INFANTILE PERCEPTION OF THE HUMAN FACE

by

George Allyn

University of London

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ABSTRACT

When infants were allowed to fixate their own mother's face under various degrees of completeness, all showed differential fixation. A face without both eyes was fixated significantly less frequently than were the eyes only with or without other facial features and was also associated with a negative reaction of actively refusing to look. A full or complete face, however, was not fixated any more frequently than an incomplete which contained eyes.

In another study, infants were allowed to fixate two television monitors on which were simultaneously presented filmed versions of a strange female face under various degrees of completeness. In spite of decided positional preferences, the results of the two studies correlated significantly, which indicates that infants responded to a filmed version of a face as face-like. It was therefore suggested that the human face as a visual stimulus can be conceived to be built up in the manner of a heterogeneous summation effect organized around a privileged feature, namely, one eye.

The literature on imprinting was reviewed and the ~~difference~~ distinction between the minimally sufficient and the optimal conditions was drawn. Moreover, different types of imprinting were argued for. Then the development of attachment in the human infant, with particular reference to perception of the human face, was compared with imprinted recognition of and response to visual stimuli in birds, and it was pointed out that by 4 to 6 months, most infants evidence behaviour which indicates an internalized face schema.

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PART I

INFANTILE PERCEPTION: A REVIEW OF THE LITERATURE

INTRODUCTION

At the turn of the century, the problem of perception in the human neonate had not been raised. While the majority of the population (psychologists included) considered infants to be sightless, a few physiologists and physicians were willing to ascribe to infants at least the mechanisms of vision. Early experiments were concerned with an infant's ability to distinguish colours, to fixate and/or track a stimulus object or light and to dilate the pupil. Before 1958, there had only been a handful of empirical studies concerned with vision and perception in the infant. The major hindrance to research was the lack of experimental techniques. The human infant presented the same perennial practical and theoretical problems as chimpanzees, rats or other non-verbal organisms: namely, "How does an observer know what an organism perceives if it cannot speak?". Obviously, special techniques are needed. It was not until after the middle of the century that appropriate techniques had been developed. It was as late as 1964 that publications concerning infantile vision and perception became a regular occurrence in the technical journals. Nevertheless, only a dozen or so publications concerning perception of the human face have appeared to date.

Since the human face as a stimulus is a complex pattern and since perception in general is dependent upon physiological mechanisms, it is impossible to separate the problems of perception of the human face from those of vision or perception in general. Therefore, all relevant publications have been reviewed.

Each research published has been classified in one of thirteen categories.* Methodology, physiology, pharmacology, handling, motility, fixation, colour perception, pattern perception, face perception, depth perception, habituation, sex differences, cognition. Each research reviewed has been introduced by a bracketed heading which indicates its content. Reviews have been grouped according to year of publication and arranged chronologically. Researches published prior to 1958 constitute the first section; those including and subsequent to that year, the second. A final section presents a summary of the work reviewed.

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*Physiological researches have been included because of their relevance to the problem of determining criteria of fixation. Studies of fixation, habituation and cognition have been selected because of their relevance to methodological issues.

EARLY STUDIES ON INFANTILE PERCEPTION

1913

[colour perception] One of the first empirical studies on vision in the human infant was carried out by Valentine (1913). His sample consisted of one infant tested at 4 and 8 months of age with pairs of Holmgrens wools (used in testing colour blindness). At 4 months, a record was made of the amount of time the infant spent gazing at one of two colours. At 8 months, the infant was allowed to grasp one of two wools (His grasp was then considered to represent his preference.) As a result of these experiments, Valentine considered there to be good evidence that by 3 months an infant can experience sensation of colour and in the following order of decreasing preference: 1) yellow, 2) white and pink, 3) red, 4) brown and black, 5) blue and green, 6) violet. Though this order of preference seemed to be at least partially determined by brightness, Valentine was of the opinion it could not be explained entirely by reference to brightness but by the "relative powers of the various colours as stimuli to the organism". By 7 months, yellow was the most preferred colour, though white had decreased in attractiveness to last, (comparable with violet,) while red and pink were the second most preferred.

Obviously, Valentine's experiments have many limitations. A population sample of only one infant is too small. Moreover, it is now questionable whether accurate fixation can be determined merely from eye or head orientation. Likewise, grasping at a coloured bit of material does not necessarily indicate visual preference. In short, too many variables were left uncontrolled. Nonetheless, Valentine's study is of considerable importance for it posed the problem of infantile vision, and, in particular, of colour perception, in its first testable formulation.

1925

[physiology] In contrast to Valentine who studied perception via behaviour, Sherman and Sherman (1925) concerned themselves with the physiological mechanisms of infantile perception. They observed 23 neonates, aged 30 minutes to 33 hours, when light was "thrown into the eye". A pupilary response was found to be present, though in a very sluggish form, from about 3½ hours and to become increasingly adequate up to the age of thirty hours by which time it was described as "good".

1929

[physiology] Another early study involving the pupilary reflex was carried out by Guernsey (1929), who observed 25 infants, aged from 8 hours to 6 months. She noted that the average size of the pupil increases with age and that rapid pupilary adjustment is markedly less for the infant than for the adult. What she considered to be unco-ordinated horizontal eye movements occurred in 60% of the infants under 2 weeks; the amount dropped to 30% by 6 weeks. The blinking reflex occurred in 80% of the infants tested, though only in response to contacts or intense stimulation. Guernsey was unable, however, to observe what she considered fixation before the second month

Unfortunately due to primitive techniques, Guernsey's results led her to conclude that an infant's visual reflexes are much less developed than was to be indicated by later, more refined studies. Like Sherman and Sherman (1925), she receives the credit of being one of the first to document mechanisms which could be considered to provide a physiological substrate for vision in the human infant.

1930

[physiology, methodology] McGinnis (1930) published a comprehensive review and bibliography of the early literature on the optic nystagmus, on co-ordinated eye movements and pursuit, and on early experimental and recording techniques. As a result of his observations and experiments on 6 infants during the first 6 weeks of life, he noted the optic nystagmus to occur the first time each subject opened its eyes (even during the first 12 hours after birth) and to be composed both of large saccadic eye-movements and of slow, gliding, pursuit movements. A few infrequent co-ordinated eye-movements were seen to occur within a few days after birth. Moreover, the number of eye movements was correlated with (i.e. influenced by) the nature of the visual stimulus to which the infant was attending.

McGinnis observed successful ocular pursuit to occur towards the end of the second week, i.e., well in advance of Guernsey's (1929) observation of its first occurrence. However, with increasing age, ocular pursuit and orientation of the head to a moving stimulus were observed to be more frequent and more successful and by 6 weeks to attain many of the characteristics of adult visual behaviour, i.e. "practically free of gross ocular movements which do not correspond with the movements of the stimulus". The number of ocular adjustments in pursuit of a moving object was observed to be inversely related to the speed of the object. Yet, the proportion of eye movements in the correct direction was found to be usually greater for the relatively more rapid movement of stimuli used in the experiment than for the slower.

1932

[colour perception] Staples (1932) studied the reactions of 262 infants, aged from 69 days (i.e., approximately 2 months) to 24 months, to equally bright cards of red, yellow, green, blue and grey, each colour paired with every other. The preferences of older infants were determined by the coloured card grasped; of younger infants, by amount of looking. Like Valentine (1913), Staples was unable to find behavioural evidence for the perception of colour as distinct from grey before the 3rd month, after which red appeared to be the most effective, followed by yellow, blue and then green. Staples believed there to be a sex difference in response to colours, with female infants showing a earlier preference for blue and green than the male. In spite of the fact that infants younger than 6 months did not show preferences for any colours, it does not follow that they cannot differentiate them or are colour blind. Unfortunately, unpatterned, homogeneous colours were used as stimuli. More recent studies tend to indicate that form and not colour per se is a crucial faction in eliciting an infant's attention.

1933

[physiology] Beasley (1933) attempted to study visual pursuit in 109 white and 142 negro newborn infants, aged from a few hours to 12 days. Unfortunately, due to primitive design and ambiguous statistics few conclusive results were obtained. Visual pursuit was observed with varying frequencies at different ages. Negro children may have exhibited a greater relative frequency of pursuit than whites, though not of higher "quality". Beasley argued for unambiguous signs of learning, maturation or functional improvement, even thought the results could "not be graphed in the manner of the conventional 'learning curve'".

1934

[motility] Weiss (1934) conducted a series of experiments in which she noted that mild auditory and visual stimuli presented simultaneously tend to reduce activity of newborns in proportion to the intensities of the stimuli used. When different levels of illumination alone (i.e. without sound) constituted the stimulus variables, activity was observed to be greatest under minimal and least under moderate light. (Moderate illumination was the strongest illumination used in the study.) To the contrary, crying was greatest under minimal and least under moderate light.

These results were contributed by 90 infants ranging in age from birth up to approximately 10 days. A further 67 infants of similar ages were observed under darkness (Irin & Weiss, 1934). Activity was found not to be maximum in darkness. A preliminary period of darkness tended to be followed by an increased amount of activity under minimal light intensities; to the contrary, decrement in activity followed under dim and moderate light intensities.

Unfortunately, the results of Weiss' experiments have little to offer a student who is concerned with perception as an autonomous activity.

1936

[fixation] Gesell and associates produced four publications (1936, 1940, 1947, 1949) which deal in part or in entirety with the development of perception. In contrast to later researchers, Gesell et al focused on the localization of stimuli, and on the use of perception to direct motor activities but not on differential visual responses to the patterned quality of stimuli. Descriptive age norms were obtained as a result of patient observations and ingenious experiments of a game like nature. The development of an infant's gross visual responses were beautifully documented.

1937

[cognition] Piaget (1937) was concerned with perception as a general cognitive activity beyond looking. He viewed perception not as intrinsic but as a result of interaction, i.e., perception is of a reality constructed by the actions of a child and the reactions of the environment to him.

For Piaget, the neonate is only sensitive to light in a reflexive or passive way. When a stimulus moves, the neonate is described as exhibiting merely an attempt to follow it. However, at one month or thereabouts Piaget places the beginning of the Primary Circular Reaction. "Looking" of a primitive variety takes place. The infant now makes "active accommodatory attempts" to fixate stationary and even to follow moving objects. But it is looking for its own sake, i.e. looking to look, in other words, looking to receive visual sensation. But Piaget considers looking at this stage to lack intentionality and environmental orientation. However, by the 4th month, the infant becomes interested in the surrounding milieu in so far as it affects him as a result of his actions. Piaget describes "motor recognition" and motor activities for "many interesting sights last". In short, perception is autocentric, i.e., it is concerned more with its own function or with the self than with the environment. Time, intentionality and anticipation do not come until the Secondary Circular Reaction at 8 months, from which period on, Piaget is concerned exclusively with perception as something far beyond looking.

1939

[motility] In agreement with Weiss (1934), Redfield (1939) concluded as a result of her work with 180 newborns that light has an inhibitory effect upon bodily activity and that the inhibitory effect becomes progressively greater as intensities increase. Sensitivity to light was observed to increase proportionally to the length of the preceeding period in darkness. Crying was found to be inhibited by light more effectively after longer periods of dark adaptation.

1941

[pattern perception] One of the first experimental studies of vision in the infant to concern itself with form perception was carried out by Ling (1941). In an intensive set of experiments, 14 infants between the ages of 6 and 12 months were trained to reach for geometrical solids.

As early as 6 months, infants proved capable of using discrimination as a learning cue in establishing definite approach (or selection) and avoidance habits. Individual differences were very marked and consistent throughout the whole of the study. Neither changes in relative position, spatial orientation, nor size, had much effect on discriminability. However, as number of stimuli (blocks) presented simultaneously were increased, discrimination appeared to become more difficult. Similar stimuli were most difficult to be discriminated when presented in close proximity. Though sudden reversals of functional relationships between positive and negative stimuli caused temporary confusion, adaptation occurred very soon and sometimes with what Ling described as "insight". Positional cues were sought by infants only at the beginning of the experiments or when temporarily confused. Ling considered the factors affecting discrimination in her experiment to occur in the following order of decreasing potency: 1) number, 2) similarity, 3) sequence, 4) proximity, 5) size, 6) orientation (in space) and 7) position. In conclusion he observed that "the young human infant tends spontaneously to select (i.e. to "prefer") the more complex angular forms as opposed to the "primitive" circle form".

1942

[fixation physiology] In a subsequent study, Ling (1942) observed the responses of 25 full-term infants, aged from 7 minutes to 24 weeks, to an approaching/receding disk. Infants tended to respond differently to the stimulus when at close range than when farther away. Sustained fixation was absent at birth but appeared in a rudimentary form a few hours afterwards and reached its peak at about 4 to 5 weeks. Ling characterized the development of fixation as follows:

I. Absence of fixation.

II. Dawning of fixation.

III. Sustained near fixation.

IV. Pre-perfect (Variable) fixation.

V. Perfecting sustained fixation (4 to 5 weeks).

VI. Roving fixation.

It is to be noted that what Ling describes as "roving fixation" could equally well be described as primitive visual scanning.

Even neonates inhibited spontaneous movements and adapted the entire body to facilitate fixation. Conjugate deviation was considered to be functional immediately after birth. Co-ordinated compensatory eye movements were likewise observed soon after birth, (though not truly efficacious until the 4th or 5th weeks, as mentioned previously). Binocular fixation was considered to appear first at 7 to 8 weeks. When convergence was first observed to occur, it was characterized by a series of globus jerks. Frequency of blinking tended to decrease with age, while palpebral fissures tended to increase; both were related to the intensity of the illumination.

1946

[face perception] Spitz (1946, 1948, 1965) was one of the first researchers to study the social implications of perception in the human infant. He observed that by the third month the infant is "able to recognise the human face and to indicate this by smiling". He described the acquisition of this responsiveness as an indication of a transition from "reception of stimuli coming from the inside to the perception of stimuli coming from the outside"; in another formulation by Spitz, "a shift from passive to active". However, a careful reading of Spitz's publications gives the impression that he seems to consider the smiling response as a sufficient and reliable indication of perception, and that he is concerned with perception as a general or global process rather than with the way in which an infant localizes and discriminates sources of stimulation.

As a result of his observations and naturalistic impromptu experiments, Spitz came to the explicit conclusion that the human infant does not respond to the human face as a face, but rather as a "privileged Gestalt ... of forehead, eyes, and nose, the whole in movement". He is most emphatic that both eyes (presumably open) plus the nasal and supraorbital structures must be present to form the "sign Gestalt". In short, the head in profile is insufficient. Though Spitz did not state it explicitly, he seems to imply, in contrast to Kaila (1932), that an infant at three to four months is unable to distinguish the Gestalt of a living face from that of a mask or a model. Such an assumption seems to follow from his contention that smiling can be evoked equally well by the appropriate pattern on a piece of cambric as by a real face and from his above-mentioned acceptance of the smiling response as a sufficient and reliable behavioural indication of visual perception. Yet, Spitz has also suggested that it is the light reflecting property of the eyes which contributes to their central position in facial Gestalt. If this is the case, then his concept of a "privileged Gestalt" qua Gestalt is in need of revision.

1954

[face perception] Ahrens (1954) undertook a detailed study of the specific properties of the face which are requisite to evoke smiling. In basic agreement with Spitz, he concluded that eyes are of central importance. During the first weeks, only a dot or a primitive equivalent for an eye seemed sufficient to evoke smiling. However, the actual eye configuration plus nose and forehead became increasingly necessary especially by the third to fourth months. Likewise, the outline seemed to acquire significance with increasing age. As stimuli, Ahrens used masks and marked cards, as well as actual faces, and found, contrary to Spitz, that at about 4 months the two could be distinguished. In addition, he noted that a configuration of face with eyes evoked more smiling than that of one without. Artificial eyes worn on a real face evoked smiling from infants up to 5 or 6 months, after which time they elicited negative responses.

It is important to stress that neither was Ahrens directly concerned with perception in the narrower sense of the term. However, it is obvious that his findings, as well as those of Spitz, can be extrapolated to conclusions about the development of looking: whatever evokes social smiling must be seen, heard, felt or in some way sensed. Unfortunately, smiling is neither a reliable nor a sufficient single criterion to be used in more refined and more specialized study of an infant's perception of the face. Ambrose (1961), Wolff (1963) and others (Brackbill, 1958; Gewirtz, 1965) have done rigorous studies on smiling per se and offer evidence that smiling is a very complex set of responses, is highly influenced by the present environment as well as by the past history of the individual infant, and must be considered differently according to the particular stage of development and the momentary somatic and emotional state of a given infant.

[methodology, physiology] Schwarting (1954) studied the smallest wire moving across an illuminated field which would elicit a "following reflex" in a series of normal infants. He approximated normal visual acuity at 3 months to be "finger counting" (Snellen), 6 months 20/400, 12 months 20/200. However, Schwarting's results were limited by primitive methodology and experimental apparatus.

1955

[physiology] Zetterström (1955) recorded flicker electro-retinograms for 35 infants, aged from birth to 8 weeks. No flicker was obtained for infants within 24 hours of birth; however, by 2 - 3 days a measurable flicker was obtained for every infant tested. Flicker frequency rose rapidly during the first weeks of life and by 8 weeks was comparable to an adult's record.

1957

[physiology, methodology] Gorman, Cogan and Gillis (1957) described an apparatus for "grading visual acuity by means of the opticokinetic response" and determined 93 newborns aged 1½ hours to 5 days to perceive a pattern which corresponds to a minimal Snellen notation of 20/670. In other words, newborn infants are definitely not blind. Gorman, Cogan and Gillis suggested that under optimal testing conditions this index may be found to be lower, as subsequently proved to be the case.

Contemporary Studies of Infantile Perception, with Special Reference to the Perception of Form in General and of the Human Face in Particular.

1958

[methodology, pattern perception] With Fantz' 1958 publication, infantile perceptual research took on a new direction. Fantz assumed that when the reflection of a pattern coincides with the pupil of the eye, the pattern can be considered to be fixated. Twenty-two infants were seen between one and 20 weeks. They were allowed to fixate pairs of stimuli; a cross and a circle equated in area; two identical triangles; a checkerboard and a homogeneous grey square; a bull's eye and stripes, equated in area. Though there were position preferences, Fantz felt it was possible to come to 3 conclusions.

1) differential fixation is possible within the first 20 weeks of life.

2) changes in frequency of fixation are independent of amount of testing, i.e. there were developmental changes.
3) consistent visual preferences are present as early as the first two months (if one assumes length of fixation to be an indication of preference). For example, infants younger than 8 weeks "preferred" stripes while older preferred a bull's eye.

[pattern perception] Berlyne (1958) conducted an experiment in which 14 infants ranging in age from 3 to 9 months were presented with pairs of stimuli. The stimulus gazed at first was considered to be preferred. Berlyne noted that "the two patterns in the complexity series that were especially attractive were ones with much more contour than others in the same series". Berlyne made no published reference to positional preferences, which usually plague the paired stimuli method. Though Berlyne's results are comptatible with those of later studies, his basic assumption that the stimulus to which an infant first looks is preferred is of doubtful tenability. For this to be the case, infants would have to have peripheral vision developed to such a degree that it would be possible to respond to both stimuli before directly looking at either one of the pair. Positional preference above all makes such a first choice unlikely, even if peripheral perception were sufficiently developed in the younger infants. Moreover, the age range of the sample was too diverse; the visual development of a three-month infant is unlikely to be comparable to that of a nine-month.

1961

[physiology] Pendleton and Paine (1961) made electro-oculographic and photographic recordings of the vestibular nystagmus. Rotational and post rotational nystagmi were obtainable in all normal full-term infants and in most normal prematures, but only if the infant was thoroughly awake in both cases. Only tonic deviation of the eyes without the quick component of the nystagmus could be obtained from a sleepy, satiated or abnormal infant. No response to rotation, not even forced deviation, was considered a sign of grave abnormality.

[colour, pattern and face perception] Fantz (1961a, 1963) presented infants with stimuli singly and in a random order. An infant was allowed to look at a stimulus as long as he wished; when he looked away, a new stimulus was presented. For younger infants (under 5 days), a schematic face was reported to have been more frequently fixated than a bulls-eye. However, Fantz (1965) was unable to obtain similar results when he later repeated the experiment. Both the schematic face and the bulls-eye elicited greater fixation than did newsprint or pure colour. By contrast, infants of 2 - 6 months showed a decided preference for the schematic face. The bulls-eye and the newsprint were now about equally preferred. Colour was still least preferred. Fantz concluded that infants "act as if patterns are innately perceivable and are intrinsically interesting. While colour and brightness without patterning offer little to attract their attention". When a schematic was compared with a scrambled face, the schematic face was always more frequently fixated though the difference was not always great and no statistical test was employed. Fantz did note that a preference for face-like patterns of greater complexity increased with age and that at 3 months there was a decrease in the size of the difference between the amount of fixation for a scrambed and a schematic face.

1962

[physiology, pattern perception] A further publication by Fantz in co-authorship with J. M. Ordy and M. S. Udelf appeared in 1962. Relative measures of visual acuity were established for young infants. A card containing vertical black and white stripes was found to be preferred to a homogeneous grey card of equal over-all light reflectance. Infants up to 2 months could resolve 40 minutes of visual angle; infants from 2 to 4 months, 20 minutes; and infants from 4 to 6, 10 minutes. When intensities of illumination were compared, a moderately bright illumination (20 foot candles) was preferred.

1964

[pharmacology, pattern and face perception] Sheckler (1964) investigated the effects of medication during labour on neonatal attention. Twenty full-term infants from 2 to 4 days old were exposed to a random order of 3 stimuli: a schematic face; drawing of one die; a blank or homogeneous field. Infants whose mothers had received heavy medication were less attentive than those whose mothers had received light. Moreover, there was a significant negative correlation between the time of drug administration in relationship to birth and total looking time; "the more drugs administered closer to delivery the less attentive is the infant likely to be". The more complex of the two stimuli, a schematic face, was fixated longest.

[handling] White and Castle (1964) studied the effects of handling on the development of visual exploration. Ten institutionally-reared infants were given 20 minutes of extra handling each day for one month, starting with the sixth month. When compared with infants who were from the same institution but who received no extra handling, the handled infants showed "significantly more interest in the environment" than the non-handled controls.

[physiology] Dayton, Jones, Aiu, Rawson, Steele and Rose (1964) studied the responses of 13 infants aged 8 hours to 8 days to a moving target. Electro-oculography combined with direct observation of the optokinetic nystagmus indicated that some new born infants are capable of more refined visual acuit than found by Schwarting (1954) who used a more primitive technique of measurement. In fact, Dayton et al observed that some neonates possess a visual acuity of at least 20/150 as well as a developed fixation reflex with conjugate eye movements.

[physiology] In a second study, Dayton, Jones, Steele & Rose (1964) studied 30 infants, aged 8 hours to 10 days, of which 17 demonstrated a fixation reflex with both eyes moving in close conjugation. They pointed out that their finding was contrary to McGinnis (1930) and that their results point to "an innately more highly developed fixation reflex in the newborn than heretofore realized".

[physiology] Dayton collaborated with Jones (1964) in a third study. Again direct current electo-oculography was used to study the development of the fixation reflex. 127 infants, aged from birth to 6 months, gave 163 recordings of which 62 demonstrated definite fixation. The number and amplitude of refixation movements for infants was greater than for adults, who, by contrast, could trace a target very smoothly. The greatest decrease in amplitude of refixation occurred during the first 10 days of life. Conjugation of both eyes was good from the first day. According to Dayton and Jones, the previously held conclusion that the newborn was incapable of purposeful eye movements probably resulted from a misinterpretation of the many refixations of large amplitude which are to be observed.

[depth perception] Bower (1964) trained 9 infants, 3 months of age, to turn their head in response to various sized cubes which were presented at differing distances. Infants appeared not to respond to the size of the retinal image but to use depth perception to discriminate the objects. Bower pointed out that his findings do not support a hypothesis to the effect that depth discrimination is dependent on prior action in space. Rather "the initial phases of perceptual differentiation is certainly independent of action".

[pattern perception] Munsinger and Weir (1964) conducted an experiment with 32 children, aged 9 to 41 months (medium age 24 months) in which stimuli of 4 increasingly complex levels of variability were presented in pairs. Munsenger and Weir found no change either with exposure or with age.

They claimed that the relationship between complexity and preference was not characterized by an inverted U-shaped function but rather by an increasing linear function of stimulus complexity. However, due to missing data and other technical limitations this reviewer would not take the findings of the Munsinger and Weir study as conclusive without further experimentation. Above all, the visual behaviour of a 9 months old child and a 3½ year old child are not comparable.

[pattern perception] Hershenson (1964) investigated the fixation preferences of 36 neonates, aged 2 to 4 days, for stimuli varying independently in brightness and in complexity. An inverted U-shaped relationship between brightness and frequency of fixation was obtained and was interpreted as indicating a preference for illumination of intermediate intensity. Preferences were ordered transitively, with the least degree of complexity the most preferred; "however, only the extremes of complexity, least and most complex were significantly different". Hershenson noted apropos Fantz that "it is not possible to state whether the crucial dimensions underlying the preferences were those classified as contributing to "pattern" or whether they were more "primitive in nature". He pointed out that the patterned stimuli used frequently in previous studies were also ones of intermediate brightness. He concluded that results of such experiments are frequently "ambiguous in terms of their pertinence for a general theory of perceptual development". Unfortunately there have been no experiments todate which would indicate whether there is differential fixation of different comply patterns of equal intermediate brightness.

[colour and pattern perception] Spears (1964) used relative fixation time to assess visual preference and discrimination. Six separate experiments were run, each composed of 10 infants aged 4 months. Contrary to Staples (1932), Myers (1908), and Valentine (1914), only blue and red were "preferred" to a grey of equal or greater brightness, but not to yellow. There was no "preferential" difference obtained for other colours. Shape appeared to dominate colour as a basis for choice, i.e. "preference for shpae is not necessarily dependent on colour". Spears noted that a bull's-eye was preferred to either a diagonal, a checkerboard or a hexagonal pattern. These findings are compatible with those of Fantz (1958).

[habituation, colour and form perception] Saayman, Ames and Moffett (1964) operationally defined a novel stimulus as one "which has not been presented during the familiarization period". Stimuli differed as to form only, colour only, or both form and colour. Fifty six infants, most aged from

12 to 15 weeks, were presented with a pair of stimuli for two trials in order to determine a base looking-time. Then a familiarization period followed in which only one of the two stimuli was presented, usually the more preferred. (One group, however, was familiarized on the non-preferred stimulus). Afterwards came two further presentations of the original paired stimuli. During the familiarization period, all stimuli were fixated significantly less frequently as time passed. During the post familiarization period, an initially preferred stimulus was fixated significantly less than in the pre-familiarization period. There was no such decrement for non-preferred stimuli when pre- and post-familiarization fixation times were compared. When stimuli differed either in form only or in colour only, familiarization had no significant effect on the non-familiarized stimulus during the post familiarization period. However, when both colour and form differed, the non-familiarized stimulus tended to elicit increased fixations. Though evidence for discrimination of circles from crosses did not appear in spontaneous visual preferences across subjects, this discrimination could be demonstrated (in spite of individual preferences) when one stimulus was familiarized, therefore making the other stimulus to appear relatively more novel.

1965

[fixation] Wolff and White (1965) tested for visual pursuit 48 three to four-day old infants in the following attentional states: 1) alert and inactive; 2) waking and active; 3) vigorous pacifier sucking; 4) satiated pacifier suck. It was found that the range of pursuit movements was reduced by pacifier sucking since head rotation was simultaneously inhibited. However, infants were observed to pursue with the eyes "as well as or better while sucking on a pacifier than during alert activity and constantly better than during waking activity". (These results contradict Bruner's (1968) hypothesis that younger infants are one channel organisms and cannot both suck and look at the same time.) Moreover, Wolff and White observed that pursuit was better after three minutes of sucking had elapsed than just after it had begun.

[fixation] In a second study, Wolff (1965) observed 10 infants over the first month and noted a "week by week increase in the total duration of alert-inactivity over the first month". Wolff considered alert-inactivity as an optimal state "for a 'true assessment' of the environment". At one week, approximately 11% of observation time was spent in alert-inactivity; by the fourth week, 21%. Wolff found it was possible to prolong the attentive state by presenting interesting stimuli. At one week, a state of alertness could be forcibly increased by 19 minutes, at the fourth week, by 37 minutes. The degree of increase was statistically significant.

[physiology] A study complementary to Wolff's was carried out by Haynes, White and Held (1965). Twenty-two infants, aged 6 days to 4 months, were tested with the technique of dynamic retenoscopy. Before 1 month, no infant was observed to accommodate to changes in the visual field; there appeared to be a fixed focal distance with a median value of 19 centimetres for the group in question. Images near or farther away were out of focus. However, during the second month the accommodative system "began to respond adaptively to changes in target distance", and by the 4th month approximated adult performance.

The implications of the Haynes, White and Held (1965) study are of enormous importance. Firstly, an infant has very little experience with sharply-patterned stimuli during the first month, except perhaps for the human face. Almost all other visual stimuli would be blurred or vague. However, by the fourth month, the child's visual experiences are equivalent to an adult's. In other words, first the child experiences the facial pattern only and then enlarges his perceptual environment to include non-human Gestalten.

[sex differences, pattern and face perception] Kagan and Lewis (1965) recorded the responses of 16 male and 16 female infants (seen at 6 and 13 months) to pictures of faces and geometric designs and to three patterns of blinking lights. Measures of attention were 1) total fixation, 2) bodily activity, and 3) cardiac rate. At six months the infants in their study "preferred" photographs of faces to a symbolic representation of a panda bear. Curiously enough, at 13 months a schematic face elicited more fixation than photographs of either male or female faces. Kagan and Lewis suggested that this latter finding indicated a developmental increase of attention to "partial violations or distortions of familiar patterns". However, most perplexing was the finding that the older infants preferred the most simple blinking light pattern (a simple repetative point) to a less predictable helix. For all infants, an inverse relationship between activity and capacity for sustained attention, as measured in this study, was found. Moreover, interesting individual differences in attention were observable by 6 months.

Nonetheless, Kagan and Lewis felt there were definite sex differences to be found in their sample of American infants. They claimed that female infants are capable of more sustained attention to visual stimuli and that males showed rapid habituation. Assuming that "sustained attention and a preference for deviations from the familiar are mature attentional habits", Kagan and Lewis argue that females are developmentally advanced over males as early as the 6th month of life.

[pattern perception] Hershenson, Munsinger and Kessen (1965) published a study which yielded results contradictory to a previous study by Herschenson (1964). The present study of 17 infants, 2 to 4 days old, found a preference for stimuli of intermediate complexity. In fact, the least complex experimental stimuli were now least preferred, whereas they had been most preferred in the previous study. The authors suggested that a variable other than complexity may have contributed to the later results. However, they were unable to suggest what the new or extraneous variable might be. They did note, however, that the findings of their present study were strikingly similar to those of Munsinger and Kessen (1964) and therefore may be taken "as partial support for the postulated limited capacity of human beings to process environmental variability".

[pattern and face perception] Another experiment concerned with the responses of infants to stimuli of varying degrees of complexity was carried out by Thomas (1965). The sample of 49 infants was divided into two age groups (younger, 2 - 14 weeks, older, 15 - 26 weeks), and were presented with 4 stimuli of varying complexity. In ascending order of complexity, these stimuli are: A) an oval with 2 stripes, B) an oval with a checkerboard effect, C) a schematic face, D) an oval with a schematic drawing of a clothed female figure.

For the younger infants, all conditions were significantly different except for the face and figure. Whereas Fantz (1961a) considered all his infants to "prefer" a face-like pattern, a checkerboard effect was statistically the most preferred by the younger infants in Thomas' sample. For the older infants, however, all conditions were significantly different; the face now the most preferred. For both age groups the stripe was the least preferred stimulus. There was partial support for the hypothesis that older infants fixate more complex stimuli (as defined in this experiment) than do younger. Thomas interpreted his findings, contrary to Fantz (1961a), that infants "preferred" the human facial Gestalt "not because of some primitive response, but because it was closer to an appropriate complexity level .... than were the remaining stimuli". Thomas also pointed out that the preference of the face over the checkerboard in his study could have resulted from "some learned response to the face stimulus". It is to be noted that Thomas' experimental techniques and statistical analyses are superior to Fantz' (1961a).

1966

[pattern perception] Another study concerned with stimulus complexity as a determinant of visual fixation was published by Brennan, Ames and Moore (1966). Their total sample consisted of 30 infants, divided into 3 age groups. The youngest age group, 3 weeks old, "preferred" patterns in decreasing order of complexity; the intermediate, 8 weeks old, "preferred" a pattern of intermediate complexity; the oldest, 14 weeks, "preferred" patterns in increasing order of complexity. The older an infant, the longer it looked at the more complex stimulus, in this case a checkerboard pattern. However, an inverse relationship was found between total looking time, regardless of condition, and increasing age. The authors noted the compatibility of the results of their study with that of Thomas (1965). They made reference to Salapatek and Kessen (1966) and suggested that the developmental preference for increased complexity may be attributed to a change in scanning patterns, and that more primitive preferences may be limited by the tendency of younger infants not to scan a figure but only to fixate parts of it.

[face perception] Watson (1966) conducted three experiments with a total of 48 home-reared infants. Four age groups were 7 to 8 weeks, 13 to 14 weeks, 19 to 20 weeks and 25 to 26 weeks. In the first and second experiments, each infant was presented with a moving human head, either that of the experimentor or of the infant's own mother, at either 0 degrees, 90 degrees, or 180 degrees rotation. Smiling, the measure in question, occurred most frequently to a face of 0 degrees rotation and with optimal strength at 13 to 14 weeks, at which age Ambrose (1961) noted a peak in smiling for home-reared infants. By contrast, the 90 degree orientation showed its peak efficiency at 20 weeks.

In the third experiment, the same infants were presented with either a schematic face, a circle with a dot or a circle with a "T". Record of total cumulative fixation indicated that the effects of orientation appeared only for the schematic face.

Watson concluded that infants under 6 months of age can perceive the orientation of the face and that they appear to be more sensitive to a change in facial orientation of 90 degrees than to a contrast between the face of their own mother and that of a stranger.

[pattern anddepth perception] Bower (1966) reviewed his 1964 article and quoted related studies and concluded that "motion paralax was the most effective cue to depth, followed by binocular paralax" in the young infant. Shape constancy was demonstrated in 3 months old infants. A trapezoid was distinguishable from a slanting rectangle, both of which produced the same retinal image. An operant response was the behaviour used to indicate the differentiation. Moreover, another experiment gave results which would indicate that infants "seem to complete objects as adults do". Completion occurred only to real objects and not to photographs of them. In short, eight-week old infants were found capable of depth and orientation discrimination and of size and shape constancy but unable to discriminate pictorial cues or to maintain shape constancy and orientation discrimination simultaneously. Bower emphasized that perception is the result of more than a momentary retinal image. He concluded that there is evidence to suggest that "infants can in fact register most of the information an adult can register but can handle less of the information than adults can".

[methodology, face perception] Kagan, Henker, Hen-Tov, Levine and Lewis (1966)* conducted two experiments in which a total of 66, 4 month-old infants were presented with four different 3-dimensional representations of a human face: a regular, full or natural face; a face in which the eyes, nose and mouth were re-arranged; a face without eyes; and a blank solid with a face-like contour, though without any features. Measures of first and total fixation to the regular and rearranged faces were not significantly different whereas smiling and decreases in heart rate were significantly more frequent to the regular (or natural) face. Vocalization tended to increase over trials, whereas fixation tended to decrease.

Kagan et al pointed out that long fixations do not necessarily imply "preference", "liking" or "pleasure inducing". If preference is nothing more than relatively longer fixation, then nothing is gained by using the term "preference" instead of the phrase "relatively longer fixation", for a long fixation may reflect either an attempt to reduce uncertainty and to categorize an unfamiliar stimulus as well as/or a desire to gaze at a pleasing Gestalt. The authors theorized that "fixation time is apt to be low to very familiar and very novel patterns but equally high for a band of stimuli representing recently formed schema as well as moderate violations of these schema". In short, long fixations must be considered ambiguous unless complimented by other measures such as smiling, activity or changes in heart rate. Unfortunately, measures additional to total fixation did not yield any significant results for the study in question. Nonetheless, the logical basis of the argument against the interpretation of long fixation as preference cannot be denied. One striking result did emerge, however; facial patterns containing eyes (either regular or scrambled)

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* In the meantime, Jerome Kagan et al. have brought out a new book Change and Continuity in Infancy (John Wiley 1971) in which the 1966 study is extended.

tended to elicit longer fixation than faces without eyes.

[methodology, face perception, sex differences] A similar pair of experiments were conducted by Lewis, Kagan and Kalafat (1966). The first experiment involved 6 stimuli: photographs of a male and of a female face, a schematic line drawing of a male face, a bull's-eye, a checkerboard, and a nursing bottle. The second involved three patterns of blinking lights, varying in complexity of movement.

The same 32 infants, 24 weeks of age, served as subjects for both experiments.

Measures were taken of 1) first fixation, 2) longest fixation, 3) total fixation, 4) number of fixations, 5) latency to first fixation, as well as of a) cardiac and respiratory rates, b) activity (as measured by arm and head movements) and c) vocalization.

The results of first and total fixations gave ambiguous results; one measure sometimes gave a significant result for one sex and not for the other. Differences between longest fixation and number of fixations were also unclear. An inverse correlation was found between length of fixation and number of fixations. However, number of fixations and length of fixations are not independent measures and therefore must be correlated. Therefore, it is ambiguous whether a high negative correlation is indicative of psychological effect or is a statistical artifact. Though none of the measures used gave insightful results, Lewis, Kagan and Kalafat maintain with some reason the pattern of fixations is as important as lengths of fixation. They even went so far as to claim that the "longest and the first fixations were better indices of discriminations than was total fixation because the human faces were more likely to evoke one or two long fixations, while non-facelike designs tended to evoke many shorter fixations". Finally, there was evidence for possible sex differences, the meaning of which, however, remained ambiguous.

[methodology, habituation, depth, pattern and form perception] In the eight years that followed Fantz' article on "Pattern Vision in Infants" (1958), he published a further 6 articles. These articles were reviewed by Fantz himself in his classic paper on "Pattern Discrimination and Selective Attention as Determinents of Perceptual Development from Birth" (1966).

Fantz concentrated on the "perceptions vs action" controversy, in which one school of thought postulates perception as innate and the other, to the contrary, as arising out of action. In contrast to Gesell et al (1949), Hebb (1949), and Piaget (1952), Fantz argues that "perception precedes action and that early perceptual experience is necessary for the development of co-ordinated and visually directed behaviour". He continues "... learning through past responses will change what is attended to and how it is responded to, but these are secondary influences which do not create perception or fundamentally alter it. What is perceived, on the other hand, is crucial for determining behaviour and for determining what is learned from experience at all stages of development, including the early months when sensorimotor co-ordination is developing". Fantz mentions the well-known difference between localization and discrimination of stimuli and reminds the reader that for infants, localization of stimulus source is not automatic as it is for adults.

Fantz discusses the methodological problems in testing infants' perception and argues that looking response can be used "to test discrimination simply by comparison of the amount of fixation of different targets exposed in a systematic way in a test chamber". Apparently unaware of the criticism by Kagan, Henkez, Hen-Tov, Leven and Lewis (1966), Fantz argues as well that "consistent differential fixation of different targets on repeated exposures with positions varied indicates a visual preference". Fixation is equated with the coincidence of the corneal reflection of a stimulus and the pupil of the eye. (Fantz suggests in passing that fixation may be an ambiguous measure and that first and longest fixations, as well as other behaviours such as smiling, ought not to be ignored).

From the 1961 experiment, Fantz concluded that "two configurational characteristics of the human face can be perceived and are selectively attended to — the complexity of the patterning of the face starting from birth, and the particular arrangements of the features at least by the third month". However, he warns that "the results with the particular face-like patterns used do not necessarily accurately reflect the development of responsiveness to actual faces, since faces have many further and varied visual aspects; thus, lack of preference for the schematic face might mean not lack of discrimination but the ability to distinguish between a real and simulated face".

Infants under two months "preferred" a flat to a solid form, whereas at two months a sharp reversal occurred. Fantz considered the reversal to indicate both depth discrimination and preferences for 3 dimensional or solid figures.

As a result of experiments on early sensory deprivatic Fantz postulated a "complex interaction of innate, maturational, and experiential influences on the development of pattern selectiveness".

In the last two experiments which Fantz discussed, he studies the effect of successive exposures on fixation time. In one experiment 2 stimuli were presented singly in alternating exposures. Each exposure consisted of 5 repeated presentations of one stimulus. Though Fantz had expected fixation to decrease with repeated presentations of one stimulus and to increase when the stimulus was changed, this, in fact, did not happen. Instead, there was an overall response decrement (though the 3rd and 4th and sometimes the 5th fixation appeared to be less than the first and/or second for any 5 presentations). The infants in question were 2 to 6 months old. In the other experiment, infants were allowed to view either the same pattern or varying patterns of the same relative complexity.

Infants of the same age showed a decrease in fixation time to the same pattern and a slight increase to the variable pattern. Fantz suggested that his results could be interpreted as evidence that infants over 2 months can in some sense recognize a pattern they have seen, at least a short time before.

"Thus action as well as perception may have an effect on later visual behaviour during the early months; the question is that of the degree and type of influence of each. It is difficult to imagine how a lasting or consequential effect on what is perceived or what is learned from experience can result from a general decrease in length of fixation, while decreased attention to repeatedly exposed patterns can easily be shown to be essential for effective visual exploration and familiarization with the environment.

"In the adult organism, and presumably in the infant as well, visual exploration allows examination of objects and places of potential importance for present or future behaviour. Neither unvarying reflex fixations nore completely random fixations will serve this function; visual preferences assure both variability and selectiveness in the explorations. At first exploration is facilitated by the unlearned pattern selectiveness. Eventually, perhaps starting around 2 months of age, the explorations are made more efficient by less looking at objects already explored, leaving more time to examine unknown objects. The unlearned selectiveness remains useful in the selection among novel objects and for preventing complete habituation to objects of potential importance for behaviour."

In conclusion Fantz listed some of the following points:

1) From birth onwards, human infants can "see and discriminate patterns as the basis of form perception". In comparison to adults, all infant's perceptual abilities are limited, yet they are sufficient to permit much visual experience.

2) "Visual patterning is intrinsically stimulating or interesting. It elicits much more visual attention from birth than do colour and brightness alone". In general, more complex patterns are preferred to the simpler.

3) "At some point, at least by the third month, the unlearned visual selectiveness begins to be modified by past visual experience. One of the changes is decreased attention to familiar patterns and consequently

increased attention to novel ones".

Fantz considered his findings to give evidence that "in development, visual perception precedes action rather than the reverse".

In basic agreement with Gibson and Gibson (1955) Fantz hypothesized that perceptial learning may be nothing more than experiential changes in selective attention.

Unfortunately, most of Fantz' experiments lack sophisticated design, particularly as regards controls, to warrant all the generalizations he makes. Above all, the infrequency of statistical tests make it difficult to accept as significant certain conclusions, especially when they have not been substantiated by other studies.

[physiology] Kiff and Lepard (1966) used the optokinetic nystagmus to study the visual development of 44 premature infants, weighing 2 lbs. 7 oz. to 5 lbs. 8 oz. Only 24 infants responded to the experimental situation. A Snellen visual acuity of 20/820 was obtained for the majority of infants 4 lbs. or over. The earliest response was given by an infant weighing 3 lbs. 1½ oz.

[physiology] Brazelton, Scholl and Robey (1966) tested 96 neonates during the first week for ability to fixate and to pursue visually a test stimulus. Of normal infants, 57½% evidenced both pursuit and fixation while 7% yielded an optokinetic response. Abnormal infants were capable of neither.

[motility, fixation] Stechler, Bradford and Levy (1966) also studied visual attention in neonates. Fifteen 2 to 6 day old infants showed "lower motility and greater reactivity of skin potential while attending to a visual target than when equally alert but inattentive". By contrast, electrodermal reactivity was enhanced when an infant fixated a target. This fact was interpreted as indicating that relative motor quiescence during fixation is "not simply an indication of overall inhibition". Stechler, Bradford and Levy considered motor quiescence to be best compared to vigilance in more mature humans.

[fixation] Haith (1966) focused on the suppression of non-nutritive sucking by an intermittent moving stimulus. Forty-one infants, aged 3 to 5 days, showed a greater reduction in sucking to experimental than to control trials. "No habituation was found with repeated presentations of the stimulus". Nor were any sex or age differences related to the suppression of sucking rate. In other words, even very young infants like to look and will divide their attention between sucking and looking. These results are compatible with those of Wolff and White (1965).

[fixation, pattern perception] Another study with neonates was carried out by Salapatek and Kessen (1966). Twenty awake, alert neonates, aged 7 days or less, were presented with either a homogeneous blank field or a large solid central triangle. Infra-red photographs were taken of the corneal reflection for one eye only. Visual scanning of a homogeneous field tended to be "widely dispersed with a greater dispersion in the horizontal than in the vertical dimension", while scanning of a triangle was markedly less dispersed, with ocular orientations clustering at one of the vertices only and not in the central region of the figure. Infants responded only to a part of the stimulus and not to the whole stimulus. The authors speculated that for very young infants "a preferred figure may well be one in which there is a predominant number of attractive elements".

[physiology] An attempt to determine an absolute threshold for very young infants was carried out by Doris and Cooper (1966). 16 infants, 4 to 69 days old, viewed a field of moving black and white stripes of varying intensities. A filmed record was made of each infant's optokinetic nystagmus response to the varying intensities of illumination. When Weber's fraction and the difference between the black and white stripes were calculated, they correlated significantly with age, indicating that "brightness sensitivity undergoes rapid development in the first two months of life". Doris and Cooper pointed out that their results were compatible with those of Fantz, Ordy and Udelf (1962) and of Zetterström (1955). The validity of the Weber fraction, however, was called into question because of an unforeseen confounding of changes in overall intensity in the stimulus pattern. Therefore the experiment was repeated, the results of which were published the following year.

1967

[physiology] Doris, Casper and Poresky (1967) calculated the differential brightness thresholds for 10 younger infants, aged 1 to 4 days, and for 10 older, aged 45 to 113 days. Using the optokinetic nystagmus response to a moving field of alternate light and dark-grey stripes, they obtained an average Wever fraction of .50 for the younger and of .26 for the older. This difference was significant and therefore was taken as evidence for "rapid development of brightness discrimination in the first months of life". The authors speculated that neonates may register half-tones (greys) with much loss of detail due to their inability to resolve anything but strong contrasts in greys. (While infants of 5 to 6 months, by implication, appear to be capable of somewhat more subtle differentiations). If such a loss of detail does occur, it would tend to reduce the "meaningfulness" of stimuli from the "infant's point of view".

[physiology, methodology] Wickelgren (1967) presented 28 awake neonates, aged 2 to 5 days, with pairs of stimuli. Photographs of ocular orientation were interpreted as indicating, in contrast to Dayton et al (1964), that to a large extent a neonate's eyes do not necessarily converge upon the same part of a given stimulus or even necessarily upon the same stimulus. However, the difference between these two studies appears to be one of criteria applied to observations rather than of observations per se. Unfortunately, dominant position preferences made it virtually impossible to obtain reliable stimulus preferences. In conclusion, Wickelgren suggested that variability rather than duration of ocular orientation may be a more accurate measure of attention.

[cognition, sex differences, methodology] McCall and Kagan (1967) conducted an experiment in which a standard stimulus pattern on a mobile was exposed to fifteen first-born infants regularly for one month. The experienced or familiarized infants as well as thirty first-born non-experienced or "naive" infants were tested at the fourth month with the standard stimulus and with three stimuli which deviated from it. Magnitude of cardiac deceleration for female infants was "an increasing function of the degree of discrepancy" between the standardized stimulus and stimuli which were graded discrepancies from it. The cardiac responses of male infants revealed no such differentiation. McCall and Kagan concluded that a stimulus event which "closely matches a schema elicits less deceleration than a moderately discrepant event, while a stimulus which is moderately discrepant evokes greater deceleration than if the stimulus is completely unfamiliar". That is, cardiac deceleration can be used as "an index of the dynamic process of matching a new imput to a schema". To explain the sex differences, McCall and Kagan speculated that "girls are perceptually precocious compared with boys". Measures of fixation were also taken but gave no significant results.

[cognition, sex differences] Another experiment using the cardia response was carried out by Meyers and Cantor (1967). Twenty-two male and an equal number of female infants within one week of six months were familiarized with repeated presentations of either a photograph of a ball or a clown. Measures of fixation, heart period change (i.e., the difference between the pre-stimulus and the old stimulus levels of heart rate) and latency of heart period change gave no evidence of response decrements during the familiarization period. When a "novel" stimulus was presented, heart period latency responses indicated that infants responded differently to a familiarized and to a novel stimulus. Males only showed a significantly larger heart period change to non-familiarized stimuli than to familiarized. However, visual fixation times failed to show any differences between familiarized and non-familiarized stimuli. Meyers and Cantor noted that the deceleration of cardiac response found by them was congruent with similar findings by other researchers (Kagan and Rosman, 1964; Lacey, Kagan, Lacey and Moss, 1966) that a decrement in heart rate accompanies presentation of visual stimuli.

[pattern perception, methodology] Caron (1967) rewarded 22 infants, aged 3½ months, with variable patterned stimuli whenever they rotated the head in the appropriate direction. Differential reinforcement increased head turning in the desired direction. However, when contingent pattern stimuli were withdrawn and instead, an imageless stimulus was substituted, extinctinction took place. Some infants became angry, fussy, fretted or even cried in "protest" to the withdrawal. Caron therefore concluded that "it was the opportunity to view an image and not illumination change or its accompanying auditory events which maintained the infant's behaviour" and that "the opportunity to view heterogenerous visual patterns is reinforcing for infants".

1968

[fixation, cognition] Nelson (1968) presented 21 infants, aged 42 to 133 days, with repetitions of a left-to-right linear sequence of lights. Video-taped records of eye movements indicated that infants show "an initial persistent tendency to track only in strings of adjacent lights". Anticipatory eye movements were noted, suggesting at least a primitive form of stored representation or plan which guide eye positioning in a visual field temporarily devoid of stimuli. Obviously, four month old infants can scan moving stimuli. The question remains, however, whether infants scan a non-moving, complex stimulus.

[fixation, pattern perception, methodology] Bruner (1968) reports the results of two experiments. In the first experiment, Siqueland obtained evidence that three-month old infants would adjust their sucking to increase the illumination of a picture projected on a back-lighted screen. In the second experiment, Kalnins demonstrated that infants would "work for visual clarity" by co-ordinating the "two ordinarily independent activities of sucking and looking". Infants one to three-months of age were presented with an unfocused picture which they could bring into focus by sucking on a pacifier (i.e., dummy). However, if sucking drove a picture out of focus, then infants would refrain from the activity even when a pacifier was available (i.e., in the mouth).

[face perception] In an experiment by Wilcox and Clayton (1968), ten female infants, aged 20 to 23 weeks, were allowed to fixate silent, colour motion pictures of a woman's face either smiling, frowning or neutral in expression. All pictures elicited significantly greater amounts of fixation than a controle stimulus (white light). Moreover, moving faces elicited more fixation than non-moving faces. But no differential reactions to facial expression were found. Wilcox and Clayton suggested that "movement may be an important variable in visual preference regardless of the stimuli used". They also noted that their study was unable to find a negative correlation between visual fixation and body activity as reported by Kagan and Lewis (1965).

[habituation] Caron and Caron (1968) recorded the fixation of 50 3½ month-old infants to successive exposures of differing stimuli and of the same stimulus. Fixation decreased whenever the same stimulus was presented several times in succession, though the degree of decrease was least for the most complex stimulus used. In all cases, fixation increased whenever a stimulus changed. It is most interesting that infants were observed to protest vocally and to become restless when a stimulus was repeated. This negative behaviour accompanied decreased fixation.

1969

[pattern perception, habituation, sex differences] Caron and Caron (1969) extended an experiment published the previous year. Ninety-six infants, 14 to 16 weeks old, were allowed to fixate varying and repeated exposures of visual stimuli. Fixation of a given pattern "declined significantly during repetition and upon subsequent re-exposure, the amount varying inversely with the complexity of the decrement". Though female infants showed a steeper decrement than boys, Caron and Caron considered it premature to accept the hypotheses of Kagan and Lewis (1965) and of Kagan, Kenker, Hen-Tov, Levine and Lewis (1966) that female infants are "maturationally ahead" of male. Caron and Caron did agree, however, with Brennan, Ames and Moore (1966) that a relatively more complex pattern is more likely "not only to recruit but also to maintain the attention of 14 to 15 week-old infants".

[pattern perception] Moffett (1969) presented 40 infants, aged 10 - 14 weeks, with a homogenous field paired with a stimulus pattern. Stimuli consisted of series of horizontal or vertical stripes of differing number and/or arrangement and of square areas created by the intersection of the vertical and horizontal stripes. All stripes were black lines on a white ground. Infants focused more frequently on patterned stimuli than on a homogenous field. "Infants looked longer at patterns with a greater number of lines, regardless of whether they were arranged regularly or irregularly".

No "preference" was found for either horizontal or vertical lines, but for a combination of the two. A pattern with more (i.e., 16) squares was preferred to one with less (i.e., 12); that is: "when the number of parts was varied, the number of lines became a less important determinant of visual preference". Moffett added that the patterns were probably easily resolved since infants invariably preferred the more complex. Moffett's findings are compatible with those of most previous experiments. Unfortunately, few new conclussions were reached.

[face perception] A more sophisticated version of the Wilcox and Clayton 1968 study was carried out by Wilcox alone the following year (1969). In the later study, she took measures of total and first fixation for 30 infants, aged either 4, 10 or 16 weeks, in response to 7 pictures of faces: a photograph; a realistic drawing; schematic drawings of a complete, of 3 incomplete, and of a scrambled face. No significant difference between the schematic and the scrambled faces were found at any age levels. Neither the presence nor absence of either eyes or nose or mouth was correlated with any change in visual behaviour. By 16 weeks the photograph did elicit greater total fixation than the drawings. Data from the first fixation gave varying results. Over all, there did seem to be a "preference" for a more realistic representation of the face by 16 weeks, but there was no evidence that the younger infants preferred a face-like pattern to a non-face-like pattern when both were of equal complexity, at least when represented schematically. These results are similar to those of Koopman and Ames (1967) who likewise found no significant differential fixation between a schematic face and a symmetrically scrambled controle stimulus. In general, complexity was considered to outweigh "faceness" as a determiner of preferences.

Unfortunately, in both the Wilcox and Clayton (1968) and the Wilcox (1969) scores of fixation were made directly during the experiment and without the aid of either slow motion video-tape or film. Though reliability between observers was high, the validity of such a method is always questionable and may account in part for lack of more significant results.

[cognition, methodology] Rovee and Rovee (1969) studies 18 infants, aged 9 to 12 weeks. All infants were supplied with a coloured mobile which they could fixate. An experimental group of 6 infants was supplied with an ankle cord so that leg movements could directly affect the movement of the mobile. Within the first six minutes of conjugate reinforcement of foot thrusts, operant response rate tripled for experiment

Rovee and Rovee considered their results to be "true learning as a direct result of the contingency between the thrust and the mobile movement", and not to reflect "merely a state of general arousal produced by the moving target". Moreover, they suggested that Piagel's sensory-motor Stage III ("Procedures for Making Interesting Sights Last") might be effectively brought about in advance of 4 months by operant procedures. Similar results were obtained by Caron (1967).

[fixation, pattern perception] Nelson and Kessen (1969) compared the visual responses of 36 infants, 6 days or under, to three separately presented stimulus patterns: "a complete outline triangle, only the sides of this triangle, and only the angles or verices of this triangle". Experimental results re-affirmed the conclusion of Salapatek and Kessen (1966) that "angular components of triangles are more powerful than linear side contours in attracting ocular orientation of new-born infants". Moreover, "infants typically looked only toward a single angular component" and did notscan the triangles. It will be remembered that Bower (1966) observed how two months old infants were able to complete a visually incomplete. It would therefore appear that by the end of the first month, infants no longer fix upon selected features but are able to scan and/or to register a stimulus as a whole, and that the non-angular parts of a structure such as sides per se have become more important.

[fixation, cognition, physiology] Wickelgren (1969) photographed the eyes of 36 neonates, aged 19.5 to 134 hours, in "response to intermittent visual movement created by sequentially illuminated lights". All infants "responded to the moving lights by shifting direction of gaze appropriately towards the left or right lights. Conjugate eye movements were observed with a frequency about 45 - 50%, but eyes were frequently non-convergant. Wickelgren's 1969 findings are compatible with those of Nelson (1968) though scanning of a moving stimulus was found to be earlier.

[fixation, cognition, habituation] In a similar experiment, though with older infants, Cohen (1969) investigated the effects of complexity of a matrix of blinking lights on 90 infants aged 2 to 6 months. Longest fixations were initially given to stimuli of intermediate complexity (i.e., position change) and tended to decrease over trials. However, only one part of the experiments indicate that greater stimulus change was correlated with less habituation.

Cohen pointed out that a "reduction of fixation time over trials does not necessarily indicate habituation". He considered his experiment to confirm the prediction that "an intermediate level of stimulus change will produce maximal visual exploration".

[motility, fixation, cognition] Still another experiment to use a matrix of blinking lights was published the same year as the previous two by Haith, Kessen and Collins (1969).Twelve 2 to 4 months old infants were presented with 3 levels of visual complexity. The stimuli were intermittent flashing lights which gave the effect of movement. Contrary to Kagan and Lewis (1965), limb movement and rate of sucking were suppressed by the most simple and by the most complex levels of stimulation but were facilitated by the intermediate level. There was no evidence for any systematic habituation. Of course, different experimental procedures may account for the differences between the two studies.

Berlyne's (1960) optimal-level hypothesis would predict the greatest suppression of activity to intermediate complexity or an inverted U-shaped curve. Haith, Kessen and Collins found exactly the opposite curvilinear function. Sucking was consistently suppressed by stimulation but unfortunately the degree of suppression did not appear to be discriminative of the various degrees of stimulus complexity which were under study.

1970

[physiology, pattern perception] Miranda (1970) compared 27 premature infants of less than 38 weeks conceptional age and 27 full-term neonates. Prematures were on the average post-natally older by 21 days than were the full-term infants. Nonetheless, both premature and full-term infants showed a strong preference for patterned over plain stimuli. Though no reliable preferences for linear or round contours were evidenced, a schematic face was preferred to a photograph of a face lacking in sharp contrast. A higher proportion of subjects in each group tended to fixate longer a circle with 2 centrally-located dots than with similar dots together at the periphery. Obviously, premature infants can be considered to have a "functional system for receiving patterned stimulation".

Although few differences were to be found between the prematures and the full-term, this lack of results could have been indirectly due to the difference in post-partuitional ages.

Miranda was most explicit that "it is not necessary to assume equal visual and neural development for the two groups". He concluded that it was necessary only to assume "that both groups have sufficiently developed eye and brain to discriminate some rather gross differences between stimuli;

and that both groups having the minimal sensory requirements, also have the tendency to select the same stimulus of the pairs".

[habituation, sex differences] Friedman, Nagy and Carpenter (1970) studied 20 male and 20 female neonates, aged 24 to 90 hours. Visual fixation was observed to decrease with successive presentation of each of two stimuli. Males showed more decrement in fixation time to the simpler stimulus; females, to the more complex. Because of the particular sex differences found in their study, Friedman, Nagy and Carpenter pointed out that their results were not consistent with the conclusions of Ames (1966), Caron and Caron (1969), Kagan and Lewis (1965), and Kagan, Heakey, Hen-Tov, Levine and Lewis (1966), though "a differential process of information storage and processing may exist for the two sexes as reflected in overt visual behaviour".

[handling] Another study with neonates was conducted by Korner and Thomas (1970). Sixty-four 2 to 3 day old infants were given 6 "interventions" which consisted of contact, vestibular stimulation or upright positioning, singly or in various combinations with each other. Infants were then rated for alertness. No sex differences were found. Likewise, no differences were associated with mode of feeding (breast or bottle). In spite of considerable individual differences, Karner and Thomas concluded that "in the context of soothing the infant, vestibular stimulation had a highly significant effect on alerting". Contact per se had little effect except when combined with vestibular stimulation and upright positioning. Karner and Thomas speculated that "vestibular stimulation which attends most caretaking activities may be more crucial than contact for certain aspects of early human development".

[depth perception] Bower (1970) conducted four experiments using a total of 39 infants ranging from 6 to 20 days of age. He observed that neonates show a visually controlled, distially appropriate avoidance response to approaching objects provided the object does not approach at a velocity greater than 25 centimetres a second. Bower emphasised that this discrimination was mediated neither by changes of air pressure nor by proximal cues.

[depth perception, cognition] Two further experiments on neonatal perception were conducted by Bower with the assistance of Broughton and Moore (1970). In the first experiment, 5 infants, aged 6 to 11 days, were presented with a three-dimensional object in one of 5 positions: midline; 30 degrees right; 60 degrees right; 30 degrees left, and 60 degrees left. Seventy per cent of all attempts to grasp the object came within 5 degrees (i.e., 1.5 centimetres) of the object and was therefore considered to be "oriented". In order to test the intentionality of visually-directed grasping behaviour, a second experiment was designed. Eleven infants, ranging from 8 to 31 days, were fitted with goggles and presented with a virtual object. It was assumed that if the infant intended to grasp an object then a virtual object would frustrate him; and to the contrary, if he did not, then he would experience no frustration. All infants cried 15 to 75 seconds after their first reach towards the virtual object, whereas no infant cried when reaching and contacting the real object. Bower, Broughton and Moore interpreted this as evidence for intentional grasping.

[cognition, habituation] Hunt (1970) distinguished between "perceptual satiation" (which occurs in response to continuous perceptual contact with a stimulus) and "habituation" (which occurs in response to repeated encounters with the same stimulus separated over considerable periods of time). "Perceptual satiation" would then explain how a preference for a non-familiar stimulus would take place before experience with a familiar stimulus had produced "the enduring central process codings within the central nervous system required for recognition at another time (long-term memory)". As a result of this distinction, Hunt postulated a stage of attentional preference for the familiar preceding attentional preference for what is unfamiliar or novel.

[cognition, habituation] Uzgiris and Hunt (1970) placed two mobiles over the cribs of 15 one month old infants for 4 to 5 weeks. Infants were then tested twice during the second month and again during the third. Twelve of the fifteen looked longer at the familiar pattern while none looked longer at the unfamiliar. In other words, repeated encounters with the experimentally familiarized stimuli lead to infants fixating those stimuli more frequently than novel stimuli.

As a second part of their experiment, Uzgiris and Hunt compared infants' fixation of one mobile which would move in response to their actions and of another which remained motionless. It was hypothesized that infants would fixate more frequently the responsive mobile. In contrast to Caron (1967) and to Rovee and Rovee (1969), Uzgiris and Hunt did not find a preference for the responsive mobile. However, the measure in question was visual fixation and not behaviour associated with making the mobile respond.

[cognition, habituation] Greenberg, Uzgiris and Hunt (1970) extended the previously-mentioned experiment. Twenty-four one month old infants were exposed regularly to a patterned stimulus. At the age of two months, infants were tested to compare their reactions to familiarized and non-familiarized stimuli. Most infants spent "longer than half the total looking time" attending to the familiar stimulus. However, when tested again at 3 months, the same infants looked longer at the unfamiliar stimulus. Greenberg, Uzgiris and Hunt concluded that there is "strong evidence for the existence of a process, deriving from perceptual exposure to a pattern, with a phase of attentional preferences for familiar pattern developing before the appearance of attentional preferences for the unfamiliar or novel". Since only three days of familiarization were necessary to bring about a preference in ten naive or controle infants (aged 3 months) for novel stimuli, maturation was considered to be a likely explanation of the shift.

1971

[cognition, habituation, sex difference] Weizmann, Cohen and Pratt (1971) conducted an experiment in which thirty-two infants 4 weeks old, were exposed for a half hour daily to "one of two stabiles in one of two basinettes". At 6 weeks, infants looked significantly more at the familiar than at the novel stimuli. But by 8 weeks, the novel stimulus received more looking than the familiar, though the degree of difference was not significant. Most curious was a significant "sex x environmental novelty by (=new basinette) x stabile novelty" interaction which indicated that the 8 weeks old males in the study looked more at a novel stabile in a familiar environment, while females looked more at a novel stable in a novel environment. Weizmann, Cohen and Pratt pointed out that this finding is incompatible with McCall and Kagan's (1967) tentative speculation that females may be more advanced than males.

[methodology, pattern perception] McKenzie and Day (1971) trained 10 infants, aged 6 - 12 weeks, to turn their head to the left in the presence of a predetermined stimulus and demonstrated that head turning could be brought under visually discriminated control. The authors emphasized the ambiguity of drawing conclusions from measures of fixation: "An infant may be able to perceive differences in stimuli without this difference necessarily being reflected in duration of fixation. Furthermore, any changes with age may indicate either a change of preference or of the attention-eliciting properties of the stimulus, rather than the infant's power of discrimination". They therefore concluded that an operant conditioning technique similar to the one used in their study could be used as a method (alternative to measure of fixation) for the study of perceptual discrimination during early infancy.

[methodology, pattern perception, sex differences] Greenberg and Weizmann (1971) tested 12 infants at 8 weeks and another 12 at 12 weeks to determine relative fixation times to 3 checkerboard patterns of various degrees of complexity. All infants were tested with a single stimulus and with a paired-comparisons method of presentation. Both methods were found to yield results depicting similar age and sex differences. All older infants fixated longer the more complex patterns. Yet females fixated the more complex stimuli relatively longer than the males. Females appeared to focus more exclusively on "favored" stimuli and to ignore the rest of the environment whereas males tended to deploy "their attention more widely when an alternative stimulus was readily available". Though both experimental methods were considered to be comparable, Greenberg and Weizmann advocated that "the paired comparisons method was superior in distinguishing ... blank looking from meaningful perceptual-cognitive interaction with a stimulus". Greenberg and Weizmann made no explicit reference to position effects though it appears that infants in their study did not attend equally between both sides.

[cognitive] Bower (1971) reviewed his research on infantile perception of objects. In addition to the findings of his 1970 papers (Bower, 1970 Broughton and Moore 1970), he reports the results of an experiment on infants' reactions to the disappearance and re-appearance of an object. Infants were 3 weeks to 3 months of age. Using change of heart beat, Bower concluded that infants manifested surprise when a moving object disappeared behind a screen but did not re-appear. The older the infant, the longer a delay it was capable of enduring and still show evidence of expecting an object to re-appear. Moreover, all infants anticipated the re-appearance of an object, i.e., they look to the spot where the object should re-appear. However, infants continued to track a moving object along its trajectory even after seeing the object stop. As a result of further experiments, Bower came to the conclusion that "three-month old infants do not recognize the identity of an object at a standstill and the same object in motion, and vice versa". For younger infants, movement was more important than features of an object, they did not seem perplexed when one object was substituted for another so long as the object kept moving in the same trajectory. In contrast, the older infants seemed "to have learned to define an object as something that can go from place to place along pathways of movement". That is, an object is identified by its features rather than by its movement. The transition to a world of solid objects which have features and which can move in space was considered to take place sometime around or after 16 weeks. When an infant 19 weeks or less is presented with multiple images of his mother via an arrangement of mirrors, he coos, goos and responds to all the images. The more the merrier, so to speak. But after 20 weeks, an infant becomes quite upset by the image of more than one mother.

Summary of Literature

An infant's perceptual abilities are influenced by the presence or absence of medication during labour (Stechler, 1964) and by subsequent handling (White and Castle, 1964; Korner and Thomas, 1970).

The fixation reflex is present in all normal full-term and many premature infants (Kiff and Lepard, 1966). Most full-term neonates evidence conjugate eye movement as well (Brazelton, Scholl and Robey, 1966), though eyes do not always converge (Wickelgren, 1969). Moreover, some neonates possess a visual acuity of at least 20/150 (Dayton et al, 1964). However, focal length is fixed for the first month or so at an average of 19 cm. (Haynes, White and Held 1964). Probably, the neonate is able to perceive clearly only strong contrasts of greys (Nelson 1968). Unable to scan a stationary pattern, he fixates only one part of it, such as a corner or angle (Salapatek and Kessen, 1966; Nelson and Kessen, 1969), though he is able to track a moving stimulus (e.g. Wickelgren, 1969; Bower, 1971). By 4 months his visual system seems roughly equivalent in most respects to an adults' (Haynes, White and Held, 1965; Bower, 1966).

Infants are definitely capable of distinguishing colours (Valentine, 1913; Staples, 1932), though form and shape appear to dominate colour in attracting visual attention (e.g. Fantz, 1961, 1963; Spears, 1964). Pattern or contour have been described as intrinsically interesting (Fantz, 1958, 1961, 1963, 1966; Berlyne, 1958). Moreover, infants will clearly "work" for visual clarity (Bruner, 1968). Though the mere presence of patterned stimulation has been found sufficient to elicit attention (Stechler, 1966; Moffett, 1969) infants tend to prefer stimuli which change or move in response to their own actions (Caron, 1967; Rovee and Rovee, 1969). From the first days onward, figure is perceived against ground; objects are isolated and perceived in depth (Bower 1964, 1966, 1970, 1971; Bower, Broughton and Moore, 1970; Fantz, 1966).

Moreover, complexity of a stimulus has proved an important variable. Though the results of experiments on infantile reactions to stimuli of varying degrees of complexity are dependent upon an actual stimulus condition and upon specific experimental procedures, it appears that relatively more complex stimuli elicit greater amounts of, and more frequent fixation than, simpler or homogeneous stimuli. However, there appears to be an optimal range of complexity which varies according to age. A stimulus can be too simple or too complex, an optimal stimulus lying somewhere between the extremes of complexity and simplicity. The older an infant, the more likely he is to fixate preferentially a more complex stimulus. (Herschenson, Munsinger and Kessen, 1965; Thomas, 1965; Brennen, Ames and Moore, 1966; Caron and Caron, 1969; Moffett, 1969; Cohen, 1969; Haith, Kessen and Collins, 1969)

Some experimentors (Saayman , Ames and Moffett, 1964; Friedman, Nagy and Carpenter, 1970; Fantz, 1966) claim that infants "habituate" to successive presentations of a stimulus, though the results of a few studies (Kagan and Lewis, 1965; Haith, 1966; McCall and Kagan 1967; Meyers and Cantor 1967) give results to the contrary. It appears that results may depend not only on the behaviour used to indicate perception but also on the nature of the experimental design. Nonetheless, visual fixation tends frequently to decrease with repated presentations of a stimulus. Hunt (1970) points out, however, that there is no justification fcr equating response decrement and habituation when stimulus presentations come in close succession or when they last for a considerable length of time. According to Hunt (1970), and to Cohen (1969), decrement in fixation of one stimulus over one interval or over several successive intervals is an indication of "perceptual satiation" and habituation, to the contrary, presupposes the "internalization" or commitment to long-term memory of a stimulus which can then be compared with itself at a later point in time. When the distinction between perceptual satiation and habituation is made, there is evidence that a stage of perceptual preference for the familiar precedes a preference for the novel (Uzgiris and Hunt, 1970; Greenberg, Uzgiris and Hunt, 1970). The degree to which such a sequence of preferences is maturational, experential or a combination of the two is still open to question. Different experiments point to contradictory conclusions (Greenberg, Uzgiris and Hunt, 1970; Weizmann, Cohen and Pratt 1971).

Most interesting has been evidence for possible sex differences. In some experiments, female infants have been found to be more capable of sustained attention than males or to "prefer" more complex stimuli (Kagan and Lewis, 1965; McCall and Kagan, 1967; Meyers and Cantor, 1967; Caron and Caron, 1969; Friedman, Nagy and Carpenter, 1970; Greenberg and Weizman, 1971). Kagan and associates frequently interpret this finding to indicate visual precocity in the female; other authors are more hesitant about such an interpretation. However, some experimentors have found no sex difference or, to the contrary, evidence that males remain more responsive than females, (Haith, 1966; Caron, 1968; Weizmann, Cohen and Pratt, 1971).

It has been suggested that the facial gestalt is "preferred" to (i.e. more frequently fixated than) other patterns (Fantz, 1966). Not all experiments support this hypothesis, however. In one experiment (Kagan et al, 1966), four months old infants showed no differences in cumulative fixation for masks of a natural face, a face with scrambled features or even without features. Yet smiling and large decreases in heart rate were significantly more frequent to a natural face pattern. Likewise, other experiments (Koopman and Ames, 1967; Wilcox, 1969) found no preferential fixation of face-like stimuli when alternative non-face-like stimuli were of equal complexity. In short, complexity seemed to outweigh "faceness" as a determinor of fixation. Nonetheless, a photographed face was fixated increasingly longer at four months, which in fact suggests that a more realistic respresentation of the face is "preferred" by the beginning of the second quarter.

The orientation of the face may also be an important variable (Watson, 1966). The presence of the eyes has been stressed by several experimentors (Spitz, 1946, 1948, 1965; Ahrens, 1954; Kagan, Henker, Hen-Tov, Levine and Lewis, 1966). Facial expression, however, seems to be of little importance during the first months (Wilcox and Clayton, 1968).

Methodological problems seem to plague infantile perception research as virulently as they do comparable adult studies. Above all, the age of individual infants and the range of ages in a sample can provide significant sources of variation. A week old infant is perceptually very different from a year old. Other problems are equally formidable. Firstly, the actual stimuli used appear to determine in part the type of responses an infant emits. What might be an intermediately complex stimulus in one study can be equilivant to the simplest or to the most complex in another. Secondly, the method of stimulus presentation is important. The two methods most frequently used are the single stimulus and the paired stimuli methods. Some authors claim these two methods give the same results (Greenberg and Weizmann,1971), though others have claimed that the paired stimulus method is unpracticle for infants under 6 months (Ames and Silfen, 1965). Thirdly, the problem of behavioural measures for discrimination and their meaning has not been solved as of the present. Some authors use first fixation, longest fixation or cumulative fixation (Berlyne, 1958, Fantz, 1966, Cohen, 1969). Others use habituation or "perceptual satiation" (Caron and Caron, 1968, 1969; Friedman, Nagy and Carpenter, 1970; Uzgiris and Hunt, 1970; Greenberg, Uzgiris and Hunt, 1970) Still others use responses such as heartrate, crying, smiling, bodily activity or any combination of these (Lewis, Kagan and Kalafat 1966; McCall and Kagan, 1967) a few utilized operant techniques (Bower, 1966; Caron, 1964)

Considering the varieties of experimental possibilities it is surprising that so many of the published researches have yielded compatible results.

PART II

INFANTILE PERCEPTION OF THE HUMAN FACE: ORIGINAL EXPERIMENTS

INTRODUCTION

Since there is evidence that infants four months or younger can distinguish a three dimensional object from a two dimensional (Bower 1970), that complexity of a stimulus is an important variable(Moffett, 1969) and that a more natural and/or more complete facial pattern seems to be preferred to other approximations of it (Wilcox, 1969), it would therefore be reasonable to question an assumption implicit in the conclusions drawn from several previous experiments. This assumption is that an infant would react similarly to a real, living human face as he has been shown to react to various approximations to it. The question is: From the infant's point of view, are masks, schematic drawings, photographs and plaster casts the same as an actual face?

Obviously, the human face is a very rich and extremely complex stimulus-Gestalt, but unlike most other equally complex Gestalten, it has specific social implications. Therefore, the following experiment was designed as a pilot study to investigate which parts of a living human face must be perceptually present if it is to be recognised by an infant.

PILOT STUDY

Visual recognition and discrimination in the human infant are inferable from a variety of behaviours in response to visual stimuli:
(a) differential fixation (Berlyne, 1958; Fantz, 1966, Cohen,1969),
(b) differential rates of habitation and of spontaneous recovery from habituation(Caron and Caron, 1968, 1969; Friedman, Nagy and Carpenter, 1970),

(c) differential changes in heart rate (Lewis, Kagan and Kalafat,1966; McCall and Kagan, 1967; Meyers and Cantor, 1967),

(d) differential changes in respiration (Lewis, Kagan and Kalafat,1966),

(e) differential changes in skin potential (Stechler, Bradford and Levey, 1966),

(f) differential changes in gross bodily activity or motility(Lewis, Kagan and Kalafat, 1966; Stechler, Bradford and Levy, 1966),

(g) differential smiling (Ahrens, 1954; Watson, 1966),

(h) differential vocalization and/or crying (Lewis, Kagan and Kalafat, 1966),

(i) differential supression of sucking(Haith, 1966),

(j) differential emission of operant responses(Bower, 1966;Caron,1967).

In the present study, fixation was chosen as the prime behavioural measure (1) because nothing is done to or attached to an infant (and thus neither mother nor infant is threatened), (2) because it involves no training of either infant or mother (and thus does not interfere in their relationship or routines), (3) because it is the least consuming of a mother's and of an infant's time and goodwill, and (4) because it is relatively uncomplicated and inexpensive. Therefore, a modified Fantz technique was employed with the basic assumption that differential fixation presupposes visual discrimination. Fixation, however, has been criticized as a behavioural index of "preference" (Kagan, Henker,Hen-Tov, Levine and Lewis, 1966). Consequently, it was decided to note the occurrence of alternative behavioural indices of "preference" and of its converse, "aversion", such as smiling, vocalisation, crying or the like.

Subjects and Apparatus

Twelve white infants from working and middle class London families were seen within an hour after the morning or afternoon feed. Mean age was fourteen weeks. Each infant was placed in a "safe-sitter" within a "looking box", designed in the form of a truncated pyramid, open on top. In one wall was constructed a window, covered by a shutter which could be opened to expose the stimulus.

Stimulus Conditions

For each infant, the stimulus was his own mother's face, under the following 6 conditions:

1. full face, i.e. a normal or complete face,
2. face without eyes, i.e. face with both eyes blocked by a strip of plastic inserted between the infant and the mother's eyes,
3. eyes only peering through an open band in the plastic which masked the rest of the face,
4. face without hair and forehead; i.e. face from eyebrows down, hair and forehead blocked by plastic,
5. face without nose and mouth; i.e. face without mouth and lower part of nose blocked by a plastic strip,
6. artificial outline, i.e. face peering through a circular hole in a plastic strip which concealed the natural outline.

Conditions were presented in a prearranged order, different for each infant. The presentation of each condition lasted 20 seconds, followed by an equal interval intended as a recovery period.

RESULTS

Four measures were used: (1) cumulative fixation, (2) response latency, (3) looking away (4) smiling.

Cumulative fixation: Ocular orientations to the stimulus were monitored by a concealed close circuit television system. The physical construction of the apparatus did not permit recording of the corneal reflection. Measurements of cumulative fixation as determined by orientations were taken from a video-tape record. These results, divided into two sub-groups according to age(i.e. younger and older), and arranged in order of magnitude of response are depicted in Table I; the analysis of variance is summarised in Table II. There was no significant change with age either generally or for any particular conditions. Nonetheless, the mean cumulative fixation for all conditions within the younger group is smaller than all for the older. The exact probability that this would occur is 1/64 and thus significant as to direction, though not as to degree of difference. Only differences between conditions were significant ($p < .001$). Therefore Duncan's Multiple Range Test was carried out on the mean cumulative fixation per condition for all 12 subjects: "Face without eyes" was different from all other conditions ($p < .001$). "Eyes only" were significantly different from "artificial outline" ($p < .05$), but not from any other conditions except "face without eyes". There was no statistical difference to be found among the other conditions: face "without hair and forehead", "without nose and mouth","full face" or "artificial outline".

Since "face without eyes" was fixated much less frequently than the remaining conditions and since total fixation of "face with eyes" but without either "hair and forehead" or "nose and mouth" did not differ significantly from that to "full face", it appears reasonable to conclude that the presence of the eyes is requisite if an infant is to look at a face.

Response to the "artificial outline" remains uninterpretable due to the ambiguous nature of the shield covering the natural outline. On the one hand, it might be argued that the natural outline was removed; on the other, it might be argued equally well that the circular opening created a "super-outline", or more likely, made the remaining feature "super-stimuli". Yet, a "full face" which contained a natural outline was not fixated significantly less than "eyes only", a condition without outline.

To determine whether order of presentation might have contributed to the results obtained above, a rough estimate was made: the mean cumulative fixation per ordinal position was calculated regardless of condition. No systematic differences were found. Five of the twelve infants were retested immediately upon completion of the first testing, the differences between the two mean cumulative fixations and standard deviations were calculated per condition. These are presented in Table III. No systematic pattern emerged across subjects.

Response latency: The time intervals between presentation of the mother's face and fixation of it was measured for eight infants. To compensate for primitive methods of transcription and for inevitable human error, all scores were rounded up to the nearest second. Therefore, a score of one second was assigned to any response of a second or under, no matter how small. When analysed by condition, Friedman's Two-Way Analysis of Variance yielded $\chi^2 = 4.5357$, which has a probability $p > .50$. This finding suggests that an infant does not recognise which version of his mother's face is being presented unless he looks at it directly. (The random ordering of conditions precluded anticipation of the next condition to be presented.) Response latency varied little according to serial position. The mean latency per position, regardless of condition, was 1.75 secs, except the second serial position, where it was 3 secs.

Looking-away: The opening of the shutter to expose the mother's face made a click and therefore served as a discriminative stimulus. As soon as the click was heard, all infants orientated to the open window through which the face was exposed. However, when "face without eyes" was presented, an infant usually looked away and did not glance back. It seemed that infants were not just gazing randomly around the "looking box" but were refusing to look at the stimulus. In contrast, infants looked away from other conditions only when the shutter closed.

Since the possible importance of "looking away" behaviour emerged but half way through the pilot study, records of only six infants were available for analysis. All of these infants looked away every time in response to the disappearance of the stimulus, whatever it might be, except "face without eyes".

If one makes the assumption that an infant is equally likely to look away or not to look away, the probability of the obtained rate of looking away is very low ($p < .0002$). All six infants looked away from "face without eyes" before the shutter closed. Three, however, glanced back as the closing shutter made a click, and then looked away. When the remaining three infants who refused to orient to the closing shutter are considered alone, the probability of obtaining the response of already looking away and not looking back for "face without eyes" only is 1/63.

Smiling: Six of the twelve infants smiled spontaneously during tests at least once, each time in response to the stimuli, and not otherwise. In order to determine whether or not smiling was dependent upon the particular stimulus condition, Cochran's Q test was employed and a significant difference between conditions was obtained ($\chi^2 = 11.7$, $p < .05$). Jonckheere's trend test against ordered alternatives yielded a significant positive relationship between amount of smiling and of looking ($z = 2.196$, $p < .014$). The relationship between smiling and looking is graphed in Figure I.

No infant smiled to "face without eyes". Fisher's Exact Probability test was used to determine whether the presence or absence of the eyes was crucial for smiling. The result was significant ($p < .001$). Spitz (1946, 1948) and Ahrens (1954) stress the importance of the forehead and nose, as well as the eyes; but the present experiment suggests that absence of either forehead or nose is not correlated with a systematic decrease in smiling, nor their presence with an increase.

Other responses: Only a few infants vocalised and then not consistently. At times vocalisation occurred in response to mother, irrespective of condition with the exception of "face without eyes". At other times, vocalizations occurred continuously, even in the interval or rest period. Since crying and looking are incompatible responses at four months or under, infants who cried were excluded from this analysis. Thus, crying never occurred in the twelve infants whose records were used for this paper. They protested at neither the appearance, the disappearance, nor the condition of the stimulus. Some of the few infants who did fuss (and whose records were therefore excluded) stopped crying in response to the presentation of the face under all conditions except "face without eyes".

Discussion of Pilot Study

Infants spent more time looking at a living face which contained eyes than at one without them. In fact, infants actively refused to look at a face without eyes. By contrast, the presence of the eyes only was sufficient to elicit looking. Nonetheless, eyes plus some other part of the face, be it either "hair and forehead" or "nose and mouth", received more looking than "eyes only". However, there is no evidence that a complete face was looked at any more frequently than a partial face which contained eyes.

An Impromptu Naturalistic Experiment

A 16 week old infant who participated in the pilot study was in the laboratory sitting on his mother's lap. Both mother and infant were watching a television monitor on which a test tape was being played. The author noted that as long as a human face was on, the infant watched attentively. When a geometric test pattern came on, however, the infant looked away. Therefore, the following impromptu experiment was conducted:

The infant was allowed to fixate the monitor on which was presented either a human face or a complex test pattern. The experimenter could manipulate at will which pattern would be presented. When the face was presented, the infant watched attentively. When the experimenter switched to the non-facelike pattern, however, the infant looked away. Whenever the infant glanced back,he would look away if the pattern was on. But if the face had been presented while he was looking away, then he would fixate the monitor so long as the face was on.

These incidental findings suggested that an infant of 16 weeks could "watch" television. Therefore, it was hoped that television would permit a more refined method of stimuls presentation than used in the pilot study. First of all, televised stimuli can be standardized. Secondly, films of relatively motionless faces nevertheless preserve minimal movement and small variations in light intensity which render a filmed face more complex as a stimulus than a mere photograph of it. Moreover, television permits the same face to be presented simultaneously at two separate points in space, thereby making a paired comparisons method possible.

Main Study

Hypotheses

From the pilot study, the following three hypotheses were obtained:

1. "Face without both eyes" would receive less fixation than would any other condition.
2. "Full face", "face without nose and mouth" or "without hair and forehead" would not be differentiable from each other in terms of amounts of fixation received by each.
3. "Eyes only" would be less frequently fixated than "full face", "face without nose and mouth" or "without hair and forehead".

The condition "artificial outline" was replaced with a "face without outline" (see below), and a new condition was added: "face without one eye". Therefore two further hypotheses were formulated with respect to the literature.

4. The "face without one eye" would be fixated less than all the other conditions except perhaps "face without both eyes" (Spitz, 1946,1948).
5. "Face without outline" would be fixated less than remaining conditions, except perhaps "eyes only", but more than "face without one eye" and "without both eyes".

An additional three hypotheses not involving fixation time per se were formulated. The first of these was drawn directly from the pilot study:

6. A negative reaction would occur more frequently to "face without both eyes" than to any other condition.*
7. The results obtained from measures of fixation for both the pilot and main studies, when arranged in either ascending or descending magnitude, would yield approximately the same ordering of conditions.

A correlate of hypotheses No.7 was that:

8. The paired comparisons method would yield the same basic results as the single stimulus method (c.f., Greenberg and Weizmann, 1971); i.e. the results of the pilot study would be comparable with those of the main study and neither would be an artifact of experimental procedures.

In addition, individual differences and sex differences were to be "looked for", though specific hypotheses were not formulated.

. . . .

* Looking away, however, could not be a measure in the main study since its experimental design made it impossible to distinguish "looking away" from "looking at something else".

No hypotheses were formulated concerning reaction time or latency to first fixation since these measures could not be used in the main study. There was no rest interval or recovery period between presentations, nor was there any discriminative stimulus to signal a new condition.

Subjects

Subjects were 28 white infants, aged 8 to 25 weeks, from working class, middle class and professional home backgrounds. Mothers were contacted at a local day clinic. A welfare visitor and/or member of staff made the initial approach to each mother to whom was explained the purpose and nature of the experiment. Interested mothers were then introduced to the experimenter who discussed the project with them, explained practical procedures and if the mother still seemed interested, invited her to participate. If the mother accepted, an appointment was made at her convenience. The experimenter did suggest that an hour after a morning, midday or afternoon feed, when the infant would be alert but not active, would perhaps be the best time. All mothers agreed.

Stimuli

Black and white filmed episodes were taken of a relatively motionless female face made up for seven different degrees of completeness. Features were masked with the aid of prosthetic pieces and cosmetics applied by a professional make-up artist. The seven different degrees of facial completeness (i.e., stimulus conditions) are listed below:

I. "face without both eyes", i.e. ~~only one~~ both eyes camouflaged by flesh coloured putty,
II. "face without one eye", i.e. only one eye camouflaged by flesh coloured putty,
III. "eyes only" peering through a flesh coloured sheet of plastic fitted to give the effect that the eyes were peering through a veil which grew onto the face,
IV. "face without outline", i.e. forehead, nose and mouth peering through a veil similar to the one described in No.III,
V. "face without hair and forehead", i.e. the hair and forehead blocked by a piece of board,
VI. "face without nose and mouth", i.e. the nose and mouth covered by a simian like mask, which gave the impression of a bandits mask made of flesh,
VII. the "full", natural, complete or normal face.

Photographs of the seven stimuls conditions are presented in Plates I-VII.

Each presentation of a condition lasted exactly twenty seconds. A two second interval came between presentations. Each stimulus condition was paired with each other, except for "face with one eye" which was paired only with three other conditions. Two sets of random ordered pairs were made up so that no condition would follow itself, nor would appear on either a previous or subsequent episode of the sequence with which it was paired. The paired sequences were alternated to correct for any possible positional difference; i.e. sequence X might be presented on the right and Y on the left or vice versa. The sequences are listed below*:

	Sequence I			Sequence II	
	X	Y		X	Y
1.	F-O	E only	1.	FF	F-H
2.	F-NM	F-H	2.	E only	F-2E
3.	FF	E only	3.	F-1E	F-O
4.	F-2E	F-O	4.	F-NM	FF
5.	E only	F-1E	5.	F-O	F-H
6.	F-NM	FF	6.	F-2E	F-1E
7.	E only	F-2E	7.	F-NM	F-O
8.	F-H	F-O	8.	FF	E only
9.	F-1E	FF	9.	F-O	F-2E
10.	F-2E	F-H	10.	E only	F-NM
11.	F-O	F-NM	11.	F-1E	FF
12.	F-1E	F-2E	12.	F-2E	E only
13.	FF	F-H	13.	F-2E	F-NM
14.	F-NM	F-2E	14.	F-H	E only
15.	F-1E	F-O	15.	FF	F-2E
16.	E only	F-NM	16.	F-H	F-NM
17.	F-2E	FF	17.	F-O	FF
18.	F-H	E only	18.	F-2E	F-H
19.	F-O	FF	19.	E only	F-1E

Apparatus

Stimuli were presented on two television monitors**, one beside the other; in between was located a television camera with close-up lens, which recorded all of an infant's eye movements. Monitors and camera were mounted in such a way as to obtain a standard distance of no less than 10 and no more than 12 inches between the infant's eyes and the viewing screen or lens. The viewing chamber in which the infant was placed was covered on three sides and on top (except for three openings for the two monitors and camera) by translucent plexiglass which transmitted light but no pattern. Photographs of the apparatus and recording devices are presented in Plates VIII, IX and X.

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*F-2E = face without both eyes, F-1E = face without one eye, E only = eyes only, F-O = face without outline, F-NM = face without nose and mouth, F-H = face without hair and forehead, FF = full face.

** Nine-inch monitors were used; the stimuli (i.e., faces) were five inches from tip of chin to top of forehead.

Testing Procedures and Data Collection

At a pre-arranged time, the author called at the family home to collect mother and infant. They were then taken to the laboratory where the author explained the apparatus and testing procedure and answered any further questions. Once he was convinced that the mother was comfortable, he suggested that the experiment could begin whenever she felt her infant would be most cooperative. The infant was then placed by his mother in a crib made of transparent plastic. A head rest gave the infant's head support and restricted movement without prohibiting it. The crib with infant in it was then wheeled into position in the looking chamber (i.e. under the monitors), the camera was focused on one eye and the recording device activated. Stimuli tapes were synchronized and started. The whole testing lasted 7 minutes. If an infant cried or fussed, his mother was invited to interrupt at any movement. If an infant continued to protest, the testing was terminated by the suggestion of the experimenter, with mother's consent of course. Each mother was allowed to view the video taped results as they were being made. After the experiment was over, any further questions were answered. If a second testing was considered advantageous, the experimenter raised the possibility and if the mother was interested, a further appointment was set up. In any case, each mother was given 50 new pence (10 shillings) for her infant, no matter what had happened, whether he cried, fell asleep, only watched his hands, or attended to the test stimuli. Then mother and infant were returned home.

A mother was allowed to bring her husband, her own mother, a friend, or an older pre-school sibling. A corner of the experimental room was furnished with small chairs and toys for children and ordinary chairs for the mother and any guest she wished to invite.

Data transcription

All records of eye movements were initially surveyed to determine whether or not they met predetermined criteria. These criteria were:

(a) an infant had to give evidence of visual discrimination;
(b) an infant had to remain attentive for at least 14 of the 19 paired presentations.

Once it was decided to transcribe a record for a given infant, then that record was included in the statistical analyses no matter what the results turned out to be. Only one record, the first complete, was used from each infant no matter how many records were taken. The most any infant was tested was 4 times. The majority of infants were seen twice.

The video tape record of eye movements was played back 3 times slower than the original speed. An infant was considered to be fixating only when:

(c) the eye was not dilated; i.e. the degree of pupilary opening appeared to be adaptive to light intensity emitted by the stimuli,
(d) frequent small refixations and the jerky part of the nystagmus were present,
(e) the reflection of the target was approximately 2/3 or more coincident with the pupilary opening.

By contrast, blank stares were characterized by stationary or fixed eyes, sometimes with dilation. Neither random eye movements nor blank stares were counted as fixations, even if the image was completely coincident with the pupil.*

The acceptance of criteria a - e is based on the finding by researches into the physiology of infantile vision that by three to four months an infant's visual system approximates an adult's in terms of function (Haynes, White and Held, 1964).

A Venner timer and an events recorder were both wired so that they could be activated simultaneously by the depression of a small key. When the two records thus obtained were combined, the number of fixations and length of each as well as of total fixation were obtainable.

It was found necessary to observe all eye movements before accurate measures could be taken. Because the scoring of eye movements and of the coincidence of reflected image and pupil represents such complex judgements, a transcriber must be able to anticipate how the eyes are going to move (even when 3 times slower than normal) in order to obtain two measures which, when divided by 3, would give the same result. It is impossible to make a blind transcription of eye movement patterns, especially at full or natural speed; slow motion is requisite.

Tapes were analysed according to the number of the conditions, with fixation times assigned to "right" and "left". There was no knowledge of the stimulus conditions beforehand. Though, in several of the cases, the stimulus condition was so clearly reflected in the baby's eyes that a transcriber could not remain ignorant of the conditions for which he was measuring fixation eye movements. If the first two transcriptions yielded the same result, then that measure was assumed to be accurate. If, however, there was a discrepancy, then further measurements would be taken until 3 successive measures yielded the same result. Each record

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* A diagram of an eye which meets criteria (c) and (e) is presented in plate XI and a photograph of an infant's eyes in which the monitors are reflected is presented in plate XII.

was analysed by the author a second time, at least a month after the first transcription had been made. Pearon's Product-Moment Correlation test was then applied to the two transcriptions of the same record: r varied from .93 to .99 with the average coefficient for the fourteen subjects .97 ($p<.01$).* One record was chosen at random and then analysed simultaneously by the author and by a colleague who was already familiar with transcription of eye movements and who had been trained by the author to apply his criteria. Agreement between the two raters was extremely high: $r = .98$, $p<.01$. Although many publications contain no mention of reliability, high correlations are not infrequent in those that do. Cantor and Meyers (1965) report a correlation coefficient of .93; Wickelgren (1967), .94 to .96; Nelson (1968), .97; Cohen (1969), .93; Wickelgren (1969), .92 to .96. Salapatek and Kessen (1969) do not give exact coefficients but do state that they were all greater than .90. Fixation is by and large an all-or-none phenomenon. An infant is either looking or not looking, except when the eye is moving toward or away from a given object of fixation. Moreover, the criteria for fixation can be designated in physiological and/or behavioural terms which are open to direct measurement. Thus one would expect high coeffecents of correlation, especially when data have been recorded by a means which can be repeated any number of times and which can also be repeated at slow motion or even one frame at a time.

Results

Of the 28 infants tested, 8 were seen at 12 weeks or less. ** None of these infants showed differential fixation except perhaps one whose record was patchy and incomplete. Seven of the 8 oriented fixedly to one monitor whether or not there was any patterned stimulus present. In short, they appeared to show no differential reaction to a patterned or to a homogenous field as presented by the telvision monitor. An X^2 test was applied and this result was found to be significant ($P< .003$). It was therefore concluded that infants younger than 12 weeks had been unable to differentiate patterned from homogenous stimulus fields, as presented in the main study.

This result is the opposite of numerous other findings for infants of the same age and perhaps is attributable to the ~~other~~ particular method

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* A subject's record consisted of 19 scores, each of which could be any number from zero to twenty, i.e. the fixation score for any condition.

** Of these eight, five were seen also at 16 weeks plus.

of stimulus presentation used.

Of the 18 infants who were seen at age 16 weeks or older, 14 gave at least one record which was considered suitable for analysis. Of these 14, only four attended to both monitors most of the time. Eight attended to both between one third to one half the time, though showed a decided position preference. The remaining two did not look except at one monitor, though their fixations were considered to be differential. Of the 4 infants who were able to attend to both monitors only two did not show a marked position preference.

Since a general position preference had been noted across infants before the data had been transcribed, it was decided to test for possible significance. A sum total was prepared for all stimulus conditions presented on the right and on the left. Then the larger was compared with the smaller across subjects. Student's t-test yielded a highly significant result ($t = 5.7315$, $p < .000035$).

The high degree of significance for this result came as a surprise since position preferences have been mentioned only occasionally in the published literature. In light of these results, it was considered advisable to analyse only the preferred side; in other words, the data were to be treated as if they had been obtained in a single stimulus situation. Therefore, the eighth hypothesis had to be excluded.

Seven infants preferred the left side; five, the right. Two infants showed virtually no preference for either side. Of the seven infants who orientated to the left side, four were male and three, female. Of the five who orientated to the right, two were male; three, female. There was no significant general preference for a given side, nor was there any association between sex and side preference.

Some infants seemed to "prefer" the monitor to which they were orientating when the stimuli were first presented. A few infants changed sides early on and usually with the first presentation of "face without both eyes". It was as though they refused to look back at the side on which they discovered an eyeless face. Other infants glanced back and forth between monitors but seemed to have a favourite for some unknown reason.

The measures applied to the data obtained from the 14 infants (aged 16 - 25 weeks) were:

1. Average length of first fixation per condition,
2. Average length of longest fixation per condition,
3. The length of the one longest fixation per condition, (referred to as "absolute longest" fixation),
4. Average cumulative fixation per condition,
5. The number of fixations per condition converted to a ratio (to be discussed below).

The first four measures, i.e. first, average longest, absolute longest and average cumulative fixation time, are graphed in Figure II. The analyses of variance for these 4 measures are summarised in Tables IV A - D. There was no significant differences between the sexes, though individual differences proved significant in all cases. Most importantly, differences between conditions were significant. Therefore, the following planned comparisons were made to test the hypotheses stated above:

(a) "face without both eyes" against all other conditions, i.e. against "face without one eye", "eyes only", "face without outline", "without hair and forehead", "without nose and mouth", and "full face".
(b) "face without one eye" against the remaining five conditions, i.e., against "eyes only", "face without outline", "without hair and forehead", "without nose and mouth", and "full face".
(c) "eyes only" against "face without outline".
(d) both "eyes only" and "face without outline" against the remaining three conditions, i.e., against "face without hair and forehead", "without nose and mouth", and "full face".
(e) "face without hair and forehead" against the remaining two conditions, i.e., against "face without nose and mouth" and "full face".
(f) "face without nose and mouth" against the last remaining condition, "full face".

The results of the planned comparisons are presented in Table V.

Even though the four measures are not independent, a statistic for correlation was employed for the first and the average longest fixations *. The result was extremely high (r=+.98). As the first fixation was sometimes the longest, these two measures are obviously not independent. Nonetheless, such a high correlation is good indication that both measures of fixation are measuring approximately the "same" phenomenon. Contrary to the findings of some other authors (Lewis, Kagan and Kalafat, 1966), the pattern of looking gave no further information than did total fixation.

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* Absolute longest fixation was considered to be only a variate of average longest, even though there was a slight difference between the results yielded by the two. Since measures of average first and of average longest fixation are contained in that of average cumulative, these latter three were not compared.

The first fixation was the longest for $34\frac{1}{2}$% of all presentations and the only one for 24%. Thus, if only the first fixation were taken as measure, the sampling would have contained $58\frac{1}{2}$% of the longest and of only fixations. However, there are definite individual differences. As low as 23% and as high as 47% of first fixations per condition were longest. Similarly, as low as 6% and as high as 50% were the only fixation. Thus, the first fixation was the longest or only as low as 37% of the time and as high as 86%. As can be seen in Table VI, there were no sex differences associated with the likelihood of the first response being the longest or only.

On the average, 30% of all presentations received a fixation of 10 secs. or over, though one infant never gave a response as long as 10 secs. For the two most responsive infants,53% of all presentations received fixations of 10 secs. or longer. If the occurence of these responses is considered in terms of number of responses given by an infant, instead of in terms of number of presentations, then the average was 12% with the lowest 0% and the highest 29%. These percentages are contained in Table VII.

Of the respnses 10 secs. or over, a small number were for 20 secs. or the total length of the presentation. The average number of all presentations to receive one fixation for their total duration was 7%. When considered in terms of responses, 3% of all fixations were 20 secs. in duration. As can be seen in Table VII, some infants gave no responses of 20 secs., whereas the most responsive infant fixated 29% of all presentations with one continuous fixation, this amounting to 16% of his responses.

A rate of looking was calculated from the number of fixations given in relation to the total fixation time. As the number of fixations increased, the length of individual fixations would have to decrease. However, since a given total fixation time might be the product of different numbers of fixations and since a given number of fixations might produce different totals, a ratio was considered preferable to the raw number of fixations. This ratio then represents how a given infant would have looked if he had continued to look all of the time possible and at the same rate as that part of the total time possible which he did actually fixate.

The formula is: $r = \frac{n}{t}p$ where: r = ratio
n = number of fixations
t = total cumulative fixation average
p = total possible fixation time

The results of the ratio or rate of fixation are presented in Table VIII and the analysis of variance in Table IX.

"Face without both eyes" gave a ratio significantly different from all other conditions. No other conditions were statistically significant as to degree of difference. When rate was compared with the first and longest fixations a high negative correlation was obtained in both cases. (first and ratio: $r = -0.8756$; longest and ratio: $r = -0.9329$.) Even though rate (as calculated above) is not completely independent of the first or of the longest fixations, such a high correlation would appear to be more than a statistical artifact. Nonetheless its meaning remains ambiguous. Rate of looking gave the least differentiable results.

To determine whether there was a possible change in responsiveness correlated with serial position, Jonckheere's trend test against ordered alternatives was employed for the first, average longest and average cumulative fixation times. Since some first fixations were also the longest, the analysis of first fixations fixation excluded those fixations which were both longest and first. None of the results for the three measures was significant (first fixation $p<.36$, longest fixation $p<.43$, total fixation $p<.13$). Therefore, it can be concluded that neither habituation nor practice affected responsiveness across subjects for any of the three measures in question.

Since there was no significant change in responsiveness associated with serial position, it was assumed that the distribution of scores was normal so that sex differences could be tested for. Jonckheere's trend test indicated a significant difference between the groups of males and females for average longest fixation ($p<.008$) and for cumulative fixation ($p<.003$) but not for first fixation ($p<.31$). Males as a group tended to habituate whereas females as a group, to the contrary, tended to become more responsive. However, when individual scores are considered, only three of the six males and two of the eight females showed a significant change in responsiveness for cumulative fixation. The three males showed habituation at a low level of significance(1. $p<.017$, 2. $p<.013$, 3. $p<.05$), but of the two females only one showed a tendency to increase responsiveness ($p<.0004$) whereas the other gave significantly shorter fixations ($p<.009$). Statistically significant changes in longest fixation for individual infants were given only by four infants, two females and two males. Though males as group showed decreased responsiveness and females increased, only one of the four significant individual scores, given by a male, was a result of habituation ($p<.015$). The two females (1. $p<.036$, 2. $p<.0001$) and the other male ($p<.016$) showed a definite tendency for the longer fixations to be associated with later serial position. Of the five infants who showed significant changes for cumulative fixation and of the four for average longest fixation, only two infants showed it for both. That is, of the nine scores, five were provided by different infants, the remaining four by the same two. Obviously, there is a great deal of individual difference.

The overall sex differences may be an artifact of individual differences. When cumulative fixation was the measure, four males gave progressively lesser responses and two, greater; while five females gave lesser and three greater. When first fixation was the measure, five males (that is, all but one) gave lesser responses, while six females gave greater and only two lesser. Nonetheless, other experimenters (Kagan and Lewis, 1965; Meyers and Cantor, 1967, Caron and Caron, 1969; Freedman, Nagy and Carpenter, 1970; Greenberg and Weizmann, 1971) have noted that males habituate more readily than females, though the contrary has also been recorded (Haith, 1966; Caron, 1968; Weizmann, Cohen and Pratt, 1971).

Evaluation of Hypotheses in Terms of Experimental Results

There appears to be sufficient evidence to accept the first hypothesis that "face without both eyes" would receive significantly less fixation than all other conditions. As can be seen from the planned comparisons in the analysis of variance, "face without both eyes" in fact did receive significantly less fixation ($p<.001$) than any other condition. Moreover, this difference was constant no matter what measure was considered, be it first fixation, average or absolute longest fixation, average cumulative fixation or even rate of fixation.

The second hypothesis that "full face" would not be fixated significantly more or less frequently than "face without the nose and mouth" or "without hair and forehead" can also be considered as confirmed, even though "face without hair and forehead".was found to be signifcantly different from "full face" and "face without nose and mouth" for one of the four measures. Curiously, "face without outline" could be inferred not to be different from the three previously mentioned conditions for one measure only, average longest fixation.

The third hypothesis that "eyes only" would be significantly less fixated than "full face", "face without nose and mouth" and "without hair and forehead", was substantiated by three of the four measures. In the case of the first fixation, "eyes only" were significantly different in amounts of fixation only from "full face" and "face without nose and mouth" but not any other conditions except "face without both eyes".

The fourth hypothesis that "face without one eye" would be significantly less frequently fixated than all other conditions, except perhaps "face without both eyes", was not substantiated. Instead, it can be inferred that "face without one eye" was always fixated less frequently than "full face" or "face without nose and mouth" and usually less (except when first fixation was the measure) than "face without hair and forehead". Though "face without one eye" was more frequently fixated for all measures than was "face without both eyes", it could not be distinguished in this study from the "eyes only" or from "face without outline".

The fifth hypothesis that "face without outline" would be fixated less frequently than the remaining conditions, except perhaps "eyes only", "face without one eye" and "without both eyes", was partially substantiated. For no measure were "face without outline" and "eyes only" distinguishable in terms of fixation elicited, nor were they different from "face without one eye". However, these three conditons were always significantly different from "full face" and from "face without nose and mouth" for all measures, though only from "face without hair and forehead" for two of the four measures. When the first fixation was the measure, then "face without outline" and "eyes only" were indistinguishable from "face without hair and forehead", but when average longest fixation was the measure, "face without one eye" and "eyes only" were distinguishable from "full face", "face without nose and mouth" and "without hair and forehead", though "face without outline" was not differentiable from these latter three conditions nor from the former two.

The sixth hypothesis that there would be a negative reaction to the "face without both eyes", received further confirmation. Of 9 infants who cried during testing, 7 cried for the first time to the condition "face without both eyes". Since the absence of eyes occurred 6 times (when both sides are considered) out of 19 paired presentations, a quadratic equation was used to determine the probability of such an occurrence. The formula yielded $p = .000035$ and it therefore seems relatively safe to conclude that absence of eyes continued to be associated with negative affect in infants. One infant covered its own eyes with its bib in response to the eyeless face; another hid its eyes with its hands; still another closed its eyes.

In order to see whether absence of eyes had a residual effect, an analysis of variance was done to compare a possible difference between any condition immediately prior to the "face without both eyes" and any condition immediately subsequent. On the one hand, it might be postulated that the baby would not look at the subsequent condition as continued "avoidance" of the absence of eyes. On the other, it could be that the baby would fixate progressively longer any subsequent condition which contained the eyes in an attempt to get rid of the "bad experience" associated with absence of eyes. Neither hypothesis was substantiated, however. Mean cumulative fixations for conditions prior to and subsequent to the absence of the eyes were virtually identical across subjects.

Infants who cried in response to the absence of the eyes were frequently infants who were unable to complete the test, perhaps because of crying or perhaps because of less developed visual behaviour. It appeared that an infant who could "defend" himself either by covering his face or by looking away was less likely to cry than an infant who could not. Infants who did cry seemed more position bound or even stimulus bound than infants who did not; i.e., the looking behaviours of infants who cried did not seem as much under their own control as that of infants who did not cry. These results are compatible with the observation of the "active looking away" which was noted in the pilot study. As has been mentioned previously, stimuli in the main study were paired, therefore "looking away" was not always differentiable from "looking to" another stimulus.

When one considers the extremely low cumulative fixation time for "face without both eyes" in comparison to the high rate of looking and to the negative reactions mentioned, it would appear that "absence of both eyes" was not something infants "liked" to look at but felt "compelled" to look at, perhaps as if an eyeless face was strange or threatening. It is emphasised, however, that "absence of only one eye" was not differentiable from behaviour associated with the face under all other conditions when both eyes were present.

The seventh hypothesis was definitely confirmed. In the pilot study, the stimuli were fixated in the following order of increasing magnitude:

(1) F-2E: (2) E only: (3) F-H; (4) FF; (5) F-NM

In the main study, the following order of increasing magnitude was obtained for the same conditions (new conditions omitted).

(1) F-2E; (2) E only; (3) F-H; (4) F-NM; (5) FF

It is to be noted that these two orderings are exactly the same except for the last two conditions which in both studies were found not to be significantly different.

An important question is whether infants responded to the filmed face as they did to a real face. Evidence from other sources indicates that infants can and do differentiate solid from flat objects, therefore, one would expect the infants to be able to distinguish a three-dimensional face from a filmed version of it (Bower, 1966, 1971.) Nonetheless, results obtained in the main study, especially when compared with the results of the pilot study (in which a real face as the stimulus) indicate that infants in the main study did respond to a face on television in a way which is not differentiable in terms of amount of looking from the way in whcih infants in the pilot study responded to a real or living face. Above all, the negative reaction to both a real "face without eyes" and to a filmed version of it, but not to other conditions, is most striking support of an interpretation that infants 16 weeks or older can "recognise" a filmed or televised version of a face as "face-like". Incidental observations indicated, however, that infants could distinguish real from filmed faces. This finding is congruent with Bower's (1966) observation that infants of this age and younger respond differently to a real object and to a two dimensional version of it. Even though infants smiled and vocalised to all filmed faces (except when both eyes were absent), they appeared to be more responsive to the real face, especially the mother's. Yet a difference in infantile responsiveness may be due not to an ability to recognise the Gestalt of a filmed face as face-like and at the same time to distinguish a living face from a filmed version of it, nor to a specific preference for the former, but to the responsiveness of the living face (in contrast to an unresponsive filmed version of it) and to the presence of colour.

DISCUSSION OF METHODOLOGICAL PROBLEMS

In the present study, a paired stimuli method of presentation was found to be completely ineffective for infants two months or under. However, by four months, some infants were capable of attending partially to paired stimuli, though in most cases a decided positional preference made the method virtually ineffective. Similar results were found by Ames and Silfen(1965)and by Greenberg, Uzgiris and Hunt(1971). Nonetheless, a very few infants were capable of attending simultaneously to two stimuli.

By way of incidental observation, the author noted that infants of four months or older who had had several experimental sessions became progressively more able to attend simultaneously to two stimuli. This observation suggests that at four months or after, an initial training or familiarization period may be necessary to acquaint infants with the technique of paired stimuli presentation. In other words, direct experience may be necessary if an infant is to discover that there are alternative stimuli from which he may choose. When two stimuli are of approximately equal degrees of complexity, then experience appears to offset positional biases. However, if two paired stimuli are radically different in terms of complexity, their complexity may outweigh positional preferences. It is unlikely that an infant younger than four months could make use of such training. It is about this age (i.e., four months) that Piaget describes a shift from looking for sensation's sake to looking to see, i.e. looking becomes environmentally orientated (Piaget, 1952). Naturally, when stimulation per se becomes more important than the effects it has, an infant attends to or selects among different sources of stimulation.

Some experimenters have recorded eye or head orientation as opposed to corneal reflections. Though there was a high correlation between the pilot study in which only eye orientations were recorded and the main study in which actual corneal reflections were measured, the author is convinced that the former method can at best be considered an approximation whereas the latter only can provide accurate data since it alone can specify definite criteria under which perception can be defined operationally as occurring or not.

A further technical problem is that of transcribing live, i.e., blind or directly during an experimental session. According to the author's experience, it is practically impossible to transcribe accurately any sequence of eye movements without the aid of slow motion or of frame counting and without having studied in advance each sequence of movements. For any transcript to be reliable, it must be relatively free of mechanical and human error. In short, the transcriber must first be allowed to study the eye movements in question so as to establish separately from recording of fixations which eye movements meet the criteria of fixation. Moreover, if errors due to reaction time and the like are to be eliminated, records of rapid eye movements must be transcribed with the aid of slow motion or frame counting. Any other procedures of transcription would contain too many sources of possible error for a transcription to be considered anything more than an approximation.

Kagan, Henker, Hen-Tov, Levine and Lewis (1966) pointed out that if "preference" is to be equated with "long fixation" then there is no need to use the additional word "preference" which has implications much beyond relative length of fixation per se. Obviously, a stimulus may be looked at not because it is preferred, but because it is new, or because it is too difficult to categorize and therefore provokes an attempt to do so. The logical basis of this criticism is irrefutable and for this reason supplementary measures are an advantage. However, in the present study, first, longest and cumulative fixation gave basically the same results. In short, fixation seemed to be a fairly homogenous response for the infants in the author's sample.

In the pilot study, spontaneous smiling was found to be roughly correlated with cumulative fixation. Things that were looked at longer were more likely to be smiled at. If one assumes that an infant smiles at what he 'prefers', then cumulative fixation is in some way a gross, primitive indication of "preference". Complimentarily, both refusal to continue to look at and crying at that which was fixated least seemed to indicate dislike. Nonetheless, smiling and looking can be differentiated. As Wilcox (1969) points out, smiling and looking are separate response systems and have separate courses of development. Some stimuli elicited approximately equal amounts of fixation but were not equally frequently smiled at. Obviously, equal fixation times do not presuppose an inability to discriminate, nor a lack of preference.

DISCUSSION OF RESULTS AND CONCLUSIONS

Reactions to "face without both eyes" either of crying or of looking away and/or covering the face can be considered as aversion or dislike. It is most noteworthy that such a negative reaction occurred to both a living and a filmed face. The refusal to look, in particular, suggests that infants had an expectancy of seeing eyes, perhaps as a result of association with surrounding facial features. In other words, infants of three to four months act as if they have either a primitive notion, internal representation or memory trace of certain configurations which belong together. Since infants also cried in response to a stimulus in which the expectancy of seeing eyes was appropriate but unfulfilled, it seems plausible that the absence of eyes is more than just an insufficient stimulus. To the contrary, it appears that a "face without eyes" is either disappointing or perhaps even infuriating. On the one hand, such an aversive reaction could be cognitive in origin, i.e. the result of a frustrated scan path (Noton & Stark, 1971) or an interrupted TOTE (Miller, Galanter & Pribram, 1960) in which a 'set' expectancy is not met. On the other hand, it could be reaction of a fearful and/or anxious nature in response to either a 'novel' and/or 'horrifying' stimulus. Obviously, these alternatives are not mutually exclusive.

Ahrens (1954) observed that by five to six months artificial eyes worn on a real face elicited negative responses, whereas previously they had evoked smiling. Brackbill (1958) observed that once an infant had been conditioned to smile to a responsive adult face, he refused even to look at that face during the extinction process when it no longer responded to his smiles. She described an infant's refusal to look as quite active. If he could not turn his head, then he would avert his eyes. Studies by Caron (1967) and by Rovee and Rovee (1969) offer evidence that infants four months and under become progressively more responsive to a stimulus, changes in which are directly contingent upon their own behaviour. In other words, infants respond to feedback. Not only do they look more frequently at a responsive stimulus, but they also vocalize, laugh and wave their limbs excitedly. In short, infants appear to derive pleasure from a stimulus which responds to them. By contrast, infants respond negatively to a previously "responsive" stimulus when it ceases to respond. Infants fretted, squirmed or even cried. Thus, it is possible that infants grow to "prefer" stimuli which provide feedback. It may even be that feedback is intrinsically reinforcing. The rewarding properties of feedback may be viewed as the Functionslust described by Bühler(1928) or the pleasure inherent in the functioning of cognitive structures described by Piaget(1952). However, infants' negative reactions to the cessation of feedback clearly suggest that they have a definite expectancy of feedback, that this expectancy is appetative in nature, and that whenever this exceptancy is appropriate, the absence of feedback is experienced as frustration.

Without exception, infants spent more time looking at a living or filmed face which contained eyes than one without them. In fact, the presence of the eyes alone was sufficient to elicit looking. This fact suggests that eyes are a necessary or even a central feature to which infants respond when scanning or focusing on a stimulus configuration which is potentially a facial Gestalt. Nonetheless, eyes plus some other part of the face, be it either "hair and forehead" or "nose and mouth", received more fixation than "eyes only". Thus, eyes alone seem to constitute a minimally sufficient stimulus, though not an optimal one. While a more complete face was fixated more frequently than a less complete, there is no evidence that a full or naturally complete face was looked at any more frequently than a partial face which contained eyes. In light of these findings, it is not possible to consider the face as a "privileged Gestalt" as far as looking is concerned. The present evidence suggests a heterogeneous summation effect centred around "privileged features", namely, the eyes. Both eyes are not necessary, one eye is sufficient, though only in some cases is a face with both eyes more efficient in eliciting fixation than a face with only one. In fact, "face with one eye only" was not fixated significantly more or less than "eyes only" or "face without outline", conditions which contain both eyes. Hence, it appears that the eye is to be considered as a structure "interesting" or "focal" per se and not as a paired or balanced part of a greater Gestalt.

The centrality of the eyes may be due to the fact that they are the most light reflective part of a natural face; that they contain great contrast within themselves and in relation to surrounding facial features; that they are in continuous movement; that they are the most responsive part of the face, registering changes more quickly and more consistently than other parts.

In an informal experiment, a mother was asked to get her infant's attention and then to talk to it. The infant smiled at the talking face when nose and mouth were masked, but when both eyes were masked the infant gave a definite impression of being "confused" or even "perplexed" by the talking, eyeless face.

In the pilot study, "artificial outline" received the most fixation, even more than "full face", though the degree of difference was not significant. Moreover, "artificial outline" received the most smiles. However, the implications of responses to this condition were questionable due to its physical construction. As has been said, this condition was replaced with a face which had the outline actually removed. In the main study, "face without outline" was fixated much less frequently at a significant level for three of the four measures than were "full face" or "face without nose and mouth". By contrast, "face without outline" was never distinguishable from "eyes only". This finding suggests on the one hand that "nose and mouth" are not crucial if fixation is to take place and on the other that the outline itself is not as important as the features. For one measure even, "face without outline" was not distinguishable from "full face" or from any other conditions except "face without both eyes".

If, as is maintained, an infant of four months can recognise various combinations of facial features as being face like and if he has an expectancy of seeing eyes in a stimulus configuration which is potentially a face, then it can be inferred that there is an internalized face-schema in terms of which incomplete facial features are "seen" to be face-like.

APPENDIX TO PART II

TABLES, FIGURES AND PLATES

TABLE I

Pilot Study: Mean Cumulative Fixation in seconds per condition

Facial Conditions	without both eyes	eyes only	without hair & forehead	full face	without nose & mouth	artificial outline
Younger (11 4/7 - 13 6/7 weeks)	4.3	12.8 *	15.2	14.8	14.3 *	16.8
Older (14 3/7 - 16 1/7 weeks)	5.3	14.5	15.8	16.3	17.5	17.3
Combined	4.8	13.9 *	15.5	15.6	15.9 *	17.1

* Note: missing data substituted mathematically, mean and variance unaffected.

TABLE II

PILOT STUDY: ANALYSIS OF VARIANCE

Source	df	MS	F
Age (i)	1	36.1250	1.2286
Subjects (ii)	10	29.4028	-
Aspect (iii)	5	244.1805	25.4984 *
iii x i	5	2.8250	-
iii x ii	50	9.5761	-

* p<.001

TABLE III

Mean Cumulative Fixation Difference between First and Second Test per Same Condition.

	Without both eyes	Eyes only	Without hair and forehead	Full face	Without nose and mouth	Artificial outline
Mean Difference in seconds	+0.5	+0.2	-0.3	-0.8	+1.2	+1.8
Standard Deviation	1.5	2.9	2.5	4.4	1.9	3.5

TABLE IVA

Main Study: Analysis of Variance for First Fixation

Source	df	MS	F
1. Sex (i)	1	0.2486	0.0055
2. Subjects (ii)	12	44.4458	2.2855 **
3. Condition(iii)	6	86.5336	4.4498 ****
(a) ⊕	1	290.2238	14.9244 ****
(b)	1	12.8625	0.6614
(c)	1	1.8514	0.0952
(d)	1	121.6095	6.2536 **
(e)	1	91.1458	4.6870 *
(f)	1	1.5089	0.0775
4. iii x i	6	4.9411	0.2540
5. iii x ii	72	19.4462	-

⊕ (a) "face without both eyes" against all conditions, i.e. against "face without one eye", "eyes only", "face without outline", "without hair and forehead", "without nose and mouth", and "full face".

(b) "face without one eye" against the remaining five conditions, i.e. against "eyes only", "face without outline", "without hair and forehead","without nose and mouth", and "full face".

(c) "eyes only" against "face without outline".

(d) both "eyes only" and "face without outline" against the remaining three conditions, i.e. against "face without hair and forehead", "without nose and mouth", and "full face".

(e) "face without hair and forehead" against the remaining two conditions, i.e. against "face without nose and mouth" and "full face".

(f) "face without nose and mouth" against the last remaining condition, "full face".

* p<.05
** p<.025
*** p<.01
**** p< 001

TABLE IVB

Main Study: Analysis of Variance for Longest Fixation

Source	df	MS	F
Sex (i)	1	0.9486	0.0250
Subjects (ii)	12	37.9046	2.2972 **
Condition (iii)	6	96.1483	5.8270 ****
(a) ⊕	1	413.6840	25.0713 ****
(b)	1	24.4808	1.4836
(c)	1	7.0000	0.4242
(d)	1	74.4243	4.5104 *
(e)	1	47.1001	2.8544
(f)	1	10.2003	0.6181
iii x i	6	7.2517	0.4394
iii x ii	72	16.5003	-

NOTE: See Table IVA for explanation of symbols ⊕, *, etc.

TABLE IVC

Main Study: Analysis of Variance for absolute Longest Fixation

Source	df	MS	F
Sex (i)	1	0.0689	0.0011
Subjects (ii)	12	58.2425	2.4432 **
Condition (iii)	6	130.5442	5.4761 ****
(a) ⊕	1	461.6343	19.3649 ****
(b)	1	61.7166	2.5889
(c)	1	3.5714	0.1498
(d)	1	176.1523	7.3893 ***
(e)	1	80.0476	3.3578
(f)	1	0.1428	0.0059
iii x i	6	15.8208	0.6636
iii x ii	72	23.8386	-

NOTE: See Table IVA for explanation of symbols ⊕, *, etc.

TABLE IVD

Main Study: Analysis of Variance for Cumulative Fixation

Source	df	MS	F
Sex (i)	1	0.1224	0.0036
Subject (ii)	12	33.8661	2.8632 ***
Condition (iii)	6	139.0392	11.7552 ****
(a) ⊕	1	737.4528	62.3491 ****
(b)	1	4.1402	0.3500
(c)	1	12.4889	1.0558
(d)	1	72.8333	6.1578 **
(e)	1	7.2042	0.6090
(f)	1	0.1157	0.0097
iii x i	6	5.3248	0.4501
iii x ii	72	11.8278	-

NOTE: See Table IVA for explanation of symbols ⊕, *, etc.

TABLE V

Main Study: Results of Planned Comparisons from Analyses of Variance

Facial Conditions	Without both eyes	Without one eye	Eyes only	Without outline	Without hair and forehead	Without nose and mouth	Full Face
First	2.4	6.4	5.6	6.1	6.5	9.8	9.4
Average longest	3.0	7.2	7.5	8.5	8.6	11.4	10.2
Absolute longest	5.3	9.6	9.6	10.3	11.2	14.1	14.2
Cumulative	5.2	12.5	11.2	12.5	13.4	14.3	14.2

Note: Any two conditions not underlined by the same line are significantly different according to the statistic used.

TABLE VI

Main Study: Percentage of Conditions per Infant for which the First Fixation was the Longest or only.

	first-longest	first-only	combined
Males			
1	31%	6%	37%
2	47%	32%	79%
3	28%	11%	39%
4	33%	33%	66%
5	42%	32%	74%
6	29%	29%	58%
Average	35%	24%	59%
Females			
7	35%	47%	82%
8	47%	5%	52%
9	29%	11%	40%
10	36%	50%	86%
11	35%	12%	47%
12	27%	18%	45%
13	43%	21%	64%
14	23%	23%	46%
Average	34%	24%	58%
Combined	35%	24%	58%

TABLE VII

Main Study: Percentage of Conditions and of Responses to receive Fixations of 10 secs. or longer or of 20 secs.

	Percentage of Conditions to receive a fix. 10 secs. or over	Percentage of Responses 10 secs. or over	Percentage of Conditions to receive a fix. of 20 secs. (i.e. full length of stimulus presentation)	Percentage of Responses of 20 secs. duration
Males				
1.	13%	3%	6%	1%
2.	53%	24%	5%	2%
3.	22%	6%	6%	1%
4.	13%	5%	0%	0%
5.	53%	24%	12%	6%
6.	43%	13%	7%	2%
Average	33%	13%	6%	2%
Females				
7.	41%	22%	29%	16%
8.	21%	8%	5%	2%
9.	29%	7%	6%	2%
10.	50%	29%	0%	0%
11.	47%	13%	6%	2%
12.	18%	8%	0%	0%
13.	14%	4%	14%	4%
14.	0%	0%	0%	0%
Average	28%	11%	7%	3%
Combined	30%	12%	7%	3%

TABLE VIII

Main study: Average Ratio or Rate of Fixation per Condition

Conditions:	without both eyes	eyes only	without outline	without outline	without hair and forehead	without nose and mouth	full face
Ratio:	15.1	7.0	6.1	5.3	4.8	4.4	3.9

TABLE IX

Main Study: Analysis of Variance for Rate of Fixation (in ratio)

Source	df	MS	F
Sex (i)	1	40.7458	0.7807
Subject (ii)	12	52.1862	4.0410 ****
Condition (iii)	6	204.2528	15.8165 ****
(a) ⊕	1	1166.3412	90.5490 ****
(b)	1	11.1399	0.8625
(c)	1	18.7289	1.4502
(d)	1	50.9611	3.9462
(e)	1	3.6458	0.2823
(f)	1	1.7003	0.1316
iii x i	6	13.9673	1.0815
iii x ii	72	12.9139	-

NOTE: See Table IVA for explanation of symbols ⊕, *, etc.

FIGURE I: RELATIONSHIP BETWEEN MEAN CUMULATIVE FIXATION AND SMILING IN INFANTS AGED $11\frac{4}{7}$ — $16\frac{1}{7}$ WEEKS. (PILOT STUDY)

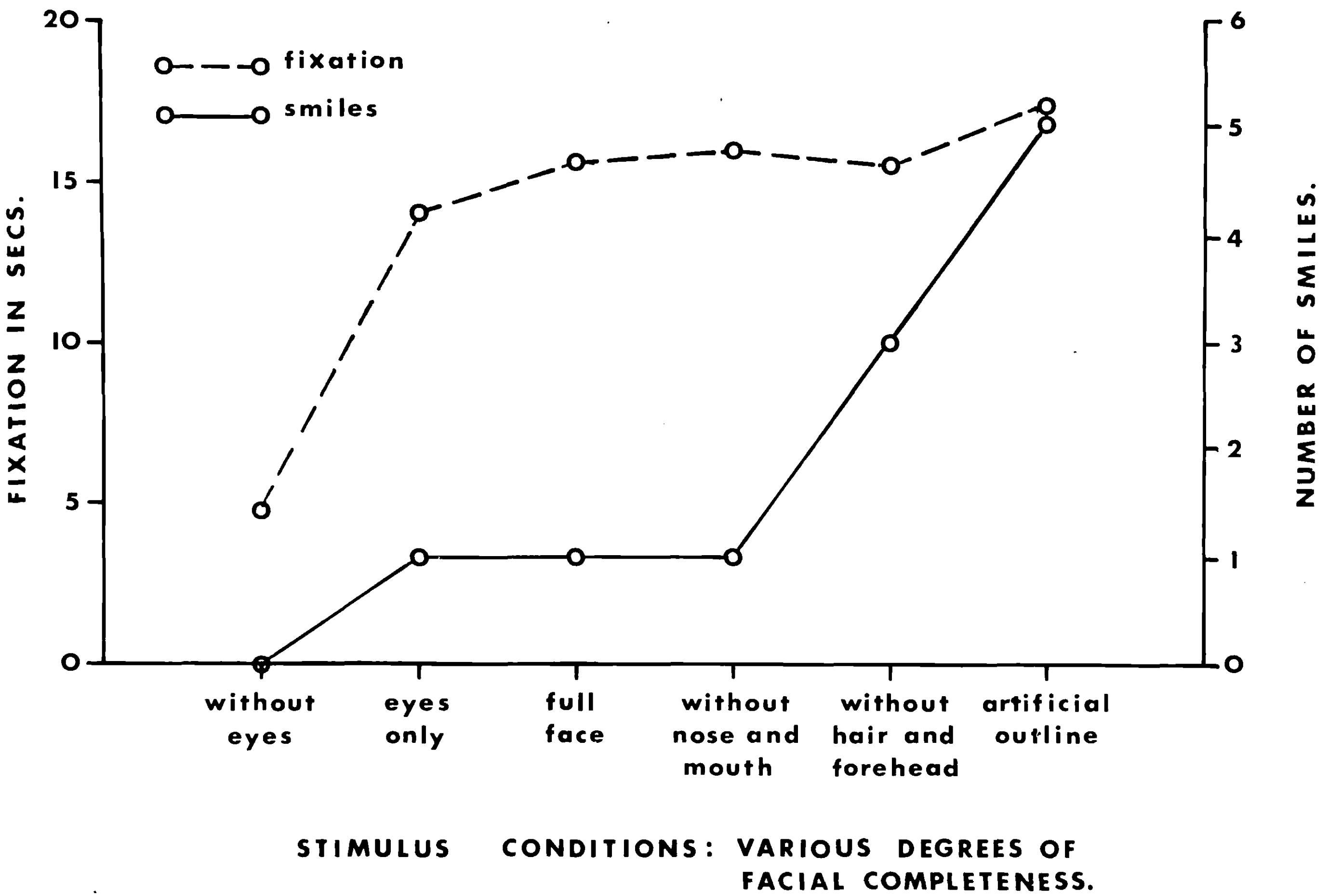


FIGURE 2: RELATIONSHIPS BETWEEN THE FOUR DIFFERENT MEASURES OF FIXATION. (MAIN STUDY)

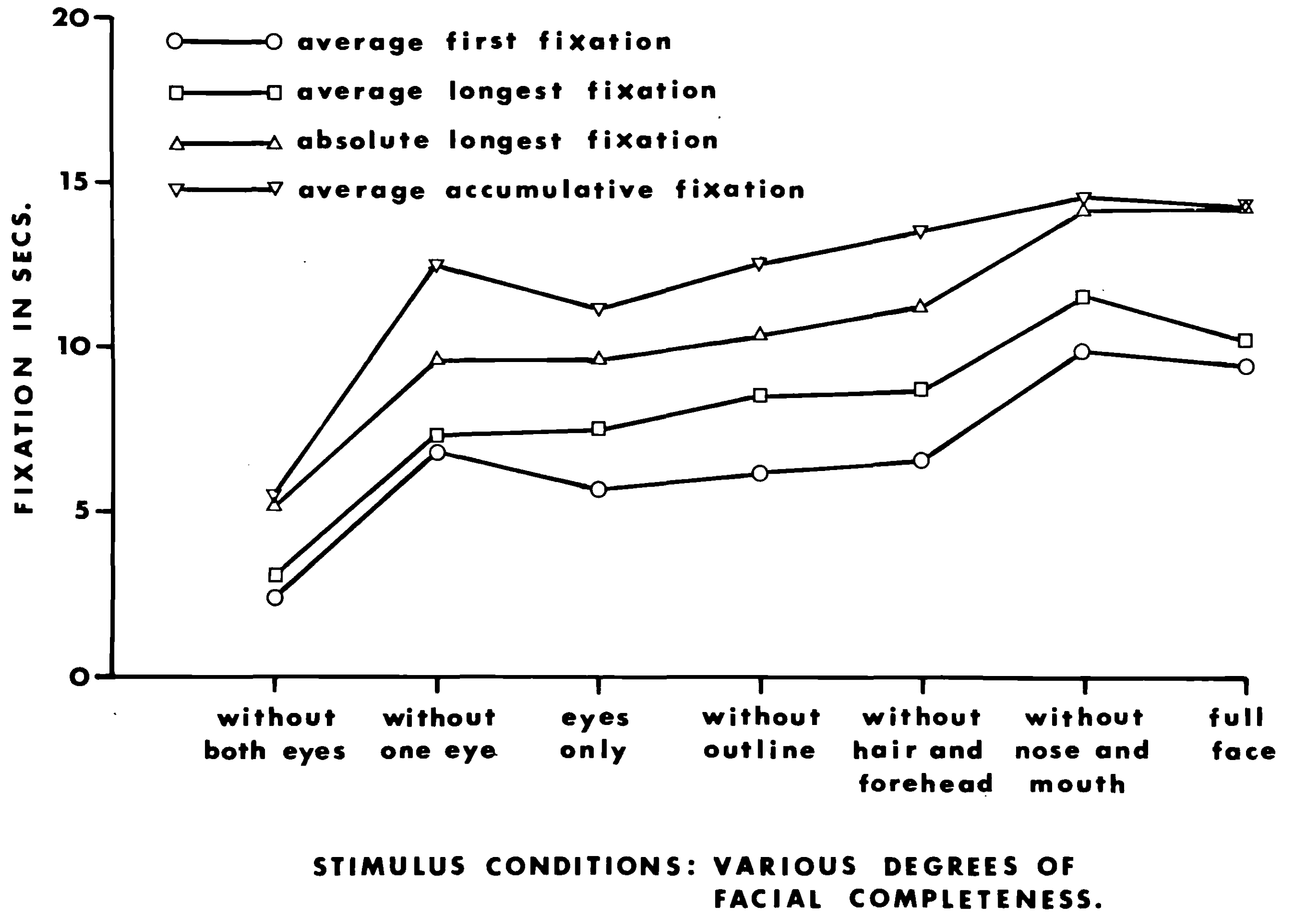


PLATE I: FACE WITHOUT BOTH EYES

PLATE II: FACE WITHOUT ONE EYE

PLATE III: EYES ONLY

PLATE IV: FACE WITHOUT OUTLINE

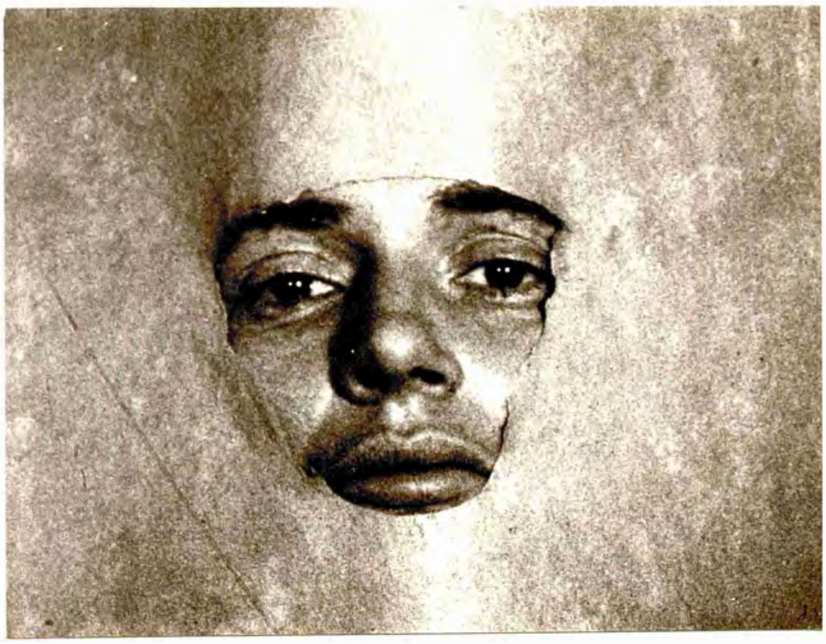


PLATE V: FACE WITHOUT HAIR AND FOREHEAD

PLATE VI: FACE WITHOUT NOSE AND MOUTH

PLATE VII: FULL FACE

PLATE VIII: FRONT VIEW OF TESTING APPARATUS

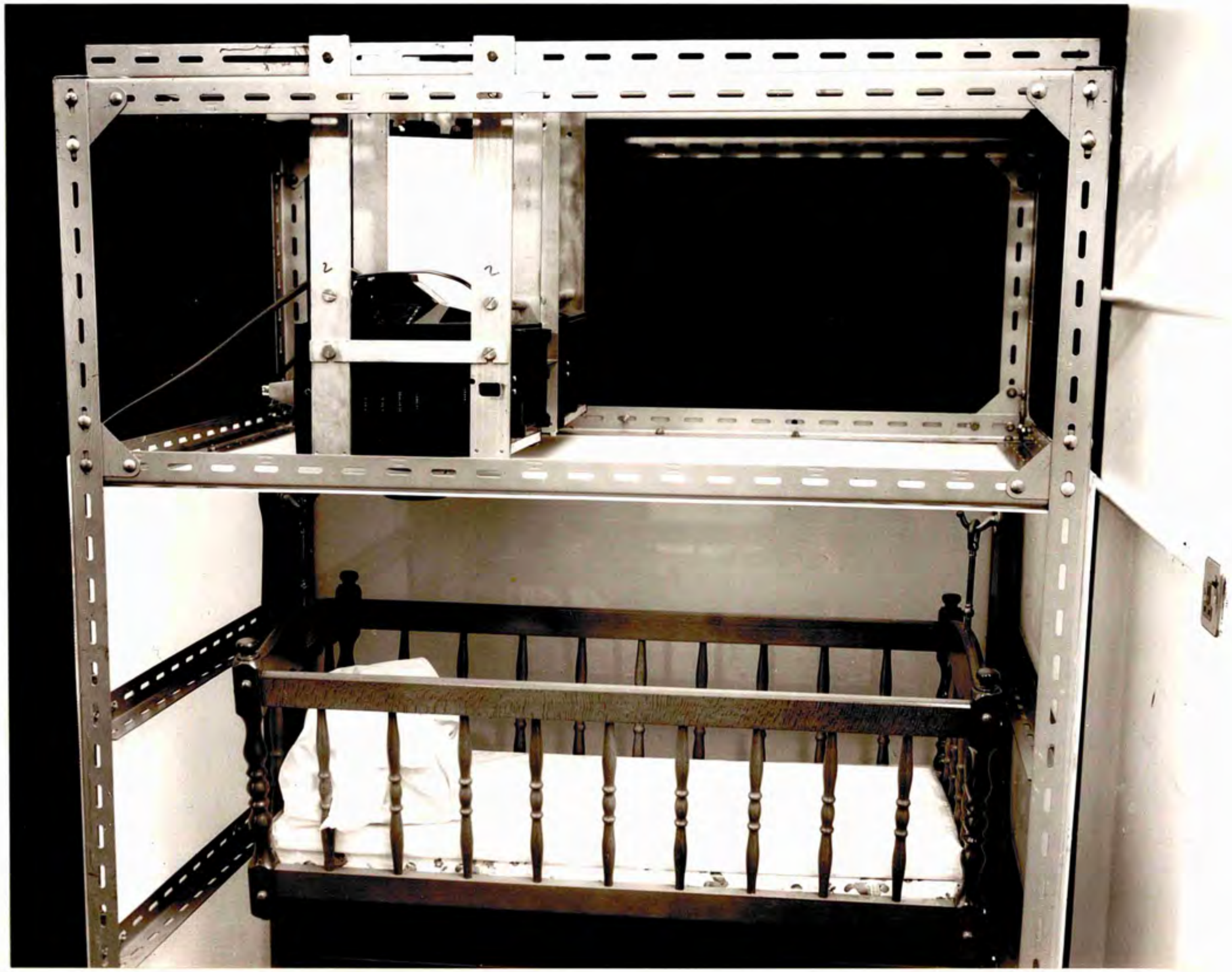


PLATE IX: SIDE VIEW OF TESTING APPARATUS

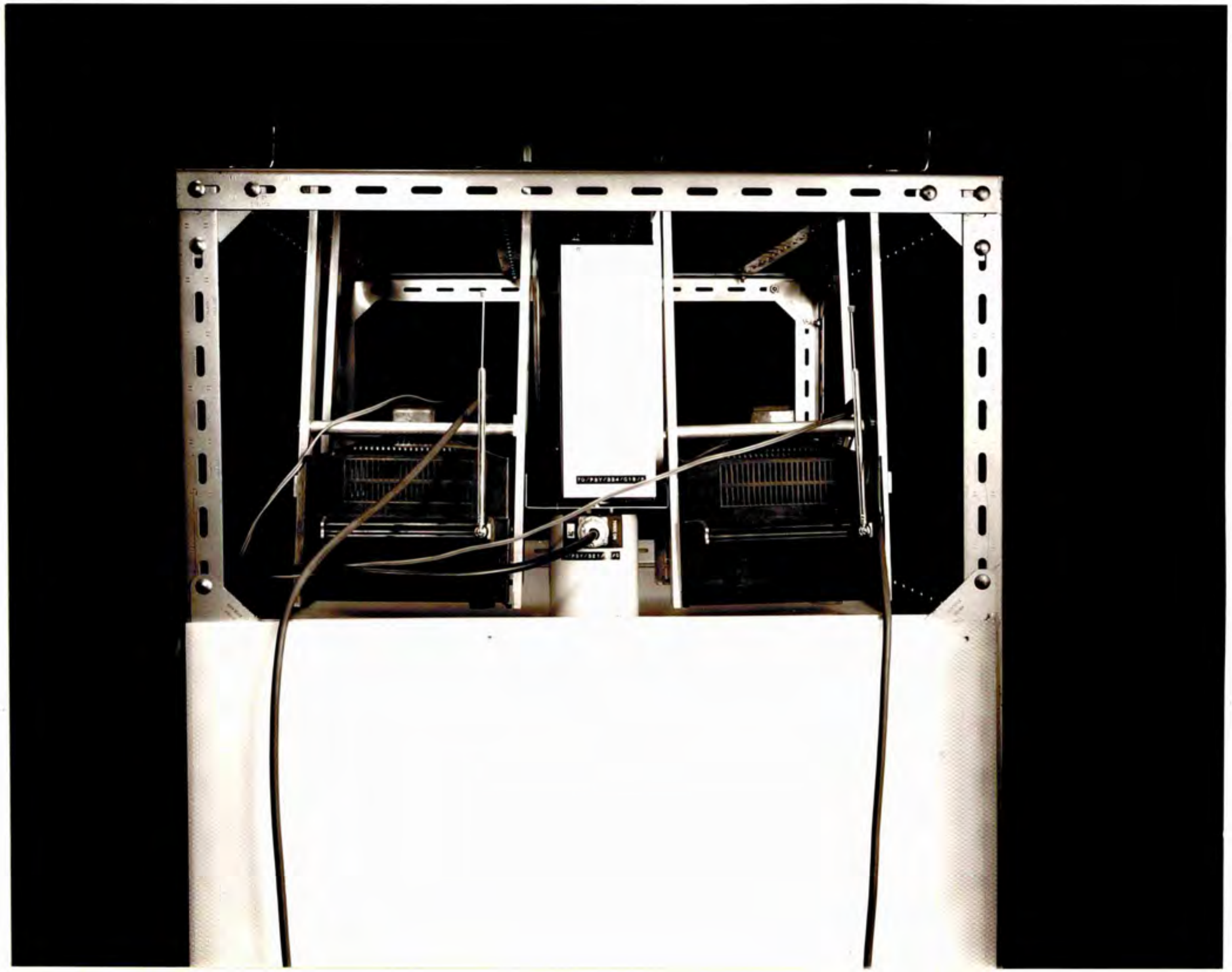


PLATE X: RECORDING DEVICES

PLATE XI

DIAGRAM OF AN EYE WHICH CAN BE CON-
SIDERED TO BE FIXATING THE STIMULUS

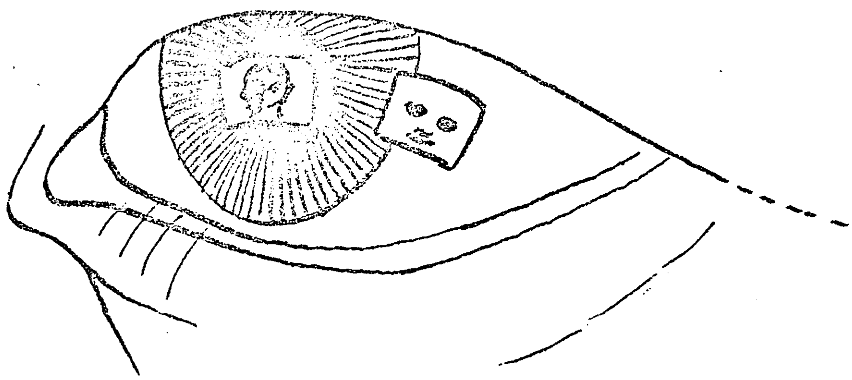
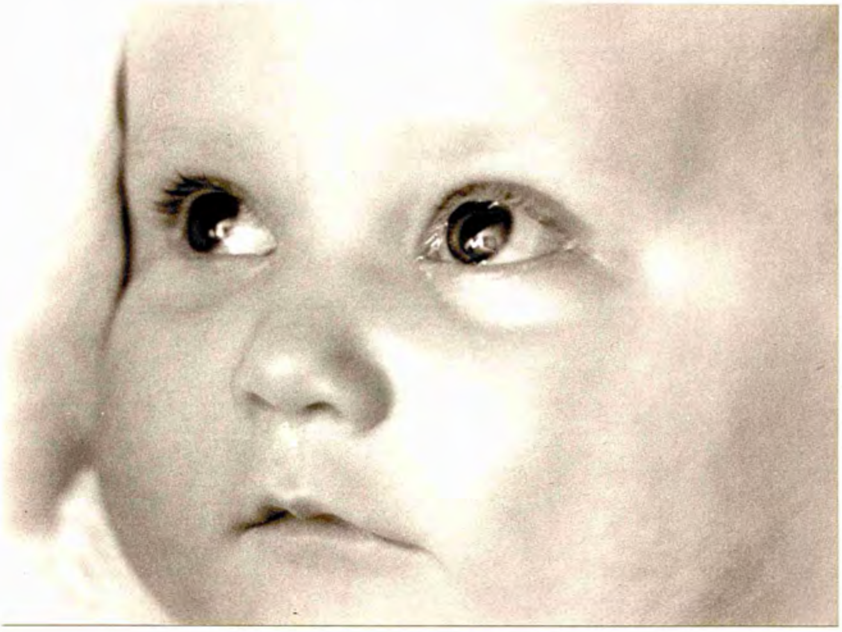


PLATE XII: PHOTOGRAPH OF AN INFANT'S EYES IN WHICH THE MONITORS ARE REFLECTED



PART III

THEORETICAL IMPLICATIONS OF AN INFANT'S REACTIONS TO THE HUMAN FACE

The Problem of Imprinting

Lorenz (1935) observed that incubator hatched goslings reacted to him as though he were the natural parent figure. That is, they followed him, tried to remain close to him and showed signs of distress if they could not. When adult, these same birds frequently attempted to court him. Obviously, something had gone wrong. A human being is an inappropriate maternal or sexual object for a goose. One implication of the "mistake" was that at least for certain species neither recognition of the mother nor choice of sexual partner was innate in the sense of "built in before birth".

Naturalistic experiments and observation led Lorenz to conclude that goslings, ducklings and many other nidifugous species of birds have a propensity to follow the first moving object present after hatching. In the average expectable environment, this moving object would most probably be the mother bird, i. e. an egg which has not been incubated by a hen would not hatch, and therefore, the presence of the hen at the time of hatching would be highly likely, if not inevitable, as far as most chicks, ducklings or the like are concerned. However, laboratory hatched birds, were observed to follow and later in life to attempt to court such diverse objects as a ball, a cube, a wooden decoy, or similar inappropriate objects. In short, it appeared that the mere presence of a moving object was all that was needed for newely hatched birds to learn its characteristics and to become attached to it. Lorenz labelled this early form of learning "imprinting". In contrast to other types of learning in which an organism changes the use or application of already existing structures, imprinting was considered to involve the formation of structures. In classical psychoanalytic language, it could be formulated as the formation of the Ego in contrast to introjected objects and/or memories which later would be contained in the Ego.

Lorenz' initial observations led him to conclude that imprinting (1) had irreversable effects, (2) took place only in a critical period which was limited in time, (3) was supra-individual learing, and (4) influenced patterns of behaviour which were yet to develop in an organism's repertoire.

In other words, imprinting could be considered like "acquired instinct", i.e. certain types of responses are built into an organism as a result of experience in such a way that once the "building-in" has taken place, it is impossible thereafter to distinguish them from responses built-in genetically. Above all, imprinting was seen as essentially different from ordinary learning in so far as imprinting could only take place in a brief or critical period and was irreversable, i.e. could not be forgotten. Unlike classical or operant conditioning, no practice was considered necessary. Moreover, there was no reward in the conventional sense of the word. Instead, imprinting appeared to be the result of an intrinsic propensity for young birds to follow a moving object. Lorenz considered the moving object to trigger an Innate Releasing Mechanism which elicited the following and brought about the preference for or bound to the object followed. Evolution was described as having provided sign-stimuli which release specific built-in responses in a way analageous to a key fitting into and opening a lock. Metaphorically, imprinting could be seen as a form of phylogenetic adaption, i.e. pre-adaption on the ontogenetic level as a result of species ~~learning~~ selection.

Zoologists and psychologists the world over were impressed with the possible importance of Lorenz' findings, though many were highly critical of his experimental procedures, or what they considered to be a lack of them. Therefore, experiments were undertaken to attempt (i) to examine the actual parameters which influence imprinting, (ii) to determine the dimensions of the critical period and (iii) to assess the later effects of the early experience in question. Naturally, if a problem is closely scrutinised, it is discovered to be more complex then previously thought.

When Ramsey and Hess (1954) compared the strength of imprinting and the effort expended by ducklings in following a wooden decoy, they concluded that there was a positive relationship between strength of imprinting and amount of effort expended in following the object imprinted to. The harder a duckling "worked", the better it imprinted. Experimental birds were induced to run up inclined planes and to jump hurdles in order to keep in contact or proximity with a wooden decoy. Hess (1957, 1958, 1959a, 1959c, 1962) formulated a "law of effort" which predicted the strength of imprinting as a function of effort expended during the critical period. He even hypothesized that it was effort on part of the subject which "caused" imprinting to take place.

Experiments by other researchers have not substantiated Hess's conclusion. To the contrary, Baer and Gray (1960) were able to imprint chicks to guinea pigs which were separated from the chicks by glass so that following was impossible. Moltz (1963) restricted the movements of ducklings by putting them in boxes; nonetheless, they still imprinted. Jaynes (1958a) and Smith (1962) found similar results. Obviously, movement of the subject is not a sufficient factor. However, the fact that effort is not prerequisite does not affect the finding that it may aid or strengthen imprinting. What must be distinguished are the minimally sufficent and the optimal conditions for imprinting. Movement of the subject is an optimal condition, while orientation of the subject is the minimally sufficient condition.

As has been said, it was originally thought that imprinting could only occur if a moving object were present at the critical time (Lorenz, 1935). However, James (1959, 1960a, 1960b) and Smith (1960) were able to imprint newly hatched birds to intermittent stimuli which were two-dimensional. Moreover, Gray (1960) successfully imprinted chicks to a static figure. Compatible results were found by Sluckin (1960, 1962). Therefore, it can be concluded that neither real nor artifical movement of the object (i. e. stimulus to be imprinted to) is necessary. In other words, heterogeneously patterned stimuli constitute the minimally sufficient conditions for imprinting to take place as regards the environment. An intermittent source of light or an actual animal would, of course, provide more optimal environmental conditions. However, the mere presence of stimulation, of something to orientate to, seems to be enough.

Hinde (1961) listed the number and type of different objects which could be imprinted on. He emphasised that in the young bird there is "initially a weak tendency to respond to a fairly wide range of objects and sounds". This tendency is then "primed by practice and conditioned to the characteristics of the particular objects which have elicited the response". Initially, the tendency to flee is low; at the same time, the tendency to follow is strong. Later, when the tendency to flee becomes stronger, it is more likely that a new object will be run away from rather than approached. Hinde stressed that "imprinting to an object involves not only an increased specifity in responsiveness and an increased tendency to respond to the object when it is present, but also an increase in the intensity of appetitive behaviour shown when the object disappears". Hinde differed from Lorenz, however, that sexual choice is a characteristic of imprinting just because it may be a consequence of it. Furthermore, Hinde quoted his own research (Hinde, Thorpe and Vince, 1965) and that of others (Fabricius, 1951; Ramsey and Hess, 1954) to demonstrate that objects which elicit following in newly hatched nidifugous birds may also elicit fear. In this connection, he emphasised that a young bird does not become attached to the species but to specific parent figures. Since parent birdsusually care only for their own young and attack those of others, it is necessary for the young to be capable of intra-species differential recognition. Amongst canabalistic fowl such as sea gulls, the ability to discriminate the caretaking figure(s) is imperative for survival.

Though Hinde (1961) specifically warned against a direct comparison of one species with another, especially of birds with mammals, he pointed out that similarities of behaviour are more likely to be a product of similar evolutionary selective forces than of similar organismic mechanisms. Nonetheless, he was willing to demarcate certain similarities of development acrosss species: first a general responsiveness, then a specific responsiveness to the parent or caretaking figure, next the emergence of fear and later aggresion. However, Hinde did not consider the establishment of a mother off-spring relationship in birds to be a special form of learning. He stressed the limitations of a rather rigid concept of an Innate Releasing Mechanism and advised that "many of the characteristics of imprinting in birds can be understood in functional terms" and can be considered similar to other learning processes.

It is practically impossible to compare the similarities of imprinting and other learning processes since there is no generally accepted view of what learning actually is. A Pavlovian, Skinnerian or Hullian conception of learning is very different from a Piagetian or Harlowian, and these from a Gutherian, Tolmanian or Köhlerian. Though Hinde advised that imprinting qua phenomenon is not categorically different from other forms of learning qua phenomena, it needs to be emphasised that the implications drawn by ethologists are very different from those drawn from other forms of learning by behaviouralists. However, if imprinting were to be compared phenomenologically with other forms of learning, Hinde would contend that it is best to postulate a continuum running from behaviour which is environmentally stable to behaviour which is environmentally labile. Imprinting would then be conceptualized as a form of learning which occurs during an environmentally labile period and which afterwards becomes relatively stable environmentally.

Though Hinde (1961,1963) conceded that "all learning is more likely to occur at some stages in the life cycle than it is at others", he did not deem it useful to ask whether imprinting occurs in species other than birds, but he did consider it legitimate to ask whether a given type of learning occurs within a sensitive period, and if it does, what limits that period.

In contrast to Hinde, Thorpe (1961) argued for a concept of imprinting extended beyond the original and narrower formulation by Lorenz. Instead of one global type of imprinting specifically concerned with the formation of parent off-spring attachment, Thorpe described at least three types of imprinting:

(a) Imprinted recognition of and response to specific patterns of visual stimulation,

(b) Imprinted recognition of and response to specific frequency patterns of auditory stimulation (fine periodicities or patterns),

(c) Imprinted recognition of and response to specific gross periodicities (rhythms) of stimulation.

Classical imprinting in the natural environment would be an example of types (a) and (b), i. e. visual and auditory imprinting. In both cases, recognition is a prerequisite for and different from any imprinted responses. The experimental findings of Smith (1960) and of James (1959), quoted above, are compatible with the notion that imprinting to only a visual stimulus can occur. Moreover, quieting to, recognition of and approaching a source of auditory stimulation have been reported by numerous investigators (Fabricius, 1951a, 1951b; Collias and Collias, 1956; Sluckin and Salzen 1961; Klopfer, 1959a, 1959b). Thorpe (1956, 1958a, 1958b) and Hinde (1958) offer evidence that in the chaffinch there is a sensitive phase for the acquisition of the species song, in otherwords imprinting to auditory stimuli.

Further evidence for different types of imprinting come from Schutz (1963, 1965a, 1965b, 1970, 1971) and Immelmann (1969). The sensitive phase for "sexual imprinting" occurs later than that for imprinting to a mother figure and forms the basis of a bird's erotic attachment to a species, but without regard to gender. The sensitive phase for the imprinting on male or female members of a species comes later than both maternal or species imprinting and can result in homosexual fixations.

Originally, the period in which imprinting took place was considered critical in two aspects: (1) limited in time, and (2) irreversible in effect.

Ramsey and Hess (1954) delineated what they hoped to be the incipient and terminal temporal limits of sensitivity for ducklings. However, experiments by Guiton (1958), by James (1960a, 1960b) and by Moltz and Stettner (1961) offer clear evidence that the "period of responsiveness can be appreciably extended" by a variety of experimental manipulations.

Various theories have been proposed to explain the termination of the optimal period. Kaufman and Hinde (1961) have classified these into four categories:

1. Maturational end of sensitivity
2. Inhibition through socialization
3. Growth of timidity and/or fear
4. End of low anxiety state

Sluckin (1965) points out that maturational age cannot be excluded as a terminating or limiting factor if the concept of maturation is interpreted narrowly. It is self-evident that no maturational period can be indefinitely extended. No organism is infinitely malleable. Thorpe (1961) has shown that the sensitive phase for learning of the species song in the chaffinch can be brought to an end without imprinting taking place. If, however, the concept of maturation is interpreted more widely, then it cannot be considered a sufficent factor. The above-mentioned studies by Guiton (1959), by James (1960) and by Moltz and Stettner (1961) testify that the period can in fact be extended. Obviously, it is not a question of either environmental influences or maturation but of an interaction of both.

Inhibition through socialization as a terminating factor implies that imprinting continues so long as no firm imprinting has taken place. This formulation can be only partially tenable. As quoted above, Thorpe (1961) demonstrated that the "sensitive" period could be brought to a close without imprinting having taken place, in which case termination could in no way be effected by the learning of an incompatible responses. Nonetheless, it is obvious that the formation of "approach and following responses to any stimulus configuration tend to inhibit approach and imprinting to new figures" (Sluckin 1965). Like maturation, inhibition through socialization can be said to contribute to the termination of the optimal period in certain circumstances, though neither can be said to be a sufficient explanation in itself.

It has long been known that fear of a figure inhibits approach and for this reason fear has been widely accepted as a terminating factor (Hess 1957, 1959b; Hinde, 1955b). However, fearfulness is not a primary response for it can be shown to be dependent on strangeness (Moltz and Stettner, 1961; Salzen, 1962). Obviously, since it takes time for stimuli to become familiar, it also takes time before non-familiar stimuli can be perceived as strange (Schaller and Emlen, 1962). Excluded, of course, is fear of or withdrawal from overwhelmingly intensive stimulation. "Whether maturation is or is not an important factor in the development of fearfulness, the tendency to flee from strange objects must be acquired in so far as 'knowledge' of what is strange is acquired" (Sluckin, 1965). If, however, avoidance or flight is taken as a criterion of fear, then birds can be imprinted to a "feared" object (Frabicius, 1951a; Jaynes, 1957; Weidmann, 1958; Guiton, 1959; Sluckin and Salzen, 1961). However, due to confusion of "fear" as a subjective state and of behaviour which is frequently considered to be "fearful", the role of "fear" remains ambiguous.

Moltz (1960) postulated newly hatched chick to be in a state of low anxiety which then became associated with a moving object. On the one hand, there is no empirical evidence that newly hatched chicks are in a state of low anxiety (Salzen and Tomlin, 1963). On the other hand, such an explanation is unnecessary, if not even untestable. Ultimately, it derives from an assumption that "all learning must be reinforced or associated with drive-reduction". It is superfluous to postulate hypothetical drives when none are evident. One of the salient characteristics of imprinting has always been the lack of rewards in the conventional sense. Thus, it is contradictory to propose them. It would be equally logical to argue that a newly hatched chick was in a high state of anxiety as a result of a phenomenon similar to the alleged "trauma of birth'.

The most plausible explanation for the end of the optimal period has been put forward by Salzen (1962) and Sluckin (1962): "imprinting ends as a result of imprinting". Though this statement may sound circular, the implication is that imprinting is an auto-terminating process. That is: the limitations of maturational flexibility, interacting with environmental influences, solidified by the formation of responses incompatible with the formation of similar subsequent responses, coupled with the awareness of novelty and the growth of fear, preclude the formation of alternative attachments. In short, there appears to be "a gradual change in the probability that imprinting will occur, depending on both the conditions of rearing and the test procedure" (Kaufman and Hinde, 1961).

Aristotle posed a similar problem of causation in his Metaphysics. The argument can be paraphrased as follows: If a boy drops a stone on a piece of glass and the glass brakes, what is the cause? Is it the weight of the stone, the brittleness of the glass, his positioning of the stone over the glass or his releasing the stone? Obviously, it is not a question of one single or ultimate cause. Rather, there are multiple determinants which interact, none of which is sufficient alone.

Lorenz (1935) considered the sensitive period to be critical because the results of imprinting appeared to be irreversible in an all-or-nothing manner. Moreover, he believed courtship-fixations to result from the process responsible for mother-infant bonding. Schutz (1963, 1965a, 1965b, 1970,1971,) however,has shown that the sensitive periods for imprinting of sexual and gender choices are different from that of infantile bonding to the maternal figure. Therefore, it is no longer possible to consider courtship fixations as examples of the irreversibility of imprinting to a maternal object. Nonetheless, it is worth noting the courtship fixations are not necessarily as irreversible as once thought (Guiton, 1962; Fisher and Hale, 1957; Wood-Gush, 1958).

Irreversibility of imprinting to a maternal object can be considered in terms of durability of felial responses. Salzen and Sluckin (1959b) observed that the duration of attachments were quite short under certain environmental circumstances. Jaynes (1958a) also found this to be the case. Thus, Sluckin (1965) and Guiton (1961) concluded that "stability of attachment appeared to be a function of the extent of initial experience". In other words, imprinting must be considered a more or less and not an all-or-nothing phenomenon and therefore not irreversible though frequently quite stable.

As a point of interest, it is to be noted that the terms "imprinting" (when denoting an infant's bond to a mother figure) and "attachments" are frequently used interchangeably in the literature.

Imprinting-like phenomena have been observed to occur in species other than nidifugous birds, e.g. in guinea pigs (Shipley, 1963), in puppies (Broadbeck, 1954; Scott, 1958, 1962), in sheep and goats (Scott, 1945; Herscher, Richmond and Moore, 1963) and in monkeys (Harlow, 1958, 1959,1960,1961,1962,1963; Harlow and Harlow, 1962,1969; Harlow and Zimmermann, 1958,1959). Sluckin (1965) pointed out that a "baby-monkey's initial exposure to its mother ties it to her, much as the chicks early experience ties it to the mother hen", and that the "behaviour of a frightened cloth-mother attacked monkey ... is strickingly similar to that of a frightened moving-box imprinted chick".

When Harlow gave infant monkeys the choice between spending time on a lactating wire surrogate or on a non-lactating, contact-comfort, cloth surrogate, they all "preferred" the cloth to the wire. Obvious, drive reduction or reinforcement could not be considered a sufficient concept to explain the attachment of an infant monkey to its mother or mother surrogate. With the exception of one, every surrogate, whether wire or cloth, was fitted with an artificial head containing monkey-like features. In the one case, however, the head was blank or featureless. When the faceless head was replaced with a faced head, the young monkey in question turned the features away from him, so that only the featureless back would be visible. Thus it appears that monkeys do imprint on conditions as specific as the maternal face. Harlow's findings are most interesting because monkeys are evolutionary closer to man than are birds and therefore permit better cross species comparisons.

There has been a great deal of controversy about the possibility of imprinting in the human infant. Gray (1958) designated a "critical period" to begin about six weeks with what he considered the onset of learning ability and to end at six months or so with the precursors of stranger anxiety or fear. Moreover, Gray held the smiling response in the human infant to be a motor equivalent of following in birds.

Ambrose (1963) criticised Gray on the grounds (1) that his definition of imprinting differed considerably from the concept generally held by ethologists, and (2) that his conclusions presupposed more evidence than he was able to present. Nonetheless, Ambrose found certain aspects of Gray's equation of smiling and following to be plausible. Ambrose emphasised however, that his own aim was not to demonstrate imprinting in man, but merely to show that "some phenomena often associated with imprinting are often to be found at a human level". Ambrose argued (1) that even though the smiling response may not be a motor equivalent of following these two responses, have a "close similarity of function" and (2) that a mother's eyes are the first figural entity to be perceived consistently by an infant. He also stresses that eyes possess the best combination of qualities which attract an infant's attention: "figure, small enough to be perceived with a minimum of multiple fixations, colour, albedo, movement and light-reflectance". In short, he considered the human eyes (in particular, those of an infant's caretaker) to be the social releaser or sign stimulus ~~Innate Releasing Mechanism~~, i.e. the human equivalent of the first moving object seen in the average expectable environment of a newly hatched bird.

Using smiling as a functional equivalent of following, Ambrose observed that infants do not respond to a human face before eleven weeks or so. Three to four weeks later, the readiness to smile to all faces reaches a peak. The strength of this general or indiscriminate responsiveness soon takes a sharpe decline, which was interpreted as due to the beginning of the ability to descriminate strangers' faces from the mother's. With the onset of discriminative smiling, Ambrose designated supra-individual learning to be at an end. Hinde (1963), however, criticised Ambrose on the grounds that "initial learning of the characteristics of the parent is not supra-individual learning".

Wolff (1963) observed smiling in home-reared American infants, though he made no reference to imprinting. He observed that during the first week "smiling can be elicited during irregular sleep and drowsiness by a variety of sounds" such as a high pitched brass bell, an Audubon bird whistle and a high pitched voice. By the second week, a voice was noted to elicit smiling more effectively than other stimuli. During the third week, infants gave their first "social smile". Though infants were now capable of smiling when bright eyed and alert, a human voice was still the most effective stimulus. It was only at about the fourth week that visual stimuli began to play a part in the eliciting of smiling. At about the same time or shortly later, infants were first observed to focus on the eyes of an adult, i.e., to make eye-to-eye contact. Thereafter smiling became a predictable and more selective response to a number of specific, highly articulated stimuli and achieved greater autonomy from organismic state. In other words, one month old infants can definately respond socially to visual stimuli, whereas previously they could not. It is obvious, of course, that the ability to perceive a stimulus is prerequisite for imprinting to it.

Bowlby (1969) noted that when the term "imprinting" is used in a generic sense, it implies (a) "the development of a clearly defined preference", (b) " a preference which develops very quickly and usually during a limited phase of the life cycle", and (c) "a preference that, once formed, remains comparatively fixed".

Hunt (1970) underlined the attentional factors involved in imprinting. He pointed out that "under at least certain conditions, perceptual encounters with objects, patterns, and places lead to perceptual preference for these familiar objects, patterns, etc., before they lead to preference for what is unfamiliar or novel". Moreover, he interpreted following behaviour to indicate that the object, pattern, etc., which is visually orientated to is "preferred". However, Hunt was careful only to make a comparison between imprinting and other types of learning.

If imprinting is to be compared with other forms of learning, then it must be realised that imprinting is always "early learning" and is presupposed by later learning from which it is different at least temporarily. Learning when an organism is immature, i.e. when an organism is malleable and in the process of rapid growth, is different from learning in a mature or already formed organism (Hebb, 1949). Since there are important anatomical differences between the brains of very young or immature and those of adult or mature organisms, it seems not unreasonable to suppose that former differ from the latter in the way they learn (Russell, 1959; Sluckin, 1965). Supporting evidence comes from the work of Scott and Marston (1950), Biel (1940), Munn (1950), James and Binks (1963), Vince (1958,1959,1960,1961). In fact, "it is the general conclusion of students of animal learning that younger individuals are better learners than are older ones" (Thorpe, 1961).

Though there is little agreement among authors as to just what learning is, it can, for convenience sake, be defined as relatively lasting changes in behaviour resulting from experience. The lasting character of behavioural change as a definition of learning distinguishes it from changes associated with fatigue, stress, drugs, or the like. The experiential aspect of the definition precludes changes dependent on maturation or ageing.

Some authors distinguish learning and adaptation (Sluckin, 1965), however, Piaget (1952) considers all forms of learning, especially cognitive, as special cases of biological adaptation.

The insightful behaviour of primates observed by Köhler (1925) is now attributed to "learning sets" or "learning how to learn" (Harlow, 1949), while both classical and operant conditioning are considered as training procedures and therefore not equatable with learning per se. Strategy and conceptual learning are poorly explained in terms of conditioning techniques. The same is true of imprinting.

Association, above all else, is held to be the salient criterion of conditioning (Morgan, 1961). But in all forms of conditioning "the pairing of stimuli and response is selective: either one out of a range of possible stimuli becomes associated with a given response, or one particular response becomes associated with some stimulus" (Sluckin, 1965). Imprinting, however, starts with a built-in, unconditioned orientation response to a source of stimulation and is frequently, though not invariably, accompanied by an equally built-in, unconditioned approach response.

Classical or Pavlovian conditioning presupposes an unconditioned stimulus which evokes an unconditioned response (Pavlov, 1927, 1928). The unconditioned stimulus is then paired or associated in time with another stimulus, the conditioned stimulus. Training then consists of repeated presentations of the two stimuli. If an experimental animal responds in a manner same or similar to the unconditioned stimulus when the conditioned stimulus alone is presented., i. e. without the unconditioned or eliciting stimulus, then that response is designated a conditioned response.

If imprinting is to be compared with Pavlovian conditioning, then the social releasor or sign stimulus would be equated with the unconditioned stimulus and the orientation cum approach response with the elicited or unconditioned response. But the comparison falls down because there is nothing equal to a conditioned stimulus. In fact, imprinting can be used as a basis for classical unconditioning (James, 1959,1960a; Abercrombie and James, 1961; Klopfer, 1959b) in which case imprinting could not be an example of classical conditioning. That is: 'A' cannot be the basis of 'B' andbe identical with 'B' at the same time.

If, for argument sake, it is assumed that oritentation and approach responses are emitted and not elicited, then imprinting can be compared with operant or instrumental conditioning. However, further problems ensue. The paradigm of Skinnerian conditioning consists of a sequence of 1. an emitted response followed by 2. reinforcement. In some cases, a discriminative stimulus is present to "tell" the experimental animal when to respond. The latter sequence is then: 1. discriminative stimulus, 2. response, 3. reinforcement. In this case, the social releaser would be both discriminative stimulus and reinforcement. However, it is nonsense for a reinforcement to precede an operant or emitted response. A reinforcement could precede a response only in classical conditioning, in which case a doubtful equation of unconditioned stimulus and reinforcement must be made.* Thus the paradigm of operant conditioning can be seen to be reducible to that of classical as far as imprinting is concerned.

Operant responses decline or habituate when reinforcement is removed. This is not true of imprinting. However, it is worth noting that operant responses are not considered to habituate but to be held in abeyance when the discriminative stimulus is absent. Therefore, if imprinting were considered a form of operant conditioning, then it would be a paradoxical form of it because habituation would be impossible, and an important characteristic of anything that is learned (e.g. conditioned responses) is that it can be forgotten (Bühler, 1927). Thus, it is obvious that neither classical nor operant conditioning provide paradigm easily compatible with the phenomena of imprinting.

'In imprinting there is no external reinforcement". Nor is there a conditioned stimulus. "The releasing stimuli itself is attractive from the start and becomes more attractive as the organism continues to be exposed to it". (Sluckin, 1965). By contrast, an unconditioned stimulus does not become more attrative when paired with a conditioned stimulus. Likewise, a reinforcement does not become more reinforcing with training. Yet, Hinde, Thorpe and Vince (1956) claim

. . . .

* If an unconditioned stimulus is unconditioned, then it is superfluous to employ another term such as reinforcement. If the two terms are synonymous, then nothing is added, but if they are not synonymous then they are contradictory.

imprinting to be self reinforcing. On the one hand, such a claim is anthropomorphic (Weiss, 1969); on the other, it is tautologous and therefore superfluous: if an unconditioned stimulus evokes a response, nothing is gained by defining that stimulus as reinforcing just because it evokes the response in question; likewise, if a discriminative stimulus signals the availability of reinforcement, then it is redundant to consider the signal as reinforcing. Sluckin (1965) is explicit that "in so far as the term, reinforcement implies or suggests external reinforcement imprinting may be described as a form of non-reinforced learning". Foss (1963) characterised imprinting as "a discriminated preference for one object is developed in the absence of any conventional reinforcers". Above all, there is no "selective pairing of stimuli and responses" in imprinting as there is both types of conditioning. To the contrary, the initial bond between eliciting stimuli and imprinted responses is strengthened with experience and becomes exclusive. Since imprinting is a form of learning in which selection is impossible, it can be described as a form of non-associative learning, for association presupposes alternatives. In both classical and operant conditioning, a response, either elicited or emitted, becomes associated with a stimulus, be it a conditioned stimulus or a reinforcement, with which it was not previously associated. Though the notion of an Innate Releasing Mechanism can be overstated, it is exactly the non-selective phenomenon of releasing stimuli which differentiates imprinting from associative learning. Conditioning always implies learning to respond to classes of stimuli, whereas imprinting to a maternal figure is just the opposite, i. e. learning to recognise and to respond to a specific stimulus. Thus, Vince (1960) considers learning to be too crude a concept for developmental changes, one of which is imprinting.

Obviously, imprinting presupposes the ability in general to distinguish figure from ground and in particular to differentiate between figures. It also presupposes perceptual learning but differs from it in that "learning of the characteristics of the environment need not ... entail the formation of any attachments". Weidmann (1956) observed that non-imprinted birds would follow only when hungry and when left alone, showed no distress.

The ability to discriminate between familiar and novel or strange, which is a consequence of imprinting, appears to be acquired "not by conditioning but through perceptual learning". (Sluckin and Salzen, 1961; Sluckin, 1962; Gibson, 1969; Hunt, 1970). In this connection, Drever coined the expression "exposure learning" which specifies both "the perceptual registration by the organism of the environment to which it is exposed" and "the familiarisation of the organism with its environment" (Sluckin, 1965).

Hess (1959a, 1959c, 1962b) considered primacy of experience to be fundamental for imprinting, whereas recency for associative learning. Hinde (1962b) criticised Hess on the claim that it is difficult to test the primacy-recency hypothesis. However, the well-known experiments concerning pro-active and retro-active inhibition are empirical statements of exactly this hypothesis.

As has been stated, following is not requisite for imprinting to take place. Orientation to a source of stimulation is the minimally sufficient condition. Thus exposure learning can be considered to underlie imprinting but cannot be equated with it, because imprinting is not just "learning of characteristics of a parent-object" (Baer and Gray, 1960), it is also the development of appetitive response to or "needs" for that object. It is precisely the appetitve aspect of imprinting which distinguish it from other forms of learning.

On the one hand, imprinting is foundation or primary learning, i. e. learning upon which other or subsequent learning rests. On the other hand, imprinting is the actualisation of "desir" in the sense that a built-in response finds its goal or object. Above all, imprinting is more than "simple" learning in so far as it can be viewed as an acquired appetitive or motivational system. Moreover, it is a type of early learning limited to a relative brief sensitive or optimal period.

Obviously, it is fruitless to argue over the use of terms. Whether something is imprinting or is not can all too easily become a verbal argument. The label is not important. What is important is how two different species are similar and different as regards a particular behaviour or function. Therefore the rest of this chapter will be concerned neither with the hypothetical critical or limited nature of a sensitive period, not with the postulated characteristics of irreversibility or supra-individual learning. Rather, it will be concerned with "imprinting" in the extended sense of the concept as used by Thorpe (1961) and in terms of the actual events and conditions specific to the development of preferences for a particular pattern of visual stimulation.

Hinde (1963) pointed out that the result of the imprinting process is that an immature organism "learns to recognise its mother as an individual, and [that] a number of discrete responses made by the young animal ... became integrated on to one object".

Therefore, similarities between the early development of attachment in humans and the initial phases of imprinting in birds will be drawn.

The human neonate is borne visually naive. To date, there is no convincing evidence that he is capable of innate recognition of the human face or of any other pattern. Rather, he is differentially sensitive to certain classes of stimuli which frequently emanate from a human source (Wolff, 1963; Bowlby, 1969). The neonate can see, though his visual abilities are limited. Unlike the young of most other species, he is unable to follow or cling. Therefore, in the environment of evolutionary adaptedness he would most likely be almost continually held by his mother (or another caretaker), whilst in modern European society, he may either lie in a crib or be held. Just like the newly hatched bird, the newborn human infant eventually becomes attached to a specific member to his species, usually his caretaker.

Bowlby (1969) lists eight points of similarity between the development of attachment in human infants and imprinting in birds:

(i) In human infants social responses of every kind are first elicited by a wide array of stimuli and are later elicited by a much narrower array, confined after some months to stimuli arising from one or a few particular individuals.

(ii) There is evidence of a marked bias to respond socially to certain kinds of stimuli more than to others.

(iii) The more experience of social interaction an infant has with a person the stronger his attachment to that person becomes.

(iv) The fact that learning to discriminate different faces commonly follows periods of attentive staring and listening suggests that exposure learning may be playing a part.

(v) In most infants attachment behaviour to a preferrred figure develops during the first year of life. It seems probable that there is a sensitive period in that year during which attachment behaviour develops most readily.

(vi) It is unlikely that any sensitive phase begins before about six weeks and it may be some weeks later.

(vii) After about six months, and markedly so after eight or nine months, babies are more likely to respond to strange figures with fear responses, and more likely also to respond to them with strong fear responses, than they are when they are younger. Because of the growing frequency and strength of such fear responses, the development of attachment to a new figure becomes increasingly difficult towards the end of the first year and subsequently.

(viii) Once a child has become strongly attached to a particular figure, he tends to prefer that figure to all others, and such preference tends to persist despite separation.

In most species, especially in higher species, e. g., humans, monkeys, dogs, etc, the development of attachment appears to follow a fairly regular epigenetic sequence.

Bowlby distinguishes four main phases in the development of human attachment behaviour. The first is characterised by an infant's indiscriminate orientation and responsiveness to social stimuli. At eight to twelve weeks the second phase begins with the appearance of discrimination of one or more persons. The third phase usually starts after the sixth month when an infant employs signals to remain in proximity to already discriminated persons. Once he can crawl, he also uses locomotion. Somewhere after the end of the second year, an infant becomes capable of a reciprocal and insightful relationship with his caretakers. Bowlby designates this fourth phase as the "formation of a goal-corrected partnership".

Ainsworth (1964) studied the development of attachments among the Ganda and subsequently (Ainsworth and Bell, 1969a, 1969b) among middle class white Americans. Her ontogenetic sequence and Bowlby's are quite similar. Ainsworth noted an absence of social responsiveness during the neonatal period. An undiscriminating social responsiveness appeared at about one month. Infants were observed to smile to any face in social interaction. However, by the third to the fourth month, responsiveness became differential and preferential when an infant was in close proximity with his caretaking figure(s). Smiling, crying, and vocalisation were among the first responses to become differential and therefore to imply discrimination. A month or so later, an infant not only greeted his caretaker when she entered the room but also cried when she left. i. e., he could now be considered differentially responsive at a distance. At around eight months, usually with the onset of locomotion, Ainsworth dated the first occurrence of active initiative on the part of the infant and a few weeks later, the onset of manifest stranger anxiety.

Sander (1962, 1964) considered the mother-infant dyad as a unit of social interaction. He concerned himself not only with attachment behaviour but also with its reciprocal compliment, caretaking behaviour. He described the interaction between mother and infant in terms of "Issues", the first of which centred around "Initial Regulation". By about two and a half or three months mother and infant had usually got on some kind of schedule and "Reciprocal Exchange in Interaction" became the second issue. At the end of the sixth month began the third issue, which had as its focus an "Infant's Initiative to Direct his Activity" and was followed at about ten months by the fourth issue: the "Availability of a Mother to an Infant's Initiative". The last issue concerned an infant's "Self-assertion".

The relationship between Bowlby's, Ainsworth's and Sander's descriptions of the developmental sequences is presented below:

Bowlby	Ainsworth	Sander
PHASE I Orientation and Signals without Discrimination of Figure [0 to 8 or 12 wks]	STAGE I (a) Neonatal Reflex [0 to 4 wks] (b) Undiscriminating social responsiveness [4 to 8 or 12 wks]	ISSUE I Initial Regulation [0 to 3 mths]
PHASE II Orientation and Signals Directed towards one (or more) Discriminated Figure(s) [2 or 3 to 6 mths]	STAGE II Differential Responsiveness in Close Proximity to the Mother Figure [8 or 12 to 20 or 25 wks]	ISSUE II Reciprocal Exchange in Interaction [4 to 6 mths]
PHASE III Maintenance of Proximity to a Discriminated Figure by Means of Locomotion as well as Signals [6 or 7 mths on]	STAGE III Differential Responsiveness at a Distance [20 or 25 to 35 wks]	ISSUE III Infant's Initiative to Direct his Activity [7 to 9 mths]
	STAGE IV Active Initiative (with onset of locomotion) [30 to 35 wks on]	
	STAGE V Stranger Anxiety [9 mths on]	ISSUE IV Availability of Mother to Infant's Initiative [10 to 13 mths]
		ISSUE V Self-Assertion of Infant [14 to 20 mths]
PHASE IV Formation of a Goal-Corrected Partnership [not before 24 mths]		

The Development of Perception and of Attachment in the Human Infant compared with "Imprinted Recognition of and Response to Specific Patterns of Visual Stimulation"

It will be remembered that the minimal requirements for "imprinting" in the more general or extended sense of the concept appear to be (1) a naive subject (2) capable of orienting to (3) patterned stimulation (4) which must be present (5) during an optimal period for learning.

(1) So far, there is absolutely no evidence that requires us to postulate innate ideas, nor innate recognition of or response to a specific visual stimulus configuration. In short, there can be little doubt that the partunate is visually naive, (5) a state which can be considered optimal for visual learning.

(2) The human partunate withdraws from overwhelmingly intense stimuli and, of course, does not even respond to stimuli above or below his thesholds of attention, but he can and does orientate to stimuli within a certain range, though not indiscriminately. Wolff (1963a) has observed that a high pitched brass bell and an audubon bird whistle are initially as effective as a human voice in eliciting smiling, and are more effective than fog horns. In fact it is quite certain that the "normal" full-term partunate is capable of orientating to sources of heterogeneous stimulation. All of the literature reviewed in the first section presupposes just that ability to orientate.

(3) Perceptual studies indicate that infants orientate "instinctively" to patterned stimuli (Fantz, 1958, 1961, 1963, 1966; Berlyne, 1958; Bruner.,1968) and "prefer" or fixate longer stimuli which are complex, but not too complex. In other words, there is an optimal level of complexity (Herschenson, Munsinger and Kessen, 1965; Thomas, 1965; Brennan, Ames and Moore, 1965; Caron and Caron, 1969; Moffett, 1969; Cohen 1969; Haith, Kessen and Collins, 1969). Moreover, a moving or varying stimulus, especially one which responds to an infant's own actions, appears to be more attractive than a static or unresponsive one (Caron, 1967; Rovee and Rovee, 1969). It does not need to be emphasised that the maternal face constitutes a relatively complex, (though not too complex), intermittent, responsive stimulus and therefore meets the requirements of the stimulus parameters to which a neonate can and does respond. Therefore, the task is to establish which stimuli are present and when. But before continuing, it pays to remember that it is unnecessary to argue for a narrowly defined Innate Releasing Mechanism, as do Lorenz (1935) and Gray (1958).

Since the ability to orient is alone sufficient for imprinting to take place, the inability of the human infant to follow poses no genuine problem. The functional equation of following and smiling is therefore irrelevant. Neither movement of the subject nor of the object, though advantageous, is sufficient. Thus, it appears possible to draw certain comparisons between the minimally sufficient conditions in newly hatched birds for imprinted recognition of a visual stimulus and the corresponding conditions under which a human infant grows responsive to or attached to the human facial Gestalt. The obvious differences between optimal conditions for the different species will not be stressed.

(4) The partunate comes equipped with a fixed focal length of approximately nineteen centimetres on the average (Haynes, White and Held, 1964). Therefore, everything beyond about five to ten inches is more or less out of focus. Objects or patterns at a distance of two feet or more from a partunate's eyes do not exist in the practical sense of the word as far as he is concerned. Also, very young infants appear to be able to resolve only strong contrasts of grey (Nelson, 1968). It is as though a neonate views the world through a camera fitted with a filter to reduce patterns to flat areas of black and white. Stimuli which are too complex cannot be resolved and therefore are visually precluded. Furthermore, a neonate is incapable of scanning a stimulus. Rather, he picks out an attractive part, usually an angular element, on which he fixates (Salapatek and Kessen, 1966; Nelson and Kessen, 1969). Moreover, it appears that neonates are perceptually bound, that is: they are forced to look at something and cannot look away (Steckler and Latz, 1966). In other words, there is no problem of divided attention or competing visual stimuli.

Each neonate lives in a very restricted Umwelt (von Uexküll, 1921, 1934). His world of experience has been greatly simplified by the above mentioned factors. It would be poetically accurate to say that he cannot see more than he can understand. Thus there are only a limited number of visual stimuli which initially impinge upon his naive visual awareness, a state optimal for learning.

In the average expectable environment, the stimulus most frequently to penetrate into a neonate's visual Umwelt would be the face of his caretaker. Spitz (1948, 1959), Benjamin (1963), Ainsworth (1967), Wolff (1963a, 1963b) and Sander (1962, 1964) describe the frequency with which and the way in which a young infant responds to his mother in the midst of routine care and games. It is therefore quite plausible that the human face is the most constantly present stimulus in a neonates restricted visual Umwelt. Casual, naturalistic observation indicates that most mothers initially hold their own face about six to twelve inches from their infant's eyes when in direct face-to-face interaction.

As was indicated above, young infant's "prefer" patterned stimuli to a homogeneous field, but they do not scan a figure. Instead, they appear to fix upon an attrative part. Moreover, they appear to have a predilection for stimuli which are intermediate in complexity and which move or vary. To be sure, the human facial Gestalt meets all of these criteria, including the criterion of "attractive" parts, namely: the eyes (Ambrose, 1963). Therefore, it comes as no surprise that the face is the first visual stimulus to which an infant responds most consistently and most vigorously with differential behaviour, and to which he shows the first signs of primitive recognition. It is by the fourth or fifth week, when an infant is capable of focally accommodating to changes in distance and of resolving subtler shades of grey, that he has become familiar with the human facial Gestalt.

Since a neonate cannot approach or follow locomotorly, the restriction of visual stimuli to which he is exposed increases the probability that extraneous stimuli do not interfere with "exposure learning" and the subsequent infant-mother bond. That is: as a consequence of the initial limitations of an infant's visual system, it is more likely that he will become familiar with and attached to or imprinted to the biologically appropriate class of visual stimuli, i. e. the mother's face. If looking is all an infant can do and if the basis of "exposure learning" or "imprinted recognition of and response to specific patterns of visual stimulation" is looking, then it is reasonable to assume some factor(s), presumably the result of evolutionary selective processes, which would limit the range of visual stimuli and thereby reduce the likelihood of maladaptation or fixation on a biologically inappropriate objects. In short, if an infant is not to be overwhelmed by the complexity of the visual environment and if the mother's face is to enjoy primacy over other patterned stimulation in his visual experience, then not only must he be equipped with a "preference" for certain classes of stimulation but also must his visual experience be restricted in such a way that, in the average expectable environment, opportunities to perceive the caretaker's face would be facilitated while opportunities to perceive other classes of stimuli, equally preferable initially, would be reduced or even precluded.*

* It is interesting to note that some young infants appear to be attached to or "imprinted on" not only the mother's face but also on a teddy bear or on a mobile.

Von Uexkull (1921,1934) distinguished between the environment in which an organism lives and its Umwelt or phenomenal-subjective "world". Though environments may overlap, Umwelten do not necessarily. In short, there is no single "world" in which all organisms live, for each particular Umwelt is a "world" created from the environment as a result of an interlocking of a species' effector and receptor systems. It is usually also the "world" to which each species is best fitted or adapted.

In higher organisms, one of the many possible, and perhaps the most important of Umwelten is visual. As von Uexkull emphasised, there can be little doubt that a visual Umwelt, for instance of either adult or infant human, has survival value and is the result of evolutionary selective forces. The question is, therefore, whether the restriction of an infant's visual Umwelt has an evolutionary function.

It could be argued that the human infant is born premature and hence the restriction. However, the mechanisms underlying the restriction must not be equated with the function of the restriction. It could equally well be argued that prematurity had been selected because it ensured restricted vision. The question would therefore have to be re-phrased: Does the restriction of an infant's vision have survival value for the species?

If attachment has the evolutionary function of ensuring survival of the species by decreasing the number of young that fall prey to predators (Bowlby, 1969), then there must be certain mechanisms to make it more likely that attachment takes place. These mechanisms would likewise have been selected phylogenetically for their contribution to the formations of the infant-mother bond.

Now, it has been shown that the consequence of the restriction is an increase in the likelihood that recognition of and attachment to the mother's face will take place. The issue is, in short, whether this consequence has an evolutionary function. Surely, whatever has as its consequence an evolutionary function must also be an evolutionary function.

Since the human neonate cannot cling, he would have to be carried or held in the environment of evolutionary adaptedness and he would usually be held in the arms or on the chest. In the first case, perception of the mother's face would be possible, though not frequently optimal (except when she lowered her head); in the latter, it would be impossible. In short, a young infant would spend most of his time looking at and therefore becoming more familiar with stimuli other than his mother's face. When one considers that in the environment of evolutionary adaptedness, a mother would have to be involved with tasks of survival such as food gathering and vigilance for predators, it is obvious that her infant would not receive her exclusive attention and would more frequently be exposed to patterns other than her face.

Since the phenomenon of imprinting to visual stimuli is not coterminal with attachment and/or imprinting to auditory and perhaps even to tactile stimuli, and since an adult's visual environment is overwhelmingly complex, it seems highly likely that visual preferences for non-human and therefore maladaptive objects would be more frequent the degree to which an infant's visual Umwelt was complex or offered alternative stimuli to be imprinted to. Above all, an overly-complex visual "world" would be cognitively overwhelming. There is strong evidence (Piaget, 1936, 1937; Hunt, 1970) that at least for cognitive functions (one of which is visual perception), there is an optimal level of complexity and that whatever is too complex or too novel is just not assimilated as such. If an infant is to develop, there must be an interlocking of his abilities or schemata and what they can handle. In other words, perceptual and cognitive experiences must be appropriate to an infant's stage of development. In short, a primitive "mind" requires restricted experience, otherwise development, and with it survival, would be impossible.

(5) As has been said, an infant's visual system goes through rapid development during the first month of life. Whereas the partunate could only resolve sharp black white contrasts, the four to five week old neonate can resolve more intermediate shades of grey and therefore more comlex patterns (Nelson, 1968). Moreover, it is somewhere around the beginning of the second month, if not before, that an infant's focal length ceases to be fixed and begins to show the first signs of accommodating to objects at various distances (Haynes, White and Held, 1967). Simultaneously, he begins to make eye-to-eye contact and to smile to a non-speaking face (Wolff, 1963). However, it is not until the fourth or fifth month that an infant's visual system is roughly equivalent in functional terms to an adult's (Haynes, White and Held, 1965; Bower, 1966).

Fantz (1963) originally claimed that there was a preference throughout the first six months for a correct arrangement of schematic facial features over scrambled. However, data from a subsequent experiment (Fantz, 1965) do not appear to support a "preference" for correct arrangement until about the second or third month. If there is initially no preference for the facial Gestalt and then, two or three months later, a preference can be observed, it would be legitimate to assume that some form of learning has taken place. But neither Kagan, Henker, Hen-Tov, Levine and Lewis (1966), Koopman and Ames (1967) nor Wilcox (1969) were able to find a preference for a face-like stimulus when an alternative non-face-like stimulus was of equal complexity. Nonetheless, a more complete or natural representation of a face and/or a pattern with eyes tended to elicit longer fixations than an incomplete or stylized facial pattern, especially without eyes. Significantly enough, from the second month on, most infants can distinguish a three dimensional object from a two dimensional representation of it and do not equate the two (Bower, 1966, 1971). Therefore, it is likely that an infant eight weeks or older can discriminate a face-like pattern from an actual face, in which case the findings of the experiments quoted above could not be considered as sufficient to provide a basis for conclusions concerning infantile perception of the face as a living, three dimensional source of stimulation. Fixation, fortunately, is not the only behavioural indication of an infant's perception of the face. Differential social responses can also be used.

Spitz (1946, 1948) emphasised the centrality of the eyes in the facial Gestalt as a determinant of smiling. Ahrens (1959) subsequently noted that eyes only were sufficient to elicit smiling and that a face wearing false eyes was reacted to negatively. Ambrose (1963) considered a mother's eyes to be the "human equivalent of what in birds is the 'first moving object seen' ".

In the pilot study, the author noted that a living face which contained eyes as well as some other feature(s) was fixated by infants three months or older as frequently as a complete face. The use of a living face was advantageous in that it could leave little doubt of what an infant was actually responding to. Results similar to those in the pilot study were found in the main study, in which black and white filmed faces constituted the stimulus variables. In fact, infants showed to filmed and to real or living faces basically the same hierarchical ordering of fixation times for various conditions of completeness. This fact suggests that the face is recognised as a coherent visual pattern. Moreover, the negative reaction to the absence of the eyes suggests not only an expectancy of seeing eyes but also an appetitive response to them. Infants either cried, covered their eyes or even refused to look to a face which did not contain at least one eye. By contrast, the mere presence of an eye or of both eyes was sufficient to elicit contented looking.

In the natural environment, an infant does not always have the opportunity to see a full face. Hats, scarves, or other articles of clothing as well as extraneous obstacles can block from view various parts of the face. Nevertheless, one thing an infant is always certain of perceiving when presented with a face is the eyes. People do not usually walk around or engage in social interaction with their eyes closed or masked.

The expectancy of seeing eyes, which is inferable from an infant's negative reaction to their absence, can be taken as evidence for internalization or learning of that specific stimulus configuration. Equally important is the appetitive aspect inferable from the negative reaction. It will be recalled that one criterion for distinguishing a recognised from an imprinted object was the presence of an appetitive response to the latter.

At the end of the first quarter, when an infants visual system is roughly equivalent in function terms to an adults, there can be little doubt that most infants respond differentially to and therefore can be said to recognise and to prefer their mother (Ainsworth, 1964, 1967; Sander, 1962, 1964; Ambrose, 1963, Wolff, 1963a, 1963b; Shaffer, 1971). Infants approximately sixteen weeks old smile, vocalise and laugh more frequently to, stop crying more readily for, and accept food more easily from a familiar caretaker than from a stranger. Though few infants show fear of or anxiety to strangers at this time, many appear to be wary of them (Bronson, 1971). Infants of this age frequently watch television and are decidedly interested in mirrors. In fact, they smile coo and wave their arms to multiple images of their own mother in a set of mirrors. This raction demonstrates "that young infants can recognise features in recognising their mothers, but they recognise the mother as one of many identical mothers" (Bower, 1971). However, infants of twenty weeks or older become quite upset at the sight of more than one mother, which implies they "know they have only one mother". In other words, they no longer identify objects with places but with features. Obviously, the stimulus characteristics of the mother's face have been internalized. The negative reaction to multiple images of one mother can be considered to betray an expectancy and an appetitive response comparable with the reaction to a face without eyes.

It is worth emphasising that visual differentiation presupposes recognition both logically and ontologically. An infant has to be able to recognise the general qualities of a facial Gestalt qua faceness as contrasted with other visual Gestalten before he can differentiate a particular facial Gestalt from others. Therefore, attachment can be said to presume both recognition and differentiation.

As has been argued, imprinting of a young organism to its caretaker must not be confused with imprinting to sexual objects etc. Therefore, imprinted recognition of and reaction to a caretaker is to be seen to involve learning of and developing a socially appetitive and/or affective response system for a specific object and not for a class of objects. "The initial learning of the characteristics of the parent is not supra-individual learning ..." (Hinde, 1963). In short, a young animal, either bird or human, becomes attached to or imprinted on the characteristics of a particular individual and not of the whole species.

When an infant shows himself capable of recognising the human facial Gestalt and especially when capable of differentiating one such Gestalt from another, it can be inferred that he is in possession of an organised memory trace of certain coherent configurations. It is as though "faceness", and in particular one person's face, has been printed in his mind as a standard with which he can compare external stimuli and which he can use as a goal in a search among them. Moreover, an infant's response to various combinations of facial features as face-like suggests a stamped-in or internalized standard, i.e. a face-schema, in terms of which incomplete facial features are recognised to be face-like. Further evidence for a stamped-in schema of the face is provided by the negative reaction to a face without eyes. That is: infants expect and even want to see eyes. Though it might be argued that a face without eyes is an insufficient stimulus, this explanation would fail to take account of the facts both that a negative (and not a neutral) reaction was associated with the absence of eyes, and that eyes alone were found to constitute a minimally sufficient stimulus and were even smiled to. Since one eye (preferable two) plus some other surrounding features elicited amounts of fixation indistinguishable from the full or complete face, it can be concluded that the organisation of the facial Gestalt is best conceived of as a hetergeneous summation effect.

Therefore, it seems not unreasonable that four months old infants, have a "scan path" (Noton and Stark, 1971) which involves definite "sets" or "goals" (Miller, Galanter and Pribram, 1960) when scanning a stimulus configuration which is potentially a face. It may even be that the eyes are "privileged features" around which the internalization representation of the facial Gestalt is organised.

Obviously, a sixteen to twenty week old infant cannot be considered visually naive for (i) he shows an ability to recognise and distinguish between human facial Gestalten, and (ii) his behaviour betrays a preference or appetitive for certain facial Gestalt(en) and a wariness of other. Thus it would appear that something functionally similar to imprinted recognition of and response to the facial Gestalt has taken place and that the optimal period for this kind of exposure learning is well on its way to termination, if not, at least in the case of certain infants, already terminated.

In summation: "The development of a human mother-infant relationship bears many similarities to the analogous process in birds" (Hinde, 1963). For instance: "the developmental sequence of first social response to the parent, then fear, and later aggression, is ... similar in birds, anthropoids, ... and humans" (Hinde, 1961). In functional terms, "the result of the imprinting process is that the young bird [or human infant] learns to recognise its mother as an individual, and a number of discrete responses made by the young ... to its mother become integrated on to one object" (Hinde, 1963).

The behaviour of a human infant which has become attached to his mother is comparable to the behaviour in birds which is known to be a result of imprinting. That is: An infant responds to the face (of his caretaker) qua facial Gestalt, as a coherent visual pattern which can be recognised as face-like, even from only a few features; moreover, his response suggests organised memory traces or internalized schemata against which a potentially face-like stimulus is measured or judged to be face-like and with which are associated both positive and negative appetitive affects. Above all, the "inner face" can be considered to constitute a "set-goal" which is highly charged with emotion and in terms of which the environment is searched.

The minimally sufficient conditions for imprinting in birds have been shown to be similar to the conditions present during the development of a human infant's recognition of and attachment to the facial Gestalt of his mother/caretaker. These conditions are:

(1) a naive subject (2) capable of orientating to (3) patterned stimulation (4) which must be present (5) during an optimal period for learning.

It was argued (a) that a neonate is visually naive; (b) that a naive state is an optimal state for learning; (c) that a neonate inhabits a restricted visual Umwelt due to his limited visual abilities; (d) that the restriction of visual stimuli occurs when the infant is naive; (e) that as a consequence of the restriction there is a higher probability that exposure learning will occur to a biologically appropriate object than to an inappropriate; (f) that a neonate has been equipped by evolution with an unconditioned response to orientate to patterned stimuli; (g) that the optimal visual stimulus to penetrate into that restricted Umwelt is the human face; (h) that the visual stimulus to penetrate most frequently into that restricted Umwelt is also the human face; (i) that though a neonate shows no preferential response to the face before one month, he does so thereafter with increasing intensity; (j) that by four months, when an infant's visual system is functionally the equivalent of an adult's, he demonstrates differential responsiveness to and appetitive behaviour for real face; (k) that the differential response can be considered to indicate a "stamping-in" or internalization of a "face schema" in an infant's "mind"; (l) that the socially appetitive nature of the response to the human face is different from most other forms of learning, though similar to imprinting; (m) that from the fourth month on, an infant becomes progressively more responsive to particular face(s); (n) that soon after an infant becomes responsive to particular faces, he differentiates those faces from other or non-familiar faces; (o) that a neonate reacts with wariness or fear to non-familiar or strange faces.

BIBLIOGRAPHY

ABERCROMBIE, B. & JAMES, H. (1961). The stability of the domestic chick's response to visual flicker. Anim. Behav.,9, 205-212.

AHRENS, R. (1954). Beitrag zur Entwicklung des Physiognomie- und Mimikerkennes. Z. Exp. Angew. Psychol., 2, Part I: 412-454; Part II: 599-633.

AINSWORTH, M.D. (1963) The development of infant-mother interaction among the Ganda In B.M. Foss (Ed.) Determinants of infant behaviour II London: Methuen; and New York: John Wiley.

AINSWORTH, M.D. (1964) Patterns of attachment behavior shown by the infant in interaction with his mother Merrill-Palmer Quart.10, 51-56.

AINSWORTH, M.D.S. (1967) Infancy in Uganda: infant care and the growth of love Baltimore: Johns Hopkins Univ. Press.

AINSWORTH, M.D.S. and WITTIG, B.A. (1969), Attachment and exploratory behaviour of one-year-olds in a strange situation , in B.M.Foss (Ed.), Determinants of Infant Behaviour, vol.4, Methuen.

AINSWORTH, M.D.S., BELL, S.M.V., and STAYTON, D.J. (1971), Individual differences in strange-situation behavior of one-year-olds , in H.R. Schaffer (Ed.) The origins of Human Social Relations, Academic Press.

AMBROSE, J.A. (1961) The development of the smiling response in early infancy In B.M.Foss (Ed.) Determinants of infant behaviour I London: Methuen; and New York: John Wiley.

AMBROSE, J.A. (1963) The concept of a critical period for the development of social responsiveness in early infancy In B.M.Foss (Ed.) Determinants of infant behaviour II London: Methuen; and New York: John Wiley.

AMES, E.W., & SILFEN, C.K. (1965) Methodological issues in the study of age differences in infants' attention to stimuli varying in movement, complexity, and novelty. Paper presented at the meeting of the Society for Research in Child Development, Minneapolis, Minnesota. (reported in Greenberg, Uzgiris and Hunt, 1971).

BAER, D.M. & GRAY, P.H. (1960). Imprinting to a different species without overt following. Percept. Mot. Skills,10, 171-174.

BEASLEY, W.C. (1933) Visual pursuit in 109 white and 142 negro newborn infants. Child Develop., 4, 106-121.

BENJAMIN, J.D. (1963) Further comments on some developmental aspects of anxiety In H.S. Gaskill (Ed.) Counterpoint.New York: International Univ. Press.

BERLYNE, D.E. (1958), The influence of the albedo and complexity of stimuli on visual fixation in the human infant. British Journal of Psychology, 49: 315-318.

BIEL, W.C. (1940). Early age differences in maze performance in the albino rat. J.Genet. Psychol. 56, 439-453.

BOWER, T.G.R. (1964), Discrimination of depth in premotor infants. Psychon. Sci., vol.1, 368.

BOWER, T.G.R. (1956), 'Stimulus variables determining space perception in infants , Science, vol.149, pp 88-9.

BOWER, T.G.R. (1966), The visual world of infants , Sci.Amer., vol.215, 80-97.

BOWER, T.G.R. (1970), Demonstration of intention in the reaching behaviour of neonate humans. Nature, vol.228, no.5272, 679-681.

BOWER, T.G.R. (1971) The object in the world of the infant. Sci. Amer., vol.225, 4: 30-38.

BOWER, T.G.R., BROUGHTON, J.M., and MOORE, M.K. (1970), Infant responses to approaching objects: an indicator of response to distal variables. Perception and Psychophysics, 9 (2B), 193-196.

BOWLBY, J. (1951). Maternal Care and Mental Health. Geneva: World Health Organization Monograph Series.

BOWLBY, J. (1953), Based on the above: Child Care and the Growth of Love. London : Penguin Books.

BOWLBY, J. (1957). Symposium on the contribution of current theories to an understanding of child development. I. An ethological approach to research in child development. Brit.J. Med. Psychol. 30, 230-240.

BOWLBY, J. (1958), The nature of the child's tie to his mother. Internat. J. Psychoanal. , 39, 1-24.

BOWLBY, J. (1960a). Separation anxiety. Internat. J. Psycho-anal. 41, 89-113.

BOWLBY, J. (1960b), Grief and mourning in infancy and early childhood. Psycho-anal. Study Child., 15, 9-52.

BOWLBY, J. (1969) Attachment and Loss. vol.I: Attachment. The Hogarth Press and the Institute of Psychoanalysis. London.

BRACKBILL, Y. (1958), Extinction of the smiling response in infants as a function of reinforcement schedule . Child Devel., 29, 115-24.

BRENNAN, W.M., AMES, E.W. and MOORE, R.W. (1966) Age differences in infants' attention to patterns of different complexities. Science,151, 354-356.

BRIDGER, W.H. (1961), Sensory havituation and dicrimination in the human neonate. American Journal of Psychiatry, 117, 991-996.

BRIDGER, W.H. (1962), Sensory discrimination and autonomic function in the newborn , J.Amer.Acad. Child Psychiat., 1, 67-82.

BRODBECK, A.J. (1954). An exploratory study on the acquisition of dependency behavior in puppies. Bull.Ecol.Soc.Am.,35, 73.

BRONSON, G.W. (1971), Fear of the unfamiliar in human infants , In H.R.Schaffer (Ed.), The Origins of Human Social Relations Academic Press.

BRUNER, J.S. (1968), Processes of Cognitive Growth: Infancy. Clark University Press with Barre Publishers.

CANTOR, G.N. (1963), Responses of infants and children to complex and novel stimulation. In L.P.Lipsitt and C.C.Spiker (Eds.) Advances in Child Development and Behavior. Vol.1. New York: Academic Press.

CARON, R.F. (1967), Visual reinforcement of head-turning in young infants. J.exp. child psychol., 5, 489-511.

CARON, R.F. and CARON, A.J. (1968), The effects of repeated exposure and stimulus complexity on visual fixation in infants , Psychonom.Sci,, 10, 207-8.

CARON, R.F., and CARON, A.J. (1969), Degree of stimulus complexity and habituation of visual fixation in infants. Psychanomic Science, 14, 78-79.

CLIFTON, R.K., GRAHAM, F.K. and HATTON, H.M. (1968), Newborn heart-rate response and response habituation as a function of stimulus duration. J. Exp., Child Psychol., 6, 265-278

COHEN, L.B. (1969), Observing responses, visual preferences and habituation to visual stimuli in infants. J. Exp. Child psychol., 7, 419-433.

COLLIAS, N.E. and COLLIAS, E.C. (1956), Some mechanisms of family integration in ducks. Auk, 73, 378-400.

DAYTON, G.O. Jr., JONES, M.H., AIU, P., RAWSON, R.A., STEELE, B., and ROSE, M. (1964), Developmental Study of coordinated eye movements I. Arch. Ophthal., 41, 867-870.

DAYTON, G.O. Jr., JONES, M.H., STEELE, B. and ROSE, M. (1964) Developmental study of coordinated eye movements II. Arch.Ophthal. 71, 871-875.

DAYTON, G.O. Jr., and JONES, M.H. (1964), Analysis of characteristics of fixation reflex in infants by use of direct current electro-oculography. Neurology, 14, 1152-1156.

DORIS, J., CASPER, M. and PORENSKY, R. (1967), Differential brightness thresholds in infancy.J. Exp. Child Psychol. 5, 522-535.

DORIS, J. and COOPER, L.(1966), Brightness discrimination in infancy. J. Exp. Child Psychol., 3, 31-39

FABRICIUS, E. (1951a). Zur Ethologie junger Anatiden. Acta Zool. Fenn, 68, 1-175.

FABRICIUS, E. (1951b). Some experiments on imprinting phenomena in ducks. Proc. X Internat. Ornithol. Congr.,375-379.

FANTZ, R,L.(1958), Pattern Vision in Young Infants. Psychological Record, 8: 43-48.

FANTZ, R.L. (1961a), The Origin of Form Perception. Scientific American, 204(5), 66-72.

FANTZ, R.L. (1961b), A Method for Studying Depth Perception in Infants Under Six Months of Age. Psychological Record, 11:27-32.

FANTZ, R.L. (1963), Pattern Vision in Newborn Infants. Science, 140: 296-297.

FANTZ, R.L. (1964), Ontogeny of Perception. In: Behavior of Non-Human Primates: Modern Research Trends. Schrier, A.M. & Harlow, H.F. (Eds.) New York: Academic Press.

FANTZ, R.L. (1965), Visual perception from birth as shown by pattern selectivity. Ann. New York Acad. Sci., vol.118, 793-814.

FANTZ, R.L. (1966), 'Pattern discrimination and selective attention as determinants of perceptual development from birth', In A.H. Kidd and J.L. Rivoire (Eds.) Perceptual Development in Children, International Univ. Press.

FANTZ, R.L. and NEVIS, S. (1967), Pattern preferences and preceptual-cognitive development in early infancy, Merrill-Palmer Q., vol.13, 77-108.

FANTZ, R.L., ORDY, J.M. and UDELF, M.S. (1962), Maturation of Pattern Vision in Infants During the First Sex Months. J. Compar. Physio. Psychol. 55, 907-917.

FISHER, E.A. and HALE, E.B. (1957), Stimulus determinants of sexual and aggressive behaviour in male domestic fowl. Behaviour,10, 309-323.

FITZGERALD, H.E. (1968), Autonomic pupillary reflex activity during early infancy and its relation to social and nonsocial visual stimuli. J. Exp. Ch. Psychol., 6, 470-482.

FOSS, B.M. (1963), Discussion in B.M. Foss (Ed.) Determinants of Infant Behaviour III pp.230-253. London: Methuen.

FRIEDMAN, S., NAGY, A.N., and CARPENTER, G.C. (1940), Newborn attention: differential response decrement to visual stimuli. J.Exp.Child Psychol., 10, 44-51.

GESELL, A., et al. (1940) The First Five Years of Life: A Guide to the Study of the Preschool Child. New York: Harper.

GESELL, A. and AMATRUDA, C.S. (1947) Developmental Diagnosis. Normal and Abnormal Child Development. Clinical Methods and Pediatric Applications. 2nd Ed.New York: Heeber.

GESELL, A. and BLAKE, F.M. (1936) Twinning and Ocular Pathology. With a Report of Bilateral Macular Celeboma in Monozygotic Twins. Arch. Ophth., 15, 1050-1071.

GESELL, A., ILG, F.L. and BULLIS, G.E. (1949) Vision: Its development in Infant and Child. New York: Harper and Brothes.

GEWIRTZ, J.L. (1965) The course of infant smiling in four child-rearing environments in Israel. In B.M.Foss (Ed.) Determinants of Infant Behaviour, vol.III, 205-248.

GIBSON, E.J. (1969), Principles of Perceptual Learning and Development. Appleton-Century-Crofts. New York.

GIBSON, J.J., and GIBSON, E.J. (1955). Perceptual learning: differentiation and enrichment. Psychol.Rev. 62, 32-41.

GORMAN, J.J., COGAN, D.G., and GELLIS, S.S. (1957). An apparatus for grading the visual acquity in infants on the basis of the optokinetic nystagmus. Pediatrics, 19: 1088-1092.

GRAY, P.H. (1958). Theory and evidence of imprinting in human infants. J.Psychol., 46, 155-166.

GRAY, P.H. (1960). Evidence that retinal flicker is not a necessary condition of imprinting. Science,132, 1834.

GREENBERG, D.J. (1971) Accelerating visual complexity levels in the human infant. Child Devel . 42, No.3: 905-918.

GREENBERG, D.J., UZGIRIS, I.C. and HUNT, J. McV. (1970) Attentional preference and experience: III. Visual familiarity and looking time. J. genetic Psychol. 117, 123-135.

GREENBERG, D.J., and WEIGMANN, F. (1971) The measurement of visual attention in infants: a comparison of two methodologies. J. exp. ch. psychol.. 11, 234-243.

GRIFFITHS, R. (1954), The Abilities of Babies. University of London Press.

GUERNSEY, M. (1929), A quantitative study of the eye reflexes in infants. Psych. Bull. 160-161

GUITON, P. (1958). The effect of isolation on the following response of Brown Leghorn chicks. Proc. Roy. Phys. Soc. Edinb. 27, 9-14.

GUITON, P. (1959). Socialisation and imprinting in Brown Leghorn chicks. Anim. Behav., 7, 26-34.

GUITON, P. (1961). The influence of imprinting on the agonistic and courtship responses of the Brown Leghorn cock. Anim. Behav. 9, 167-177.

GUITON, P. (1962). The development of sexual responses in the domestic fowl in relation to the concept of imprinting. Symp. zoo,Soc. Lond., No.8, 227-234.

HAAF, R.A. and BELL, R.Q. (1967). 'A facial dimension in visual discrimination by human infants'. Child Devel. 38, 393-9.

HAITH, M.M. (1966) The response of the human newborn to visual movement. J. Exp.Ch. Psychol. 3, 235-243.

HAITH, M.M., KESSEN, W. and COLLINS, D. (1969). Response of the human infant to level of complexity of intermittent visual movement. J.Exp. Ch. Psychol., 7, 52-69.

HARLOW, H.F. (1949). The formation of learning sets. Psychol. Rev., 56, 51-65.

HARLOW, H.F. (1958). The nature of love. Amer. Psychologist, 13, 673-685.

HARLOW, H.F. (1959). Love in infant monkeys. Sci. Amer.200, 68-74.

HARLOW, H.F. (1960). Primary affectional patterns in primates. Amer. J. Ortho-psychiat. 30, 676-684.

HARLOW, H.F. (1961). The development of affectional patterns in infant monkeys. In Foss, B.M. (Ed.) Determinants of Infant Behaviour I London: Methuen.

HARLOW, H.F. (1962). Development of affection in primates. In: Bliss, E.L.(Ed.) Roots of Behavior. New York: Harper & Bros.

HARLOW, H.F. (1963) The maternal affectional system . In B.M. Foss (Ed.) Determinants of infant behaviour II London: Methuen; and New York: John Wiley.

HARLOW, H.F. and HARLOW, M.K. (1962). Social deprivation in monkeys. Sci. Amer., 207, 137-146.

HARLOW, H.F. and ZIMMERMANN, R.R. (1958). The development of affectional responses in infant monkeys. Proc. Amer. Phil. Soc. 102, 501-509.

HARLOW, H.F. and ZIMMERMANN, R.R. (1959). Affectional responses in the infant monkey. Science, 130, 421-432.

HAYNES, H., WHITE, B.L. and HELD, R. (1965). Visual accommodation in human infants. Science, 148, 528-530.

HEBB, D.O. (1949). The Organization of Behavior. New York: Wiley.

HERSHENSON, M. (1964). Visual discrimination in the human newborn. J. Compar. Physio. Psychol., 58, 270-276.

HERSHENSON, M., MUNSINGER, H. and KESSEN, W. (1965). Preference for shapes of intermediate variability in the newborn human. Science, 147, 630-631.

HERSHER, L. RICHMOND, J.B. and MOORE, A.V. (1963) Modifiability of the critical period for the development of maternal behaviour in sheep and goats. Behaviour, 20, 311-320.

HESS, E.H. (1956). Natural preferences of chicks and ducklings for objects of different colours. Psychol. Rev,, 2, 477-483.

HESS, E.H. (1957). Effects of meprobamate on imprinting in waterfowl. Ann. N.Y. Acad. Sci., 67, 724-732.

HESS, E.H. (1958). 'Imprinting' in animals. Sci. Amer.,198, 81-90.

HESS, E.H. (1959a). Imprinting. Science, 130, 133-141.

HESS, E.H. (1959b). The conditions limiting critical age of imprinting. J. Comp. Physiol. Psychol., 52, 515-518.

HESS, E.H. (1959c) The relationship between imprinting and motivation. In: Jones, M.R. (Ed.). Nebraska Symposium on Motivation. Lincoln, Neb.: University of Nebraska Press.

HESS, E.H. (1962a). Imprinting and the 'critical period' concept. In: Bliss, E.L. (Ed.) Roots of Behavior. New York: Harper & Bros.

HESS, E.H. (1962b). Ethology: an approach toward the complete analysis of behavior. In: Brown, R., Galanter, E. Hess, E.H. and Mandler, G. New Directions in Psychology. New York: Holt, Rinehart & Winston.

HINDE, R.A. (1955a). The modifiability of instinctive behaviour. Adv. Sci.,12, 19-24.

HINDE, R.A. (1955b). The following response of moorhens and coots. Brit. J. Anim. Behav., 3, 121-122.

HINDE, R.A. (1961). The establishment of the parent-offspring relation in birds, with some mammalian analogies. In: Thorpe, W.H. and Zangwill, O.L. (Eds.). Current Problems in Animal Behaviour. Cambridge_ C.U.P.

HINDE, R.A. (1963). The nature of imprinting. In: B.M. Foss (Ed.) Determinants of Infant Behaviour II. London: Methuen.

HINDE, R.A., THORPE, W.H. and VINCE, M.A. (1956). The following response of young coots and moorhens. Behaviour, 11, 214-242.

HUNT, J. McV. (1970). Attentional preference and experience: I. Introduction. J. Genet. Psychol., 117, 99-107.

IMMELMANN, K. (1969). Über den Einfluss frühkindlicher Erfahrungen auf die geschlechtliche Objektfixierung bei Estrildiden. Z. Tierpsychol., 26, 677-691.

IRWIN, O.C. and WEISS, L. (1934). Differential variations in the activity and crying of the newborn infant under different intensities of light: a comparison of observational with polygraphic findings. University of Iowa Studies in Child Welfare 9, 137-147.

IRWIN, O.C. and WEISS, L. (1934): The effect of darkness on the activity of newborn infants. In: Irwin, Orvis C., Weiss, LaBerta, A., and Stubbs, Esther M.: Studies in Infant Behavior I. University of Iowa Studies in Child Welfare, 9, No.4, 163-175.

JAMES, H. (1959). Flicker: an unconditioned stimulus for imprinting. Canad. J. Psychol.,13, 59-67.

JAMES, H. (1960a). Imprinting with visual flicker:evidence for a critical period. Canad. J. Psychol., 14, 13-20.

JAMES, H. (1960b). Social inhibition of the domestic chick's response to visual flicker. Anim. Behav., 8, 223-224.

JAMES, H. and BINKS, C. (1963). Escape and avoidance learning in newly hatched domestic chicks. Science, 139, 1293-1294.

JAYNES, J. (1956). Imprinting: the interaction of learned and innate behaviour. I. Development and generalization. J. comp. physiol. Psychol., 49, 201-206.

JAYNES, J. (1957). Imprinting: the inetraction of learned and innate behavior. II. The critical period. J. comp. physiol. Psychol., 50, 6-10.

JAYNES, J. (1958a). Imprinting: the interaction of learned and innate behavior: III. Practice effects on performance,retention and fear. J. Comp. Physiol. Psychol.,51, 234-237.

JAYNES, J. (1958b). Imprinting: the interaction of learned and innate behavior: IV. Generalization and emergent discrimination. J. Comp. physiol. Psychol., 51, 238-242.

KAGAN, J., HENKER, B.A., HEN-TOV, A., LEVINE, J. & LEWIS, M.(1966). Infants' differential reactions to familiar and distorted faces. Child Devel. 37, 519-532.

KAGAN, J. & LEWIS, M. (1965). Studies of attention in the human infant. Merrill-Palmer Quarterly, 11, 95-127.

KARMEL, B.Z. (1969). The effects of age, complexity and amount of contour on pattern preferences in human infants. J. exp. child Psychol., vol.7, 339-54.

KAUFMAN, I.C. & HINDE, R.A. (1961). Factors influencing distress calling in chicks, with special reference to temperature changes in social isolation. Anim. Behav., 9, 197-204.

KESSEN, W., WILLIAMS, E.J. and WILLIAMS, J.P. (1961). Selection and test of response measures in the study of the human newborn. Child Devel., 32, 7-24.

KIFF, R.D. & LEPARD, C. (1966). Visual response of premature infants. Arch. Ophthal. 75, 631-633.

KLOPFER, P.H. (1956). Comments concerning the age at which imprinting occurs. Wilson Bull,, 68, 320-321.

KLOPFER, P.H. (1959a). An analysis of learning in young anatidae. Ecology, 40, 90-102.

KLOPFER, P.H. (1959b). The development of sound-signal preferences in ducks. Wilson Bull., 71, 262-266.

KOOPMAN, P.R. and AMES, E.W. (1968). Infants' preferences for facial arrangements: a failure to replicate. Child Devel.,39,481-7.

KORNER, A.F. and GROBSTEIN, R. (1966). Visual alertness as related to soothing in newnates: implications for maternal stimulation and early deprivation. Child Devel.,37, 867-76.

KORNER, A.F. and THOMAS, E.B. (1970). Visual alertness in neonates as evoked by maternal care. J. exp. child Psychol.,10, 67-78.

LEWIS, M. (1969). A developmental study of information processing within the first three years of life: Response decrement to a redundant signal. Monog. Soc. Res. Child Devel.,34, No.9.

LEWIS, M. and GOLDBERG, S. (1969). The acquisition of violation of expectancy: An experimental paradigm. J. Exp. Child Psychol. 7, 70-80.

LEWIS, M., KAGAN, J., CAMPBELL, H. and KALAFAT, J. (1966). The cardiac response as a function of attention in infants. Child Devel., 37, 64-71.

LING, B.-C. (1941). Form discrimination as a learning cue in infants. Comp. Psych. Monog.,17, No.2, 1-66.

LING, B.-C. (1942). A genetic study of sustained visual fixation and associated behavior in the human infant from birth to six months. J. Genet. Psychol., 61, 227-277.

LORENZ, K. (1935). Der Kumpan in der Umwelt des Vogels : die Artgenosse als auslösendes Moment sozialer Verhaltungsweisen. J. Ornithol.,83, 137-213 and 289-413. Also in English translation under the title 'Companionship in bird life : fellow members of the species as releasers of social behavior', in Schiller, C.H. (Ed.) (1957). Instinctive Behavior. New York: Intern. University Press.

McCALL, R.B. and KAGAN, J. (1967). Stimulus-schema discrepancy and attention in the infant. J. Exp. Child Psychol. 5, 381-390.

McCALL, R.B. and KAGAN, J. (1969). Individual differences in the infant's distribution of attention to stimulus discrepancy. Devel. Psychol.,vol.2, 90-98.

McCALL, R.B. and MELSON, W.H. (1969). Attention in infants as a function of magnitude of discrepancy and habituation rate. Psychon. Science, 17, 317-19.

McGINNIS, J.M. (1930). Eye-movements and optic nystagmus in early infancy. Genet. Psychol. Monog., 8, No.7, 321-430.

McMENZIE, B. and DAY, R.H. (1971). Operant learning of visual pattern discrimination in young infants. J. Exp. Ch. Psychol., 11, 45-53

MEYERS, W.J. and CANTOR, G.N. (1967). Observing and cardiac responses of human infants to visual stimuli. J. Exp. Ch. Psychol.,5, 16-25.

MILLER, G.A., GALANTER, E. and PRIBRAM, K.H. (1960). Plans and the Structure of Behavior, Holt, Rinehart & Winston.

MIRANDA, S.B. (1970). Visual abilities and pattern preferences of premature and full term newborn infants. J. Exp. Ch. Psychol., 10, 189-205.

MOFFETT, A. (1969). Stimulus complexity as a determinant of visual attention in infants. J. Exp. Ch. Psychol., 8, 173-179.

MOLTZ, H. (1960). Imprinting: empirical basis and theoretical significance. Psychol. Bull., 57, 291-314.

MOLTZ, H. (1961). Retinal flicker and imprinting. Science, 133, 970.

MOLTZ, H. (1963). Imprinting: an epigenetic approach. Psychol. Rev., 70, 123-138.

MOLTZ, H. and STETTNER, L.J. (1961). The influence of patterned-light deprivation on the critical period for imprinting. J. comp. Physiol. Psychol., 54, 279-283.

MORGAN, C.T. (1961). Introduction to Psychology. New York: McGraw-Hill.

MUNN, N.L. (1950). Handbook of Psychological Research on the Rat. Boston: Houghton Mifflin.

MUNSINGER, H. and WEIR, M.W. (1967). Infants' and young children's preference for complexity. J. Exp. Ch. Psychol. 5, 69-73.

NELSON, K.E. (1968). Organization of visual-tracking responses in human infants. J. Exp. Ch. Psychol. 6, 194-201.

NELSON, K. and KESSEN, W. (1969). Visual scanning by human newborns: responses to complete triangle, to sides only, and to corners only. Proceedings, 77th Annual Convention, APA, 273-274.

NOTON, D. and STARK, L. (1971). Eye movements and visual perception. Sci. Amer. vol.224, 6, 34-43.

PIAGET, J. (1936). La Naissance de l'intelligence. Neuchatel: Delachaux et Niestle. (The Origins of Intelligence in Children, New York: International Univ. Press, 1952).

PIAGET, J. (1937). La construction du reel chez l'infant. Neuchatel: Delachaux et Niestle. (The Child's Construction of Reality. London: Routledge and Kegan Paul. 1955).

PENDLETON, M.E. and PAINE, R.S. (1961). Vestibular nystagmus in newborn infants: study by visual, photographic and electro-oculographic methods; preliminary report. Neurology, 11, 45-48.

RAMSAY, A.O. and HESS, E.H. (1954). A loboratory approach to the study of imprinting. Wilson Bull., 66, 196-206.

REDFIELD, J. (1939). The light sense in newborn infants. University of Iowa Studies in Child Welfare, 16, 105-145.

RHEINGOLD, H.L. (1961). The effect of environmental stimulation upon social and exploratory behaviour in the human infant. In B.M. Foss (Ed.), Determinants of Infant Behaviour, Methuen,

ROVEE, C.K. and ROVEE, D.T. (1969). Conjugate reinforcement of infant exploratory behaviour. J. exp. child Psychol., 8, 33-39.

RUSSELL, W.R. (1959). Brain, Memory, Learning. Oxford: Clarendon Press.

SAAYMAN, G., AMES, E.W., and MOFFETT, A. (1964). Response ot novelty as an indicator of visual discrimination in the human infant. J. exp. child Psychol., 1, 189-198.

SALAPATEK, P. and KESSEN, W. (1966). Visual scanning of triangles by the human newborn. J. exp. child Psychol.,3, 155-167.

SALZEN, E.A. (1962). Imprinting and Fear. Symp. zoo. Soc. Lond., 8, 197-217.

SALZEN, E.A. and SLUCKIN, W. (1959a). An experiment in imprinting domestic fowl. Bull. Brit. psychol. Soc., 38, 35A-36A.

SALZEN, E.A. and SLUCKIN, W. (1959b). The incidence of the following response and the duration of responsiveness in domestic fowl. Anim. Behav.,7, 172-179.

SALZEN, E.A. and TOMLIN, F.J. (1963). The effect of cold on the following response of domestic fowl. Anim. Behav.,11, 62-65.

SANDER, L.W. (1962). Issues in early mother-child interaction. J. Amer. Acad. Child Psychiat.,1, no,1, 141-66.

SANDER, L.W. (1964). Adaptive relationships in early mother-child interaction. J. Amer. Acad. Child Psychiat.,3, no.1, 231-65.

SANDER, L.W. (1969). The longitudinal course of early mother-child interaction: cross-case comparison in a sample of mother-child pairs. In B.M. Foss (Ed.), Determinants of Infant Behaviour, IV, Methuen.

SCHAFFER, H.R. (1963). Some issues for research in the study of attachment behaviour. In B.M. Foss (Ed.) Determinants of Infant Behaviour II London: Methuen; and New York: John Wiley

SCHALLER, G.B. and EMLEN, J.T. (1962). The ontogeny of avoidance behaviour in some precocial birds. Anim. Behav.,10, 370-381.

SCHUTZ, F. (1963). Objektfixierung geschlechtlicher Reaktionen bei Anatiden und Hühnern. Naturwiss. 50, 624-625.

SCHUTZ, F. (1965a). Sexuelle Prägung bei Anatiden. Z. Tierpsychol. 22, 50-103.

SCHUTZ, F. (1965b). Homosexualität und Prägung. Eine experimentelle Untersuchung an Enten. Psychol. Forsch. 28, 439-463.

SCHUTZ, F. (1968). Sexuelle Prägung bei Tieren. In: Die Sexualität des Menschen. Handbuch der medizinischen Sexualforschung (Hrsg.: H. Giese), 2. Aufl. Stuttgart: Enke.

SCHUTZ, F. (1970). Zur Sexuellen Prägbarkeit und sensiblen Phase von Gänsen und der Bedeutung der Farbe des Prägungsobjektes. Zool. Anz., Supp. -BD 33, Verh.Zool.Ges. 1969, 301-306.

SCHUTZ, F. (1971). Prägung des sexualverhattens von Enten und Gänsen durch Sozialeindrücke wahrend der Jugendphase. J. Neuro-Vis Rel., Suppl. X. 339-357.

SCHWARTING, B.H. (1954). Testing infants' vision. Amer. J. Ophthal., 38, 714-715.

SCOTT, J.P. (1945). Social behavior, organization and leadership in a small flock of domestic sheep. Comp. Psychol. Monogr., 18, 1-29.

SCOTT, J.P. (1958). Critical periods in the development of social behavior in puppies. Psychosom. Med., 20, 42-54.

SCOTT, J.P. (1962). Critical periods in behavioral development. Science, 138, 949-958.

SCOTT, J.P. and MARSTON, M.V. (1950). Critical periods affecting the development of normal and mal-adjustive social behavior in puppies. J. genet. Psychol., 77, 25-60.

SHERMAN, M. and SHERMAN, I. (1925). Sensori-motor in infants. J. comp. physiol. Psych.,5, 63-65.

SHIPLEY, W.U. (1963). The demonstration in the domestic guinea pig of a process resembling classical imprinting. Anim.Behav.,11, 470-474.

SIQUELAND, E. (1964). Operant conditioning of head turning in four-month infants. Psychon. Science, 1, 223-224.

SLUCKIN, W. (1960). Towards a theory of filial responses. Bull. Brit. psychol. Soc., No.40, 5A.

SLUCKIN, W. (1962). Perceptual and associative learning. Symp. zoo. Soc. Lond.,No.8, 193-198.

SLUCKIN, W. (1966). Imprinting and early learning. London: Methuen.

SLUCKIN, W. and SALZEN, E.A. (1961). Imprinting and perceptual learning. Quart. J. exp. Psychol.,13, 65-77.

SMITH, F.V. (1960). Towards a definition of the stimulus situation for the approach response of the domestic chick. Anim. Behav., 8, 197-200.

SMITH, F.V. (1962). Perceptual aspects of imprinting. Symp. zoo. Soc. Lond., No.8, 171-191.

SPEARS, W.C. (1964). Assessment of visual preference and discrimination in the four-month-old infant. J. comp. physio. Psychol.,57, 381-386.

SPITZ, R.A. (1948). The Smiling Response (film) New York University Film Library.

SPITZ, R.A. (1959). A Genetic Field Theory of Ego Formation. Its Implications for Pathology, New York: International Univ. Press.

SPITZ, R.A. (1965). The First Year of Life New York: International Univ. Press.

SPITZ, R.A. and WOLF, K.A. (1946). The smiling response: a contribution to the ontogenesis of social relations. Genet. Psychol. Monogr., 34, 57-125.

STAPLES, R. (1932). The response of infants to color. J. exp. Psychol. 15, 119-141.

STECHLER, G. (1964). Newborn attention as affected by medication during labor. Science, 144, 315-317.

STECHLER, G. BRADFORD, S. and LEVY, H. (1966). Attention in the newborn: effect on motility and skin potential. Science, 151, 1246-1248.

THOMAS, H. (1965). Visual-fixation responses of infants to stimuli of varying complexity. Child Devel. 36, 629-638.

THORPE, W.H. (1944). Some problems of animal learning. Proc. Linn. Soc. Lond.,156, 70183.

THORPE, W.H. 1956). Learning and Instinct in Animals. London: Methuen Second edition: 1963.

THORPE, W.H. (1958a). The learning of song patterns by birds, with special reference to the song of the Chaffinch (Fringilla celebs). Ibis, 101, 535-570.

THORPE, W.H. (1958b). Further studies on the process of song learning in the Chaffinch (Fringilla coelebs gengleri). Nature,182,554-557.

THORPE, W.H. (1961). Sensitive periods in the learning of animals and men: a study of imprinting with special reference to the induction of cyclic behaviour. In: Thorpe, W.H. and Zangwill, O.L. (Eds.) Current Problems in Animal Behaviour. Cambridge: C.U.P.

UEXKULL, J. von (1934). Streifzüge durch die Umwelten von Tieren und Menschen. Berlin: Springer (reprinted 1956 Rowohlt, Hamburg).

UEXKULL, J. von (1921). Umelt und Innenwelt der Tiere. Berlin.

UZGIRIS, I.C. and HUNT, J.McV. (1970). Attentional preference and experience: II. An exploratory longitudinal study of the effect of visual familiarity and responsiveness. J. Genet. Psychol., 117, 109-121.

VALENTINE, B.C. (1913). The colour perception and colour preferences of an infant during its fourth and eighth months. Brit. J. Psychol., 6, 363-386.

VINCE, M.A. (1958).'String-pulling' in birds. 2. Differences related to age in greenfinches, chaffinches and canaries. Anim. Behav.,6, 53-59.

VINCE, M.A. (1959). Effects of age and experience on the establishment of internal inhibition in finches. Brit. J. Psychol.,50, 136-144.

VINCE, M.A.(1960). Developmental changes in responsiveness in the great tit. Behaviour, 15, 219-243.

VINCE, M.A. (1961). Developmental changes in learning capacity. In: Thorpe, W.H. and Zangwill, O.L. (Eds.). Current Problems in Animal Behaviour. Cambridge: C.U.P.

WATSON, J.S. (1966). Perception of object orientation in infants. Merrill-Palmer Quart., 12, 73-94.

WEIDMANN, U. (1956). Some experiments on the following and flocking reaction of mallard ducklings. Brit. J. Anim. Behav., 4, 78-79.

WEIDMANN, U. (1958). Verhaltensstudien an der Stockente. II. Versuche zur Auslösung und Prägung der Nachfolge- und Anschluss-reaction. Z. Tierpsychol., 15, 277-300.

WEISS,L.A.(1934). Differential variations in the amount of activity of newborn infants under continuous light and sound stimulation. University of Iowa Studies in Child Welfare, 9, 1-74.

WEISS, P.A. (1969). The living system: determinism stratified. In: Koestler, A. and Smythies, J.R. (Eds.). Beyond Reductionism. Hutchinson of London.

WEIZMANN, F., COHEN, L.B. and PRATT, R.J. (1971). Novelty, familiarity, and the development of infant attention. Developmental Psychology, vol.4, no.2, 149-154.

WHITE, B.L., and CASTLE, P.W. (1964). Visual exploratory behaviour following post-natal handling of human infants. Percept.Motor Skills, 18, 497-502.

WICKELGREN, L.W. (1967). Convergence in the human newborn. J. exp. child Psychol., 5, 74-85.

WICKELGREN, L.W. (1969). The ocular response of human newborns to intermittent visual movement. J. exp. child Psychol. 8, 469-482.

WILCOX, B.M. (1969). Visual preferences of human infants for representations of the human face. J. exp. child Psychol., 7, 10-20.

WILCOX, B.M., and CLAYTON, F.L. (1968). Infant visual fixation on motion pictures of the human face. J. exp. child Psychol., 6, 22-32,

WOLFF, P.H. (1963). The early development of smiling. In: B.M.Foss (Ed.) Determinants of Infant Behaviour II. London: Methuen; and New York: John Wiley, pp.113-34.

WOLFF, P.H. (1965). The development of attention in young infants. Ann. N.Y. Acad. Sci., 118, 815-30.

WOLFF, P.H. (1969). The natural history of crying and other vocalizations in early infancy. In: B.M. Foss (Ed.) Determinants of Infant Behaviour, IV. Methuen.

WOLFF, P.H., and WHITE, B.L. (1965). Visual pursuit and attention in young infants. J. Amer. Acad. Child Psychiat.,4, 413-84.

WOOD-GUSH, D.G.M. (1950). The effect of experience on the mating behaviour of the domestic cock. Anim. Behav.,6, 68-71.

ZETTERSTRÖM, B. (1955). Flicker electroretinography in newborn infants. Acta Ophthal., 33, 157-166.