.4
```

Duration of mouthing.

```
          ***** HISTOGRAM FOR VARIABLE: SF      *****
60.00 +
      I IXXXXXI
      I IXXXXXI
      I IXXXXXI
      I IXXXXXI
45.00 + IXXXXXI
      I IXXXXXI
      I IXXXXXI
      I IXXXXXI
      I IXXXXXI
30.00 + IXXXXXI
      I IXXXXXI
      I IXXXXXI
      I IXXXXXI
      I IXXXXXIXXXXXI
15.00 + IXXXXXIXXXXXI
      I IXXXXXIXXXXXIXXXXXI
      I IXXXXXIXXXXXIXXXXXI
      I IXXXXXIXXXXXIXXXXXIXXXXXI     IXXXXXI
      I IXXXXXIXXXXXIXXXXXIXXXXXI     IXXXXXI
      --+-----+-----+-----+-----+-----+-----+
        ^  9  ^  3  ^  2  ^  1  ^  0  ^  1  ^
        ^     ^     ^     ^     ^     ^     ^
        ^   1.00    ^   3.00    ^   5.00    ^
       .000       2.00        4.00        6.00
```

Frequency of vocalizations.

```
        ***** HISTOGRAM FOR VARIABLE: SF     *****
100.00 +
       I IXXXXXI
       I IXXXXXI
       I IXXXXXI
       I IXXXXXI
 75.00 + IXXXXXI
       I IXXXXXI
       I IXXXXXI
       I IXXXXXI
       I IXXXXXI
 50.00 + IXXXXXI
       I IXXXXXI
       I IXXXXXI
       I IXXXXXI
       I IXXXXXI
 25.00 + IXXXXXI
       I IXXXXXI
       I IXXXXXI
       I IXXXXXI
       I IXXXXXI                       IXXXXXI
       --+-----+-----+-----+-----+-----+-----+
         ^  30 ^   0 ^   0 ^   0 ^   0 ^   1 ^
         ^     ^     ^     ^     ^     ^     ^
         ^   .200    ^   .600    ^   1.00    ^
        .000       .400        .800        1.20
```

Frowning.

```
          ***** HISTOGRAM FOR VARIABLE: SF     *****
100.00 +
       I
       I
       I
       I IXXXXXI
 75.00 + IXXXXXI
       I IXXXXXI
       I IXXXXXI
       I IXXXXXI
       I IXXXXXI
 50.00 + IXXXXXI
       I IXXXXXI
       I IXXXXXI
       I IXXXXXI
       I IXXXXXI
 25.00 + IXXXXXI
       I IXXXXXI
       I IXXXXXIXXXXXI
       I IXXXXXIXXXXXI
       I IXXXXXIXXXXXI                                   IXXXXXI
       --+-----+-----+-----+-----+-----+-----+-----+-----+
         ^  13 ^   2 ^   0 ^   0 ^   0 ^   0 ^   0 ^   1 ^
         ^     ^     ^     ^     ^     ^     ^     ^     ^
         ^    2.50   ^    7.50   ^    12.5   ^    17.5   ^
        .000        5.00        10.0        15.0        20.0
```

Smiles.

Appendix 2(4).

This appendix includes the raw data for the analyses in chapter 7.

DURATION OF LOOKING

SEX	MF	MFMV	MFMVA	MFAV	MAVA	SF	SFSV	SFSVA	SFAV	SAVA	
1	23.8	14.3	20.5	13.5	19.0	11.1	24.5	30.0	30.0	28.5	1
1	19.6	24.0	9.0	15.1	5.5	15.0	8.5	2.6	24.8	6.6	2
1	12.6	9.5	9.5	30.0	14.0	19.0	17.5	18.0	4.7	24.0	3
1	17.0	24.7	28.3	20.4	18.6	14.7	24.4	28.0	20.0	30.0	4
1	25.5	10.0	12.0	11.6	18.5	27.0	22.0	16.5	24.4	19.8	5
1	10.8	26.5	10.0	5.0	23.0	3.0	19.4	11.5	27.5	12.0	6
1	21.0	12.0	13.6	15.2	2.6	2.4	12.4	9.4	6.8	10.7	7
1	16.5	15.0	23.2	30.0	25.3	19.0	24.0	30.0	2.5	13.3	8
1	25.0	19.5	18.3	22.3	28.3	21.2	19.5	5.2	11.5	15.9	9
1	26.3	22.3	30.0	27.0	29.0	14.8	4.9	1.7	20.0	7.5	10
1	3.3	4.8	25.4	2.0	27.5	30.0	6.3	21.8	18.0	9.7	11
1	16.3	25.6	18.0	19.0	16.0	21.0	13.0	15.1	18.5	15.2	12
1	13.3	8.8	30.0	27.3	28.5	30.0	30.0	2.0	5.2	30.0	13
1	20.1	26.0	24.4	5.8	21.0	19.7	27.6	11.0	18.0	20.9	14
1	13.1	15.1	16.5	10.7	12.5	5.2	19.3	10.9	23.8	7.8	15
1	28.4	27.4	27.7	27.5	30.0	25.9	27.6	29.0	20.5	29.2	16
2	17.5	16.5	26.2	30.0	30.0	17.8	23.3	27.0	25.5	30.0	17
2	24.6	17.0	6.6	19.3	0.5	10.3	0.5	25.5	12.1	13.8	18
2	16.6	18.5	29.0	24.0	25.0	26.0	6.7	16.8	14.4	9.2	19
2	14.1	26.4	29.6	20.0	28.0	18.2	28.7	30.0	26.4	30.0	20
2	19.2	16.0	18.5	16.0	27.3	19.7	27.5	22.4	30.0	18.0	21
2	14.6	17.7	13.2	18.6	19.2	24.0	20.0	24.0	22.6	21.0	22
2	2.8	13.7	13.0	11.5	12.5	8.9	21.2	11.7	21.2	17.7	23
2	7.0	13.0	9.9	21.7	19.8	23.7	16.8	22.1	25.5	20.3	24
2	21.7	30.0	17.5	25.2	14.3	24.2	20.4	30.0	30.0	30.0	25
2	12.4	25.2	22.2	10.6	28.0	7.0	18.0	19.6	19.3	16.6	26
2	20.6	27.2	11.6	6.0	20.8	10.1	22.7	21.8	13.8	22.5	27
2	12.8	5.4	27.0	22.2	25.6	18.6	8.0	23.0	3.0	18.2	28
2	14.0	12.5	21.3	14.6	4.7	22.3	25.0	15.5	24.5	18.0	29
2	5.0	30.0	21.5	11.8	30.0	13.8	27.6	23.0	30.0	23.2	30
2	21.4	13.7	26.8	22.5	30.0	18.2	20.5	28.0	21.9	21.2	31

FREQUENCY OF LOOKS

SEX	MF	MFMV	MFMVA	MFAV	MAVA	SF	SFSV	SFSVA	SFAV	SAVA	
1	2	2	5	2	4	4	2	1	1	2	1
1	1	3	5	4	2	6	6	3	3	2	2
1	2	6	3	1	9	4	7	5	2	5	3
1	3	4	2	3	4	4	4	2	7	1	4
1	3	1	3	1	4	3	6	4	3	10	5
1	5	1	3	3	3	2	2	2	3	4	6
1	3	4	6	3	1	1	3	4	2	1	7
1	6	3	5	1	4	4	5	1	2	4	8
1	2	3	4	1	3	1	7	1	4	3	9
1	3	2	1	3	2	2	3	1	4	2	10
1	2	4	4	2	2	1	2	5	3	3	11
1	3	4	2	2	2	2	3	3	5	3	12
1	1	2	3	1	1	1	1	1	4	1	13
1	4	4	5	1	4	4	1	2	2	6	14
1	2	2	2	1	3	1	4	2	1	3	15
1	4	3	4	4	2	3	4	5	1	3	16
2	5	2	2	1	1	2	6	3	4	1	17
2	3	3	3	6	1	1	1	5	3	3	18
2	4	4	4	2	3	1	3	5	3	4	19
2	2	2	2	4	2	2	1	1	3	1	20
2	3	4	1	5	4	2	5	1	2	7	21
2	4	5	4	5	3	6	2	3	5	3	22
2	2	1	4	3	4	3	3	3	3	7	23
2	2	5	5	4	5	3	4	4	3	4	24
2	3	1	3	3	2	4	3	1	1	1	25
2	6	2	3	3	2	3	2	6	4	5	26
2	4	3	3	1	3	3	1	3	4	4	27
2	2	2	2	1	3	5	3	3	1	2	28
2	3	1	3	3	1	3	5	6	4	3	29
2	2	1	3	3	1	2	3	3	1	1	30
2	8	4	3	5	1	3	6	1	4	3	31

DURATION OF FIRST FIXATION

SEX	MF	MFMV	MFMVA	MFAV	MAVA	SF	SFSV	SFSVA	SFAV	SAVA	
1	18.1	2.4	1.5	12.5	5.9	1.7	1.0	30.0	30.0	2.0	1
1	0.5	12.0	1.3	2.0	3.0	0.4	0.2	2.6	19.8	1.1	2
1	3.8	1.1	6.0	30.0	2.0	0.2	2.0	6.4	0.7	8.0	3
1	8.0	12.0	20.0	16.4	8.0	7.7	3.9	20.5	6.8	30.0	4
1	4.3	8.0	2.4	11.6	1.6	4.0	10.0	3.0	5.7	0.6	5
1	3.8	26.5	2.0	1.7	14.0	2.0	17.7	9.5	4.5	2.5	6
1	0.8	2.0	3.6	13.0	2.6	2.4	4.6	3.3	5.9	10.7	7
1	1.8	12.8	3.0	30.0	5.5	12.0	3.6	30.0	2.0	4.7	8
1	13.4	10.8	11.7	19.4	1.8	18.2	3.9	3.2	2.6	10.9	9
1	21.0	20.6	30.0	11.3	28.0	13.0	2.6	1.7	3.0	6.8	10
1	1.7	1.2	5.8	0.8	14.7	30.0	2.7	1.2	15.0	5.2	11
1	2.8	2.7	7.0	3.4	4.0	2.5	0.2	2.2	5.0	5.7	12
1	1.2	8.8	30.0	13.7	18.0	30.0	30.0	2.0	1.0	0.5	13
1	7.0	7.4	5.0	2.7	16.0	1.0	27.6	10.0	9.8	1.2	14
1	6.1	5.6	14.0	3.2	7.3	5.2	3.3	8.9	19.4	2.0	15
1	26.5	9.5	22.2	7.0	30.0	5.2	6.1	11.6	0.7	27.0	16
2	4.0	1.4	6.1	14.2	30.0	15.1	1.5	3.8	1.5	30.0	17
2	9.1	14.0	2.2	2.2	0.5	10.3	0.5	1.8	5.0	12.1	18
2	1.4	9.0	24.0	22.5	12.7	26.0	2.0	3.2	4.0	2.9	19
2	10.4	12.0	26.4	10.7	20.3	14.6	28.7	30.0	15.3	30.0	20
2	7.0	7.7	2.4	4.0	25.5	1.0	26.4	5.7	30.0	1.0	21
2	9.0	4.0	7.3	6.3	9.0	1.0	19.0	17.4	2.7	13.5	22
2	1.0	13.7	2.9	5.3	3.0	4.9	12.2	1.0	8.9	8.0	23
2	4.5	5.7	0.6	1.2	4.8	13.0	4.9	5.0	10.3	2.7	24
2	13.6	30.0	10.0	21.0	13.5	14.3	8.8	30.0	30.0	30.0	25
2	4.0	20.6	6.0	2.8	25.8	4.0	3.0	1.5	4.1	1.5	26
2	2.9	18.6	3.2	6.0	4.6	4.7	22.7	4.6	4.5	1.0	27
2	5.0	2.7	22.2	10.4	18.6	1.5	4.0	5.0	3.0	7.1	28
2	4.3	12.5	9.8	9.6	4.7	19.3	3.0	1.5	6.5	0.5	29
2	2.5	30.0	0.5	2.5	30.0	1.0	5.8	2.5	30.0	23.2	30
2	1.8	0.5	25.4	11.9	30.0	3.0	8.2	28.0	4.6	1.1	31

LOG (FIRST FIXATION +1)

SEX	MF	MFMV	MFMVA	MFAV	MAVA	SF	SFSV	SFSVA	SFAV	SAVA
1.00	2.95	1.22	0.92	2.60	1.93	0.99	0.69	3.43	3.43	1.10
1.00	0.41	2.56	0.83	1.10	1.39	0.34	0.18	1.28	3.03	0.74
1.00	1.57	0.74	1.95	3.43	1.10	0.18	1.10	2.00	0.53	2.20
1.00	2.20	2.56	3.04	2.86	2.20	2.16	1.59	3.07	2.05	3.43
1.00	1.67	2.20	1.22	2.53	0.96	1.61	2.40	1.39	1.90	0.47
1.00	1.57	3.31	1.10	0.99	2.71	1.10	2.93	2.35	1.70	1.25
1.00	0.59	1.10	1.53	2.64	1.28	1.22	1.72	1.46	1.93	2.46
1.00	1.03	2.62	1.39	3.43	1.87	2.56	1.53	3.43	1.10	1.74
1.00	2.67	2.47	2.54	3.02	1.03	2.95	1.59	1.44	1.28	2.48
1.00	3.09	3.07	3.43	2.51	3.37	2.64	1.28	0.99	1.39	2.05
1.00	0.99	0.79	1.92	0.59	2.75	3.43	1.31	0.79	2.77	1.82
1.00	1.34	1.31	2.08	1.48	1.61	1.25	0.18	1.16	1.79	1.90
1.00	0.79	2.28	3.43	2.69	2.94	3.43	3.43	1.10	0.69	0.41
1.00	2.08	2.13	1.79	1.31	2.83	0.69	3.35	2.40	2.38	0.79
1.00	1.96	1.89	2.71	1.44	2.12	1.82	1.46	2.29	3.02	1.10
1.00	3.31	2.35	3.14	2.08	3.43	1.82	1.96	2.53	0.53	3.33
2.00	1.61	0.88	1.96	2.72	3.43	2.78	0.92	1.57	0.92	3.43
2.00	2.31	2.71	1.16	1.16	0.41	2.42	0.41	1.03	1.79	2.57
2.00	0.88	2.30	3.22	3.16	2.62	3.30	1.10	1.44	1.61	1.36
2.00	2.43	2.56	3.31	2.46	3.06	2.75	3.39	3.43	2.79	3.43
2.00	2.08	2.16	1.22	1.61	3.28	0.69	3.31	1.90	3.43	0.69
2.00	2.30	1.61	2.12	1.99	2.30	0.69	3.00	2.91	1.31	2.67
2.00	0.69	2.69	1.36	1.84	1.39	1.77	2.58	0.69	2.29	2.20
2.00	1.70	1.90	0.47	0.79	1.76	2.64	1.77	1.79	2.42	1.31
2.00	2.68	3.43	2.40	3.09	2.67	2.73	2.28	3.43	3.43	3.43
2.00	1.61	3.07	1.95	1.34	3.29	1.61	1.39	0.92	1.63	0.92
2.00	1.36	2.98	1.44	1.95	1.72	1.74	3.17	1.72	1.70	0.69
2.00	1.79	1.31	3.14	2.43	2.98	0.92	1.61	1.79	1.39	2.09
2.00	1.67	2.60	2.38	2.36	1.74	3.01	1.39	0.92	2.01	0.41
2.00	1.25	3.43	0.41	1.25	3.43	0.69	1.92	1.25	3.43	3.19
2.00	1.03	0.41	3.27	2.56	3.43	1.39	2.22	3.37	1.72	0.74

DURATION OF MOUTHING

SEX	MF	MFMV	MFMVA	MFAV	MAVA	SF	SFSV	SFSVA	SFAV	SAVA	
1	13.4	11.8	12.2	12.1	5.0	14.3	1.2	3.6	3.5	8.6	1
1	13.6	10.8	9.3	14.6	21.7	14.2	8.3	0.6	17.7	10.5	2
1	3.2	2.5	0.0	0.0	0.0	5.5	5.0	2.3	7.0	2.5	3
1	7.4	18.4	4.2	11.4	6.8	10.0	4.6	0.7	4.6	2.7	4
1	11.7	0.0	15.5	16.0	7.4	5.2	8.8	15.8	12.0	3.5	5
1	13.0	4.7	4.8	5.0	6.0	6.0	4.7	10.5	6.2	8.4	6
1	6.3	2.7	1.6	6.8	2.5	8.0	14.3	4.6	3.3	6.8	7
1	16.4	8.0	1.2	0.0	9.5	4.8	0.0	5.4	11.4	15.8	8
1	5.4	10.0	0.0	10.3	13.5	0.0	8.6	1.2	14.5	5.5	9
1	11.3	14.5	10.4	12.8	6.6	0.0	16.3	8.8	14.5	8.0	10
1	3.5	10.6	9.0	4.8	3.5	5.5	1.0	15.3	10.2	12.7	11
1	4.5	0.0	8.2	4.0	1.3	4.8	8.0	8.0	6.9	6.0	12
1	3.4	13.7	0.0	5.7	13.7	7.9	4.2	9.0	8.6	1.6	13
1	5.0	0.0	10.0	1.8	2.8	19.8	2.8	7.5	6.0	7.0	14
1	12.2	10.2	10.0	11.0	13.0	15.8	19.1	24.0	13.0	11.0	15
1	7.5	12.5	5.8	8.0	6.5	10.0	9.6	8.8	11.6	11.6	16
2	17.2	16.4	11.0	9.4	3.0	20.5	9.0	14.5	12.4	14.6	17
2	7.4	10.4	19.0	8.1	16.2	3.8	25.5	8.5	18.8	1.7	18
2	9.0	17.5	0.3	7.6	13.0	6.8	12.0	5.8	2.0	9.4	19
2	12.0	12.6	0.0	8.2	10.1	5.6	1.8	5.0	12.5	0.0	20
2	14.0	1.7	9.5	0.0	0.0	0.7	0.0	7.1	3.0	8.3	21
2	17.8	23.0	13.4	15.6	23.0	25.3	21.0	13.5	11.5	14.4	22
2	5.2	5.0	9.0	9.4	9.5	15.5	10.2	12.5	9.0	17.5	23
2	6.0	11.3	25.2	8.2	15.6	24.0	14.7	17.5	19.5	10.3	24
2	13.0	14.0	18.0	1.0	2.8	8.2	5.2	0.0	0.3	11.7	25
2	8.6	12.7	9.0	12.0	17.8	18.3	9.5	4.5	2.0	28.5	26
2	13.5	10.6	13.2	8.5	8.6	14.0	0.0	7.4	7.8	13.4	27
2	0.5	0.0	7.4	6.6	7.0	14.2	0.5	6.5	3.7	4.3	28
2	5.5	2.5	6.0	6.7	8.5	1.5	8.4	16.7	10.5	3.0	29
2	9.2	11.1	11.2	7.7	10.3	11.9	8.8	9.1	8.8	10.2	30
2	12.8	13.0	9.8	9.4	7.5	8.8	5.8	7.3	9.6	4.8	31

FREQUENCY OF VOCALIZATIONS

SEX	MF	MFMV	MFMVA	MFAV	MAVA	SF	SFSV	SFSVA	SFAV	SAVA	
1	0	0	0	0	0	0	0	0	0	0	1
1	1	2	1	1	0	3	0	0	0	4	2
1	0	0	1	0	0	0	0	0	0	0	3
1	2	2	0	1	0	0	2	0	0	0	4
1	2	0	0	0	0	0	0	1	1	0	5
1	1	0	1	1	0	1	1	0	0	1	6
1	1	0	0	0	0	1	1	0	0	0	7
1	1	0	0	0	0	0	0	0	1	0	8
1	3	2	2	0	5	2	3	0	4	4	9
1	2	3	1	2	0	0	2	2	1	0	10
1	1	1	0	0	0	1	2	0	1	1	11
1	2	1	1	0	0	0	1	0	2	2	12
1	0	0	0	0	0	0	0	0	0	0	13
1	1	1	3	2	0	2	2	1	0	0	14
1	0	0	0	0	0	0	1	0	1	0	15
1	3	1	2	0	0	5	6	3	3	3	16
2	0	0	0	0	1	0	0	0	0	0	17
2	3	0	3	2	0	0	0	0	2	1	18
2	0	0	0	0	0	0	0	0	0	0	19
2	0	1	0	0	0	0	0	0	1	0	20
2	0	0	2	1	0	0	0	0	0	0	21
2	0	1	1	1	0	1	0	1	1	0	22
2	2	0	1	1	0	1	1	0	1	1	23
2	2	2	3	1	3	4	3	1	2	0	24
2	0	0	1	1	0	3	0	0	0	0	25
2	0	1	1	2	1	0	0	0	1	5	26
2	4	1	0	1	0	1	0	2	0	1	27
2	0	0	0	0	0	0	0	0	0	0	28
2	0	0	0	0	1	0	5	4	1	0	29
2	1	0	0	1	1	0	1	1	0	1	30
2	3	0	2	3	0	0	1	2	0	3	31

DURATION OF FROWNING

SEX	MF	MFMV	MFMVA	MFAV	MAVA	SF	SFSV	SFSVA	SFAV	SAVA	
1	4.5	1.5	0.0	0.5	8.0	4.0	0.0	0.0	2.0	6.6	1
1	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	2
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4
1	0.0	0.0	0.0	11.5	0.0	0.0	0.0	21.0	2.0	0.0	5
1	3.0	0.0	12.5	2.0	0.7	4.7	6.5	0.0	14.2	9.1	6
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	7
1	4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8
1	0.0	0.0	0.0	0.0	0.0	2.2	0.0	0.0	10.0	0.0	9
1	5.0	4.0	15.0	9.5	21.5	18.5	6.0	0.0	0.0	3.4	10
1	0.0	1.5	0.0	1.0	1.0	0.0	0.0	4.0	4.0	1.0	11
1	3.3	1.0	0.9	0.0	0.0	0.0	6.4	4.2	1.2	6.8	12
1	2.5	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.0	0.0	13
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	14
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15
1	1.9	1.0	0.4	0.0	1.8	0.0	2.0	0.0	0.0	1.1	16
2	1.4	0.8	0.0	0.0	0.5	0.0	0.0	0.0	0.0	3.0	17
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	18
2	0.0	0.0	11.8	0.0	0.0	3.0	0.0	0.0	0.0	2.0	19
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21
2	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	22
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23
2	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	26
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27
2	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	28
2	0.0	0.0	0.0	0.0	0.8	0.6	1.0	2.0	0.0	0.0	29
2	0.5	0.3	1.0	0.4	2.1	0.5	0.4	0.6	0.2	0.3	30
2	2.8	2.0	0.5	3.0	27.0	2.5	4.5	6.1	2.5	0.0	31

FREQUENCY OF SMILING

SEX	MF	MFMV	MFMVA	MFAV	MAVA	SF	SFSV	SFSVA	SFAV	SAVA	
1	Ø	Ø	1	Ø	Ø	Ø	Ø	Ø	Ø	Ø	1
1	Ø	Ø	Ø	Ø	Ø	Ø	1	Ø	Ø	Ø	2
1	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	3
1	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	4
1	Ø	Ø	1	Ø	Ø	1	Ø	Ø	Ø	Ø	5
1	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	6
1	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	7
1	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	8
1	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	9
1	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	1Ø
1	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	11
1	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	12
1	Ø	Ø	Ø	Ø	Ø	Ø	1	Ø	Ø	Ø	13
1	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	14
1	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	15
1	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	16
2	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	17
2	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	18
2	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	19
2	Ø	Ø	Ø	Ø	1	Ø	Ø	2	Ø	Ø	2Ø
2	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	21
2	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	22
2	Ø	1	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	23
2	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	24
2	Ø	Ø	1	Ø	Ø	Ø	Ø	Ø	Ø	Ø	25
2	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	26
2	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	27
2	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	28
2	Ø	Ø	Ø	Ø	Ø	Ø	1	Ø	Ø	Ø	29
2	Ø	Ø	Ø	Ø	Ø	Ø	1	Ø	Ø	Ø	3Ø
2	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	31

Appendix 3(1).

CASCOP.MAC.

```
.MCALL   .REGDEF,.CSIGEN,.PRINT,.EXIT,.CLOSE,.WRITW
.MCALL   ..V2..,.GTIM,.WRITC,.WRITE
         ..V2..
         .REGDEF
PSW      =177776
DRLNG    =5000
DRCSR    =176760
DRVEC    =354
DRINEN   =40
DRPRI    =240
ENTRY:   MOV      #DRST,IPTR
         MOV      #DRST,OPTR
         CLR      CHARS
         MOV      #DRLNG,ROOM
         MOV      #DRINT,@#DRVEC
         MOV      #DRPRI,@#DRVEC+2
         MOV      #BUFFER,BUFPTR
         MOV      #512.,BYTCNT
         CLR      BLOCK
         .CSIGEN  #PROGEND,#DEFEXT,#0
         BIS      #DRINEN,@#DRCSR
         .GTIM    #AREA,#TIM
         MOV      TIM,OTIM
         MOV      TIM+2,OTIM+2
LOOP:    .GTIM    #AREA,#TIM
         MOV      TIM+2,R4
         SUB      OTIM+2,R4
         CMP      R4,#10.*50.                  ;SECONDS TIMEOUT*50
         BLOS     OK
         JMP      TIMOUT
OK:      TST      CHARS
         BEQ      LOOP
         BIS      #DRPRI,@#PSW
         MOV      @OPTR,R0
         MOV      OPTR,-(SP)
         JSR      PC,NEXT
         MOV      (SP)+,OPTR
         SUB      #2,CHARS
         ADD      #2,ROOM
         BIC      #DRPRI,@#PSW
         JSR      PC,OUTPUT
         .GTIM    #AREA,#TIM
         MOV      TIM,OTIM
         MOV      TIM+2,OTIM+2
         BR       LOOP

OUTPUT:  MOVB     R0,@BUFPTR
         INC      BUFPTR
         DEC      BYTCNT
         BEQ      FULL
         RTS      PC

FULL:    MOV      #1,WAITING       ;FOR RT-11 I0 (SLOW)
         .WRITC   #AREA,#0,#BUFFER,#256.,#WRITEN,BLOCK
WATE:    TST      WAITING
         BNE      WATE
         MOV      #BUFFER,BUFPTR
         MOV      #512.,BYTCNT
         INC      BLOCK
         RTS      PC
```

```
WRITEN: CLR     WAITING           ;TRANSFER COMPLETE
        ROR     RØ
        BCS     WTERROR
        RTS     PC


DRINT:  TST     ROOM
        BEQ     FULER
        MOV     @#DRCSR+4,@IPTR
        MOV     IPTR,-(SP)
        JSR     PC,NEXT
        MOV     (SP)+,IPTR
        ADD     #2,CHARS
        SUB     #2,ROOM
        RTI

NEXT:   ADD     #2,2(SP)
        CMP     2(SP),#DRST+DRLNG
        BEQ     CYCLE
        RTS     PC

CYCLE:  MOV     #DRST,2(SP)
        RTS     PC
FULER:  CLR     @#DRCSR
        CLR     @#PSW
        .PRINT  #ISFUL
        .CLOSE #Ø
        .EXIT
WTERROR:CLR     @#DRCSR
        .PRINT  #WTER
        .EXIT

FERROR: CLR     @#DRCSR
        CLR     @#PSW
        .PRINT  #FER
        .EXIT

TIMOUT: CLR     @#DRCSR
        CLR     RØ
        JSR     PC,OUTPUT
        MOV     BUFPTR,RØ
        SUB     #BUFFER,RØ
        ASR     RØ                ;WORD COUNT
        MOV     RØ,TEMP
        .WRITW  #AREA,#Ø,#BUFFER,TEMP,BLOCK
        BCS     WTERROR
        .CLOSE  #Ø
        .PRINT  #DONE
        .EXIT
WTER:   .ASCIZ  "WRITE ERROR"
FER:    .ASCIZ  "FRAMING ERROR ON DR-11"
ISFUL:  .ASCIZ  "BUFFER FULL"
DONE:   .ASCIZ  "***FILE TRANSFERED"
        .EVEN
WAITIN: .WORD   Ø
TEMP:   .WORD   Ø
TIM:    .WORD   Ø
        .WORD   Ø
```

```
OTIM:    .WORD   Ø
         .WORD   Ø
OTIME:   .WORD   Ø
BLOCK:   .WORD   Ø
BUFPTR:  .WORD   Ø
BYTCNT:  .WORD   Ø

IPTR:    .WORD   Ø
OPTR:    .WORD   Ø
ROOM:    .WORD   Ø
CHARS:   .WORD   Ø
BUFFER:  .BLKW   512.
AREA:    .BLKW   2Ø
DRST:    .BLKB   DRLNG
DEFEXT:  Ø
         .RAD5Ø  "CS "
                 Ø
                 Ø
PROGEND:.END     ENTRY
.
```

```
;        PROGRAM CASPV1
;        ==============
;
;        CONVERTS 8-BIT ASCII RECORDS BOUNDED BY * TO 7-BIT ASCII
;        BOUNDED BY CARRIAGE-RETRUN ,LINE-FEED
;        THE RECORDS CONTAIN 9 3-DIGIT NUMBERS. THE FIRST IS LEFT
;        AS A LINE NUMBER,, THE REST ARE CONVERTED TO THEIR NUMERIC
;        VALUES AND THEN GIVEN A 2-DIGIT BINARY CODE
;                 INPUT FILE = CASINP.DAT
;                 OUTPUT FILE = CASOUT.DAT

;        CASPV1 - + AND * CANNOT BE REPLACED BY /

;
.MCALL ..V2..,.FETCH,.ENTER,.LOOKUP,.READW,.WRITW,.REOPEN
.MCALL ..V2..,.TTYOUT,.REGDEF,.EXIT,.CLOSE,.PRINT,.SAVESTATUS
.REGDEF
ERRWD=52
OBPTR=%3          ;POINTER TO OUTPUT BUFFER

IBPTR=%4          ;POINTER TO INPUT BUFFER

LINPTR=%5         ;POINTER TO TEMPORARY LINE STORE(1 LINE = 1 RECORD)


;INITIALISE INPUT/OUTPUT CHANNELS AND BUFFER SPACE
START:  .FETCH #GASHAN,#GASOB              ;FETCH DISK HANDLER
        BCC LAB2
        JMP BADFET
LAB2:   .ENTER #GASIO,#2,#GASOB            ;OPEN CHANNEL 2 - OUTPUT
        BCC LAB1
        JMP BADENT
LAB1:   .LOOKUP #GASIO,#1,#GASIB                    ;OPEN CHANNEL 1 - INPUT
        BCC LAB3
        JMP BADLK
LAB3:   MOV #-1,STAR            ;STAR IS -1,0 OR 1
        MOV #1000,BUFFO
        MOV #1000,BUFF
        MOV #1001,IBCNT         ;SET INPUT BUFFER COUNT TO SHOW BUFFER
        CLR OBCNT               ;MUST BE READ - NOT WRITTEN
        MOV #OBUF,OBPTR         ;RESET POINTER TO START OF BUFFER

PLOOP:  JSR PC,INPUT     ;GET A CHARACTER FROM CASINP.DAT
        CMP #'*,ENTRY    ;LOOP AROUND TILL FIRST * IS FOUND
        BNE PLOOP
        BR LAB4A


LOOP1:  JSR PC,INPUT
        CMP #'*,ENTRY           ;IS ENTRY A STAR?
LAB4A:  BEQ NEWLIN              ;YES -SO SHOULD HAVE NEW LINE
        MOVB ENTRY,(LINPTR)+    ;MOVE FORM BUFFER TO LINE
        INC LINCNT       ;COUNT NUMBERS IN LINE
        CMP LINCNT,#44          ;AND CHECK HOW MANY
        BLT LOOP1
        JSR PC,BADLIN           ;TOO MANY NUMBERS
        JMP FIRST               ;IGNORE LINE START AGAIN

NEWLIN: INC STAR         ;SET STAR FOUND FLAG
        TST STAR
        BEQ FIRST               ;MUST BE THE FIRST STAR IN FILE
```

```
        CMP STAR,#1                  ;IF NOT PREVIOUS LINE MUST BE
        BEQ LAB5
        JSR PC,BADSTR                ;STUFFED INTO OUTPUT UNLESS TOO MANY
        JMP FIRST
LAB5:   JSR PC,SCAN                  ;SCAN LINE INTP ONE ASCII NUMBER AND 8 BINARY
        TST ERF
        BNE FIRST
                                     ;NUMBERS
        MOV #NUMBRS,R5
        JSR PC,CODER                 ;CHECK BINARY VALUES AND CODE
        CLR STAR                     ;STAR = Ø WHEN NEW LINE EXPECTED

FIRST:  CLR ERF
        MOV #LINBUF,LINPTR
        CLR LINCNT                   ;RESET LINE POINTER AND COUNTER
        JMP LOOP1

;       SUBROUTINE SCAN
;       ===============
;       SCAN LINE FORM * TO * INTO 9 3-DIGIT NUMBERS
;       CHECK THAT THERE ARE THE RIGHT SEQUENCE OF DIGITS AND +
;       CONVERT THE 3-DIGITS INTO NUMERIC VALUES AND STORE IN NUMBRS
;
SCAN:   MOV R3,-(SP)
        MOV R1,-(SP)
        MOV #-1,PLUS
        MOV #LINBUF,R5
        CLR BIGCNT        ;KEEP CHECK OF NUMBER OF 3-DIGIT NUMBERS
        MOV #3,R1                    ;R4 IS ACOUNT OF NUMERALS IN NO 1
        MOV #NUMBRS,R2
BYTLP:  MOVB (R5)+,R3
        CMPB R3,#'+
        BEQ PLUS1
        CMPB R3,#'/
        BEQ PLUS1
        JMP NMFND

;PLUS FOUND. RESET NUMBER COUNT ADD 1 TO BIGCNT SET PLUS FOUND FLAG
PLUS1:  CLR NUM
        CLR CNT
        INC PLUS
        BEQ BYTLP
        JSR PC,BADDAT     ;PLUS FLAG WAS ALREADY SET I.E. 2 PLUSES TOGETHER
        JMP SCANE
;PLUS NOT FOUND - ASSUME A NUMBER. DONT CONVERT TILL WHOLE LINE FOUND
NMFND:  TST BIGCNT        ;FIRST NUMBER IN LINE STORED AS 3 ASCII BYTES PLUS ANULL
        BNE NMFND2
        MOVB R3,(R2)+
        SOB R1,BYTLP
        INC BIGCNT
        MOVB #Ø,(R2)+                ;MAKE UP TO AN EVEN ADDRESS
        MOV #-1,PLUS
        JMP BYTLP
NMFND2: TST PLUS
        BEQ LAB6
        JSR PC,BADDAT     ;MORE THAN 3 DIGITS TOGETHER - + MISSING
        JMP SCANE
LAB6:   CMPB R3,#'Ø
        BHIS LAB7
        JSR PC,BADDAT     ;CHARACTER NOT NUMERIC
```

```
        JMP SCANE
LAB7:   CMPB R3,#'9
        BLOS LAB8
        JSR PC,BADDAT     ;CHARACTER NOT NUMERIC
        JMP SCANE
LAB8:   SUB #60,R3        ;GETT NUMERIC VALUE
        INC CNT
        CMP CNT,#1        ;TEST POSITION OF DIGIT
        BEQ HUNDRD
        CMP CNT,#2
        BEQ TENS
        CMP CNT,#3
        BEQ UNITS
        JSR PC,BADDAT     ;TOOMANY DIGITS IN NUMBER
        JMP SCANE


HUNDRD: MOV R3,R1         ;MULTIPLY X BY 100
        ASH #6,R3         ;X * 2**6
        ADD R3,NUM
        MOV R1,R3
        ASH #5,R3         ;X * 2**5
        ADD R3,NUM
        MOV R1,R3
        ASH #2,R3         ;X * 2**2
        ADD R3,NUM        ;NUM = X*64 + X*32 + X*4
        BR BYTLP


TENS:   MOV R3,R1         ;MULTIPLY Y BY 10
        ASH #3,R3         ;Y * 2**3
        ADD R3,NUM
        MOV R1,R3
        ASL R3            ;Y * 2
        ADD R3,NUM        ;NUM = Y*8 + Y*2
        BR BYTLP


UNITS:  ADD R3,NUM        ;NUM = X*100 + Y*10 + Z
        MOV NUM,(R2)+
        MOV #-1,PLUS
        INC BIGCNT
        CMP BIGCNT,#11    ;HAVE 9 NUMBERS BEEN FOUND?
        BNE BYTLP
SCANE:  MOV (SP)+,R1
        MOV (SP)+,R3
        RTS PC
BIGCNT: .WORD 1 ;NUMBER OF 3-DIGIT NUMBERS
CNT:    .WORD 1 ;POSITION OF DIGIT
PLUS:   .WORD 1 ;PLUS FOUND FLAG
NUM:    .WORD 1


;       SUBROUTINE CODER
;       =================
;       TAKE 8 NUMBERS FORM ARRAY NUMBRS AND TEST THEM AGAINST
;       HIGH AND LOW VALUES. CODE EACH NUMBER ACCORDINGLY
;       EITHER 00 ,01 ,10 ,11 OR 99
;       OUTPUT TO CASOUT.DAT THE FIRST 3-DIGIT NUMBER, THE  8
```

```
;       CODES AND A CARRIAGE RETURN LINEFEED
;
CODER:  MOV #3,R2
LOOP:   MOVB (R5)+,CHAR          ;R3 ISAN ASCII NUMERAL
        JSR PC,OUTPUT
        SOB R2,LOOP              ;LOOP AROUND 3 TIMES
        MOV SPACE,CHAR
        JSR PC,OUTPUT
        MOV #-10,CODC1           ;THERE ARE 8 NUMBERS LEFT IN ARRAY NUMBERS
        MOVB (R5)+,CHAR          ;EVEN UP THE POINTER


ILOOP:  MOV #-4,CODC2            ;4 ENTRIES INEACH COMPARISON TABLE
        MOV #HIGH,R0             ;R0 POINTS TO HIGH VALUES
        MOV #LOW,R1              ;R1 POINTS TO LOW VALUES
        MOV #ASCII,R2            ;R2 POINTS TTO ASCII CODES


        MOV (R5)+,NUM            ;GET NEXT NUMBER
JLOOP:  CMP NUM,(R0)+            ;IS NUM <= HIGH(J)?
        BHI STEP1                ;BRANCH IF NUM > HIGH(J)
        CMP NUM,(R1)+            ;IS NUM >= LOW(J)?
        BLO STEP2                ;BRANCH IF NUM < LOW(J)
        MOVB (R2)+,CHAR          ;OUTPUT ASCII VALUES
        JSR PC,OUTPUT
        MOVB (R2)+,CHAR
        JSR PC,OUTPUT
        BR EILOOP

STEP1:  MOV (R1)+,CHAR           ;STEP UP LOW ARRAY
STEP2:  MOV(R2)+,CHAR            ;STEP UP ASCII ARRAY
        INC CODC2        ;KEEP UP POSITION IN ARRAYS
        BLT JLOOP
        MOV NINE,CHAR            ;NO MORE ARRAY ELEMENTS TO TEST
        JSR PC,OUTPUT            ;SO MUST BE OUT OF RANGE
        MOV NINE,CHAR            ;CODE AS 99
        JSR PC,OUTPUT

EILOOP: INC CODC1                ;HAVE ALL 8 NUMBERS BEEN CODED?
        BLT ILOOP
        MOV CR,CHAR              ;YES - TERMINATE RECORD WITH
        JSR PC,OUTPUT            ;CARRIAGE RETURN/LINEFEED
        MOV LF,CHAR
        JSR PC,OUTPUT
        RTS PC
CODC1:  .WORD 0          ;COUNT OF NUMBERS IN ARRAY NUMBRS
CODC2:  .WORD 0          ;COUNT OF ELEMENTS IN ARRAYS HIGH,LOW

;ARRAY HIGH - UPPER BOUNDS OF RANGES
HIGH:   .WORD 226                ;150
        .WORD 536                ;350
        .WORD 1046               ;550
        .WORD 1356               ;750

;ARRAY LOW - LOWER BOUNDS OF RANGES
LOW:    .WORD 63                 ;50
        .WORD 404                ;250
        .WORD 700                ;450
        .WORD 1126               ;600
```

```
;CODE VALUES
ASCII:  .BYTE '0
        .BYTE '0
        .BYTE '0
        .BYTE '1
        .BYTE '1
        .BYTE '0
        .BYTE '1
        .BYTE '1
NINE:   .WORD '9
CR:     15
LF:     12
SPACE:  40


;SUBROUTINE INPUT - INPUT A CHARACTER FROM INBUF
;WHEN INBUF IS EMPTY FILL IT UP FROM CHAN 1

INPUT:  CMP IBCNT,BUFF          ;IS BUFFER FULL?
        BLT NOBUFL              ;BRANCH IF NOT FULL
        .READW #GASIO,#1,#INBUF,#400,IBLK       ;READ INTO INPUT BUFFER
        BCC LAB4
        JMP BADRD
LAB4:   ASL R0
        MOV R0,BUFF             ;COUNT OF BYTES IN BUFFER
        INC IBLK                ;KEEP COUNT OF BLOCKS
        CLR IBCNT               ;RESET COUNTAND POINTER
        MOV #INBUF,IBPTR

NOBUFL: MOVB (IBPTR)+,ENTRY             ;GET NEXT ENTRY FROM BUFFER
        BICB MASK,ENTRY         ;CLEAR 8 BIT OF 8-BIT ASCII CODE
        INC IBCNT               ;KEEP COUNT OF ENTRIES IN BUFFER
        RTS PC
SPOT:   .BLKW 6
MASK:   .WORD 200

;SUBROUTINE OUTPUT - OUTPUTS A CHARACTER TO OUTPUT BUFFER
; WHEN BUFFER IS FULL WRITES IT TO CHANNEL 2

OUTPUT: CMP BUFFO,OBCNT
        BGT NOBUFO
        .WRITW #GASIO,#2,#OBUF,#400,OBLK
        BCC LAB9
        JMP BADWRT
LAB9:   INC OBLK
        MOV BUFF,BUFFO
        CLR OBCNT
        MOV #OBUF,OBPTR
NOBUFO: MOVB CHAR,(OBPTR)+
        INC OBCNT
            RTS PC
CHAR:   .WORD 0


;ERROR MESSAGES
;==============

BADFET: .PRINT #FMSG
        .EXIT
```

```
FMSG:   .ASCIZ/DSK NOT AVAILABLE/
        .EVEN
BADLK:  .PRINT #LMSG
        .EXIT
LMSG:   .ASCIZ/CANT FIND CASINP/
        .EVEN
BADENT: .PRINT #EMSG
        .EXIT
EMSG:   .ASCIZ/CANT OPEN CASOUTT/
        .EVEN
BADLIN: .PRINT #LNMSG
        .PRINT #LINBUF
BADDL:  JSR PC,INPUT
        CMP #'*,ENTRY           ;IGNORE REST OF LINE
        BNE BADDL
        RTS PC
LNMSG:  .ASCIZ/TOO MANY NUMBERS IN LINE/
        .EVEN
BADDAT: .PRINT #DMSG
        .PRINT #LINBUF
        INC ERF
        RTS PC
DMSG:   .ASCIZ/ILLEGAL CHARACTER IN /
        .EVEN
BADSTR: .PRINT #SMSG
        .PRINT #LINBUF
BADSL:  JSR PC,INPUT
        CMP #'*,ENTRY
        BNE BADSL
        CLR STAR
        RTS PC
SMSG:   .ASCIZ/MISSING OR TOO MANY * IN/
        .EVEN
BADRD:  MOVB @#ERRWD,R2
        TST R2
        BEQ EOFRW
        .CLOSE #1
        .LOOKUP #GASIO,#1,#GASIB
        .PRINT #RMSG
        ADD #60,R2
        .TTYOUT R2
        JMP INPUT
        .EXIT
RMSG:   .ASCIZ/BAD READ NO. /
        .EVEN
EOFRW:  .CLOSE #1
        ASR BUFF
        .WRITW #GASIO,#2,#OBUF,BUFF,OBLK
        .CLOSE #2
        .EXIT
BADWRT: MOVB @#ERRWD,R2
        TST R2
        BEQ EOFRW
        .PRINT #PMSG
        ADD #60,R2
        .TTYOUT R2
        .EXIT
PMSG:   .ASCIZ/BAD WRITE NO./
        .EVEN
```

```
;STTORAGE AREA
;=============

;DEVICE AND FILE SPECIFICATIONS
GASIO:   .BLKW 10
GASOB:   .RAD50/DK CASOUTDAT/
GASIB:   .RAD50/DK1CASINPDAT/

;INPUT BUFFER
IBCNT:   .WORD 0
INBUF:   .BLKW 400
IBLK:    .WORD 0
BUFF:    .WORD 0

;OUTPUT BUFFER
OBCNT:   .WORD 0
OBUF:    .BLKW 410
OBLK:    .WORD 0
BUFFO:   .WORD 0

;LINE STORE
LINCNT: .WORD 0
LINBUF: .BLKW 22
        .WORD 0

;STORE FOR THE DECODED NUMBERS
NUMBRS: .BLKW 12
ENTRY:   .WORD 0
ERF:     .WORD 0
STAR:    .WORD 0
GASHAN=.
         .END START
.
```

```
C P R O G R A M   I N T A C

C THIS PROGRAM ACCEPTS 16 DIMENSIONS OF DATA AS PRODUCED BY CASPV1
C AND CALCULATES DURATIONS, FREQUENCIES, OFFSETS, PERCENTAGE DURATIONS
C FOR EACH BEHAVIOURS AND USING THE BINOMIAL EXPANSION CALCULATES THE
C CHANCE PROBABILITIES OF ALL INTERACTIONS BETWEEN A PAIR OF BEHAVIOURS
C ONLY INTERACTIONS OF LESS THAN 0.1 PROBABILITY ARE OUTPUT.
C INTERACTIONS IN TERMS OF ALTHAM'S CHI 2 ARE ALSO CALCULATED.
      DIMENSION K(2,25),M(16),JFREQ(25),LASTON(25)
      DIMENSION DUR(100,25),JINT(16,25,25),JIDENT(30)
      DIMENSION JIN(16,25,25),TODUR(25),PDUR(25),JOFF(25)
       READ(21,100)DUMMY
      READ(21,100)JIDENT
100   FORMAT(4X,30A1)
C RESETOVERALL
77    JEND=0
      JCOUNT=0
      DO 1 I=1,25
      JFREQ(I)=0
      JOFF(I)=0
      LASTON(I)=0
       DO 15 L=1,25
      DO 20 MJ=1,16
      JINT(MJ,L,I)=0
20    CONTINUE
15    CONTINUE
      TODUR(I)=0
      PDUR(I)=0
      DO 2 J=1,100
      DUR(J,I)=0
2     CONTINUE
1      CONTINUE
      DO 25 I=4,25
        K(1,I)=0
25     CONTINUE
C
C
C READ DATA
66    READ(21,101,END=51)M
101   FORMAT(4X,16I1)
      DO 3 I=1,16
      K(2,I)=M(I)
      IF(K(2,I).NE.0.AND.K(2,I).NE.1) WRITE(5,555)
555   FORMAT(5X,' XXXXX     CHECK DATA     XXXXX ')
3     CONTINUE
       DO 21 I=17,25
21     K(2,I)=0
      IF(K(2,5).EQ.1.AND.K(2,15).EQ.1)K(2,17)=1
      IF(K(2,5).EQ.1.AND.K(2,15).EQ.0)K(2,18)=1
      IF(K(2,11).EQ.1.AND.K(2,14).EQ.0)K(2,19)=1
      IF(K(2,13).EQ.1.AND.K(2,14).EQ.0)K(2,20)=1
      IF(K(2,11).EQ.1.AND.K(2,14).EQ.1)K(2,21)=1
      IF(K(2,13).EQ.1.AND.K(2,14).EQ.1)K(2,22)=1
       IF(K(2,15).EQ.1.AND.K(2,16).EQ.0)K(2,23)=1
       IF(K(2,15).EQ.0.AND.K(2,16).EQ.1)K(2,24)=1
       IF(K(2,15).EQ.1.AND.K(2,16).EQ.1)K(2,25)=1
C END?
      JEND=0
      DO 4 I=1,16
      IF(K(2,I).EQ.1)JEND=JEND+1
4     CONTINUE
```

```
      IF(JEND.EQ.16)GOTO 51
      GOTO 53
51    DO 52 I=4,25
      IF(K(1,I).EQ.1)DUR(JFREQ(I),I)=JCOUNT-LASTON(I)+1
52    CONTINUE
      GOTO 99
53    CONTINUE
      IF(K(2,2).NE.K(1,2).OR.K(2,3).NE.K(1,3))GOTO 99
      LCON=K(2,2)*2+K(2,3)+1
C IGNORE?
      IF(K(2,1).NE.1)GOTO 6
      DO 7 I=4,25
      IF(K(1,I).EQ.1)DUR(JFREQ(I),I)=JCOUNT-LASTON(I)
      K(2,I)=0
7      CONTINUE
      GOTO 11
6      CONTINUE
      JCOUNT=JCOUNT+1
C FREQ DUR CALC
       DO 10 I=4,25
      IF(K(2,I).EQ.K(1,I))GOTO 10
      IF(K(2,I).EQ.0)DUR(JFREQ(I),I)=JCOUNT-LASTON(I)
      IF(K(2,I).EQ.0) JOFF(I)=JOFF(I)+1
      IF(K(2,I).EQ.0)GOTO 10
       JFREQ(I)=JFREQ(I)+1
      LASTON(I)=JCOUNT
10    CONTINUE
C INT CALC
      DO 11 J=4,25
      DO 12 I=4,25
       L=K(2,I)*8+K(2,J)*4+K(1,I)*2+K(1,J)+1
      JINT(L,I,J)=JINT(L,I,J)+1
12    CONTINUE
11    CONTINUE
      DO 13 I=1,25
      K(1,I)=K(2,I)
13    CONTINUE
      GOTO 66
99     CONTINUE
      DO 98 I=4,25
      IF(K(1,I).EQ.1)DUR(JFREQ(I),I)=JCOUNT-LASTON(I)
98     CONTINUE
      DO 60 I=1,25
      DO 61 J=1,100
      DUR(J,I)=DUR(J,I)*80/1000
      TODUR(I)=TODUR(I)+DUR(J,I)
61    CONTINUE
60    CONTINUE
       TOT=TODUR(4)+TODUR(5)+TODUR(6)
      IF(TOT.LE.1) WRITE (5,556)
556   FORMAT(1X,' CHECK TOT - NULL CONDITION? ')
      DO 70 I=1,25
        PDUR(I)=TODUR(I)*100/TOT
70    CONTINUE
      WRITE(23,200)JIDENT
C
200   FORMAT(5X,' IDENTIFICATION IS ',31A1)
      WRITE(23,201)LCON
201   FORMAT(' CONDITION IS ',I3)
      WRITE(23,202)TOT
```

```
202     FORMAT(1X,' TOTAL TIME IS ',F10.2)
        IFS=0
        DO 40 I=1,16
40      IFS=JFREQ(I)+IFS
         IF(IFS.EQ.0)GOTO 62
        WRITE(23,203)
203     FORMAT(1X,' FREQUENCIES ARE  ')
        WRITE(23,204)(JFREQ(I),I=1,25)
204     FORMAT(1X,25I5)
        WRITE(23,209)
209     FORMAT(1X,' OFFSET FREQUENCIES ARE ')
        WRITE(23,204)(JOFF(I),I=1,25)
        WRITE(23,205)
205     FORMAT(1X,' DURATIONS ARE ')
        WRITE(23,206)((DUR(J,I),I=1,25),J=1,100)
206     FORMAT(1X,25F5.1)
        WRITE(23,400)
400     FORMAT(1X,' TOTAL DURATIONS ARE ')
         WRITE(23,199)(TODUR(I),I=1,25)
199     FORMAT(1X,25F5.1)
        WRITE(23,401)
401     FORMAT(1X,' PERCENTAGE DURATIONS ARE ')
        WRITE(23,198)(PDUR(I),I=1,25)
198     FORMAT(1X,25F5.1)
C CALC OF BINOMIAL PROB
        DO 41 J=4,25
        DO 42 I=4,25
        IF(I.EQ.J) GOTO 42
        N=JINT(14,I,J)+JINT(9,I,J)
        IX=JINT(14,I,J)
        ITOP=JINT(5,I,J)+JINT(6,I,J)+JINT(7,I,J)+JINT(8,I,J)
        IF(N.EQ.0.OR.ITOP.EQ.0) P=0
        IF(N.EQ.0.OR.ITOP.EQ.0) Z=0
        IF(N.EQ.0.OR.ITOP.EQ.0) Y=1.0
        IF(N.EQ.0.OR.ITOP.EQ.0) GOTO 89
        IB=JINT(1,I,J)+JINT(2,I,J)+JINT(3,I,J)+JINT(4,I,J)
        P=FLOAT(ITOP)/FLOAT(ITOP+IB)
        Z=PRBX2N(N,IX,P)
        Y=PRB02N(N,IX,P)
        IF(Z.GE.0.1.AND.Y.GE.0.1) GOTO 89
87       WRITE(23,901) I,J,N,IX,P,Z,Y
89         JN=JINT(3,I,J)+JINT(8,I,J)
         JX=JINT(8,I,J)
         JTOP=JINT(13,I,J)+JINT(14,I,J)+JINT(15,I,J)+JINT(16,I,J)
        IF(JN.EQ.0.OR.JTOP.EQ.0) P2=0
        IF(JN.EQ.0.OR.JTOP.EQ.0) U=0
        IF(JN.EQ.0.OR.JTOP.EQ.0) V=1.0
        IF(JN.EQ.0.OR.JTOP.EQ.0) GOTO 38
         JB=JINT(9,I,J)+JINT(10,I,J)+JINT(11,I,J)+JINT(12,I,J)
          P2=FLOAT(JTOP)/FLOAT(JTOP+JB)
        U=PRBX2N(JN,JX,P2)
        V=PRB02N(JN,JX,P2)
        IF(U.GE.0.1.AND.V.GE.0.1) GOTO 38
37      WRITE(23,902)I,J,JN,JX,P2,U,V
38      AM=JINT(1,I,J)+JINT(2,I,J)+JINT(3,I,J)+JINT(4,I,J)
        BM=JINT(5,I,J)+JINT(6,I,J)+JINT(7,I,J)+JINT(8,I,J)
        CM=JINT(9,I,J)+JINT(10,I,J)+JINT(11,I,J)+JINT(12,I,J)
        DM=JINT(13,I,J)+JINT(14,I,J)+JINT(15,I,J)+JINT(16,I,J)
        ZNM=AM+BM+CM+DM
        TOPM=ABS((AM*DM)-(BM*CM))
```

```
      BOTM=(AM+BM)*(CM+DM)*(AM+CM)*(BM+DM)
      IF(BOTM.EQ.0) GOTO 42
      CHIM=(ZNM*TOPM*TOPM)/(40*BOTM)
      IF(CHIM.LT.3.0) GOTO 42
      WRITE(23,903) I,J,AM,BM,CM,DM,CHIM
42    CONTINUE
41    CONTINUE
62    CONTINUE
      DO 14 J=1,25
      K(1,J)=K(2,J)
      DO 16 I=1,25
      DO 17 L=1,16
      JIN(L,I,J)=JIN(L,I,J)+JINT(L,I,J)
17    CONTINUE
16    CONTINUE
14    CONTINUE
      IF(JEND.EQ.16)GOTO 88
      GOTO 77
88    WRITE(23,800)
800   FORMAT(////,4X,' OVERALL INTERACTION ANALYSIS ')
       DO 18 J=4,25
      DO 19 I=4,25
      IF(I.EQ.J) GOTO 19
      NJIN=JIN(14,I,J)+JIN(9,I,J)
      IXJIN=JIN(14,I,J)
      ITJIN=JIN(5,I,J)+JIN(6,I,J)+JIN(7,I,J)+JIN(8,I,J)
      IF(NJIN.EQ.0.OR.ITJIN.EQ.0) PJIN=0
      IF(NJIN.EQ.0.OR.ITJIN.EQ.0) R=0
      IF(NJIN.EQ.0.OR.ITJIN.EQ.0) S=1.0
      IF(NJIN.EQ.0.OR.ITJIN.EQ.0) GOTO 84
      IBJIN=JIN(1,I,J)+JIN(2,I,J)+JIN(3,I,J)+JIN(4,I,J)
      PJIN=FLOAT(ITJIN)/FLOAT(ITJIN+IBJIN)
      R=PRBX2N(NJIN,IXJIN,PJIN)
      S=PRB02N(NJIN,IXJIN,PJIN)
      IF(R.GE.0.1.AND.S.GE.0.1) GOTO 84
83    WRITE(23,901) I,J,NJIN,IXJIN,PJIN,R,S
84    NJO=JIN(3,I,J)+JIN(8,I,J)
      IXO=JIN(8,I,J)
      ITO=JIN(13,I,J)+JIN(14,I,J)+JIN(15,I,J)+JIN(16,I,J)
      IF(NJO.EQ.0.OR.ITO.EQ.0) PJO=0
      IF(NJO.EQ.0.OR.ITO.EQ.0) RO=0
      IF(NJO.EQ.0.OR.ITO.EQ.0) SO=1.0
       IF(NJO.EQ.0.OR.ITO.EQ.0) GOTO 39
      IBO=JIN(9,I,J)+JIN(10,I,J)+JIN(11,I,J)+JIN(12,I,J)
      PJO=FLOAT(ITO)/FLOAT(ITO+IBO)
      RO=PRBX2N(NJO,IXO,PJO)
      SO=PRB02N(NJO,IXO,PJO)
      IF(RO.GE.0.1.AND.SO.GE.0.1) GOTO 39
36    WRITE(23,902) I,J,NJO,IXO,PJO,RO,SO
39    AN=JIN(1,I,J)+JIN(2,I,J)+JIN(3,I,J)+JIN(4,I,J)
      BN=JIN(5,I,J)+JIN(6,I,J)+JIN(7,I,J)+JIN(8,I,J)
      CN=JIN(9,I,J)+JIN(10,I,J)+JIN(11,I,J)+JIN(12,I,J)
      DN=JIN(13,I,J)+JIN(14,I,J)+JIN(15,I,J)+JIN(16,I,J)
      ZN=AN+BN+CN+DN
      TOPN=ABS((AN*DN)-(BN*CN))
      BOTN=(AN+BN)*(CN+DN)*(AN+CN)*(BN+DN)
      IF(BOTN.EQ.0) GOTO 19
      CHIN=(ZN*TOPN*TOPN)/(40*BOTN)
      IF(CHIN.LT.3.0) GOTO 19
      WRITE(23,903) I,J,AN,BN,CN,DN,CHIN
```

```
19      CONTINUE
18      CONTINUE
901     FORMAT(1X,2I6,5X,2I8,3F12.4,40X,' ONSETS ')
902     FORMAT(1X,2I6,5X,2I8,3F12.4,40X,' OFFSETS OFF ')
903     FORMAT(1X,2I6,55X,4F7.0,F12.4,14X,' CHI ')
        STOP
        END
         FUNCTION COM(N,IR)
        IC=IR
        IF(IR.GT.N-IR)IC=N-IR
        COM=1
        IF(IC.EQ.0)RETURN
        DO 43 K=1,IC
43      COM=COM*FLOAT(N-K+1)/FLOAT(K)
        RETURN
        END
        FUNCTION PROB(N,IX,P)
        E=0.1**25
        PK=1
        IF(IX.EQ.0) GOTO 444
        DO 47 I=1,IX
         PK=PK*P
         IF(PK.LE.E) GOTO 111
47      CONTINUE
444      PL=1
         JOK=N-IX
        IF(JOK.EQ.0) GOTO 445
         DO 48 I=1,JOK
           PL=PL*(1-P)
          IF(PL.LE.E) GOTO 111
48      CONTINUE
445      PROB=COM(N,IX)*PK*PL
          GOTO 49
111       PROB=E
49        RETURN
        END
        FUNCTION PRBX2N(N,IV,P)
        X=0
        DO 44 K=IV,N
44      X=X+PROB(N,K,P)
        PRBX2N=X
        IF(IV.EQ.0)PRBX2N=1.0
        RETURN
        END
        FUNCTION PRB02N(N,IV,P)
        X=0
        DO 45 K=0,IV
45      X=X+PROB(N,K,P)
        PRB02N=X
        RETURN
        END
```

Appendix 4.

Data from chapter 9.

The data used in the results section on differential responsivity to mother and stranger are included here.

ONE MONTH OLDS PERCENTAGE LOOKING DATA

SUBJECT	MOTHER (TOTAL)	MOTHER (TALK)	MOTHER (NOT TALK)	STRANGER (TOTAL)	STRANGER (TALK)	STRANGER (NOT TALK)
1.000000	92.60000	95.94595	89.00415	93.00000	98.64865	84.80392
2.000000	53.20000	54.37500	52.11538	34.30000	35.53114	32.59912
3.000000	10.30000	14.73684	1.492537	2.000000	0.0000000	3.200000
5.000000	22.50000	22.76029	21.26437	39.70000	39.39850	40.29851
6.000000	81.60000	85.99509	78.58347	65.50000	65.33546	65.77540
7.000000	27.60000	29.26829	25.98425	5.800000	7.006369	4.725898
8.000000	30.00000	30.25362	29.68750	38.80000	55.46875	9.166667
9.000000	20.50000	28.83721	5.352113	17.10000	22.68786	4.870130
10.00000	36.00000	42.85714	31.44759	11.80000	17.01571	8.576052
11.00000	58.60000	67.39130	45.52239	84.30000	84.71810	83.43558

TWO MONTH OLDS PERCENTAGE LOOKING DATA

SUBJECT	MOTHER (TOTAL)	MOTHER (TALK)	MOTHER (NOT TALK)	STRANGER (TOTAL)	STRANGER (TALK)	STRANGER (NOT TALK)
1.000000	81.50000	81.91489	81.32076	86.50000	97.45958	78.13051
2.000000	75.90000	82.21649	71.89542	62.30000	105.5714	38.46154
3.000000	56.90000	66.22517	52.86533	65.50000	69.35484	61.70635
4.000000	75.90000	91.91617	67.86787	72.50000	70.38216	73.46939
5.000000	45.40000	47.92208	36.95652	64.00000	63.01115	64.93507
6.000000	51.70000	55.15548	46.01542	36.40000	44.07028	19.55836
7.000000	22.20000	28.20513	13.73494	30.00000	34.51043	22.54642
8.000000	56.40000	61.08696	52.59259	77.40000	93.52751	70.33285
9.000000	85.80000	91.52542	71.91781	70.20000	84.35754	53.77970
10.00000	40.80000	43.93491	34.25926	100.0000	100.0000	100.0000
11.00000	87.50000	87.79528	86.99187	94.50000	94.52954	94.65930
12.00000	65.10000	72.30769	47.36842	55.00000	48.37800	71.13402

THREE MONTH OLDS PERCENTAGE LOOKING DATA

SUBJECT	MOTHER (TOTAL)	MOTHER (TALK)	MOTHER (NOT TALK)	STRANGER (TOTAL)	STRANGER (TALK)	STRANGER (NOT TALK)
1.000000	38.90000	30.51181	47.56098	15.90000	13.68821	18.35443
2.000000	35.00000	40.51447	28.57143	20.50000	22.63314	16.04938
3.000000	6.400000	4.895105	7.002801	91.20000	93.76054	87.46929
4.000000	79.50000	83.29897	75.92233	94.60000	95.44670	93.39934
5.000000	88.00000	90.66427	84.42438	83.50000	87.67123	80.24911
6.000000	30.80000	37.57310	16.13924	25.10000	25.07987	25.13369
7.000000	33.00000	30.53546	38.51133	22.30000	28.27939	13.80145
8.000000	40.90000	31.57895	49.14286	68.00000	74.72767	62.10721
9.000000	65.40000	67.81193	62.63982	60.10000	71.81409	36.33634
10.00000	92.60000	95.45669	83.53659	88.30000	92.44186	86.12805
11.00000	63.40000	67.77494	60.59113	52.90000	64.11150	48.38710
12.00000	23.10000	20.78086	32.03883	24.50000	23.15522	29.43925
13.00000	17.10000	20.93750	10.27778	83.20000	96.58344	40.58577

FOUR MONTH OLDS PERCENTAGE LOOKING DATA

SUBJECT	MOTHER (TOTAL)	MOTHER (TALK)	MOTHER (NOT TALK)	STRANGER (TOTAL)	STRANGER (TALK)	STRANGER (NOT TALK)
1.000000	72.70000	78.85615	64.30260	95.30000	95.95687	94.91256
2.000000	56.60000	56.27803	55.85921	24.30000	43.62745	10.97973
3.000000	73.00000	90.04739	60.55363	69.50000	89.92248	56.60685
4.000000	32.80000	35.33520	26.40845	93.50000	93.38521	93.88646
5.000000	26.40000	29.29104	23.06034	43.90000	51.93622	37.61141
6.000000	91.90000	93.49693	84.85487	93.80000	94.31938	92.74924
7.000000	18.60000	18.52227	25.00000	15.10000	11.91011	40.00000
8.000000	72.20000	75.19084	68.69748	39.80000	47.83505	32.03884
9.000000	49.70000	50.88409	48.47251	83.60000	82.69618	84.49304
10.00000	57.80000	57.28155	58.33333	97.50000	100.0000	96.22926
11.00000	43.40000	46.76354	32.51029	34.00000	38.00979	27.64858
12.00000	23.20000	28.57143	18.12977	37.70000	41.16608	33.17972
13.00000	8.700000	7.711443	12.75510	24.40000	19.38169	50.31447

FIVE MONTH OLDS PERCENTAGE LOOKING DATA

SUBJECT	MOTHER (TOTAL)	MOTHER (TALK)	MOTHER (NOT TALK)	STRANGER (TOTAL)	STRANGER (TALK)	STRANGER (NOT TALK)
3.000000	5.100000	8.732394	3.255814	75.80000	78.57143	73.67491
4.000000	11.00000	13.72283	3.409091	57.10000	55.75102	60.91954
5.000000	16.90000	25.61308	11.84834	55.60000	60.84071	51.27737
6.000000	28.90000	32.36797	23.97094	87.10000	85.18519	88.55634
7.000000	11.50000	14.87805	9.152542	11.60000	9.411765	12.72727
8.000000	43.60000	52.21745	112.6246	57.60000	52.58621	64.52381
9.000000	39.30000	44.09449	24.35975	89.90000	89.08766	90.92971
10.00000	37.10000	36.86200	37.36730	91.60000	91.52000	91.46667
11.00000	57.50000	67.60300	46.13734	39.60000	42.88703	36.39847
12.00000	20.20000	17.50000	23.33333	29.40000	28.65672	30.60606
13.00000	3.000000	4.063604	1.612903	45.70000	53.34421	33.59173

SIX MONTH OLDS PERCENTAGE LOOKING DATA

SUBJECT	MOTHER (TOTAL)	MOTHER (TALK)	MOTHER (NOT TALK)	STRANGER (TOTAL)	STRANGER (TALK)	STRANGER (NOT TALK)
1.000000	50.70000	46.21329	58.92351	37.20000	34.02204	45.62044
2.000000	40.10000	39.82301	40.24205	21.60000	30.25000	15.83333
3.000000	23.50000	25.45932	22.29402	19.50000	12.17839	29.73621
4.000000	23.60000	25.75942	14.12429	84.90000	84.67005	100.0000
6.000000	27.20000	29.69072	24.85437	45.60000	52.89079	39.21201
7.000000	9.600000	12.68882	8.071749	72.50000	70.68966	74.06716
8.000000	45.50000	48.50746	0.0000000	35.50000	42.54144	17.02899
9.000000	38.20000	40.03527	35.79677	89.60000	91.16379	88.24527
10.00000	71.10000	68.61199	75.40984	14.90000	12.16931	23.36066
11.00000	46.30000	48.40484	25.27472	74.10000	75.40778	68.96552
12.00000	40.90000	40.02294	46.87500	20.40000	20.26210	37.49999
13.00000	20.70000	22.37522	18.61575	57.10000	65.90510	45.70766

SEVEN MONTH OLDS PERCENTAGE LOOKING DATA

SUBJECT	MOTHER (TOTAL)	MOTHER (TALK)	MOTHER (NOT TALK)	STRANGER (TOTAL)	STRANGER (TALK)	STRANGER (NOT TALK)
1.000000	31.30000	35.95506	28.72671	55.80000	51.23043	59.49367
2.000000	23.00000	21.39423	23.97260	60.40000	69.82622	44.14169
3.000000	13.60000	24.59016	8.920863	27.30000	28.35052	25.83732
4.000000	56.00000	56.10795	55.74324	67.00000	53.71901	102.1898
7.000000	3.400000	2.732240	5.223881	30.00000	34.78788	7.428571
8.000000	43.40000	53.65419	30.29613	51.40000	56.85841	46.89781
9.000000	40.90000	44.51146	22.80702	63.20000	61.96536	67.40088
10.00000	19.40000	23.15341	10.47297	19.10000	18.57506	21.02804
11.00000	40.50000	41.22563	40.09360	36.50000	41.33535	0.0000000
12.00000	6.600000	6.419753	6.722689	6.300000	0.0000000	6.441718
13.00000	9.900000	10.64516	8.421053	18.60000	18.88112	17.89474

EIGHT MONTH OLDS PERCENTAGE LOOKING DATA

SUBJECT	MOTHER (TOTAL)	MOTHER (TALK)	MOTHER (NOT TALK)	STRANGER (TOTAL)	STRANGER (TALK)	STRANGER (NOT TALK)
1.000000	31.50000	37.82895	21.68367	40.40000	50.70140	30.13972
2.000000	39.70000	40.09585	38.77005	47.00000	52.30769	41.04167
3.000000	2.800000	0.0000000	5.405405	24.40000	22.82609	26.33929
4.000000	21.10000	18.37524	24.01655	97.20000	95.00000	100.0000
5.000000	40.50000	44.13408	38.47352	81.70000	82.12766	81.32076
7.000000	9.900000	9.081633	50.00000	38.40000	38.88889	35.59322
8.000000	17.00000	23.07692	12.18638	76.40000	84.34783	58.38710
9.000000	45.60000	49.91681	39.09774	68.30000	64.57055	75.28736
10.00000	44.10000	45.35566	40.46693	18.00000	18.12256	17.59657
11.00000	39.60000	51.12782	26.49573	56.90000	60.53640	52.92887
12.00000	54.20000	48.79518	59.56175	9.400000	11.00000	8.333333
13.00000	58.60000	60.33994	54.42177	51.10000	52.68041	0.0000000

ONE MONTH OLDS
PERCENTAGE OF TIME IN EACH BEHAVIOUR

	MOTHER				STRANGER			
SUBJECT	MOUTH	SMILE	FROWN	VOC	MOUTH	SMILE	FROWN	VOC
1.00	26.60	0.00	0.80	0.00	39.50	0.00	0.80	2.00
2.00	4.50	0.00	0.00	4.00	33.10	0.00	0.00	0.10
3.00	7.50	2.70	5.00	1.00	7.50	0.00	3.90	1.30
5.00	26.20	0.60	15.70	4.40	21.90	0.00	14.90	2.00
6.00	56.80	0.00	0.00	0.00	85.70	0.00	2.80	2.30
7.00	10.20	0.00	0.00	0.10	7.20	0.00	0.00	3.70
8.00	12.40	2.00	3.00	0.40	1.10	4.60	0.70	2.10
9.00	29.50	0.00	30.40	30.50	3.50	0.10	3.10	8.70
10.00	5.20	0.40	0.00	0.10	0.70	0.00	0.00	0.70
11.00	53.10	3.40	0.00	1.30	37.30	22.10	0.00	0.00

TWO MONTH OLDS
PERCENTAGE OF TIME IN EACH BEHAVIOUR

	MOTHER				STRANGER			
SUBJECT	MOUTH	SMILE	FROWN	VOC	MOUTH	SMILE	FROWN	VOC
1.00	47.30	23.50	0.60	3.90	21.60	29.20	1.60	8.90
2.00	50.10	2.30	1.80	4.50	41.00	1.20	2.50	4.20
3.00	79.10	2.60	0.80	2.90	31.40	1.80	7.20	5.80
4.00	42.30	7.90	3.30	7.80	48.80	0.00	1.70	1.20
5.00	7.00	5.00	4.00	1.40	3.90	3.80	1.10	2.10
6.00	11.10	2.80	0.20	0.50	10.50	0.00	0.00	1.50
7.00	8.40	0.10	0.00	3.00	11.20	0.20	0.00	2.10
8.00	54.10	10.20	1.40	5.80	39.40	9.00	0.00	1.00
9.00	36.70	12.30	0.30	6.40	26.80	9.20	0.20	5.90
10.00	4.70	7.30	0.00	9.70	5.20	3.20	7.20	11.70
11.00	40.80	10.20	0.90	13.80	33.00	1.30	1.60	30.20
12.00	35.80	0.00	27.20	21.10	17.20	0.00	12.70	8.10

THREE MONTH OLDS
PERCENTAGE TIME IN EACH BEHAVIOUR

	MOTHER				STRANGER			
SUBJECT	MOUTH	SMILE	FROWN	VOC	MOUTH	SMILE	FROWN	VOC
1.00	2.20	27.20	0.00	1.50	0.60	32.10	0.00	5.80
2.00	46.50	1.60	9.70	30.60	63.70	2.30	6.90	32.30
3.00	29.80	8.10	4.00	3.20	71.20	49.10	0.60	9.50
4.00	21.20	0.00	0.00	80.80	13.40	4.40	0.00	1.40
5.00	35.00	3.80	4.30	7.50	44.70	3.40	0.00	0.90
6.00	10.80	5.00	6.90	20.00	9.00	0.00	4.00	12.80
7.00	59.20	0.30	0.00	9.60	51.50	1.10	0.00	15.90
8.00	26.50	0.00	9.20	0.70	45.00	0.50	7.10	3.80
9.00	10.50	8.60	0.00	4.90	3.80	3.60	0.00	1.80
10.00	18.40	3.10	0.00	0.50	41.90	4.30	0.00	3.80
11.00	59.70	7.00	12.60	6.20	44.50	8.90	0.10	4.70
12.00	2.10	0.00	3.20	0.30	14.50	1.10	32.90	16.70
13.00	22.10	5.10	13.90	8.80	35.00	22.80	1.80	14.90

F O U R   M O N T H   O L D S
PERCENTAGE OF TIME IN EACH BEHAVIOUR

	MOTHER				STRANGER			
SUBJECT	MOUTH	SMILE	FROWN	VOC	MOUTH	SMILE	FROWN	VOC
1.00	3.30	1.00	0.00	0.00	5.10	8.00	0.00	0.40
2.00	63.50	2.20	22.30	29.00	61.30	0.00	29.50	31.80
3.00	11.50	8.00	0.00	4.00	2.10	3.50	0.00	3.60
4.00	64.80	0.40	7.50	15.00	34.90	18.90	0.00	0.40
5.00	55.40	8.00	1.00	0.00	62.20	0.00	3.90	4.50
6.00	56.30	18.90	0.00	10.40	31.60	8.00	0.00	3.20
7.00	21.10	3.90	16.90	13.00	24.60	0.00	15.50	31.00
8.00	30.50	0.00	5.20	10.20	6.40	0.00	0.00	0.80
9.00	12.10	2.70	0.10	0.90	1.20	13.70	0.00	1.50
10.00	9.40	23.90	3.80	0.00	17.20	17.70	9.80	0.20
11.00	15.80	14.50	0.00	1.80	35.10	0.00	2.10	0.40
12.00	8.70	3.00	0.00	3.00	15.70	4.90	1.10	27.70
13.00	22.50	1.30	0.00	0.00	14.10	7.00	0.00	0.90

F I V E   M O N T H   O L D S
PERCENTAGE OF TIME IN EACH BEHAVIOUR

	MOTHER				STRANGER			
SUBJECT	MOUTH	SMILE	FROWN	VOC	MOUTH	SMILE	FROWN	VOC
3.00	35.50	1.70	16.00	18.40	72.10	34.60	0.00	10.50
4.00	34.90	4.40	0.00	3.00	25.10	4.40	0.00	0.00
5.00	12.80	0.00	0.00	0.00	18.90	0.00	0.00	0.40
6.00	14.00	1.40	12.00	10.00	30.60	0.30	0.00	23.90
7.00	15.80	2.70	0.00	2.70	21.80	2.80	0.00	5.30
8.00	33.20	2.90	0.00	6.20	77.50	12.30	0.10	34.60
9.00	9.80	0.40	10.20	17.20	2.00	4.10	0.00	0.60
10.00	26.60	6.60	0.00	0.00	16.20	5.10	0.00	0.00
11.00	29.00	0.00	0.00	0.20	18.70	1.10	0.00	0.00
12.00	53.40	1.20	0.00	1.60	30.30	0.00	0.00	0.00
13.00	58.90	1.40	0.00	0.00	38.30	7.10	0.00	0.00

S I X   M O N T H   O L D S
PERCENTAGE OF TIME IN EACH BEHAVIOUR

	MOTHER				STRANGER			
SUBJECT	MOUTH	SMILE	FROWN	VOC	MOUTH	SMILE	FROWN	VOC
1.00	3.90	16.90	0.00	0.60	6.50	6.90	0.00	0.00
2.00	8.20	0.20	0.00	22.10	9.70	0.40	0.00	2.30
3.00	3.10	0.00	0.00	2.70	1.30	35.80	0.30	3.90
4.00	6.40	3.60	0.40	3.80	0.00	49.30	0.00	27.60
6.00	29.50	0.30	0.00	0.00	20.20	1.20	0.00	0.00
7.00	7.40	1.10	1.40	7.80	19.60	14.30	0.00	9.20
8.00	28.40	13.50	0.00	11.90	20.70	54.30	0.40	11.90
9.00	32.90	2.50	0.00	8.30	72.90	11.70	0.00	33.50
10.00	2.90	0.00	0.00	0.00	2.90	17.70	0.00	8.30
11.00	6.10	0.00	1.30	20.20	1.30	2.60	0.00	0.70
12.00	0.00	30.30	0.00	2.90	3.30	18.80	3.40	1.60
13.00	3.30	0.00	1.90	0.60	0.00	0.00	16.40	14.80

S E V E N   M O N T H   O L D S
PERCENTAGE OF TIME IN EACH BEHAVIOUR

SUBJECT	MOTHER MOUTH	MOTHER SMILE	MOTHER FROWN	MOTHER VOC	STRANGER MOUTH	STRANGER SMILE	STRANGER FROWN	STRANGER VOC
1.00	10.40	14.30	0.00	14.70	7.20	5.60	1.10	2.00
2.00	3.40	0.00	0.00	0.00	4.30	9.50	7.10	1.60
3.00	0.00	0.00	3.00	3.70	9.10	3.80	0.00	0.00
4.00	1.70	19.50	0.00	5.90	3.60	29.00	0.00	2.20
7.00	1.70	0.00	0.00	0.30	0.00	0.00	35.00	6.90
8.00	13.30	31.00	12.90	0.70	3.20	47.50	0.00	14.10
9.00	0.00	0.00	0.00	0.00	0.00	3.30	0.00	4.60
10.00	3.70	4.80	40.80	4.30	1.20	1.60	4.40	2.60
11.00	4.80	0.00	12.40	0.00	4.90	0.00	0.00	4.60
12.00	13.90	0.30	0.00	1.40	5.50	6.30	0.00	18.80
13.00	29.50	0.00	0.00	2.70	26.70	0.00	73.30	83.20

E I G H T   M O N T H   O L D S
PERCENTAGE OF TIME IN EACH BEHAVIOUR

SUBJECT	MOTHER MOUTH	MOTHER SMILE	MOTHER FROWN	MOTHER VOC	STRANGER MOUTH	STRANGER SMILE	STRANGER FROWN	STRANGER VOC
1.00	39.20	9.60	0.00	9.30	32.90	0.50	0.00	1.70
2.00	8.90	15.30	0.00	4.30	0.00	0.40	0.00	1.20
3.00	0.00	0.00	0.00	0.00	14.10	6.10	3.10	4.40
4.00	9.10	2.50	0.00	0.00	14.70	0.00	19.30	16.50
5.00	24.60	3.40	1.80	7.40	19.10	0.00	7.60	1.10
7.00	0.00	1.00	0.00	0.70	2.20	7.00	0.40	3.70
8.00	16.90	4.80	1.70	4.50	30.10	0.00	25.50	32.00
9.00	5.40	4.40	0.60	2.20	5.50	14.50	0.40	4.10
10.00	29.40	0.00	9.30	21.20	25.20	4.10	0.00	3.40
11.00	23.50	0.00	6.10	13.90	18.30	0.00	0.00	1.40
12.00	31.30	18.80	0.20	5.40	14.90	2.60	0.00	0.00
13.00	15.80	4.30	0.00	26.40	3.40	0.00	0.00	54.50

ONE MONTH OLDS
FREQUENCIES PER MINUTE

	MOTHER					STRANGER				
SUBJECT	LOOK	MOUTH	SMILE	FROWN	VOC	LOOK	MOUTH	SMILE	FROWN	VOC
1.00	4.62	3.60	0.00	0.51	0.51	1.33	4.66	0.00	0.67	0.67
2.00	5.17	2.16	0.00	0.00	4.31	6.07	3.03	0.00	0.00	0.00
3.00	2.37	1.19	0.59	2.96	1.19	0.79	2.36	0.00	3.15	1.57
5.00	5.59	3.19	1.20	4.79	2.40	6.67	1.75	0.00	4.91	0.70
6.00	4.37	2.92	0.00	0.00	0.00	7.10	2.58	0.00	0.65	0.65
7.00	1.65	4.30	0.00	0.00	0.33	2.04	3.21	0.00	0.00	2.04
8.00	7.39	1.27	0.64	1.53	0.25	7.59	0.54	1.08	0.81	1.90
9.00	2.88	3.29	0.00	7.41	7.00	3.75	1.36	0.34	1.36	2.73
10.00	2.74	1.70	0.26	0.00	0.26	2.99	0.33	0.00	0.00	0.33
11.00	2.84	8.73	1.01	0.00	1.22	1.37	5.21	4.66	0.00	0.00

TWO MONTH OLDS
FREQUENCIES PER MINUTE

	MOTHER					STRANGER				
SUBJECT	LOOK	MOUTH	SMILE	FROWN	VOC	LOOK	MOUTH	SMILE	FROWN	VOC
1.00	1.98	3.97	4.96	0.33	3.97	5.15	3.17	3.56	1.58	7.92
2.00	7.38	6.23	0.92	1.15	2.77	6.62	3.41	0.60	1.41	2.41
3.00	4.50	6.52	1.57	0.22	1.57	6.20	5.10	1.45	0.73	1.45
4.00	9.64	5.78	1.28	1.28	3.21	7.79	7.08	0.00	0.71	0.71
5.00	2.90	2.93	1.29	1.94	1.29	3.98	2.28	1.71	0.85	1.14
6.00	2.17	13.81	0.99	0.20	0.79	5.19	12.99	0.00	0.00	2.23
7.00	2.29	1.78	0.25	0.00	1.27	2.55	2.12	0.21	0.00	0.64
8.00	5.59	8.10	1.96	0.84	5.03	5.64	6.94	2.17	0.00	0.87
9.00	4.79	4.24	2.95	0.37	3.32	3.46	4.56	1.46	0.36	3.10
10.00	2.48	1.93	1.38	0.00	7.44	0.35	1.39	1.04	1.74	3.48
11.00	7.22	4.44	2.50	1.39	8.60	5.14	3.52	0.27	1.62	11.64
12.00	2.97	5.10	0.00	2.76	3.61	2.15	3.22	0.00	1.93	1.50

THREE MONTH OLDS
FREQUENCIES PER MINUTE

	MOTHER					STRANGER				
SUBJECT	LOOK	MOUTH	SMILE	FROWN	VOC	LOOK	MOUTH	SMILE	FROWN	VOC
1.00	3.25	4.00	6.01	0.00	2.75	2.49	0.93	4.66	0.00	5.28
2.00	6.53	5.30	1.09	3.94	5.85	6.57	3.70	1.01	5.56	6.23
3.00	2.99	5.97	2.99	1.49	1.49	5.91	10.34	7.39	0.99	10.84
4.00	5.68	3.25	0.00	0.00	1.22	2.92	4.17	1.67	0.00	1.67
5.00	3.65	5.68	1.22	1.22	4.06	3.17	5.43	0.90	0.00	1.36
6.00	3.21	7.66	0.99	2.22	4.70	2.44	5.97	0.00	1.63	2.71
7.00	8.26	5.80	0.53	0.00	3.51	3.25	7.05	0.54	0.00	4.52
8.00	8.92	6.69	0.00	3.97	0.99	7.57	7.30	0.27	2.43	1.89
9.00	4.98	3.60	2.92	0.00	5.83	2.51	1.88	1.67	0.00	2.09
10.00	2.64	9.50	1.32	0.00	1.32	2.10	4.45	0.79	0.00	2.36
11.00	9.29	8.32	1.94	3.48	3.10	5.91	4.88	2.31	0.26	2.05
12.00	3.98	1.14	0.00	1.14	0.57	5.53	2.79	5.58	1.40	4.19
13.00	5.05	5.05	2.53	6.10	2.83	3.24	3.10	5.60	1.18	3.54

FOUR MONTH OLDS
FREQUENCIES PER MINUTE

	MOTHER					STRANGER				
SUBJECT	LOOK	MOUTH	SMILE	FROWN	VOC	LOOK	MOUTH	SMILE	FROWN	VOC
1.00	6.58	3.76	0.94	0.00	0.00	4.34	3.26	1.63	0.00	1.09
2.00	2.66	6.84	1.14	4.18	7.60	7.29	7.29	0.00	4.86	4.86
3.00	6.67	3.03	2.73	0.00	3.03	12.36	4.23	4.23	0.00	8.46
4.00	7.25	8.06	0.40	2.42	4.84	3.32	8.78	4.74	0.00	0.24
5.00	13.78	7.52	2.51	1.25	0.00	4.57	6.09	0.00	4.57	4.57
6.00	4.40	9.90	7.70	0.00	7.15	2.21	5.69	3.48	0.00	3.16
7.00	7.23	3.99	2.24	3.74	5.74	5.69	14.63	0.00	11.38	12.20
8.00	6.78	24.41	0.00	0.68	3.39	5.58	9.93	0.00	0.00	1.24
9.00	5.21	3.79	0.47	0.47	0.47	4.14	0.35	4.49	0.00	1.38
10.00	8.99	3.85	7.71	3.85	0.00	2.50	6.25	1.25	5.00	1.25
11.00	9.64	4.19	5.03	0.00	1.58	6.64	3.12	0.00	0.78	0.39
12.00	6.50	4.33	1.62	0.00	3.79	8.73	2.49	1.25	0.42	7.07
13.00	4.00	8.00	1.14	0.00	0.00	7.59	3.04	2.53	0.00	0.51

FIVE MONTH OLDS
FREQUENCIES PER MINUTE

	MOTHER					STRANGER				
SUBJECT	LOOK	MOUTH	SMILE	FROWN	VOC	LOOK	MOUTH	SMILE	FROWN	VOC
3.00	1.86	3.72	1.24	2.48	3.10	8.13	5.42	6.20	0.00	2.71
4.00	3.25	6.09	2.43	0.00	1.22	7.06	5.20	1.12	0.00	0.00
5.00	5.59	5.19	0.00	0.00	0.00	8.90	8.01	0.00	0.00	2.67
6.00	4.99	4.58	0.42	3.74	4.58	1.88	7.99	0.47	0.00	8.93
7.00	5.30	3.63	1.40	0.00	2.23	4.91	4.09	1.64	0.00	4.09
8.00	7.26	5.73	1.53	0.00	3.06	8.17	8.17	6.54	0.54	8.72
9.00	7.55	5.66	0.63	5.66	9.43	4.44	2.66	2.66	0.00	0.89
10.00	6.64	4.43	1.11	0.00	0.00	6.32	3.79	2.53	0.00	0.00
11.00	8.44	5.91	0.00	0.00	0.42	6.83	3.64	0.91	0.00	0.00
12.00	11.33	4.93	0.49	0.00	1.48	6.46	2.58	0.00	0.00	0.00
13.00	2.33	7.00	0.58	0.00	0.00	8.65	5.09	3.05	0.00	0.00

SIX MONTH OLDS
FREQUENCIES PER MINUTE

	MOTHER					STRANGER				
SUBJECT	LOOK	MOUTH	SMILE	FROWN	VOC	LOOK	MOUTH	SMILE	FROWN	VOC
1.00	7.42	7.10	4.52	0.00	0.97	6.72	9.85	3.13	0.00	0.00
2.00	7.56	3.78	0.29	0.00	8.43	5.91	2.22	0.18	0.00	1.48
3.00	3.72	5.15	0.00	0.00	3.72	3.97	1.99	2.78	0.40	4.77
4.00	6.95	0.69	0.46	0.45	2.32	5.09	0.00	2.04	0.00	9.16
6.00	7.51	6.51	0.50	0.00	0.00	9.16	5.39	1.08	0.00	0.00
7.00	5.08	3.63	1.45	1.45	4.36	6.56	5.52	3.80	0.00	4.14
8.00	7.83	2.32	3.71	0.00	6.03	5.62	2.01	4.82	0.80	7.23
9.00	5.15	4.86	0.43	0.00	2.00	15.60	24.00	11.40	0.00	24.60
10.00	4.12	4.57	0.00	0.00	0.00	4.43	3.88	6.65	0.00	4.43
11.00	7.78	0.82	0.00	2.05	5.73	6.76	0.40	0.80	0.00	0.80
12.00	9.38	0.00	3.13	0.00	2.50	8.03	1.27	2.54	2.54	2.11
13.00	7.64	3.47	0.00	0.69	2.08	8.85	0.00	0.00	5.90	5.31

SEVEN MONTH OLDS
FREQUENCIES PER MINUTE

	MOTHER					STRANGER				
SUBJECT	LOOK	MOUTH	SMILE	FROWN	VOC	LOOK	MOUTH	SMILE	FROWN	VOC
1.00	7.41	11.24	4.30	0.00	5.50	10.31	14.72	2.58	0.37	1.84
2.00	3.99	3.99	0.00	0.00	0.00	8.82	6.86	4.90	0.98	1.96
3.00	2.28	0.00	0.00	0.57	1.14	5.08	10.63	0.92	0.00	0.00
4.00	5.14	3.27	3.50	0.00	5.14	7.16	5.73	4.77	0.00	2.86
7.00	2.62	0.87	0.00	0.00	0.44	9.38	0.00	0.00	9.38	4.69
8.00	6.10	13.43	3.66	3.66	0.61	10.02	4.77	7.64	0.00	3.34
9.00	9.02	0.00	0.00	0.00	0.00	5.45	0.00	1.06	0.00	2.11
10.00	5.41	6.88	0.98	3.44	1.97	7.91	2.47	1.48	1.48	0.99
11.00	6.33	8.14	0.00	2.71	0.00	6.63	11.60	0.00	0.00	4.97
12.00	2.79	9.06	0.70	0.00	1.39	2.75	11.01	2.75	0.00	11.01
13.00	2.55	5.11	0.00	0.00	1.28	3.82	7.64	0.00	3.82	5.73

EIGHT MONTH OLDS
FREQUENCIES PER MINUTE

	MOTHER					STRANGER				
SUBJECT	LOOK	MOUTH	SMILE	FROWN	VOC	LOOK	MOUTH	SMILE	FROWN	VOC
1.00	7.78	6.48	2.59	0.00	5.83	6.47	6.01	0.46	0.00	1.39
2.00	11.25	1.12	3.94	0.00	2.25	8.75	0.00	0.97	0.00	1.94
3.00	1.74	0.00	0.00	0.00	0.00	3.99	5.76	3.10	0.89	1.77
4.00	5.55	3.70	1.48	0.00	0.00	6.82	13.64	0.00	12.27	12.95
5.00	6.80	7.56	2.27	0.76	2.27	6.23	3.11	0.00	2.08	1.04
7.00	3.46	0.00	2.31	0.00	1.15	7.31	0.25	2.77	0.76	2.77
8.00	5.08	6.17	1.81	0.36	1.45	7.16	14.33	0.00	8.96	12.54
9.00	7.96	7.00	0.97	0.48	1.21	4.96	7.22	4.06	0.45	2.26
10.00	7.37	7.78	0.00	0.82	4.50	3.76	8.47	2.82	0.00	2.35
11.00	4.75	5.94	0.00	3.56	4.16	6.26	4.55	0.00	0.00	1.14
12.00	6.80	9.47	6.56	0.49	1.94	4.32	2.16	1.08	0.00	0.00
13.00	11.20	16.00	1.60	0.00	14.40	7.06	7.06	0.00	0.00	9.41

Appendix 5.

In this appendix are included the significant results of the interactinal analyses for interactions between infants and extra strangers and also for the overall session where the interaction is treated as an interaction between the infant and other regardless of the changes in other's identity.

Labels for adults are

s2 second female stranger
ms male stranger
o overall interaction

GAZE

One month olds.

Infant 8.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	la	la	86	84	0.9174	0.0232	0.9947
	la	ll	86	0	0.0355	1.0000	0.0448
o	offsets						
	la	la	86	77	0.9479	0.9860	0.0351
	lr	la	44	43	0.8781	0.0233	0.9967

Two month olds.

Infant 10.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	la	lr	22	2	0.0106	0.0106	0.9984
	la	la	22	18	0.9894	1.000	0.0001
	offsets						
	lr	lr	13	2	0.0159	0.0176	0.9990
	lr	la	13	11	0.9841	0.9990	0.0176

Three month olds.

Infant 4.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	la	lr	21	0	0.1557	1.0000	0.0286
	la	la	21	21	0.8381	0.0245	1.0000

Infant 5.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	ll	ll	11	2	0.0101	0.0053	0.9998
	offsets						
	la	ll	18	2	0.0108	0.0160	0.9991

Infant 9.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	la	la	46	40	0.9671	0.9999	0.0008
	la	ll	47	4	0.0182	0.0106	0.9984
	offsets						
	la	la	45	41	0.9718	0.9915	0.0375
	lr	la	29	25	0.9806	0.9998	0.0023
	lr	lr	29	1	0.0017	0.0478	0.9989
	lr	ll	29	3	0.0143	0.0081	0.9992

Infant 13.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	offsets						
	lr	lr	31	2	0.0033	0.0047	0.9992

Four month olds.

Infant 1.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	ll	llp	20	2	0.0145	0.0336	0.9971
	la	ll	33	9	0.4535	0.9896	0.0262

Infant 2.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
ms	onsets						
	la	lr	8	0	0.3167	1.0000	0.0475
	lr	lr	4	4	0.0584	0.0000	1.0000
	la	la	8	8	0.6389	0.0278	1.0000
	lr	la	4	0	0.8345	1.0000	0.0008
	ll	la	4	0	0.7971	1.0000	0.0017
	ll	ll	4	3	0.0976	0.0034	0.9999
ms	offsets						
	la	lr	7	4	0.0624	0.0005	1.0000
	lr	lr	4	0	0.5429	1.0000	0.0437
	la	la	7	0	0.8304	1.0000	0.0000
	lr	la	4	4	0.4571	0.0437	1.0000
	la	ll	7	3	0.1072	0.0309	0.9965
o	onsets						
	lr	lr	27	6	0.0703	0.0099	0.9978
	ll	ll	28	6	0.0461	0.0015	0.9998
o	offsets						
	la	la	54	30	0.8373	1.0000	0.0000

Infant 4.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	lr	lrp	36	2	0.0075	0.0301	0.9975
	offsets						
	la	lrp	40	2	0.0079	0.0399	0.9961
	m	la	68	60	0.9537	0.9960	0.0131

Infant 7.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	la	la	41	33	0.9226	0.9964	0.0122
	ll	la	22	15	0.9293	0.9999	0.0006
	ll	ll	22	4	0.0184	0.0006	1.0
	la	ll	41	4	0.0261	0.0219	0.9958

Infant 9.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
ms	onsets						
	lr	lr	2	1	0.0094	0.0187	0.9999
	offsets						
	la	lr	2	1	0.0094	0.0187	0.9999
o	onsets						
	lr	lr	24	2	0.0120	0.0334	0.9971

Infant 11.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	ll	la	33	28	0.9588	0.9979	0.0108
	lr	lra	99	5	0.0192	0.0425	0.9877
	ll	llp	33	2	0.0037	0.0067	0.9997
	m	la	58	52	0.9635	0.9949	0.0189
	offsets						
	la	la	131	110	0.9541	1.0	0.0
	la	lrp	131	2	0.0012	0.0111	0.9994

<u>Five month olds.</u>

Infant 3.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	ll	la	26	22	0.9458	0.9882	0.0497
	ll	llp	26	2	0.0071	0.0145	0.9992
	lr	lrp	16	2	0.0178	0.0322	0.9973

Infant 4.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	offsets						
	la	la	52	51	0.8816	0.0114	0.9986

Infant 5.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	s	lrp	4	1	0.0040	0.0159	0.9999

Infant 7.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
ms	offsets						
	m	la	7	3	0.8299	0.9979	0.0190

Infant 8.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	lr	lr	18	2	0.0190	0.0452	0.9955
	lr	ll	18	3	0.0142	0.0020	0.9999

Infant 11.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	lr	lrp	24	2	0.0062	0.0098	0.9996

Infant 12.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	ll	llp	35	2	0.0026	0.0038	0.9999
	offsets						
	ll	lrp	35	3	0.0138	0.0123	0.9987

Infant 13.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
ms	onsets						
	lr	la	10	5	0.7938	0.9925	0.0371
	ll	llp	7	1	0.0038	0.0264	0.9997
	offsets						
	la	lla	14	2	0.0255	0.0484	0.9951
o	onsets						
	ll	ll	35	3	0.0190	0.0286	0.9957

Six month olds.

Infant 1.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	la	lrp	45	3	0.0093	0.0084	0.9992
	lr	lrp	59	3	0.0069	0.0080	0.9992
o	offsets						
	ll	lrp	30	2	0.0049	0.0097	0.9996
	lr	lrp	59	3	0.0103	0.0234	0.9967

Infant 2.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	ll	llp	63	2	0.0025	0.0107	0.9995
	offsets						
	lr	llp	38	1	0.0013	0.0467	0.9989

Infant 3.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	lr	la	47	31	0.8547	0.9998	0.0007
	lr	lrp	48	6	0.0281	0.0022	0.9996
	ll	llp	36	5	0.0300	0.0042	0.9993
	m	lr	47	9	0.0898	0.0225	0.9920
	s	ll	20	1	0.0005	0.0108	0.9999

Infant 6.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
ms	onsets						
	ll	ll	2	1	0.0225	0.0445	0.9995
	lr	lrp	3	1	0.0007	0.0020	1.0
	offsets						
	la	lrp	5	1	0.0007	0.0035	1.0
o	onsets						
	lr	la	34	27	0.9331	0.9985	0.0065
	lr	lrp	34	5	0.0056	0.0	1.0

Infant 7.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	offsets						
	la	lrp	34	2	0.0051	0.0129	0.9993

Infant 8.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	lr	lr	22	3	0.0189	0.0079	0.9993
	offsets						
	s	la	29	25	0.9654	0.9971	0.0170
	v	la	44	38	0.9651	0.9992	0.0041

Infant 9.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	lr	lrp	43	5	0.0046	0.0	1.0
	v	la	54	53	0.8972	0.0206	0.9971
	offsets						
	la	lrp	61	5	0.0057	0.0	1.0
	m	la	71	59	0.9211	0.9966	0.0092

Infant 10.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	offsets						
	ll	lr	11	2	0.0182	0.0164	0.9991

Infant 12.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	lr	lr	25	4	0.0365	0.0122	0.9981

Infant 13.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
s2	onsets						
	ll	llp	8	3	0.0372	0.0025	0.9999
	offsets						
	la	la	11	5	0.7386	0.9902	0.0422
	la	llp	11	3	0.0491	0.0145	0.9985
o	onsets						
	ll	llp	54	6	0.0108	0.0	1.0
	lr	lrp	43	2	0.0077	0.0430	0.9956
	offsets						
	la	la	96	64	0.9088	1.0	0.0
	la	llp	96	5	0.0111	0.0045	0.9993

Seven month olds.

Infant 1.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	lr	lrp	49	4	0.0074	0.0005	1.0
	ll	llp	23	1	0.0013	0.0292	0.9996
	offsets						
	la	lrp	72	3	0.0086	0.0244	0.9965

Infant 3

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
ms	onsets						
	ll	la	4	2	0.9325	0.9999	0.0222
	ll	ll	4	2	0.0197	0.0023	1.0
o	onsets						
	la	la	28	21	0.9283	0.9994	0.0030
	ll	ll	20	2	0.0073	0.0092	0.9996

Infant 9.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	lr	la	46	38	0.9270	0.9945	0.0173
	ll	llp	32	3	0.0051	0.0006	1.0
	lr	lra	46	4	0.0257	0.0303	0.9936
	offsets						
	la	la	55	45	0.9555	1.0	0.0001
	la	llp	55	3	0.0073	0.0077	0.9993
	la	lrp	55	1	0.0009	0.0471	0.9989

Infant 10.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	lr	lrp	21	1	0.0015	0.0307	0.9995
	offsets						
	ll	lr	32	1	0.0009	0.0286	0.9996

Infant 11.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
ms	onsets						
	ll	llp	4	2	0.0441	0.0110	0.9997
o	onsets						
	ll	llp	16	2	0.0097	0.0104	0.9995
	v	la	22	9	0.6849	0.9981	0.0069
	offsets						
	lr	la	37	28	0.5831	0.0217	0.9913
	m	la	52	34	0.3743	0.0	1.0

Infant 13.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
ms	onsets						
	lr	lr	4	2	0.0353	0.0071	0.9998
	offsets						
	la	lr	5	2	0.0455	0.0188	0.9991
o	onsets						
	lr	lr	17	4	0.0095	0.0	1.0
	lr	lrp	17	1	0.0013	0.0218	0.9998
	lr	la	17	11	0.9551	1.0	0.0
	offsets						
	la	lr	22	4	0.0148	0.0003	1.0
	la	lrp	22	1	0.0020	0.0434	0.9991
	la	la	22	16	0.9752	1.0	0.0

Eight month olds.

Infant 2.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
ms	onsets						
	ll	ll	1	1	0.0178	0.0178	1.0
o	onsets						
	ll	la	17	8	0.8053	0.9996	0.0021
	ll	ll	17	4	0.0517	0.0099	0.9984
	offsets						
	la	la	36	24	0.8011	0.9826	0.0409

Infant 3.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
ms	onsets						
	ll	llp	4	1	0.0018	0.0073	1.0
	offsets						
	la	llp	7	1	0.0042	0.0290	0.9996
o	onsets						
	ll	llp	15	2	0.0073	0.0052	0.9998

Infant 4.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	lr	lra	18	3	0.0319	0.0185	0.9978
	ll	llp	16	1	0.0031	0.0479	0.9989
	offsets						
	lr	lrp	17	4	0.0527	0.0106	0.9985
	lr	la	17	13	0.9373	0.9968	0.0190

Infant 5.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
ms	onsets						
	lr	lrp	5	1	0.0051	0.0252	0.9997
	ll	llp	4	1	0.0039	0.0155	0.9999
	la	llp	9	1	0.0044	0.0387	0.9993
o	onsets						
	ll	la	17	12	0.9202	0.9985	0.0088
	ll	ll	17	3	0.0181	0.0034	0.9998
	ll	llp	17	1	0.0009	0.0146	0.9999
	lr	lrp	26	2	0.0039	0.0047	0.9999
	offsets						
	la	la	42	23	0.9271	1.0	0.0
	ll	la	16	16	0.7476	0.0096	1.0
	ll	ll	16	0	0.2039	1.0	0.0260
	la	lla	42	14	0.0298	0.0	1.0
	la	lrp	42	2	0.0049	0.0182	0.9988

Infant 7.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	offsets						
	la	la	44	37	0.9282	0.9878	0.0361

Infant 8.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	lr	lrp	14	3	0.0125	0.0006	1.0
	offsets						
	ll	lrp	15	1	0.0009	0.0137	0.9999

Infant 9.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	lr	lr	30	5	0.0242	0.0007	0.9999
	lr	lrp	30	1	0.0008	0.0237	0.9997
	ll	llp	25	1	0.0018	0.0448	0.9901
	offsets						
	la	la	50	41	0.9211	0.9949	0.0153
	la	lr	50	5	0.0351	0.0305	0.9921

Infant 12.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	lr	lr	19	3	0.0269	0.0136	0.9985
	lr	la	19	4	0.9406	1.0	0.0

Smiles and vocalizations.

One month olds.

Infant 5

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	la	sv	32	1	0.2140	0.9996	0.0044
	offsets						
	ll	sv	26	2	0.2835	0.9981	0.0107

Infant 8.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	la	st	83	28	0.2263	0.0137	0.99287
	v	st	9	6	0.2834	0.0190	0.9970
	offsets						
	lr	st	43	17	0.2421	0.0186	0.9919
	lr	sv	43	13	0.1391	0.0045	0.9985

Infant 11.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	s	sv	22	8	0.1263	0.0040	0.9991

Two month olds.

Infant 1.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	v	st	39	16	0.2516	0.0216	0.9908
	offsets						
	f	vo	6	1	0.6960	0.9992	0.0116
	lr	sv	27	4	0.0354	0.0143	0.9977

Infant 3.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	la	sv	37	5	0.0512	0.0390	0.9894
	lr	vt	26	3	0.3143	0.9955	0.0182
	v	vt	9	0	0.3763	1.0	0.0143

Infant 4.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	s	so	2	2	0.1368	0.0187	1.0
	v	st	7	5	0.2852	0.0231	0.9972

Infant 5.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	la	sv	24	11	0.1337	0.0001	1.0
	m	sv	18	12	0.1933	0.0	1.0
	s	sv	10	6	0.1907	0.0050	0.9994
	la	vo	24	6	0.5285	0.9986	0.0053
	m	vo	18	2	0.4647	0.9998	0.0017
	offsets						
	ll	st	20	8	0.1328	0.0022	0.9995

Infant 6.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	lr	vo	18	0	0.3903	1.0	0.0001
	lr	sv	18	10	0.2905	0.0166	0.9954
	offsets						
	ll	sv	12	5	0.1419	0.0191	0.9965

Infant 8.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	s	vt	11	8	0.3686	0.0172	0.9969
	s	st	11	7	0.1812	0.0011	0.9999
	s	sv	11	4	0.0632	0.0037	0.9997

Infant 9.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	ll	sv	38	14	0.6238	0.9996	0.0012
	la	sv	47	19	0.2384	0.0086	0.9964

Infant 10.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	s	st	13	11	0.5155	0.0149	0.9976
	f	st	7	0	0.5406	1.0	0.0043
	f	vo	7	6	0.2744	0.0023	0.9998
	offsets						
	ll	vt	14	2	0.5018	0.0210	0.9963
	m	vo	17	1	0.3216	0.9986	0.0124

Infant 11.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	v	st	81	20	0.1281	0.0026	0.9989

<u>Three month olds.</u>

Infant 1.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	m	st	31	4	0.3771	0.9995	0.0023
	m	vo	30	15	0.2853	0.0105	0.9963
	la	sv	26	2	0.3023	0.9989	0.0063
	s	sv	48	13	0.1334	0.0086	0.9968
	offsets						
	s	sv	47	16	0.5278	0.9969	0.0074

Infant 2.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	s	sv	13	6	0.1803	0.0227	0.9951
	f	sv	62	2	0.2124	1.0	0.0001
	v	sv	79	11	0.2431	0.9920	0.0174

Infant 3.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	m	vt	36	21	0.3415	0.0025	0.9991
	f	st	15	1	0.3752	0.9991	0.0086
	s	sv	21	8	0.0987	0.0006	0.9999
	v	sv	30	14	0.2227	0.0027	0.9992
	offsets						
	s	vo	25	8	0.1201	0.0020	0.9983
	la	sv	29	4	0.3945	0.9994	0.0026
	lr	sv	19	4	0.0479	0.0114	0.9983
	s	sv	25	7	0.6273	0.9999	0.0004

Infant 5.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	v	st	19	19	0.8028	0.0154	1.0

Infant 7.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	v	so	59	15	0.1404	0.0145	0.9938
	la	st	83	44	0.3733	0.0026	0.9987
	v	sv	59	7	0.3017	0.9998	0.0008
	offsets						
	v	vt	58	31	0.3977	0.0187	0.9905

Infant 11

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
s2	onsets						
	la	so	17	3	0.0367	0.0225	0.9971
	v	so	6	3	0.0856	0.0103	0.9993
	m	sv	15	3	0.0372	0.0162	0.9981
	offsets						
	ll	so	10	3	0.0617	0.0203	0.9977
o	onsets						
	la	vo	115	33	0.2037	0.0187	0.9878
	lr	vt	71	13	0.3422	0.9990	0.0024
	la	st	115	13	0.0608	0.0229	0.9898
	lr	st	72	4	0.1946	0.9998	0.0008
	s	st	25	8	0.1211	0.0074	0.9982
	v	so	40	8	0.0845	0.0173	0.9946
	offsets						
	la	vo	114	18	0.2754	0.9951	0.0023
	la	so	114	7	0.1241	0.9905	0.0221

Infant 12.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	la	st	20	10	0.1681	0.0006	0.9999
	s	st	5	4	0.2496	0.0155	0.9990
	offsets						
	la	vt	20	10	0.7645	0.9946	0.0090
	lr	st	12	5	0.1302	0.0134	0.9978

Infant 13.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
O	onsets						
	ll	vt	48	30	0.7719	0.9932	0.0154
	s	so	60	1	0.1046	0.9987	0.0106
	v	so	45	9	0.0841	0.0115	0.9964
	la	sv	59	17	101351	0.0016	0.9994
	s	sv	60	28	0.2317	0.0001	1.0
	f	sv	49	6	0.3294	0.9998	0.0008
	offsets						
	la	vt	58	39	0.8656	1.0	0.0001
	s	vo	60	18	0.1738	0.0114	0.9950
	ll	st	48	20	0.1939	0.0003	0.9999
	la	so	58	9	0.0587	0.0064	0.9981
	ll	sv	49	13	0.1169	0.0034	0.9989
	m	sv	57	12	0.3674	0.9965	0.0083
	s	sv	59	37	0.8026	0.9995	0.0013

Four month olds.

Infant 2.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	v	vo	40	10	0.4641	0.9984	0.0045
	s	st	3	3	0.2731	0.0204	1.0
	offsets						
	lr	vt	25	19	0.5196	0.0123	0.9963

Infant 5

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	offsets						
	la	so	12	8	0.2193	0.0011	0.9999

Infant 6.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	m	sv	40	26	0.4183	0.0026	0.9991
	s	sv	26	19	0.4610	0.0049	0.9986

Infant 7.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	ll	vo	22	9	0.7870	1.0	0.0001
	ll	sv	22	8	0.1139	0.0021	0.9996
	s	sv	9	4	0.1224	0.0170	0.9933
	offsets						
	la	vo	40	19	0.6484	0.9920	0.0182

Infant 9.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	ll	st	14	0	0.3724	1.0	0.0015
	la	st	39	12	0.1688	0.0235	0.9907
	offsets						
	ll	sv	14	2	0.0097	0.0080	0.9997

Infant 12.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	offsets						
	lr	vo	34	16	0.2778	0.0128	0.9951

Infant 13.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	lr	so	25	6	0.0562	0.0022	0.9997
	offsets						
	ll	so	14	3	0.0471	0.0187	0.9978

Five month olds.

Infant 3.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	offsets						
	s	vt	20	3	0.4012	0.9965	0.0156

Infant 4.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	offsets						
	lr	vt	29	27	0.7306	0.0074	0.9987

Infant 5.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	ll	vo	24	17	0.4344	0.0068	0.9981
	offsets						
	la	vo	30	21	0.4897	0.0162	0.9941

Infant 8.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	m	so	64	2	0.1147	0.9962	0.0178
	s	sv	35	21	0.3406	0.0015	0.9995

Infant 9.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	v	vo	22	14	0.3775	0.0123	0.9963
	s	sv	5	4	0.1994	0.0066	0.9997

Infant 11.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	ll	vt	38	14	0.5453	0.9967	0.0214
	v	st	9	8	0.5113	0.0229	0.9976

Infant 12.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	la	st	51	30	0.4285	0.0157	0.9925
	offsets						
	m	vt	25	10	0.6172	0.9918	0.0227

Six month olds

Infant 2.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	v	st	48	11	0.4147	0.9978	0.0057

Infant 3.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	m	vt	47	17	0.5517	0.9971	0.0068
	ll	st	35	2	0.2289	0.9987	0.0072
	s	sv	20	5	0.0479	0.0021	0.9997
	offsets						
	lr	vo	47	27	0.3884	0.0075	0.9968
	lr	sv	47	4	0.2332	0.9982	0.0068

Infant 4.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	ll	vo	31	5	0.3405	0.9926	0.0229
	offsets						
	m	so	6	2	0.0309	0.0132	0.9994
	v	so	53	5	0.0277	0.0155	0.9966

Infant 6.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	s	st	12	6	0.1226	0.0016	0.9998

Infant 7.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	offsets						
	la	st	34	15	0.6446	0.9953	0.0122
	v	vo	20	8	0.1419	0.0042	0.9991

Infant 8.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	la	st	44	3	0.1883	0.9936	0.0235
	v	st	45	3	0.2020	0.9970	0.0119
	offsets						
	lr	vo	21	17	0.5194	0.0060	0.9987

Infant 9.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	ll	st	34	2	0.2460	0.9992	0.0042
	s	vo	21	3	0.4272	0.9989	0.0057
	s	so	21	6	0.0985	0.0135	0.9970
	offsets						
	la	st	61	7	0.2745	0.9993	0.0022

Infant 10.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	s	sv	13	7	0.1670	0.0024	0.9997
	offsets						
	ll	vt	11	3	0.6255	0.9965	0.0191

Infant 12.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	lr	vo	24	15	0.3898	0.0168	0.9944
	s	vo	15	4	0.5582	0.9947	0.0219
	f	vo	13	10	0.4560	0.0226	0.9953
	f	st	13	2	0.4937	0.9980	0.0127
	ll	sv	27	18	0.3613	0.0012	0.9997
	lr	sv	25	4	0.4691	0.9998	0.0013

Infant 13.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	la	vo	75	21	0.4230	0.9963	0.0075
	s	st	2	2	0.1411	0.0199	1.0

Seven month olds.

Infant 1.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	s	so	24	7	0.1203	0.0197	0.9946
	v	sv	29	7	0.0139	0.0157	0.9957

Infant 3.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
ms	onsets						
	ll	st	4	0	0.7413	1.0	0.0045
	ll	vo	4	3	0.1467	0.0112	0.9995
o	onsets						
	s	vt	7	7	0.4653	0.0047	1.0

Infant 8.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	lr	vt	23	7	0.5667	0.9971	0.0100
	offsets						
	la	vt	31	12	0.5789	0.9901	0.0097
	v	vt	10	2	0.5563	0.9960	0.0249

Infant 9.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	lr	st	32	12	0.5690	0.9915	0.0212
	s	st	6	6	0.4703	0.0108	1.0
	v	st	22	16	0.4479	0.0076	0.9980
	offsets						
	la	st	55	26	0.6455	0.9971	0.0064
	la	vo	55	24	0.2948	0.0179	0.9912

Infant 10.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	lr	vo	21	3	0.4018	0.9977	0.0106
	s	so	5	3	0.0977	0.0080	0.9996

Infant 11.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	la	vo	41	9	0.3893	0.9934	0.0163
	offsets						
	lr	so	5	2	0.0522	0.0245	0.9987

Infant 12.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	offsets						
	m	vo	46	11	0.4216	0.9969	0.0078

Infant 13.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	v	vt	19	17	0.6646	0.0230	0.9955
	offsets						
	lr	vo	15	13	0.5310	0.0072	0.9989
	f	st	8	2	0.0107	0.0031	0.9999

Eight month olds.

Infant 1.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	v	st	25	1	0.2257	0.9983	0.0139

Infant 2.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	ll	vo	17	6	0.6278	0.9946	0.0198
	v	sv	6	4	0.0917	0.0009	1.0

Infant 3.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	s	so	10	3	0.0463	0.0093	0.9992
	offsets						
	v	vo	7	7	0.5628	0.0179	1.0

Infant 5.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	m	vo	25	17	0.4474	0.0163	0.9946

Infant 7.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	la	vo	44	37	0.6987	0.0245	0.9905
	la	sv	44	2	0.2308	0.9999	0.0010

Infant 8.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	offsets						
	la	vt	18	7	0.6766	0.9971	0.0113

Infant 10.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
ms	onsets						
	lr	vt	11	11	0.5349	0.0010	1.0

Infant 11.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	lr	vt	25	8	0.5913	0.9984	0.0056
	lr	so	25	7	0.1038	0.0116	0.9971
	offsets						
	la	vt	26	11	0.6448	0.9939	0.0173

Infant 12.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	lr	vt	19	13	0.4344	0.0250	0.9925
	m	st	42	34	0.5964	0.0028	0.9991
	s	sv	28	14	0.2577	0.0051	0.9984
	offsets						
	la	so	35	9	0.4568	0.9954	0.0124

Infant 13.

ADULT	INFANT BEH.	ADULT BEH.	TOTAL FREQ.	OBSERVED FREQ.	EXPECTED PROB.	P(obs or more)	P(obs or less)
o	onsets						
	s	so	1	1	0.0058	0.0058	1.0