FACE PERCEPTION AND MEMORY IN THE THREE-MONTH-OLD INFANT

By

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Abstract

This thesis examined the ability of the three-month-old infant to recognize and discriminate photographs of faces and facial expressions, and what information he perceives and processes when he is exposed to a face. It also investigated the effects of previous experience with a three-dimensional face and whether or not infants would generalize their knowledge of the real face of the mother to a photograph of the same face. Two experimental techniques, the visual preference and the habituation paradigms, were used. With the visual preference paradigm (Experiments 1 and 6), infants showed evidence of discriminating a photograph of the mother's face and a photograph of another female's face. These results imply that infants generalized what they knew about the real face of the mother to a picture of the same face.

After the visual preference test of Experiment 1, each infant was habituated to the photograph of his mother's face and then tested with photographs of the habituated face and a new face. Infants again showed evidence of discrimination. However, whereas in the visual preference test infants looked longer at the photograph of the mother than at that of a novel stranger, after habituation to the mother's photograph they looked longer at the photograph of a novel stranger. This change suggests that a preference for a novel stimulus may develop only after extensive experience with the familiar stimulus and thus involve a finer process of recognition than that involved in a preference for a familiar stimulus.

Although previous studies have not found discrimination of photographs of strangers before four and a half months of age, the author suspects that infants may show this discrimination at an earlier age if they were provided with extensive experience with a photograph of a stranger in the laboratory. After infants were habituated to a photograph of a stranger they were given a recognition test. Infants showed evidence of discriminating between dissimilar strangers (Experiment 2) and between similar strangers (Experiment 3).

The discrimination of facial expressions posed by the same persons was tested next. The only other study which has found some evidence of discrimination of facial expressions at three months of age used expressions posed by a male stranger. However, given the results of Experiments 1 to 3 one would expect that three-month-olds could discriminate facial expressions more readily on a familiar face--the mother's--than on a stranger's. Infants were habituated to either a frowning expression or a smiling expression, posed by the mother (Experiment 4) or by a female stranger (Experiment 5), and subsequently tested with the habituated and novel expressions. Infants showed evidence of discriminating the expressions regardless of whether they were posed by the mother or by a stranger. Yet, a greater number of infants showed the discrimination when the expressions were posed by the mother than by the stranger. These data thus indicate that three-month-olds can recognize a frowning or a smiling face after they are exposed to either for a period of time, especially when those expressions are posed by a familiar face like the mother's.

Sex differences were found when infants were habituated to the mother's expressions (Experiment 4) and when the tests involved discriminating the mother's face from a stranger's (Experiments 1 and 6), i.e., whenever the face of the mother was the stimulus or one of the stimuli. Hence, the author proposes that these sex differences may be the result of differences in the way mothers interact with male and female infants.

Finally, in Experiment 7 three-month-old infants were presented with a life-size photograph of a face to determine what features they would fixate. Infants looked longer at the area of the eyes than at any other area of the face, even though they scanned the entire face. The discrimination data from Experiments 4 and 5 and the scanning data of Experiment 7 suggest that by three months of age infants perceive and process some internal features of the face.

The most general implication of the findings of this dissertation is that at least by three-months of age the areas of the brain responsible for processing and integrating complex arrays, like faces, are functioning and that some memory for such arrays is already present.

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Table of Contents

List of Figures

List of Tables

Introduction

For a long time psychologists have investigated how the young infant perceives the visual world and what he knows about it. In the visual world of the young infant, faces of people are very prevalent stimuli; the infant has to learn to recognize them and to discriminate them from each other. At what point during infancy the ability to recoghize and to discriminate faces develops is a question which many investigators have tried to answer.

A face, like any other stimulus, has a number of physical properties including brightness, contrast, shading, contour, shape, color, texture, mobility, three-dimensionality and an invariant arrangement of its elements (Gibson, 1969). As a natural object the face has been used by some investigators to study the perception of objects, for they have assumed that how the infant perceives the face may tell us more about how he perceives objects in general (Gibson, 1969). Unlike most other stimuli, however, the face and its expressions acquire unique social attributes through experience: they become the most effective vehicles of non-verbal socio-emotional communication among humans, as well as among members of many other species (Argyle, 1975; Blurton-Jones, 1968; Darwin, 1872; Izard, 1971, 1977; Vince, 1973).

As an important social stimulus the face has been traditionally used to study the development of infants' social behavior such as smiling (e.g., Ahrens, 1954; Ambrose, 1961). Because faces are both very prevalent and important objects in the infant's natural

environment and because faces and facial expressions acquire a significant social role among people, it is also important to determine when the infant learns to recognize faces and facial expressions.

The objectives of the research described in this dissertation were multifold. On the one hand it was aimed at finding out whether infants as young as three months of age can recognize faces and facial expressions. On the other hand, this research was also aimed at investigating two questions about the perception of objects in infants; namely, whether the infant perceives some similarity between a three-dimensional object (a real face) and a picture of the same object, that is, a two dimensional representation of the same object, and how the three-month-old scans an object (a face), i.e., what does he look at most.

In order to show the importance of the questions asked in this dissertation, the first chapter presents a brief description of some experimental techniques used in the area and a historical review of the relevant literature. Subsequent chapters present the experimental work.

Chapter 1

Face Perception and Memory in the Infant: A description of commonly used techniques and an historical review of the literature

Although human infants are very appealing to other human beings, infants as research organisms were not very popular among psychologists before the 1960's, especially if an investigator was interested in studying perceptual and cognitive capacities. As Charlesworth and Kentzer (1973) stated, if studying cognitive abilities is difficult in a verbal human being who can both comprehend verbal instructions and use words to indicate what he perceives, studying such abilities in the infant is virtually impossible. Investigators have, thus, had to use all their ingenuity to research the perceptual and cognitive capacities of the infant.

Experimental techniques

In the early work on face perception and memory, investigators used a combination of observational naturalistic techniques and a semi-experimental approach. Infants' spontaneous reactions were observed when they were confronted with faces which the investigator presented or which naturally appeared in the infant's environment.

In the late 1950's, Fantz (1958, 1961) developed an observational and experimental technique for the study of infants' perception. He designed an observational chamber in which the infant was shown stimuli while the investigator observed and measured the infant's visual fixations[1]. When the infant fixated a stimulus, the

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1 Visual fixation, visual regard, infant's gaze, and looking usually refer to the same behavior; thus they may be used interchangeably.

stimulus was reflected off his cornea and its image appeared near the center of the pupil. Fantz measured how long and how often a stimulus was reflected near the center of the pupil.

In addition to the observational technique, Fantz also systematized an experimental procedure which he called the spontaneous visual preference paradigm.

Fantz's methodological breakthrough has stimulated a large amount of research in the last 20 years. With a few exceptions (e.g., Bower, 1966; Koch, 1967; Wahler, 1967) in most of the recent experimental work on discrimination of faces and facial expressions investigators have measured visual fixations using Fantz's observational technique. Investigators have studied infants' discrimination and recognition of faces and facial expressions using three main paradigms: spontaneous visual preference, familiarization-novelty and habituation-recovery.

The spontaneous visual preference technique is very simple. The infant is exposed to visual stimuli either singly or in pairs and the duration and the frequency, or both, of his visual fixations on each stimulus are measured. If the infant looks longer (or more often) at one stimulus than at the other, the investigator assumes that the infant prefers one stimulus over the other and that he can discriminate between the stimuli.

There are several versions of the familiarization-novelty paradigm. The version which is most widely used is that developed by Fagan (1970, 1972). The infant is usually presented with two identical pictures for a period of time, which is called familiarization. The

exposure time has varied from about 15 sec to 120 sec. depending on the questions asked, the stimuli used, and the age of the subjects. During familiarization, the infant is presumably learning something about the stimulus he is being exposed to. After the familiarization trial, the infant is given a recognition test: Typically the familiar stimulus is presented with a new stimulus. The test usually consists of two trials; during one trial the familiar stimulus is on one side of the center of the visual field; and during the next trial, on the other side. The infant is expected to look longer at the new stimuli than at the familiar one; that is, he is expected to show a preference for novelty (Fantz, Fagan & Miranda, 1976). If he does so, the investigator assumes that the infant recognizes the old stimulus and discriminates it from the new one.

The habituation-recovery paradigm, as used in the study of infant perception and memory, was developed mainly from Sokolov's (1963, 1969) observations of the orienting response (Cohen, 1976; Jeffrey and Cohen, 1971) i.e., animals and humans stop orienting towards a stimulus if the stimulus is presented repeatedly. However, if a new stimulus is presented, the orienting response reappears. Sokolov explained the disappearance or reduction of the orienting response as a result of the development of a neuronal trace, or a memory representation of the stimulus, against which subsequent new stimuli are compared.

The habituation-recovery paradigm used with infants consists of two basic phases: habituation trials, during which a stimulus is repeatedly presented, and a recognition or recovery test, during which

at least one novel stimulus is presented. During the habituation trials (which may also be called the study time) it is assumed, in line with Sokolov's memory model, that the infant is learning something about the stimulus being presented and is developing a memory representation of it. During the recognition test infants are expected to look longer at a novel stimulus than at the habituated one. This indicates that infants recognize the stimulus presented during habituation and that they can discriminate it from a new one.

The visual preference paradigm typically only measures whether or not the infant shows evidence of discriminating two stimuli, whereas the last two paradigms measure not only whether the infant shows evidence of discriminating stimuli but also measures whether the infant shows evidence of recognizing one of the stimuli, i.e., whether he remembers something about it.

All three paradigms were used in the investigation reported here. The visual preference paradigm served to evaluate whether the infant could discriminate between photographed faces and between photographs of facial expressions, presumably without previous experience with pictures. It also served to evaluate whether the infant could transfer knowledge of a three-dimensional face to a picture of the same face. The other two paradigms served to evaluate whether the infant could discriminate photographed faces and facial expressions after a short exposure to one of them in the laboratory.

Historical Review

The human infant, like many other infant animals, learns to perceive, recognize, and discriminate between faces mainly by repeated

exposure (Gibson, 1969). Because infants are exposed to faces from the first days of their lives, they may acquire these abilities at an early age.

The first observations of infants' recognition of faces can be traced back to Charles Darwin (1872, 1877). He noticed that his children appeared to recognize different people within the first year of life. Darwin, like many child psychologists of the last century, recorded the behavior of his own infants. However, unlike child psychologists who are mainly interested in the developing behavior of the young child, Darwin was interested in observing infants because he considered them excellent organisms in which to observe and demonstrate "pure" innate behavior. The empirical nature of Darwin's observations of his children influenced the early work in the area of face perception (Ahrens, 1954) and in the area of infants' socio-emotional development (e.g., Ambrose, 1961; Bowlby, 1969; Spitz & Wolf, 1946).

In the area of face perception, the early observations of the discrimination of faces were made somewhat incidentally by investigators who were mainly interested in the development of smiling (Spitz & Wolf, 1946; Ahrens, 1954). These early observations are very important because they became a fertile source of ideas for subsequent research. These studies, however, do not meet today's standards for scientific research. For example, the duration and frequency of a stimulus was not controlled, the description of infants' behaviors was largely subjective; and frequently the experimenter was both the stimulus and the observer at the same time.

From these early observations, some investigators became interested in studying the development of infants' social behaviors, e.g., smiling and vocalizing to people. Other investigators became interested in finding out what the infant perceives about a face and how early he could recognize and discriminate between faces.

Discrimination of mother from other people. The naturalistic tradition initiated by Darwin had great theoretical and empirical impact in the area of animal behavior as well as in the area of socio-emotional development--attachment--of infants. In other species, the recognition of other members of the social group, particularly the mother, has been considered of great survival value (Hamburg, 1969). For example, in the infant monkey, recognition of the mother allows the infant to remain in proximity with her. Proximity is crucial for the youngster as at an early age it is incapable of defending itself from predators or of providing its own food (Eibl-Eibesfeld, 1975; Hamburg, 1969). Neonatal animals of precocious species learn to recognize other members of the species to which they are exposed during a critical period (Hess, 1964, 1973). This learning (i.e., imprinting, [Lorenz, 1935]) also has great survival value for it keeps the youngster in the proximity of its protector(s).

For the human infant the recognition of the mother or other members of the family is also very important. Recognition of these familiar figures, especially their faces, is considered a prerequisite for the development of an emotional bond between the infant and his mother and other important figures (e.g., Bowlby, 1969; Schaffer, 1971).

Among the early reports, Spitz and Wolf (1946) observed that before six months of age infants smiled at any human face, but after six months infants smiled more at a familiar face than at a new face. And Ahrens (1954) observed more smiling at familiar people than at strangers at seven or eight months of age. Spitz and Wolf's and Ahrens' infants were reared in institutions; this event might have limited the infants' social experience with specific people.

Following the line of naturalistic observations set by early workers, Ambrose (1961) studied infants' smiles at the experimenter's expressionless face. He observed that home-reared infants decreased their smiling at the experimenter's face at about 20 weeks, whereas institutionalized infants followed the same pattern several weeks later. Ambrose suggested infants did so because they began to smile more frequently at familiar figures than at other people. Other investigators (Ainsworth, 1964; Piaget, 1952; Schaffer and Emerson, 1964; Wolff, 1963) also observed infants in their natural environment and suggested that at about three months of age infants may differentiate the mother's face; infants seem to show that by smiling at, and vocalizing at, the mother more often than at others.

In the laboratory, Wahler (1967) used an operant conditioning paradigm to study three-month-olds' smiling at people. Infants' smiles were rewarded by either the mother or by the experimenter. The infant smiled more often if the mother rewarded him than if the stranger did so. Kooh (1968) also conditioned infants but recorded head turning rather than smiles. Four- to five-month-old infants turned their heads more often when the stranger's face was presented as the reward than

when the mother's face was; younger infants did not respond differently depending on what face they were rewarded with. Rebelsky (1971) presented to three- to four-month-old infants the face of the mother and of a stranger, both accompanied by voice, and recorded infants' vocalizations and smiles. She found that infants smiled and vocalized more at a stranger's face and voice than at the mother's. In short, the laboratory studies in which smiling, vocalizing or head turning were measured suggest that infants may be able to discriminate the mother's face from a stranger's face between three to five months of age.

With the visual preference technique the results in three month old infants or younger infants are inconsistent. For example, Carpenter and her associates (Carpenter, 1973, 1974; Carpenter, Tecce, Stechler & Friedman, 1970) and Maurer and Salapatek (1976) have suggested that infants under two months of age can discriminate the mother's face from a stranger's or from a manikin (in some of Carpenter's studies). In contrast, Haith, Bergman & Moore (1977 or Bergman, Haith & Mann, 1971) found no evidence of discriminating the mother's face from a stranger's face in one-, two- or two- and a half-month-olds. Carpenter's and Maurer & Salapatek's studies cannot rule out the possibility that the difference between the looking at the mother's face and at the stranger's (or a manikin's) was due to differences in brightness (i.e., black mother, white stranger) or texture. Also, experimental bias in Carpenter's studies cannot be ruled out, given that the experimenter was aware of the identity of the stimuli. Moreover, Maurer & Salapatek only found the effect in one-

month-olds (they looked longer at a stranger's face than at the mother's) but not in two month olds. This result is difficult to interpret, because the younger infants spent most of the time looking away from the faces. However, one-month-olds looked mainly at the external contour of a face when they did look at it. Thus, if methodological variables can be ruled out, the findings with one-month-olds (in Maurer & Salapatek's study) may be explained by differences between the mother's and the stranger's faces in external contour. The findings with two-month-olds (no evidence of discrimination) in Haith et al.'s and in Maurer & Salapatek's studies may also be explained by the infants' scanning of a face: they look longer at the internal detail of the face, mainly the eyes, than at its edges. Two-month-olds might not have had sufficient exposure to a face in order to process its internal features and hence to discriminate that face from another.

Also, with the visual preference technique, Bigelow (1977) found that three-month-olds looked longer at the stranger's face than at the mother's face. Klein & Jennings (1977) found the same result at five months of age, whereas their three-month-old infants looked at the stranger's face as long as at the mother's face. Moreover, Cohen (1974) found the same preference in five- to eight-month-old infants.

Finally, in a study in which photographs of faces rather than real faces, were presented to one- to four-month-old infants, Fitzgerald (1968) found that only the four-month-olds showed evidence of discrimination between the photographs: they showed more pupillary dilation to a stranger's face than to the mother's face.

In summary, the studies of visual preference indicate that if infants under two months of age discriminate faces they may do so on the basis of external features of the faces (such as hair style) or on the basis of other physical features such as brightness, rather than on the basis of internal features. With older infants studies of visual preferences indicate that between four and five months infants consistently show evidence of discrimination between the mother's and the stranger's faces. This discrimination may be done on the basis of some knowledge of the internal features of the face since as early as two months infants look inside the face longer than at the borders of the face (Haith, Bergman & Moore, 1977; Maurer & Salapatek, 1976).

One of the objectives of this investigation was to test whether or not three-month-old infants could discriminate the mother's face from a stranger's face with the visual preference paradigm and/or with a paradigm which provides some experience in the laboratory with one of the faces before a test of recognition (and discrimination) is administered.

Discrimination of stranger's faces. Although since the early 1950's there have been many studies of the discrimination of the mother's face from other faces there were no experimental studies on the discrimination of faces of strangers before the mid 1960's. Kagan and Lewis's (1965) study perhaps represented the first experimental attempt in this area. They measured visual fixations, motor activity, vocalizations and smiles while the six-month-old infants were exposed to photographs of a male face, of a female face and of other objects. Although the faces elicited more visual fixations and physical activity

than the other stimuli, the two faces elicited equal amounts of visual fixations. The female face, however, tended to elicit more vocalizations than the male face. This study thus suggests that by six months of age infants may differentiate between faces of people they have never seen before.

Most of the work on the discrimination of faces of strangers has been done in the last six years. Fagan (1972) tested four-month-olds (in one experiment) and five- to six-month-olds (in other experiments) with the familiarization-novelty paradigm to determine whether or not the infants could do the discrimination. Four-month-old infants looked at the new face as long as at the familiar face, whereas in most of the other experiments five- to six-month-olds looked longer at the face of the novel stranger than at the face of the familiar stranger during the recognition test. Longer looking at the new face suggests that the infants discriminated the two faces and it implies that they recognized the face they were exposed to before the test. Fagan's finding with five- to six-month-olds has been consistently replicated by other investigators in five- to seven-month-old infants, with color photographs, with black and white photographs, and with filmed faces, as well as both with persons of the same and of different sex (Cornell, 1974; Fagan, 1973, 1974, 1977; Miranda & Fantz, 1974; Spelke, 1977; Strauss, De Loache & Maynard (1977).

Using a different paradigm, habituation, Cohen, De Loache and Pearl (1977), however, found evidence of the discrimination of the photographed faces of strangers in four and a half-month-old infants. After the infant was habituated to a color photograph of a woman, he

looked longer at the new face of a man or a baby than at the habituated face of the woman. This finding implies that infants discriminated between the pictures of the strangers after they were given substantial experience with one of them. It also implies that infants recognized something about the habituated face.

The fact that Cohen et al. found evidence of discrimination of strangers' faces earlier than previously found by Fagan may be because they used a paradigm which may be more sensitive than the paradigm used by Fagan. For example, in the familiarization paradigm that Fagan used infants are allowed to study one of the faces for a fixed amount of time, usually one or two minutes, before they are tested. During the test, the familiarized face is paired with a new face, so that the new and the old faces are presented simultaneously for a very short time e.g., 10 to 20 sec. Thus, the study time during the familiarization may not be sufficient for the infant to encode the stimulus. Even if the infant encodes the stimulus during the familiarization period, the testing time may not be sufficient for the infant to retrieve whatever information about the familiarized face he may have stored.

In contrast, infants in Cohen et al.'s study looked at the habituated face in every trial for an unlimited amount of time, until they looked away. Infants also had as many trials as needed to reach the criterion of habituation. Thus, the habituation paradigm may have provided each infant with more exposure to a face than did the familiarization paradigm.

If in a habituation study infants four- and one-half-months of age showed evidence of discriminating between the faces of strangers,

with sufficient experience infants may even show such evidence at an earlier age. The purpose of some of the experiments in this dissertation was to determine whether the three-month-old infant would show discrimination of faces of strangers and if so, what are some of the variables are which would facilitate this discrimination. In addition, the evidence of the discrimination of strangers' faces was compared to the evidence of the discrimination of the mother's from a stranger's face to determine whether or not there were any differences.

Discrimination and recognition of facial expressions

Like the face, facial expressions may convey social and emotional signals in humans and in other animals (Darwin, 1872; Izard, 1971, 1977; Ekman, 1973). Among nonhuman primates, members of the same species must learn to recognize different facial expressions (e.g., of aggression, of submission, of play and of sexual arousal) so that they can interact accordingly (Chevalier-Skolnikoff, 1973).

In humans, facial expressions are considered by some investigators the most reliable reflection of emotional states (Izard, 1977; Ekman, 1971, 1973). Facial expressions are also very effective social cues (e.g., for attending, approving or disapproving) during face-to-face interactions among adults (Argyle, 1975) and children (Izard, 197 ; Vince, 1975). When two people interact their mutual facial expressions seem to regulate the nature and the duration of the interaction. How early the infant can tell facial expressions apart would determine how early he could perceive the social cues conveyed by facial expessions and interact accordingly with other people.

The first observations of infants' recognition of facial expressions are found in Darwin's work. Although he was more interested in the origin of facial expressions across species and within a species, he made insightful observations of the recognition of facial expressions by his own infants and from these observations he suggested that at a very early age the infant "understands... the meaning or feelings of those who care for him by the expressions of their (facial) features" (Darwin, 1877, cited by Charlesworth and Kreutzer, 1973). In addition, in his book (1872) The Expression of Emotions in Man and Animals, Darwin pointed out the importance of recognizing facial expressions of others in human and in nonhuman animals and suggested that facial expressions convey socio-emotional meaning to others, even though he did not elaborate this subject (Charlesworth & Kreutzer, 1973).

Darwin's theoretical and naturalistic approach influenced the early work on infants' recognition of facial expressions. Thus, it is not surprising that the early reports basically consisted of naturalistic observations of infants' reactions to various facial expressions. Buhler and Hetzer's (1928) work probably represents the first systematic report of infants' reactions to a "positive" face (smiling) and a "negative" one (angry) (Charlesworth & Kreutzer, 1973). Infants within the first year of life were shown a live face acting out one expression at a time. The infant's reactions were recorded and classified as "positive" if the infant smiled and showed "joyful movements" and as "negative" if the infant was motionless and cried. At three months or under, 90% of the infants showed positive reactions

to the angry face; at four months 50% of the infants showed negative reactions; however, from 5 months on 100% of the infants showed negative reactions to the angry face. In contrast, Spitz and Wolf (1946) found that two- to six-month-olds reacted (e.g., smiled or cried) similarly to happy or angry faces acted out by the investigator or presented on a mask. Also, Ahrens (1954) observed that two- to five-month-old infants reacted in a similar way to real or pictured faces that were laughing, crying or neutral. With six-month-old babies, however, Ahrens observed that brow wrinkles had a slight negative effect on some infants. It was not until 8-months that Ahrens observed negative reactions (e.g., crying, withdrawal movements) to a frowning face.

More recently, Wilcox & Clayton (1968) reported a more systematic study of the discrimination of facial expressions by five-month-old infants. They used the visual preference paradigm and recorded visual fixations, while the infants saw photographs and films of smiling, frowning and neutral faces. Infants looked at the smiling face longer than at the others only when the faces were presented for 28 sec, but not when they were presented for 60 sec. This conflicting finding within the same experiment makes it difficult to interpret whether or not the infant could actually differentiate the facial expressions.

Kreutzer & Charlesworth (1973; reported in Charlesworth & Kreutzer, 1973) filmed four- to ten-month-old infants' behavior while an experimenter acted out the facial expressions of anger, happiness, sadness and neutrality. From the films they recorded infants'

emotional responses (e.g. smiles, laughs, fusses, cries), amount of attention and general activity. Kreutzer & Charlesworth found that four-month-olds behaved the same way to all facial expressions. Six-month-olds, however, showed evidence of discriminating between various expressions. Thus, Kreutzer & Charlesworth's findings are consistent with some of the earlier observations (Buhler & Hetzer, 1928) that by six months infants begin to discriminate facial expressions.

In contrast to most earlier work, two recent studies (La Barbera, Izard, Vietze & Parisi, 1976; Browne, Rosenfeld & Horowitz, 1977) have reported evidence of visual discrimination of facial expression in three- to six-month-old infants. La Barbera et al. used the visual preference technique to present four- and six-month-old infants with photographs of a male adult acting out happy, angry and neutral expressions. Each picture was presented until the infant looked away from it. Infants looked longer at the happy face than at the angry or neutral faces. Infants looked equally long at the angry and neutral faces. La Barbera et al. suggested that the four- to six-month-old infants not only discriminated joyous or happy expressions from other expressions, but that they actually recognized the emotion of joy and "the positive reward value inherent in the expression" (p. 537). Whether or not La Barbera et al.'s interpretation is correct, their findings represent the first consistent data on the discrimination of facial expressions by infants under six months of age. Moreover, their findings are consistent with Izard's (1969) findings with two- to nine-year-old children. Izard found that children make fewer errors identifying or recognizing a happy face (by

choosing the appropriate expression) and discriminating it from faces with other expressions than they make recognizing other expressions and discriminating them from each other. La Barbera et al.'s findings are also consistent with the data on recognition of expressions by adults from many cultures: adults, too, make fewer errors in recognizing a happy face than any other facial expression (Ekman & Friesen, 1972; Izard, 1977).

Browne, Rosenfeld & Horowitz (1977) used an habituation paradigm and visual fixation as the measure to determine whether three-month-olds can discriminate between happy, sad and surprised faces. After habituation, infants looked longer at a new face with a new expression than at the habituated face; this was the case if one face was happy and the other one surprised. They also looked longer at a novel face than at the habituated face if the novel face was surprised and the habituated face was sad, but not if the novel face was sad. Finally, infants looked at the sad face as long as at the happy face, after they were habituated to either face. From these results, Browne et al. suggested that infants showed evidence of discriminating between a happy face and a surprised face because these two faces differed in the area of the eyes. If this is the case, it is quite surprising that infants showed inconsistent evidence of discriminating surprised from sad faces, for these expressions also differed markedly in the area of the eyes. It is also surprising that Browne et al. did not find evidence of discrimination between happy and sad faces for La Barbera's findings and cross-cultural research with children and adults clearly suggest that discriminating a happy expression from other expressions

is easier than discriminating other expressions? It is especially surprising that Browne et al. did not find differential looking at the happy and sad faces, in light of the fact they used an habituation paradigm which seems very sensitive for assessing discriminations in the young infant.

One possible explanation for the failure of Browne et al. to find evidence of discrimination between happy and sad faces is that within a session the infant was first habituated to one face and tested with a new one; the new face was then presented repeatedly until the infant habituated; then another new face was presented. The order of this sequence varied across infants. Since discrimination between surprised and sad faces only appeared when the surprised face was the novel stimulus, it appears that there were some order effects which may have affected the results. Moreover, it is not unlikely that being habituated for a second time led to fatigue in some infants. Finally, since there were only four infants in each order, it is possible that the typical variability of habituation data masked the effect of some facial expressions.

Although La Barbera et al.'s and Browne et al.'s work suggests that infants, contrary to previous findings, can discriminate some facial expressions before the age of five months, the issue is still far from closed. On the one hand, La Barbera et al. proposed that four- to six-month-old infants recognize the facial expression of joy for its "positive reward value", but were insensitive to the aversive informational content of the angry face. Although infants did not show evidence of discrimination between an angry and a neutral face, this

finding cannot be interpreted as if infants were unable to perceive an angry face. Early observations (Buhler and Hetzer, 1928) suggest that by four months infants begin to react negatively (e.g. the infant remained motionless or fussed) to an angry face and that by 5 months all infants consistently reacted negatively to this face. Thus, whether or not infants under six months of age can recognize an angry face is a question which needs to be answered.

On the other hand, Browne et al. showed discrimination of surprised and happy faces in three-month-olds but failed to demonstrate discrimination between happy and sad faces. Because their results might have been affected by the order of the stimuli, it is possible that three-month-olds would show evidence of discriminating several facial expressions when no effects of order are suspected. Moreover, if the three-month-old infant looks extensively at the inside features of the face, at least like two-month-olds do (Haith, Bergman & Moore, 1977; Maurer & Salapatek, 1976), one would expect (from La Barbera et al.'s findings and from work with children and adults) that the infant would discriminate a happy expression from another expression after substantial exposure to one of the facial expressions. The purpose of some experiments in this dissertation was to determine whether or not the three-month-old infant could discriminate a smiling face from a frowning face and to determine whether previous experience, in the real world, with the person acting out the facial expressions would facilitate this discrimination. The latter hypothesis is based on the assumption that infants in the real world are exposed to some faces (and their expressions) more often than to other faces.

Scanning of the face

If the infant can discriminate faces, what information does he use to do so? Does he perceive the face as a whole, or does he perceive only single features? The answers to these questions are important not only because they will increase our understanding of the infant's perception of the face but also because how the infant perceives the face may tell us something about how he perceives objects in general.

Early studies were designed to investigate what part of the face was necessary to elicit smiles in the infant. Buhler and Hetzer (1928) showed infants face-like designs with isolated features and observed that three- to four-month-old infants smiled whenever eyes were present. Kaila (1932, in Freedman, 1964) suggested that not only the eyes but the entire area of the eyes (including the eyebrows and surrounding wrinkles) attracted the infants' attention. Similar observations were reported by Spitz and Wolf (1946). Of the early studies, Ahrens' (1954) represents the most extensive analysis of what facial features are most effective for eliciting smiles and attention in the infant at various ages. Ahrens used face-like designs or dummies with all facial features or only some of them, a picture of a boy's face with some features covered, and the investigator's face, also with some features covered. He showed infants the dummies and observed whether or not smiling appeared. At one month, infants smiled more readily at an oval design with dots in the place of eyes than at a real face; however, six dots were more effective in eliciting smiles than one dot. With a picture of a boy folded in half, so that only the

area of the eyes was visible, Ahrens observed that at two months the infants hardly appeared to notice the absence of the mouth; at four months, infants' smiles were briefer when exposed to the folded picture than when exposed to the full picture. Moreover, at two and at four-months of age infants reacted to an oval contour with all the features of a face the same as they did to a face design with the mouth absent.

Ahrens explored further the role of the mouth by introducing movement into a real face: widening the mouth, slight mouth movements such as puckering, and opening and closing the mouth. At three months infants looked consistently only at the opening and closing movements. At four months, infants also glanced at the slight movements, yet those movements did not arouse smiling at either age; at five to seven months, infants looked and smiled mainly at the widening of the mouth. However, at eight months the effect of widening mouth declined both in terms of looking and of smiling. When Ahrens covered the lower part (mouth) of the investigator's face and gradually uncovered it, he observed that the three- and four-month-old infants attended very carefully to the "moving mask" while their smile disappeared.

Ahrens concluded from all these observations that although the three- to four-month-old infant is capable of looking at the mouth, the mouth is not as attractive as the eyes. By five months, the infant begins to look away from the eyes and looks at the mouth as well. However, if the mouth is motionless he still looks more readily at the eyes.

More recently, investigators have studied what features of the face infants look at either by using the Corneal Reflection photo-

graphy, i.e., filming the infants' eye movements (Dönnee, 1973, or Hainline, 1978; Bergman, Haith & Mann, 1971 or Haith, Bergman and Moore, 1977; Maurer & Salapatek, 1976), or by testing infants' discriminations (Caron, Caron, Caldwell and Weiss, 1973).

Haith et al. (1977), and Maurer and Salapatek (1976) filmed the infant's eye while he was looking at a real face; Hainline (1978) did so while the infant was looking at a photograph of a face or a face-like pattern. These investigators found that at one month, infants look mainly at the contour of the face, e.g., hairline and chin, presumably a part of the face which provides high contrast. At two months, they found that infants look mainly at the area of the eyes, just as earlier studies (Ahrens, 1954, Kaila, 1932) had suggested. At two- and a half months, Haith et al. found that infants fixate the area around the eyes even more than the two-month-olds do. In contrast, Hainline found that two- and a half-month-old infants fixate the high contrast borders of the face, behaving more like the one-month-olds than the two-month-olds in the same study. The main difference between these two studies was the nature of the face: live in Haith's study and photographed in Hainline's study.

The inconsistency of the data found with two and a half-month-olds makes it difficult to speculate about what features of a photographed face the three-month-old infant would look at, and what features he would look at most in order to discriminate and recognize faces. Since there are no scanning data on three-month-olds, the last experiment of this dissertation was designed to furnish such data. Since photographs of faces were used in this experiment, as in

Hainline's, its results may clarify the discrepancies between Haith's and Hainline's results.

Caron, Caron, Caldwell and Weiss (1973) used schematic face-like drawings similar to those used by Ahrens and others, to study four- to six-month-old infants' discrimination between a face-like pattern and patterns with the features of the face abnormally arranged. Caron et al. tested infants with a normal face-like pattern after infants were habituated to a distorted face-like pattern. Four-month-old infants looked longer at the new regular face-like pattern than at the habituated pattern without eyes or with distortions around the eyes and hairline. However, four-month-olds did not look longer at the regular face-like pattern than at the habituated patterns with distortions of the mouth and nose. These findings suggest that the four-month-old attends more to the upper part of the face than to the lower part, for he notes changes around the hairline and eyes but not around the nose and mouth.

In contrast, the six-month-old infants in Caron et al.'s study differentiated distortions of the mouth from the regular face-like pattern as well as those around the eyes. This finding suggests that the mouth eventually becomes as important as the eyes, a finding which is consistent with Ahrens' early observations. Caron et al's data are very important for they provide some experimental evidence about what part of a facial stimulus infants attend to and, perhaps, process at four and at six months of age. It is unknown, however, if infants of these ages will behave the same way with more realistic presentations

of a face, such as a color photograph, or even with a live face as with the schematic representations used by Caron et al.

In summary, the studies reviewed here suggest, as suggested by Ahrens (1954) and proposed by Gibson (1969), that at different ages infants attend to some facial features more than to others. At one month infants attend more to the borders of the face than to the other features; at two months, infants seem to look more at the eyes than at any other feature. At four months infants still attend more to the upper part of the face than to the lower part. And at five- to six-months infants look at the eyes as much as they look at the mouth. In fact, the eyes seem to be the most attractive facial feature even for adults (Yarbus, 1969).

Although one cannot measure whether looking at a facial feature is equivalent to processing that feature, one can only assume that if the infant looks at a facial feature he may also process it. Looking at a stimulus may be a necessary but it may not be a sufficient condition for the visual processing of such stimulus.

Infant's perception of similarity between two-dimensional and three-dimensional objects.

Most of the perceptual research on infants has been done using two-dimensional shapes or patterns, instead of three-dimensional objects. Several investigators have questioned the generalizability of this research to the infant's perception of his real three-dimensional world (Bond, 1972; Ruff, Kohler & Haupt, 1976). A real face or a real object provides more visual cues (e.g., movement, shaded areas, texture) than a two-dimensional representation, and even within the

two-dimensional representations, a photograph provides more visual cues than a drawing. Thus, it is important to know whether the cues provided to the infant by a two-dimensional representation are sufficient for perceiving similarily between three-dimensional objects and its two-dimensional representation.

One way to test whether infants' perception of two-dimensional forms can be generalized to their perception of three-dimensional objects is by determining whether or not infants respond to a two-dimensional representation of an object, in a similar manner as they respond to the real three-dimensional object, or by determining whether or not infants can transfer information from one dimension to the other.

With young infants, the transfer of information across dimensions has not been directly investigated. Rather, investigators have asked whether or not infants differentiate three-dimensional objects from two-dimensional ones, or whether discrimination within one dimension is more easily done than discrimination within the other. With respect to the first question, early investigators such as Ahrens (1954), Polak, Emde & Spitz (1964) and Spitz & Wolf (1946) found no differences in smiling at a live face and at its two-dimensional replica at two months of age. By three months Ahrens and Polak et al. found that infants smiled more frequently (Ahrens) or sooner (Polak et al.) at the real face than at the photograph. Fantz (1961) and Fantz & Nevis (1967) found that infants under two months of age looked longer at a face-like contour than at a solid head model, whereas infants over two months looked longer at the three-dimensional model. Bower (1966)

found that young infants (two months or under) showed size constancy with a three-dimensional sphere but not with its two-dimensional representation. Pipp (1975) found that two-month-olds scanned longer along the vertical axis of a three-dimensional "L" figure than along the vertical axis of the two-dimensional representation of the same figure. In summary, these data suggest that young infants can perceive the differences between two-dimensional representations of objects and the objects themselves even when the objects are faces. In addition, these data suggest that two- to three-month-old infants prefer the three-dimensional object over its picture. These data, however, do not answer the question of whether or not the young infant can transfer his knowledge from a three-dimensional object to its picture.

The discrimination between two-dimensional objects as opposed to the discrimination between three-dimensional ones has been investigated by Ruff, Kohler & Haupt (1976). Ruff et al. familiarized three- and five-month-old infants to either real or pictured common household objects. Subsequently, infants were tested with new stimuli and the familiarized stimulus. Ruff et al., found evidence of discrimination by the three-month-olds with neither the three-dimensional objects nor with pictures of the same objects. The five-month-old infants, however, looked longer at a new object than at a familiar object if the objects were three-dimensional, but not if the objects were pictured. On the basis of these findings, Ruff et al. concluded that infants learn to discriminate real objects sooner (i.e., with less experience) than they learn to discriminate pictures of the same objects. Although infants seem to discriminate real objects

sooner than they do pictures of the same objects, this does not necessarily mean that they cannot transfer information from one dimension to the other.

Fagan (1972) used the familiarization-novelty paradigm to test the discrimination of three-dimensional models of faces, of photographs of faces and of drawings of faces in five- to six-month-old infants. Infants looked longer at the new face than at the familiar face if the faces were either photographed or three-dimensional models; however, if the faces were drawn, infants looked at a novel one no longer than they looked at the familiar one. In another experiment (Fagan, 1974) Fagan varied the duration of the familiarization experience to determine the minimum exposure time necessary to obtain evidence of discrimination between faces and between other stimuli. He found that while infants discriminated two photographs of faces after only 22.4 sec, they showed no evidence of discrimination between drawings of faces even after 35 sec. These findings, then, suggest that infants need less experience to discriminate photographs of faces than to discriminate drawings of faces.

Fagan's findings suggest that a photograph of a face provides sufficient visual cues to five- and six-month-old infants for discriminating faces. Infants did so, even when the exposure time during familiarization to one face was minimum. Infants, however, may need extensive exposure to drawings of faces, in order to show evidence of discriminating them.

Direct tests of whether or not infants behave similarly to an object and its picture have been reported by Ross (1976) and Dirks &

Gibson (1977). Ross familiarized six-month-old infants to a three-dimensional geometric design and tested them with pictures of a new geometrical design and of the design the infants saw during familiarization. Infants looked longer at the novel design than at the familiar design. Dirks & Gibson habituated five- and a half-month-olds to a live face of a stranger and then tested them with pictures of a new face and of the face which they saw during the habituation trials. Infants looked longer at the new face than at the familiar face, at least when the faces differed grossly in their features (i.e., hair color and style, and sex).

Both Ross' and Dirks & Gibson's studies suggest that at least by five to six months infants can perceive some similarity between real objects and pictures of the same objects, be they geometric figures or faces.

Within the two-dimensional domain, Strauss, De Loache and Maynard (1977) investigated whether infants can transfer their knowledge from one mode of representation – color photograph – to another mode, either a black and white photograph or a drawing of the photograph. They familiarized five- to six-month-old infants to a color photograph of a woman and tested them with a new face and the familiar one. For some infants the pictures in the test were, as in the familiarization condition, color photographs; for others, the pictures were black and white photographs; and for still others, the pictures were drawn faces. Infants looked longer at a new face than at the familiar one when the pictures were either color or black and white photographs but not if they were drawings of faces. Thus, it appears

that some cues, such as color, may be less important than others in the recognition and discrimination of faces, and that a drawing of a face may not provide sufficient distinctive cues for the infant to perceive similarity between it and a color photograph of the same face.

The faces used by Dirks and Gibson and by Strauss et al. were faces of strangers. Adults and children from primitive cultures recognize pictures of animals they are familiar with more easily than pictures of animals which they are only allowed to inspect briefly before they are tested, but with which they had no previous experience in the natural environment (Kennedy, 1977; Kennedy and Ross, 1976). In our culture, children (Diamond & Carey, 1977; Chance, Goldstein & Schicht, 1967) and adults (Yarmey, 1975) discriminate photographed faces of friends and public figures more readily than they do faces of strangers. Thus, since the five- and a half-month-old infant seems capable of transferring knowledge of a live (three-dimensional) face of a stranger to a picture (two-dimensional) of the same face, it is reasonable to expect that the infant might make such a transfer at an earlier age, especially if the face were familiar to him prior to the experiment.

Another aim of this investigation was to test whether or not the three-month-old could perceive some similarity betwen a real face (his mother's) which he has experienced in the natural environment, and a two-dimensional representation (a picture) of the same face.

In summary, this dissertation is about infants' perception of, and memory for, faces. Specifically, the purpose of this investigation was multifold: (a) to determine whether or not the three-month-old

infant can discriminate between photographs of faces, and recognize one of them; (b) to ascertain whether or not experience with a face (the mother's), prior to the laboratory visit, results in faster discrimination of that face from another than discriminaiton between faces of strangers; (c) to determine whether or not the three-month-old infant can discriminate some facial expressions acted out by either his own mother or a stranger; (d) to establish whether or not facial expressions of a "familiar" face are more easily discriminated than facial expressions of a new face; (e) to determine what facial features the three-month-old infant attends to most; (f) to investigate whether or not the infant can perceive some similarity between the live face of his mother and her photographed face.

It is hoped that this investigation will increase our knowledge of what the young infant knows about faces and will clarify some theoretical issues about infant's perception and processing of faces.

Chapter 2

Discrimination and recognition of mothers' photographed faces with the visual preference and the habituation paradigms

Experiment 1

Many investigators have observed infants in their natural environment and concluded that some infants can recognize their mothers within the first six months of life (Ainsworth, 1964; Ambrose, 1961; Piaget, 1952; Schaffer & Emerson, 1964; Stern, 1974; Wolff, 1963). Mothers have reported that they perceive their infants begin to recognize them at about three months of age (Emde, Gaensbauer & Harmon, 1976). In the laboratory, investigators have found that infants of four to five months consistently look longer at, turn their head towards more often, and dilate their pupils more frequently, to a stranger's face than the mother's (Cohen, 1974; Fitzgerald, 1967; Klein & Jennings, 1977; Koch, 1968). The results with three to four-month-old infants, however, tend to be inconsistent. Thus, in some studies infants tended to prefer the mother (e.g., Wahler, 1967), in other studies they tended to prefer a stranger (e.g., Bigelow, 1977; Rebelsky, 1971) and still in another study they preferred neither (Klein & Jennings, 1977). Thus, the question of whether or not infants under four months of age can visually discriminate between the mother's and a stranger's face and, hence, recognize the mother's face, is still open.

In a pilot experiment (see Appendix 1) three-month-old infants familiarized to the photograph of the mother looked longer at a photograph of a novel face (the stranger's) than at a photograph of the familiar face (the mother's). This finding, however, did not seem as strong as one might have expected. Some of the features of the procedure might have weakened the effects. The photographs were color prints, with a white background and rectangular borders which, when the picture was pasted on a black screen, emphasized the flatness once typical of pictures. The presentation of the photographs in pairs produced a great deal of side bias which might have interacted with the effects of the stimuli. The duration of the trials might have been insufficient. Nevertheless, the importance of this tentative result made it worthwhile to reexamine the same question with a paradigm which seems to be much more effective with young infants (habituation) than the paradigm used in the pilot study (familiarization-novelty). Thus, one of the purposes of this experiment was to determine whether or not the three-month-old infant can visually recognize the face of his mother and discriminate it from the face of a stranger.

Another question which was raised in this experiment was whether or not the three-month-old can perceive similarity between a three-dimensional object and a two-dimensional representation of the same object; that is, whether or not the infant can transfer information across dimensions. Ross (1976) found that six-month-old infants can do so with geometric designs, and Dirks and Gibson (1977) found that five and a half-month-old infants seem to transfer knowledge from a real face to its picture. It should be pointed out that the

faces used by Dirks and Gibson were those of strangers. The evidence mentioned above on the discrimination of the mother from a stranger suggests that infants may recognize the mother's face more easily than they recognize other faces with which they have had less experience. Thus, infants may transfer more easily from a three-dimensional real face to a two-dimensional face--a picture--if they are familiar with the three-dimensional face. Thus, infants younger than previously tested may generalize from a face to its picture, at least if the face is the mother's.

To test this hypothesis, in the present study infants were given a visual preference test in which they saw photographs of the mother and of a stranger. Since the infant had presumably been exposed to the live face of his mother in the natural environment, no additional exposure to the mother's live face was provided in the laboratory. The visual preference test, then, tested whether or not the infant would transfer previous information about the three-dimensional face of the mother to her picture, without having previous experience with pictures in the laboratory.

In this and subsequent studies three-month-old infants were selected because (a) the literature suggests that at this age the visual system is almost fully developed (see Haith, 1977); (b) at least by this age infants are very likely to show evidence of memory after training (Fagan, 1970); and because (c) by two and two- and a half months infants look at the internal features of the face, mainly the eyes. (Haith et al., 1977; Maurer and Salapatek, 1976; and Hainline, 1978, found this result at two months, but not at two and a half

months; this inconsistency is discussed in Chapter 1 and is further explained in Experiment 8). It is important that the visual system be well-developed because a face is a very complex stimulus with many internal features and an invariant arrangement. An immature visual system might not be able to perceive the fine internal features typical of a face.

In summary, in this experiment infants were first given a visual preference test in which the pictures of the mother and a stranger were presented singly, twice each. Subsequently, the mother's face was repeatedly presented until a criterion of habituation was met (see below). Then, infants were given a recognition test with the mother's face and the novel face of another female.

Method

Subjects

The subjects used in this and in subsequent experiments were born in or near Hamilton, Ontario and came from a variety of family backgrounds. The babies were chosen from birth announcements in a local newspaper and from the pool of babies whose parents agreed to participate in studies at the Infant Vision Laboratory. The latter group of parents were contacted at the hospital (McMaster Medical Center or St. Joseph's Hospital) after their babies were born. The criteria for inclusion in the studies were that the infant was 12 to 14 weeks of age at the time he was tested; that the infant had no known neurological or visual abnormalities; and that the infant was at least 38 weeks of gestational age and weighed at least 5-1/2 pounds at birth.

The subjects in this experiment were 12 three-month-old infants (6 males and 6 females). Their mean age was 88 days (range 85 to 98 days). Eight other babies were tested but excluded from the study due to brightness differences between the photograph of the mother and of a stranger (n=4), sleepiness (n=2) and crying (n=2).

Apparatus

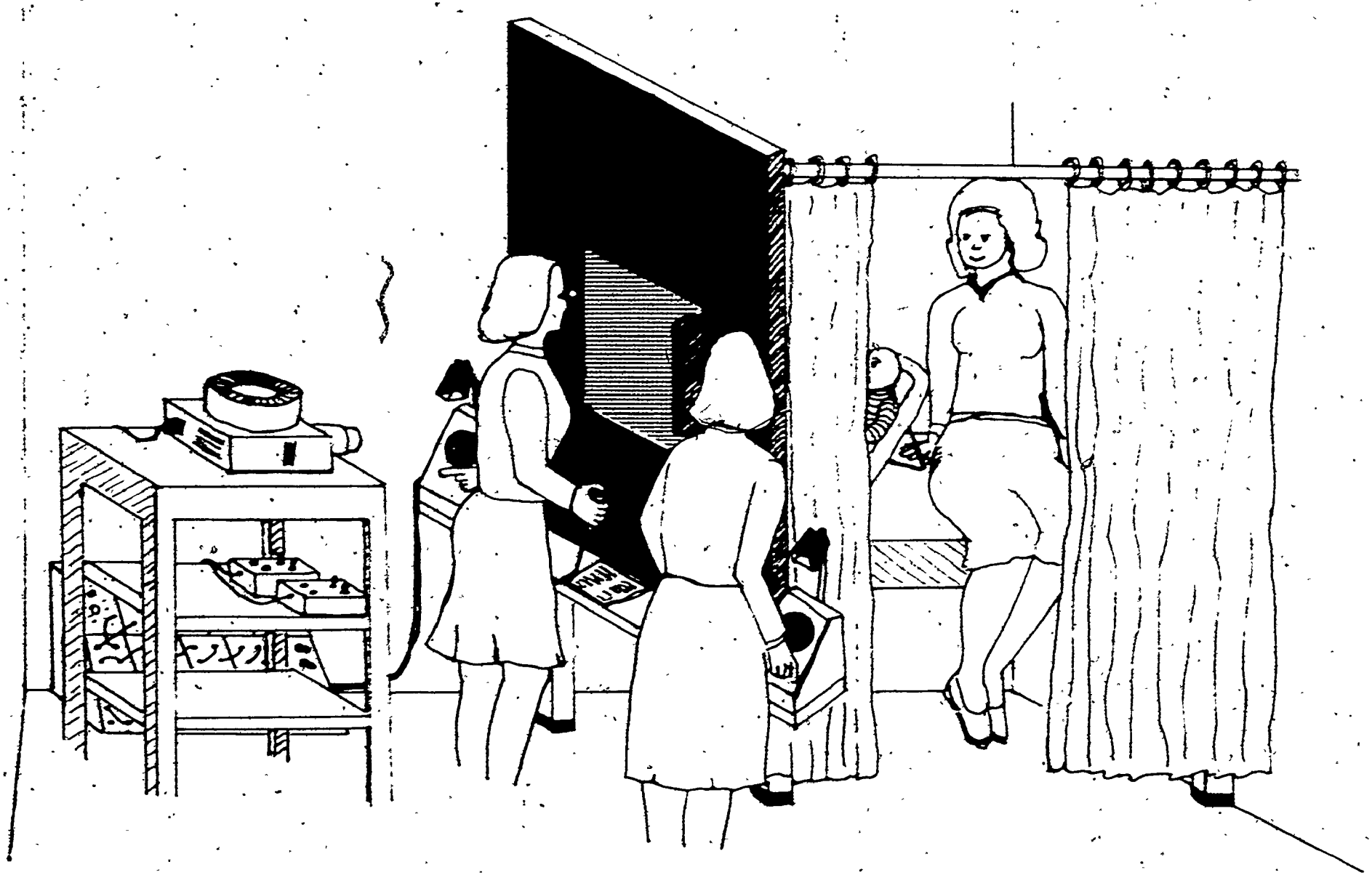
The apparatus used in this and most of the subsequent experiments is shown in Figure 1. It consisted of a rear-projection screen (46 x 33 cm) on which the stimuli were projected. The screen was mounted in a black panel, which was placed on a table. On the table the infant sat in an infant seat facing the screen, which was 46 cm from the babies' eyes and 87 cm from a slide projector. The mother sat behind the infant throughout the session. Two 1 cm-wide peepholes were located at 2.5 cm from either side of the screen. Through these holes two observers looked at the infant's eyes. A black blind prevented one observer (see below) from seeing the stimuli on the screen. Behind the observers were a projector with a shutter which could occlude the projector, and the control equipment.

Each observer had a cumulative timer located behind and below the screen, and a pair of control buttons. One control button activated a shutter mounted in front of the projector; the other button changed slides. The shutter and the slides were activated only after both observers had pressed their respective buttons. That is, the last button to be pressed activated the system.

Stimuli

The stimuli were color slides of the smiling faces of the 12

Figure 1.- Apparatus used in Experiments 1 to 6



women whose babies participated in this study, of a female "stranger" and of a 24 x 24 black and white checkerboard. All the women were Caucasian. The projected size of each face in this and in subsequent studies of habituation was approximately 23 x 18 cm, i.e., life-size; each face subtended a vertical visual angle of 26° 34' and a horizontal angle of 21° 22'. The checkerboard's projected size was 18 x 18 cm and subtended a visual angle of 21° 22'.

Each baby saw his mother's face, the faces of two other ladies (A & B) and the checkerboard. Stranger A was the same for all babies and was used in the test of visual preference. The similarity of facial features between stranger A and the mother varied randomly across the sample. Since the mothers and the stranger were both Caucasian and their pictures were taken under the same standard conditions, brightness differences between the pictures were minimal.

Stranger B was used in the recognition test after habituation. The face of stranger B varied from baby to baby, i.e., for each baby the stranger B was matched in brightness to the mother's face. The brightness density of each picture was measured with a densitometer. The densitometer provided readings of the brightness density of four points on the face: left and right cheeks, hairline and chin. A densitometer measures the "light stopping power" of a particular point in a slide or color negative, and provides a ratio between the total amount of light that strikes an area and the amount of light that is absorbed by this area. Stranger B was also matched to the mother in hair color. Figure 2 shows the checkerboard, stranger A, the face of one of the mothers and the face of the stranger (B) matched to that

Figure 2. Photographs of strangers, of some mothers and of the checkerboard used in Experiments 1, 2, 3 and 6. The original pictures were color slides projected life-size


STRANGER MH
STRANGER JW (A)
STRANGER R
MOTHER
MOTHER

mother's face. The main reason for using two strangers was so that in the preference test and in the recognition test one of the faces would be clearly novel.

The checkerboard, a non-face pattern, was also presented in the recognition test as a novel stimulus. Because two faces have more features in common than a face and a checkerboard, it is reasonable to assume that the discrimination between two faces may be more difficult than the discrimination between a face and a checkerboard. If infants show no differences between the habituated face and a novel face and between the habituated face and a checkerboard, this may be taken as evidence of fatigue, since it is highly unlikely that infants under optimal conditions would not discriminate a face from a pattern which differs from a face in a great number of ways. However, if infants look longer at the checkerboard than at the habituated face this result may rule out the effects of fatigue.

Experimental design

During the first four trials the infant saw the face of stranger A and the face of his mother (M) either in the order MAAM, or AMAM (the mother's face was always the last stimulus of the sequence). These four trials constituted the visual preference test. Then the mother's picture was repeatedly presented to the infant until he reached the criterion of habituation (see below). Finally, the baby was given a recognition test. The recognition test consisted of a novel face (stranger B), the picture of the mother and the checkerboard (C). Half of the infants had a MBBMCC test order and the other half a BMMBCC order.

The criterion of habituation was based on the first three presentations of the mother's picture, including the two trials of the preference test, and was determined in the following way. On every trial both observers recorded the duration of the visual fixation, and the larger number recorded was chosen. The sum of the larger numbers, on the three trials was divided by two to yield the criterion of habituation against which the sum of subsequent sets of 3 trials were compared. When the sum of three consecutive trials was less than the criterion value, the recognition test was initiated. Except for the initial preference test, the experimental design of this experiment is identical to the experimental design of all other habituation experiments reported in this dissertation.

Procedure

The general procedure for this and the following habituation experiment was the same. The experimenter explained the procedure to the parent(s) and, upon obtaining written permission from either parent, placed the baby in the infant seat and adjusted the distance between the baby's eyes and the screen. The mother sat behind the baby and remained silent during the session. However, she was instructed to comfort the baby with a pacifier, pats or coos if he fussed. Before the session began the room lights were turned off and white noise was turned on.

The experimental procedure was similar to the infant control procedure initially used by Horowitz and her associates (Horowitz, 1975; Horowitz, Paden, Bhana & Self, 1972). During a trial each observer independently judged when the infant was fixating the stimulus

i.e., when the stimulus was reflected near the center of the baby's pupil. Each observer activated a cumulative timer at the beginning of the fixation and released it as soon as she judged that the baby looked away from the stimulus. Then she pressed the shutter control button to cover the stimulus. The closing of the shutter automatically started a 15-sec intertrial interval. Next, the observers opened the shutter to start the next trial. During the intertrial interval the observers recorded the duration of the visual fixation, reset the cumulative timers and, during the test trials, pressed the button which advanced the slides.

To determine if the observers were reliably recording the same behavior, Pearson Product-Moment correlations were calculated for the data of each infant using the two scores recorded by the observers on each trial. These correlations are reported in the last column of Table 1. The mean correlation was .99; the range was .93 to .99.

Results

Table 1 shows the individual data for the visual preference test, the recognition test, and three habituation measures. Since there were two trials with each picture during the two tests the data for each stimulus are the sum of the two trials. Also, since there were two observers the mean of the fixation times recorded by the two observers was used as the score for each trial. Except for Experiment 7, this procedure was followed in subsequent experiments.

Visual preference data

In the preference test, ten out of 12 babies looked longer at the photograph of the mother's face than at the photograph of the

Table 1

Data from Experiment 1: Habituation to mother

	Subjects	Visual Preference Test: Time looking (sec) at Mother	Visual Preference Test: Time looking (sec) at Stranger	Habituation: No. of Trials	Habituation: Criterion of Habituation (sec)	Habituation: Total Looking (sec)	Recognition Test: Time looking (sec) at Novel face	Recognition Test: Time looking (sec) at Familiar face	Recognition Test: Time looking (sec) at Checker-board	Interobserver Reliability: r
Females	5	68.95	54.55	13	48.8	215.1	189.25	41.05	214.85	1.00
	8	65.15	97.25	9	51.15	156.5	51.95	40.25	49.95	1.00
	16	167.15	77.4	9	274.7	661.8	88.25	38.35	41.5	.99
	17	356.4	298.65	7	215.05	555.4	318.85	39.25	229.0	1.00
	19	102.5	107.5	7	89.1	236.5	195.25	42.5	89.95	1.00
	20	51.7	37.25	11	42.25	327.2	53.2	18.45	108.6	.97
Females	6	266.1	172.6	10	162.0	818.35	139.2	15.15	87.35	.98
	7	147.9	51.1	12	109.9	679.8	46.0	27.5	170.6	1.00
	10	417.65	114.45	9	308.45	920.9	70.5	29.85	90.4	1.00
	11	57.8	50.8	19	54.75	469.4	40.25	21.9	75.7	.93
	15	38.9	19.85	7	44.0	112.6	7.3	19.85	33.35	.99
	18	54.95	36.65	9	67.7	271.9	21.25	20.8	214.1	1.00
	$\bar{X}$ =	149.6	93.17	10.17	122.32	452.12	101.77	29.58	117.12	
	sd =	129.19	77.58	3.38	95.28	272.04	92.06	10.22	71.17	

stranger's face. The mean looking time at the mother was 149.6 sec; at the stranger, 93.17 sec. An analysis of variance[2] using stimuli (mother vs. stranger) as a within factor and sex[3] as a between factor, showed a significant main effect of stimulus ($F = 12.97$, $df = 1,10$, $p < .01$): Infants looked longer at the mother's face than at the stranger's face. There was also a significant interaction between stimuli and sex ($F = 5.20$, $df = 1,10$, $p < .05$). An analysis of this interaction using the Tukey procedure for post hoc comparisons (Winer, 1971) showed that although both boys and girls tended to look longer at the mother's face than at the stranger's, only the girls did so significantly ($q = 4.33$, $df = 4$, $p < .05$).

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2 Analyses of variance in this and subsequent experiments were calculated on the actual time in seconds and on their transformed equivalents. The data were transformed to the scale of natural logarithms in order to homogenize the variability (Winer, 1971), so common in infant research, and to normalize the time scores. Although the study of variability alone may be very important, its study was not the purpose of this research. Rather, the purpose of this research was to investigate infants' discrimination and recognition of faces and facial expressions, and hence how their behavior vary as a function of facial stimulation. The transformation of time measures to logs is a procedure commonly used by other investigators of infant behavior (e.g., Cohen, DeLoache & Pearl, 1977; McCall, 1977). These investigators have reasoned that the great variability typical of infants' data often masks meaningful effects. Unless specified the F ratios reported here and in the next experiments are those from the raw data; the transformed data typically yielded larger F ratios on the same direction as those of the raw data.

3 Although no sex differences were expected, the individual data for boys and girls appeared markedly different. Thus sex was included as a factor.

Habituation data

The measures of habituation in this and subsequent habituation studies were the number of trials to reach the criterion of habituation, the habituation criterion and the total looking time during habituation. Very little variability was found across babies in the number of trials needed to reach habituation. The mean number of trials was 10.17, ranging from 7 to 19. The mean criterion of habituation was 122.32 sec, ranging from 44.00 sec to 308.45 sec; the mean of the total looking time was 852.12 sec, ranging from 112.6 to 818.25 sec. An analysis of sex on each of the habituation measures yielded no sex differences or specific trends.

Recognition test data

After habituation was reached, all but one baby looked longer at the novel face of a stranger than at the familiar face of the mother. An Anova with sex as a between factor and stimuli (novel vs. familiar) as a within factor indicated that the difference between looking at the familiar and at the novel face was clearly significant ($F = 12.20$, $df = 1,10$; $p < .01$). The mean of looking at the novel face was 101.77 sec; at the familiar face was 29.58 sec. The main difference between sexes was also significant ($F = 8.09$, $df = 1,10$, $p < .05$). Boys, in general, looked at the pictures longer than girls. The interaction between sex and stimuli, however, was only marginally significant ($F = 3.15$, $df = 1, 10$, $p > .05$). Finally, the mean looking time at the checkerboard was significantly greater than the mean looking at the mother's face ($t = 4.31$, $df = 11$, $p < .01$).[4]

Discussion

The visual preference data suggest that infants can recognize some aspects of the mother's face and that they can discriminate the mother's face from that of a stranger's even though the faces were pictured and the infants had apparently no previous experience with pictorial material. The recognition test data also suggest that infants can discriminate the two faces.

The implications of these results are very important. Not only do infants seem to recognize the mother's face represented in a picture, but they seem to have perceived some similarity between what they presumably know about her live face and her picture. In other words, the three-month-old might have transferred his knowledge of a real face to a picture of it. If this interpretation is correct, these results provide some support to Gibson's (1971) hypothesis that the mechanisms involved in the perception of two-dimensional objects are similar to those involved in the perception of three-dimensional objects.

Transfer from a stranger's real face to his picture has been demonstrated at five- and a-half months by Dirks and Gibson (1977). The results reported here suggest that an infant can make the transfer across dimensions at least by three months at least if the mother's face is used. Moreover, infants seemed to make the transfer with almost no exposure to pictures in the laboratory. This supports

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4 Because the purpose of the checkerboard was only to control for fatigue, this result is not discussed in this experiment, nor are similar results with the checkerboard discussed in subsequent experiments.

previous suggestions (Dirks & Gibson, 1977; Rose, 1976) that infants need very little experience with pictorial material in order to discriminate between pictured objects, one of which the infant had seen before only three-dimensionally.

The results of the preference test are consistent with Bigelow's study (1977) in that she also found discrimination between the mother's face and a stranger's face. The direction of the preference, however, is inconsistent with Bigelow's: infants in this study looked longer at the mother's face than a stranger's, whereas infants in Bigelow's study did the reverse.

The difference in the direction of the preference may be due to the nature of the faces: real in Bigelow's study and photographed in this experiment. The infants in Bigelow's study were obviously familiar with the mother's real face, and hence, as predicted by the memory model proposed by Sokolov (1963), they looked longer at the novel stimulus. In the case of the photographs, however, both faces were presented in a new form: two-dimensionally. Thus, as the discrepancy hypothesis (McCall & McGhee, 1977) would predict, infants may have preferred the face which they had seen before, but in a different dimension, because of the two faces the mother's face was the one that had a moderate degree of novelty or discrepancy.

Although both a preference for a novel stimulus (the face of a stranger) or for a familiar stimulus (the face of the mother) can be interpreted as evidence that the infant recognizes something about the stimulus he has seen repeatedly (Cohen, 1976), it is possible that preference for familiarity appears in the early stages of recognition,

i.e., with very little experience, and preference for novelty appears in the later stages, i.e., after a great deal of experience. This hypothesis is further supported by the fact that although infants preferred the mother's face in the preference test, the same infants preferred the novel face after habituation to the mother's face. In other words, after extensive exposure to the mother's face they, like Bigelow's infants, looked longer at the stranger's face than at the familiar face. That infants shift their preference (from the mother's face to the stranger's face) after extensive experience with the mother's picture is consistent with Greenberg, Uzgiris & Hunt's (1970) findings with one- to two-and-a half-month-old infants. At first, infants looked longer at a toy they were familiarized to in the natural environment than at a new toy; several weeks later infants reversed their preference.

The results of the recognition test in this experiment are clearly consistent with the tentative results of the pilot study. In addition, there is some evidence which suggests that infants in this experiment may have found the test easier than infants in the pilot study. First, 11 out of 12 babies (92%) looked longer at the stranger than at the mother in this experiment, whereas only 64% or nine out of 14 babies did so in the pilot study. Second, the difference between the time they looked at the two faces was about twelve times larger than the difference between the time they looked at the novel and the familiar faces in the pilot experiment. Several methodological problems could have been responsible for the tentative results of the pilot study. For example, although 22 infants were excluded from the

data analysis because of extreme side bias, individual data showed that side bias was not totally eliminated. In fact, an independent analysis of looking at the left and at the right side of the visual field by the infants who remained in the study showed a significant preference for the right side (Barrera, Dalrymple & Wiberson, 1978). In contrast, in this experiment the effects of side bias were eliminated from the start of the experiment, for each face was presented in the center of the visual field.

The comparison between this experiment and the pilot study suggest that the study of the behavior of young infants is highly dependent on the sensitivity of the method employed by the investigator. Specifically, in the study of young infants' recognition and discrimination of faces the habituation paradigm seems to be more sensitive than the familiarization paradigm, because it ensures substantial exposure to a standard stimulus before a recognition test is given and because it eliminates problems of side bias.

It was surprising to find an interaction between sex and faces in this study because boys and girls in the pilot study did not seem to differ in their looking at the pictures. In this study, both boys and girls looked longer at the mother's than at the stranger's picture during the preference test. Yet, only girls did so reliably. However, after habituation, both boys and girls looked longer at the stranger's picture than at the mother's. In other words, after extensive experience with the photographed face of the mother, the boys seemed to discriminate the pictures as reliably as the girls. Yet, sex differences remained after habituation in that boys in general looked

longer at the pictures than did the girls. Since there were only 6 infants in each sex group, one should be cautious in drawing any conclusions, especially because sex differences in looking time are not consistent in the literature. For example, Caron (1969) found greater decrement of looking at complex patterns in three- and a half-old girls than in boys of the same age, whereas Cohen, Gelber & Lazar (1971) only found decrement of looking at a pattern during habituation in four- to five-month-old boys but not in girls. Except for one study of memory for faces (Fagan, 1972) investigators have typically not found sex differences when they have used photographs of strangers. Interestingly enough, in the only study in which Fagan (1972) found sex differences, five- to six-month-old girls showed consistent evidence of discrimination of photographs whereas boys did not. Moreover, Lewis (1969) tested three- to 13-month-olds and found evidence of better visual discrimination of several representations of faces (schematic face-like patterns, photographs and a three-dimensional head model) in girls than in boys, at all ages combined. Similarly, in older infants (12- to 24-months of age), Barrera (1973) found that although boys looked longer at the photographs of the mother and of a stranger than girls, girls showed better evidence of discrimination than boys.

In conclusion, the meaning of sex differences in this study are difficult to interpret in light of the existing literature. However, when infants have been shown faces, sex differences if present, are consistent with the sex differences found in this study. Although one could speculate about the meaning of these differences, given the size of the sample in this experiment a clearer picture may appear after

evidence from subsequent experiments has also been presented. The following experiments in this dissertation were also analyzed with sex as a factor.

In summary, the results of this experiment suggest that three-month-old infants can discriminate between the pictures of the mother and of a stranger without having previous experience with pictorial material. They also suggest that the infant can recognize his mother's face in a picture and hence that he can perceive some similarity between the real face of mother and a picture of the same face, i.e., that he can transfer information from a three-dimensional object to its picture.

In the experiments reported in the following chapter, the question of whether or not three-month-old infants would show evidence of discrimination between photographs of strangers is investigated. Specifically, the hypothesis to be tested in the next three experiments is whether the three-month-old infant would look longer at a photograph of a novel stranger than at a photograph of a "familiar" stranger if he is provided with extensive exposure to one of the photographs before a recognition test.

Chapter 3

Recognition and discrimination of strangers after habituation

For years, investigators have been interested in determining when the ability to recognize and discriminate faces develops during infancy. Experiment 1 suggests that at least by three months of age infants show evidence of recognizing the mother's face and discriminating it from another face in a visual preference test and in a recognition test after habituation. The question that arises is: Can a three-month-old also discriminate between faces of strangers? If the three-month-old has learned to recognize his mother's face, then he should be able to learn to recognize another face if he is given extensive experience with it.

In the pilot study (see Appendix 1) three-month-old infants did not show evidence of discrimination between photographs of strangers, not even after familiarization with one of the photographs. This finding, however, was not surprising because Fagan (1972) found no evidence of this discrimination at four months of age, using, as in the pilot study, the familiarization paradigm. Yet, with this paradigm, Fagan (1972, 1973, 1974, 1976) and many others (e.g., Cornell, 1974; Miranda & Fantz, 1974; Strauss, De Laache & Maynard, 1977) have consistently found discrimination of photographs of strangers and recognition of the "familiar" stranger in five- to six-month-old infants.

With a different paradigm, habituation, Cohen, De Lonóhe & Pearl (1977) found evidence of this ability at four- and a-half months. The fact that Cohen et al. found discrimination between two strangers at four- and a-half-months whereas Fagan did not at four months may be related to the differences in experimental procedures. For example, in Fagan's (1972) study the infant was exposed to two identical pictures for a fixed length of time during familiarization, whereas in Cohen et al.'s study the infant was exposed to a single picture in a trial; each trial continued until the infant finished his first fixation and the picture was presented repeatedly until the infant's looking decreased by more than half the mean of the first three fixations, e.g., until the infant habituated. The latter procedure may allow every infant extensive exposure to a picture before he is tested. Since some infants may take longer to learn the features of a picture than others, the familiarization procedure may provide sufficient exposure to a picture only for some babies.

At the present time no one has tested whether or not infants younger than the infants tested by Cohen et al. may discriminate faces of strangers if the habituation paradigm is used. Thus, the purpose of the experiments in this chapter was to test the hypothesis that if the three-month-old infant were given extensive time to study a stranger he would then be able to discriminate that stranger from another one. The habituation paradigm was chosen for it appears to be more sensitive than the familiarization paradigm for assessing three-month-old infants' memory for faces.

By comparing the findings of Experiment 1 (discrimination between photographs of the mother and a stranger) with the experiments in this chapter one may also find out whether the discrimination of two strangers is more difficult than the discrimination of the mother's face from another face.

In a preliminary study, three-month-olds (5 boys and 3 girls) were habituated until they reached a criterion of habituation (as in Experiment 1). Then they were given a recognition test during which they saw a novel face (N), the habituated or familiar face (F) and a checkerboard (C) pattern. The test sequence was NFFNC and was the same for every infant. The apparatus and procedure, were the same as in Experiment 1. During the recognition test all babies looked longer at the novel face than at the habituated face. The mean looking at the novel face (57.64 sec) was significantly different from the mean looking time at the familiar face (27.75 sec) ($t(7) = 2.75$, $p < .025$, one-tailed test). The results of this experiment thus suggested that three-month-olds could discriminate faces of strangers if one face was presented long enough for the baby to reach habituation.

Although the data from this study were straightforward, there were some methodological shortcomings which may have biased the results. First, all subjects were habituated to the same face. Infants might not habituate to other faces and might not be able to discriminate between other faces. Second, all subjects received the stimuli in the recognition test in the same order. Thus, both observers were probably aware of the identity of the pictures in the recognition test. This limitation may have resulted in observer bias.

Third, since the new face was always the first stimulus in the recognition test an infant might have looked longer at the novel face because of regression to the mean after habituation, rather than because he perceived the differences between the faces. Finally, the size of the sample was too small to allow any meaningful generalizations.

To overcome these problems the experiment was replicated with the following modifications: (a) half the babies were habituated to one face and the remainder to another; (b) during the recognition test, half of the babies had a NFFN stimulus sequence and the other half, a FNNF sequence; (c) the principal observer was always blind as to which face was used for habituation and which sequence was used in the recognition test; (d) the faces were more systematically selected on the basis of ratings of similarity made by a panel of judges, and on the basis of brightness density; and (e) finally; instead of having one checkerboard test at the end, two checkerboards were used to test for recovery (from habituation) to a novel stimulus which differed in many ways from a face. The use of two checkerboards, as in Experiment 1, allowed an appropriate comparison of the recognition data for the familiar face and for a novel non-facial stimulus, thus controlled for fatigue effects.

Experiment 2

Discrimination of photographed faces of two different strangers

The preliminary study suggested that infants as young as three months of age can discriminate between the pictures of two strangers' faces after habituation to one of them. This finding is very important

for it is the first demonstration of memory for photographed faces of strangers at three months of age. Because of the importance of this finding, a more systematic study was designed using the same method with some modifications in the stimuli and experimental design.

Method

Subjects

The subjects were 12 three-month-old infants (6 males and 6 females). Their mean age was 91 days (range: 86 to 98 days). Four other babies were tested but excluded from the study due to distress (n = 2) or sleepiness (n = 2).

Apparatus and Stimuli

The apparatus was the same as in Experiment 1 and is shown in Figure 1. The stimuli were color slides of single faces of two women and of the black and white checkerboard used in Experiment 1. The stimuli are shown in Figure 2. The size and visual angle of the stimuli were the same as in Experiment 1.

The two faces were chosen from ten smiling-faces of white women who had no unusual features such as scars or moles and who did not wear glasses, hats, scarves or handkerchiefs. The faces were selected on the basis of similarity ratings ranging from very similar to very dissimilar and on the basis of brightness density readings made with a densitometer. Similarity ratings made by adults are a fairly common basis for selecting facial stimuli in studies with adults and children (e.g., Goldstein, Harmon & Leak, 1971). The faces for this study were selected from those rated very dissimilar by judges. The judges were seven undergraduate students at McMaster University who were unfamiliar

with most of the persons in the photographs. The judges were shown 44 pairs of faces (e.g., combinations of the ten faces), one pair at a time, and instructed to look at each face of the pair carefully in order to find physiognomical similarities or differences to make the ratings. They were told to rate the pictures from 0 to 3 if perceived as very similar, from 7 to 10 if perceived as very dissimilar, and from 4 to 6 if perceived as neither. These ratings are shown in Table 13 (see Appendix 2). Faces which were judged very dissimilar were selected as possible pairs for the study.

Following this selection procedure the brightness of all faces was measured with a densitometer. Table 14 (see Appendix 2) shows the measures for each face. Faces with variable readings across the four points (e.g., B,G,A,C, and D in Table 14) were not considered even if they were a member of a pair judged to be dissimilar.

The pair selected was DYsR. This pair satisfied both criteria: the two faces were judged to be dissimilar and had very similar brightness readings.

Procedure and Experimental Design

The procedure in this experiment was the same as in Experiment 1, except that the preference test was omitted. During the habituation trials infants were shown the same face repeatedly until their looking time declined sufficiently to reach the criterion of habituation. For half the babies the repeated stimulus was Face DY and for the remaining babies Face R. After a baby's looking declined to the criterion of habituation he was tested (recognition test) with the novel face (N), the familiar face (F) and the checkerboard (C). Half of the babies had

a NFFNCC order and the remaining a FNNFCC order. To control for observer bias, one observer was always blind with respect to which face was used during the habituation trials and to the order in which the stimuli were presented in the recognition test.

As in the previous experiments the agreement between the two observers for each baby was calculated by Pearson Product-Moment correlations. The mean correlation was .98 (range: .91 to .99).

Results

Table 2 shows the individual data for the habituation measures and the recognition test.

Habituation Data

The mean number of trials to criterion was 13.59 (sd = 9.15 sec). The variability in the number of trials was due to one subject who took 41 trials to reach the criterion of habituation. When the mean was calculated without the extreme case the mean was reduced to 11.09. The mean total looking time was 377.26 sec (sd = 184.1 sec), the range 139.1 sec to 900.0 sec. The mean criterion of habituation was 50.94 sec (sd = 36.33), the range 7.73 sec to 132.4 sec. Analyses of variance on each of the three measures were calculated using sex and stimulus (either habituation to R or DY) as the factors. No main effects nor interactions were found in any of the measures.

Recognition Test

All subjects looked longer at the novel face than at the habituated face. The mean looking time at the novel face was 56.38 sec and at the familiar face, 26.3 sec. An Analysis of Variance was computed using stimulus (novel face vs. familiar face) and sex. Only

Table 2

Data from Experiment 2: Habituation to dissimilar strangers

Subjects	Habituation			Recognition Test Time Looking (sec) at			Interobserver
	No. Trials to Criterion of Habituation	Criterion of Habituation (sec)	Total Looking (sec)	Novel Face (sec)	Familiar Face (sec)	Checkerboard (sec)	r
1	10	11.66	139.3	51.3	8.50	74.20	.99
2	12	19.73	283.1	16.5	9.30	233.70	.99
4	13	25.23	433.5	33.5	21.85	31.60	.99
6	7	132.40	483.2	74.9	17.95	11.25	.96
7	7	67.56	292.8	116.1	46.55	43.90	.97
10	41	7.73	423.-	21.0	16.85	(1)	.93
11	9	60.30	297.2	68.6	43.45	46.25	.97
12	7	104.73	399.4	73.1	19.70	163.80	.99
13	22	61.33	990.9	65.0	32.40	125.75	.99
14	16	16.53	243.2	12.7	7.05	173.25	.98
15	9	36.33	201.7	18.0	33.25	92.00	.99
16	10	67.66	429.6	126.2	79.00	127.15	.99
Mdn = 10							
$\bar{X}$ = 13.59		50.94	377.26	56.36	28.30	82.96	.98
sd = 9.15		36.33	184.1	38.21	21.08	57.3	.02

(1) session ended because of crying

the difference between the novel and the familiar faces was significant ($F = 19.463$, $df = 1, 10$, $p < .01$). This was the case whether babies were habituated to face R or BY (for R, $t = 1.08$, $df = 5$, $p < .025$; for BY, $t = 3.29$, $df = 5$, $p < .025$). Infants also looked longer at the checkerboard than at the habituated face. The mean looking time at the checkerboard was 86.96 sec and it was significantly larger than the mean of 26.1 sec of looking at the familiar face ($t = 1.28$, $df = 10$, $p < .01$).

Discussion

The results of this experiment clearly replicated the findings of the preliminary study in that the three-month-old infants looked longer at the photograph of the novel stranger than at the photograph of the habituated stranger. Thus, these findings support the hypothesis that even three-month-olds can discriminate faces of strangers and can recognize one of the faces after sufficient experience with it during habituation.

This study not only replicated the discrimination effect found in the preliminary study but the results were remarkably similar in the magnitude of the difference between the looking time at the novel and the familiar faces, in the number of trials to reach habituation, and in the total looking time during habituation.

Although the discrimination of pictured faces of strangers has been shown by some investigators at about six months (e.g., Cornell, 1975; Fagan, 1972, 1974, 1976) and by others at four-and a half months (Cohen et al., 1977), the results of this and of the preliminary study

combined represent the youngest age in which this ability has been demonstrated.

In this Experiment the data from the habituation trials and the recognition test were analysed including sex as a factor, so they could be compared to the data in Experiment 1. During the recognition test of Experiment 1, infant boys looked at the pictures longer than infant girls. In contrast, in this experiment boys looked at the pictures of strangers no differently than girls.

Other investigators, with one exception (Fagan, 1972), have not found sex differences in recognition and discrimination of faces, using pictures of strangers (e.g., Cohen et al., 1977). Thus, the lack of sex differences in this experiment seems to be consistent with the previous literature. It appears, then, that the sex differences found in Experiment 1 may be related to the fact that the mother's face was one of the photographs. However, since in the pilot study no sex differences were found when either the mother's or strangers' photographs were used, more investigation is needed before a meaningful interpretation of sex differences can be drawn.

The generality of the findings that infants as young as three months can discriminate faces of strangers may be limited because the two faces were purposely chosen to be physiognomically very different from one another. Thus, from the findings of this and Experiment 1, one might argue that infants discriminate between faces only (a) when one of the faces is the mother's, or (b) when the faces are judged to be very different from one another. In order to overcome this limitation in generality, in the next experiment infants were tested

with faces judged by undergraduate students to be very similar to one another.

Experiment 3

Discrimination of photographed faces of two strangers judged very similar to one another

The purpose of this experiment was to test whether three-month-old infants could discriminate between faces of strangers, judged to be similar to each other, after habituation. If infants show discrimination between similar faces of strangers this finding would suggest that with sufficient experience young infants may discriminate between two faces which differ subtly as well as between two faces which differ grossly.

Method

Subjects

The subjects were 12 three-month-old infants (6 boys and 6 girls). The mean age was 91.92 days; the range 86 to 97 days. Two other infants were tested but replaced because of sleepiness (1) and crying (1).

Apparatus and Stimuli

The apparatus was the same as that used in Experiments 1 and 2. The stimuli were two color slides of smiling faces (see Figure 2) and of the checkerboard used in previous experiments. The faces were chosen from the pool of 44 pairs listed in Table 13 (see Appendix 2). The criteria for choosing the pair of pictures were that the pictures in the pair were judged to be very similar to each other and that the brightness density ratings of the two pictures were approximately the

same. MH and R (Table 1, see Appendix 2) were the pictures used in this experiment.

Procedure and Experimental Design

The procedure and experimental design in this experiment were identical to that of Experiment 2. Half of the babies were habituated to MH and the other half to R. After the baby reached the criterion of habituation he was given a recognition test. The recognition test consisted of two trials with the novel face (N), two with the familiar face (F) and two with the checkerboard (C). Half of the babies had a NFFNCC order and the other half had a FNNFCC order. Agreement between the two observers on the visual fixations for each infant was calculated using Pearson Product-Moment correlations. The mean correlation was .99 (range: .98 to .99).

Results

Table 1 shows the individual data for the habituation measures and the recognition test.

Habituation Data

The mean number of trials to habituate was 9.58 (sd = 2.45); the mean criterion of habituation was 95.82 sec (sd = 55.19); and the mean looking time during habituation was 390.74 sec (sd = 228.77). As in Experiment 2, an Analysis of Variance on each habituation measure was calculated using sex and face as the factors. As in Experiment 2, no main effects or interactions were found on any of the measures.

Recognition Test

All infants looked longer at the novel face than at the familiar face. The mean looking time at the novel face was 72.15 sec

Table [illegible]

Data from Experiment [illegible]: Habituation to Similar Strangers

Subjects	Habituation			Recognition Test: Time Looking, sec at			Interobserver
	No. Trials to Habituation	Criterion of Habituation sec	Total Looking sec	Novel Face	Familiar Face Checkerboard		r
[illegible]	13	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	13.25	[illegible]	[illegible]
5	12	50.8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9	8	[illegible]	136.3	[illegible]	[illegible]	[illegible]	[illegible]
10	14	[illegible]	[illegible]	[illegible]	45.25	[illegible]	[illegible]
[illegible]	11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13	[illegible]	30.3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14	7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	$\bar{X}$ = 9.58	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
	sd = 2.50	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	

and at the familiar face, 36.50 sec. An Analysis of Variance was calculated using sex and stimulus (novel face vs. familiar face) as the factors. There was only one main effect: longer looking at the novel face than at the familiar face ($F = 16.827$, $df = 1,10$, $p < .01$). Finally, all babies looked longer at the checkerboard than at the familiar face ($t = 3.01$; $df = 11$, $p < .01$).

Discussion

Infants in this experiment looked longer at a photograph of a novel face than at the photograph of the familiar face, even though the faces were judged to be physiognomically similar to each other. This finding extends the findings of Experiment 2, in which infants also looked longer at a novel face than at a familiar face of strangers; in that experiment, however, the faces were judged to be dissimilar to each other.

The consistency of these findings across experiments and the use of pairs of faces from a wide range of similarity (as rated by adults) suggest that infants, at least by three months, can perceive differences between a variety of faces of strangers after extensive experience with one of them. Moreover, these findings also imply that infants can recognize the photograph they saw before the test.

Investigators who use the familiarization or habituation paradigms (see Cohen, De Loache & Strauss, in press; Olson, 1974, for reviews) assume that during the exposure to one stimulus (during the habituation trials and the familiarization period in the laboratory, or during a familiarization period in the natural environment) infants develop a memory representation or memory trace (Sokolov, 1963, 1969)

or a schema (Kagan, 1971) of that stimulus. Since studies of discrimination and recognition of faces, like the ones reported here, do not provide direct information as to what the infant is learning about a face, one can only suggest that the infant has stored some information about the face he saw before he was tested. Whatever the nature of the infant's memory trace may be, Experiments 2 and 4 constitute the first demonstrations of recognition and discrimination of photographs of strangers by the three-month-old after extensive exposure.

This experiment was also consistent with Experiment 2 in that infants in neither experiment showed sex differences. Thus, once again this negative evidence suggests that the sex differences found in Experiment 1 may have been related to the fact that the picture of the mother was one of the stimuli.

Finally, as in the previous experiments of habituation in this dissertation, infants looked at the photographs for very extensive periods of time during habituation and showed evidence of discrimination during the recognition test. This finding further supports the hypothesis that the three-month-olds in the pilot study and the four-month-olds in Fagan's (1972) study did not show evidence of discrimination between faces of strangers because the amount of exposure to one face during the familiarization period was not sufficient for them to learn some of the facial features of that face in order to later distinguish it from another.

Comparison between the discrimination of mother and stranger (Experiment 1) and the discrimination between two strangers (Experiments 2 and 3)

First, the habituation measures of the three experiments were compared to find out whether or not infants' behaviour varied as a function of the face they were habituated to. A one-way Analysis of Variance on each measure showed that infants habituated to a photograph of a stranger (Experiments 2 and 3) or of the mother (Experiment 1), did not differ in the number of trials it took them to habituate, in the total time they looked during habituation, nor in the criterion of habituation. Since infants in Experiment 1 were the only ones who had a preference test before the habituation trials, it is difficult to tell whether there were no differences during habituation because of the preference test or in spite of the preference test.

Next, the recognition data were analyzed to determine whether or not the evidence for the discrimination between the mother's face and a stranger's face was different from the evidence for the discrimination between strangers. The difference between the looking at the novel face and at the familiar face was calculated for each infant. Then, the mean score of the difference for the "similar" strangers was compared to the mean score of the difference for the "dissimilar" strangers. Infants tested with "similar" strangers did not differ significantly in their recognition data from the infants tested with "dissimilar" strangers ($F = .69$, $df = 1, 22$, $p > .05$). Subsequently, the recognition data from these two groups were combined and compared to the recognition data from Experiment 1 (in which infants were

habituated to the mother's face and tested with the habituated face and a novel face of a stranger). The difference in the time the infants looked at the novel versus the familiar face was larger in Experiment 1 than in Exeriments 2 and 3 combined ($F = 4.66$, $df = 1, 34$, $p < .05$).

Moreover, a 2 x 2 x 3 Analysis of Variance was also calculated, with sex, stimulus (novel versus familiar), and person (mother, similar strangers, dissimilar strangers) as the factors. This analysis showed a significant main effect of stimulus (novel vs. familiar) ($F = 29.42$; $df = 1, 30$; $p < .01$). This result was not surprising given that the difference between looking at the familiar face and at the novel face was highly significant in the individual experiments. There was also an interaction between sex and stimulus ($F = 4.27$; $df = 1, 30$; $p < .05$). This interaction indicates that the difference between looking at the novel vs. familiar stimuli was greater in boys than in girls. Sex was marginally significant, so that boys tended to look longer than girls ($F = 3.08$; $df = 1, 30$; $p > .05$). There was no main effect of person, but there was a marginal interaction between person and stimulus ($F = 2.45$, $df = 2, 30$; $p > .05$). It was surprising that the interaction was only marginal since a similar analysis was significant when the data of the two experiments with strangers were combined and compared with the data of the mother-stranger experiment. This inconsistency between the two analyses may be due to the great variability in the discrimination between the faces of the mother and of a stranger. Although ten babies showed an enormous difference in their looking times, one baby actually showed greater looking in the

opposite direction and the last baby showed virtually no difference in looking time.

In summary, the comparisons of the results of Experiments 1, 2 and 3 show that the infants did not differ in the number of trials they had before they reached habituation, even though infants in Experiment 1 had two extra trials at the start of the experimental session. Nor did they differ in the other measures of habituation. The comparison of the recognition data suggests that although it is possible that three-month-old infants might discriminate the mother's face from a stranger's face more easily than they discriminate photographs of strangers, it is not clear whether or not those discriminations actually differ. Finally, the interaction between sex and person indicated that boys, in general, showed greater looking at the novel face than girls did. This result was probably a function of the boys' general tendency to look at the pictures longer than girls, as was shown in Experiment 1.

The experiments reported here so far did not test whether infants processed a face as an entire configuration or whether they processed only isolated features of it in order to be able to recognize and discriminate faces. It is nevertheless important to know what information the three-month-old infant processes when he sees a face. One way investigators have dealt with this question is by observing what facial features the infant looks at most. What features the infant looks at most may indicate what information the infant processes in order to make discriminations. Experiment 7 of this dissertation explored this question in three-month-olds.

Another way to learn about what information the infant processes when he sees a face is by varying some of the facial features and keeping others constant. In the following two experiments (Experiments 4 and 5) infants were tested with two photographs of the same person. The photographs were identical in all respects except that in one of them the person was smiling and in the other one the person was frowning. In other words, the two photographs were identical with respect to the external features of the face, but differed from each other in the internal features. This experimental manipulation should provide some information as to whether or not the three-month-old infant processes the internal features of the face. If he does not process the inside features of the face he would not be able to differentiate the photograph of a smiling face from that of a frowning face.

Chapter 1

Recognition and discrimination of facial expressions in familiar (mother's) and unfamiliar (stranger's) faces

The study of the infant's perception of facial expressions has attracted the attention of investigators since the last century, i.e., since the beginning of child psychology. It was not a psychologist, however, who provided us with the first observations of infants' recognition of facial expressions: instead, it was the great naturalist Charles Darwin (1972), who studied facial expressions in animals and human beings, including his own infants. Although Darwin's observations were mainly on the expression of emotions, he also observed that infants begin to recognize facial expressions at a very early age.

Darwin (1872) observed similar facial expressions in infants, children, adults from several cultures, the insane and animals. The universality of his observations led him to propose that facial expressions and their recognition are genetically determined. More recently, several investigators (e.g., Ekman, 1971, 1973; Ekman & Friesen, 1972; Ekman, Friesen & Tomkins, 1971; Izard, 1971, 1977) have also observed and studied the recognition and reproduction of facial expressions of emotions in adults and school children from many cultural backgrounds. Typically, investigators have shown adults and children photographs of several facial expressions (e.g., happy, angry, sad, surprise, interest, fear) in order to test the subjects'

recognition accuracy and ability to discriminate among facial expressions. Investigators have found that by and large subjects are very accurate in recognizing facial expressions, even those subjects who have virtually no experience with pictorial material. Thus, these findings seem to support Darwin's original proposal that the mechanisms underlying facial expressions and their recognition are innate.

However, there is also evidence from studies of preschool and school age children that the ability to recognize facial expressions improves with age (Izard, 1971; Odom & Lemond, 1972). If the ability to recognize facial expressions improves with age it is important to find out whether or not infants have any of this ability. The two experiments reported in this chapter were designed to investigate whether or not infants can recognize some facial expressions and discriminate between them by three months of age.

Early studies of the recognition of facial expressions by infants suggest that infants respond undifferentiatedly before six months of age, i.e., infants smile both at a "happy" face and at an "angry" face (Ahrens, 1954; Spitz & Wolf, 1946). With more systematic and objective techniques, Kreutzer & Charlesworth (1973) found that infants four months old or younger, react to angry, happy, sad and neutral faces in a similar way; six-month-olds, however, showed evidence of discriminating between the expressions. Thus, the suggested age of onset of recognition and discrimination of facial expressions in Kreutzer & Charlesworth's study is consistent with early findings.

Wilcox and Clayton (1968) were unable to find consistent differences in five-month-olds' responses to smiling, frowning and neutral faces, when they used the visual preference technique and fixed-duration trials. Although Wilcox & Clayton's findings were inconsistent with five-month-old infants, La Barbera, Izard, Vietze & Parisi (1976) found that four- to six-month-olds showed evidence of discriminating a happy face from an angry face. Like Wilcox & Clayton, La Barbera et al. used the visual preference technique and photographs of happy, angry and neutral faces. Unlike Wilcox and Clayton, however, the infants in La Barbera et al.'s study were shown each picture until each was judged to look away from it, rather than for a predetermined fixed duration. The difference in procedures might have been responsible for the different findings.

In a more recent study, Brown, Rosenfeld & Horowitz (1977) found evidence of discrimination of facial expressions at an earlier age than previous investigators. With the habituation paradigm, rather than with the visual preference paradigm, Brown et al. found that three-month-olds discriminated a surprised face from a happy face and sometimes a surprised from a sad face, but not a happy face from a sad one.

Brown et al.'s and La Barbera et al.'s work suggests that, contrary to previous experimental findings and some naturalistic observations, infants under six months of age can discriminate facial expressions. Yet, there are still several questions which need to be answered. On one hand, La Barbera et al. suggested that although their infants recognized the happy expressions they did not recognize the

angry expression. However, some early observations (Buhler & Hetzer, 1928, cited in Charlesworth & Kreutzer, 1973) suggest that infants begin to react negatively to an angry face as early as four months and that by five months infants consistently stop smiling and remain still in the presence of an angry face. Thus, these observations question La Barbera et al.'s conclusion that four-to-six month olds do not recognize an angry face. On the other hand, Brown et al. found evidence of consistent discrimination only between happy and surprised faces. La Barbera et al. (1976) and Izard (1977) have suggested that infants may discriminate a happy face from other expressions earlier than they may discriminate between other expressions. It is important to find out whether or not three-month-olds would show evidence of discriminating between a happy expression and other expressions like anger or sadness. The experiments reported in this chapter were designed to obtain some of this evidence.

In all the studies of facial expressions in infants investigators have used facial expressions posed by a stranger. However, given the results of Experiments 1 to 4 one would expect that three-month-olds would discriminate more readily facial expressions posed by a familiar person than by a stranger. In the first experiment of this chapter infants were tested with photographs of the mother's smiling and frowning expressions. In the second experiment of this chapter infants were tested with the same facial expressions but posed by a female stranger. Then, the results of the two experiments were compared.

The infant has to become able to discriminate one facial expression from another not only with regard to the physical and perceptual differences between expressions, but also with respect to the social and emotional meaning of each facial expression. For example, Ia Barbera et al. (1976) and Izard (1977) have suggested that infants recognize happiness because this facial expression strengthens the mother-infant bond and increases both the infant's and the mother's rewarding experiences when they interact. However, there is no behavioral evidence which indicates that young infants do perceive social-emotional meaning conveyed by the expressions. These experiments may provide such evidence. Finally, the experiments reported in this chapter may provide some evidence as to whether or not the three-month old processes the internal features of the face to discriminate it from another. If the infant differentiates the frowning face from the smiling face this may show that he has processed at least some of the internal features of the face, for the photographs of the expressions were identical with respect to the external features.

Experiment 1.

Discrimination and recognition of facial expressions posed by the mother

The purpose of this experiment was to determine whether the three-month-old infant can recognize a smiling or a frowning expression and discriminate between these facial expressions when they are acted out by the mother. To test for such discrimination the habituation paradigm was used.

Method

Subjects

The subjects were 24 three-month-old infants (12 boys and 12 girls). The mean age was 90.67 days, the range 87 to 98 days. Two other babies (from the frowning condition) were replaced because of crying.

Apparatus and Stimuli

The apparatus was the same as that used in Experiment 1. For each infant the stimuli were the smiling and frowning pictures of his mother's face. The only difference between the two pictures was the facial expression.

A smiling face is typically identified with the emotional expression of joy or happiness, and a frowning face, with the expression of anger. Izard (1971) defined smiling as a "universally understood social symbol of a feeling of friendliness, acceptance and a verbal expression of joy" (p. 30). Moreover, Izard (1977) defined joy or happiness as "the expression which pulls the lips back and curves them gently upward like a crescent moon and puts a twinkle in the eyes" (p. 201). Thus, it appears that for practical purposes investigators have identified a smiling face with the facial expression of joy. A smiling face tends to convey social signals of friendliness and acceptance, but it may not always be an expression of joy or happiness. Hence, in this dissertation a face with the lips pulled back and curved gently upward is simply called a smiling face.

A frowning face consists of eye brows pulled together from the inner corners, with a vertical wrinkle between the inner corners, and

the corner of the mouth pulled downwards (Grant, 1969). A frowning face is typically identified with the expression of anger; however, since frowning may not always convey anger, in this dissertation it is simply referred to as a frowning face.

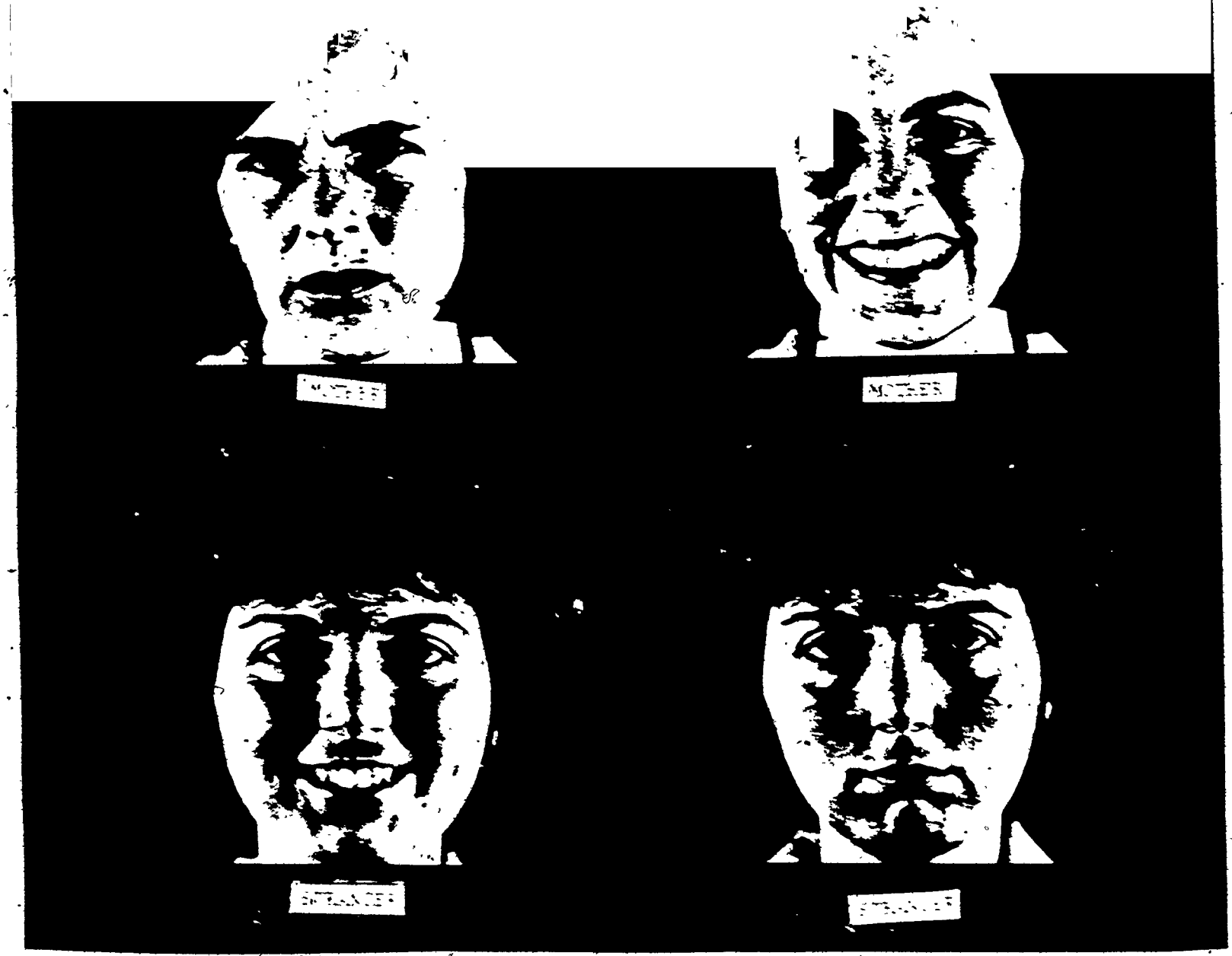
All photographs were taken with the same background and illumination. Before the pictures were shot each woman was shown several pictures of smiling and frowning faces and was encouraged to imagine situations which would make her happy (for the smiling face) or angry (for the frowning face). Examples of faces used in this experiment are shown in Figure 1. As in previous experiments, the projected size of each face was approximately life-size. The checkerboard used in the previous experiments was also used here.

Procedure and Experimental Design

The procedure in this experiment was the same as that in experiments 2 and 4. Infants were habituated to a facial expression until they met the criterion of habituation. They were then tested with both the new and the old expressions, half of the babies were habituated to the frowning (F) expression and the other half to the smiling (S). After habituation, half of the infants had a SFFFSSC test order and the other half had a FSSSFCC order. (C refers to the checkerboard).

As in previous experiments, every baby was observed by two people. The interobserver reliability for every infant was calculated as before and is shown in the last column of Table 4. The mean correlation was .91 and the range was .81 - .99.

Figure 1. Photographs of a smiling and frowning mother (Experiment 4) and of the smiling and frowning stranger (Experiment 5). The original pictures were color slides projected life-size



Results

Table 4 shows the habituation and recognition data for every baby. The data are grouped by sex and expression.

Habituation data

Analyses of Variance were calculated on the number of trials to habituation, the criterion of habituation and the total looking time during habituation, using sex and expression (smiling vs. frowning) as the factors. No main effects or interactions were found in the number of trials to reach the criterion of habituation. However, both the analysis of the criterion of habituation and of the total looking time showed that boys, in general, looked at the pictures significantly longer than girls ($F = 8.972$, $df = 1, 20$, $p < .05$, for the criterion of habituation; and $F = 5.05$, $df = 1, 20$, $p < .05$, for the total looking time). The mean criterion of habituation for boys was 91.15 sec, for girls, 56.0 sec. The mean total looking time was 501.08 sec for boys, and 269.60 sec for girls. An analysis of the total looking time during habituation excluding the first three trials (on which the criterion of habituation was based) showed no significant sex differences nor any interaction between sex and expression. Total looking time at the frowning face was higher (377.18 sec) than total looking time at the smiling face (296.21 sec); however, this trend was nonsignificant ($F = 1.015$, $df = 1, 20$; $p > .05$).

Recognition Test

During the recognition test all babies but one looked longer at the face with the novel expression than at the face with the familiar expression. The mean looking time at the novel face was 66.68 sec, and

Table 4

Experiment 4

Habituation to facial expressions posed by the Mother

Subjects	Habituation: No. trials to Habituation	Habituation: Criterion of Habituation (sec)	Recognition test: Total looking (sec)	Recognition test: Time looking (sec) at Novel	Familiar	Checkerboard	Interobserver
1	20	141.1	1904.6	71.15	20.7	90.15	1.00
4	7	199.05	569.7	179.05	38.4	217.9	.81
5	16	61.15	768.6	188.85	31.75	143.15	.92
16	8	117.2	401.6	128.65	40.7	236.15	.99
17	17	25.1	523.1	60.7	21.2	49.8	.98
21	10	87.65	311.7	38.35	9.4	37.0	1.00
X =	11	107.24	679.08	96.79	25.69	122.39	
sd =	5.17	61.51	447.86	51.1	10.91	89.76	
6	11	97.8	999.1	101.85	56.9	168.9	1.00
7	12	96.1	941.8	221.7	11.85	316.5	1.00
8	13	104.85	696.1	109.1	64.5	37.8	.84
11	7	75.2	226.7	71.4	18.2	55.25	1.00
12	7	96.9	150.8	85.8	54.65	211.15	1.00
14	10	31.55	138.7	37.0	6.9	28.65	1.00
X =	9.67	77.07	428.80	96.48	52.17	136.41	
sd =	2.16	28.45	372.97	70.51	17.27	115.78	
9	19	59.1	594.7	24.4	12.8	20.0	.99
10	21	91.0	400.6	50.5	6.7	64.3	.82
13	8	41.25	148.6	25.0	4.1	35.7	1.00
22	7	20.6	71.7	12.1	11.05	21.05	.99
24	7	81.65	177.9	68.45	17.25	117.0	1.00
25	7	95.55	260.5	89.4	19.1	104.0	.95
X =	13.83	54.23	275.67	44.09	18.51	64.34	
sd =	7.22	26.49	192.32	29.16	15.51	42.21	
1	10	46.95	241.8	29.95	11.5	17.7	.99
2	12	26.55	111.5	8.45	11.99	57.2	1.00
15	10	75.8	804.7	33.25	19.15	97.9	.95
18	7	97.85	262.2	33.75	7.1	18.8	1.00
19	11	37.15	250.3	31.15	6.35	46.4	.95
20	12	61.45	387.7	39.45	15.05	27.0	1.00
X =	10.11	57.66	263.64	29.31	11.37	44.17	
sd =	1.86	26.28	83.02	11.07	4.82	30.66	

at the familiar one it was 26.40 sec. An Analysis of Variance using sex and expression (whether the infant was habituated to smiling or frowning) as the between-factors, and novel vs. familiar as the within-factor, showed two main effects: novel vs. familiar expressions ($F = 41.631$, $df = 1, 20$, $p < .001$) and sex ($F = 9.523$, $df = 1, 20$, $p < .01$). Infants looked at the novel expression significantly longer than at the familiar expression. As in the habituation trials, boys looked significantly longer than girls; in fact, they looked more than twice as long as girls. Infants looked longer at the checkerboard (a new stimulus) than at the habituated face. This finding was clearly significant ($t = 4.71$, $df = 23$, $p < .01$).

Discussion

Infants looked longer at the face with the new expression than at the face with the familiar expression. This was equally true whether the new facial expression was smiling or whether it was frowning. This finding implies that the three-month-old infant can in fact discriminate a smiling expression from a frowning expression when the expressions are posed by the mother. It also implies that the infant can recognize either a smiling ("happy") or a frowning ("angry") expression on the mother's face.

These findings are consistent with La Barbera et al.'s (1976) and Browne et al.'s (1977) findings in that they show infants seem to discriminate facial expressions earlier than traditionally thought. In addition, these findngs extended La Barbera et al.'s findings to an earlier age: as with the four- to six-month-olds in their study, the three-month-olds in this study showed evidence of discriminating

between a happy (smiling) face and an angry (frowning) face.

La Barbera et al, concluded that infants recognize the happy expression but not the angry expression because recognition of a happy face is ethologically more important than recognition of an angry face. Although in the real world the infant is more likely to encounter smiling faces than angry faces, this does not mean that he can not recognize the angry face. The data of this study suggest that the infant can recognize the frowning ("angry") expression as well as the smiling expression posed by the mother, even if he may "prefer" smiling (happy) expressions. The infants in La Barbera et al.'s study could have recognized the angry face but still preferred the happy face.

Although there are descriptive analyses of the nature of each feature within a facial expression (e.g., Grant, 1969; see method section of this experiment for a description of a frowning face and a smiling face), there is no direct evidence as to what the subject processes when he sees a happy face as opposed to an angry face. Does he process all the facial features in relation to each other, does he process all features as isolated parts, or does he process only a few features? The fact that infants showed evidence of discriminating the smiling face from the frowning face implies that they processed, at least, some of the internal features of the face such as the eyes and their surrounding area and/or in the mouth area.

Browne et al. suggested that infants discriminated a happy face from a surprised face because the two facial expressions differ in the area of the eyes. However, if only the information of the eyes were encoded, infants in Browne et al.'s study should have shown evidence

of discriminating between a surprised and a sad face which also differ in the area of the eyes. Moreover, Ahrens (1954) suggested that infants at three months see the mouth if it is moving but that they still look longer at the eyes. And Haith, Bergman and Moore (1977) found that when the voice was coming from the mouth 11-week-old infants looked extensively at the eyes and occasionally looked at the mouth. Thus, even if infants prefer to look much longer at the eyes than at the mouth, it does not mean that the mouth is not processed. It is possible that infants need little experience with a stimulus in order to learn about it, but that they spend a great deal of time looking at it because they are greatly attracted by it.

In conclusion, although this study, like previous work on facial expressions, did not measure what features were responsible for the discrimination, it suggests that infants might have perceived the difference between a frowning and a smiling expression on the basis of information they obtained from the internal features of the face: mainly the eyes and the mouth.

An interesting result of this experiment was that boys looked at the pictures significantly longer than girls both during the first three trials of habituation and during the recognition test. This finding is consistent with the results of the recognition test in Experiment 1 (in which infants were tested with pictures of the mother and a stranger). In contrast, in Experiments 2 and 3 or in others reported in the literature, infant boys did not differ from infant girls. Thus, it appears that boys and girls engage in different amounts of looking only when the mother's face is one of the stimuli.

The sex differences reported throughout this dissertation may result from infants' different amounts of visual experience with their mothers in the natural environment. Girls perhaps, have seen the mother's faces more often than boys, and hence may need less exposure to a photograph of her in the laboratory in order to discriminate the mother's face from the other faces. Several reports based on naturalistic observations of the mother and her infants support this hypothesis. For example, Moss (1967) observed that within the first three months of life mothers respond more contingently towards their female infants than towards their male infants, even though male infants are apparently more demanding, i.e., cry more often than female infants. Lewis (1972) and Judd & Lewis (1975) observed that three-month-old girls' vocalizations produced more maternal responding than boys. And Goldberg & Lewis (1969) observed that mothers touched, talked to and handled their six-month-old daughters more than their six-month-old sons. These observations suggest that mothers interact more with the infant girl than they do with the infant boy. If this is the case, girls may actually have more opportunities to see the mother's face than boys do; girls may come to the laboratory with more knowledge about their mothers faces than boys, and, therefore, look at the mother's face less than infant boys do.

An interesting observation came from a comparison of the recognition test with pictures of the mother and a stranger (Experiment 1) and the recognition test with pictures of the mother's facial expressions; the mean difference between looking at a stranger and at the mother was almost twice as large (72.19 sec) as the mean difference

between a novel and a familiar facial expression (40.17 sec) acted out by the mother. This observation suggests that the three-month-old infants may find it easier to discriminate two different faces, at least when the mother's face is one of them, than two different facial expressions of the same person.

Finally, did infants perceive the differences between facial expressions simply as physical changes of the internal facial features or as social signals of, e.g., friendship, acceptance, affection, rejection, or did they perceive both the physical changes and the social meaning conveyed by the expressions? Several aspects of the data suggest that infants perceived some social meaning in addition to physical changes.

During the habituation trials, infants in the frowning condition tended to look longer at the frowning face than infants in the smiling condition looked at the smiling face. This trend suggests that during the habituation trials infants might have perceived the frowning face as more novel than the smiling face. Moreover, the two babies who were replaced because of uncontrollable crying during the habituation trials were in the frowning condition; and of the babies who finished the experiment, most of the babies in the frowning condition fussed at some point during the session, whereas those babies in the smiling condition showed virtually no fussing.

The discrimination of facial expressions posed by the mother in this experiment might have been easier than the discrimination of facial expressions posed by a male stranger, in La Barbera et al.'s and in Brownie et al.'s experiments. Whether the three-month-old infant can

discriminate a frowning face from a smiling expression on a stranger's face was investigated in the next experiment.

Experiment 5

Discrimination of facial expressions on a stranger's face

The infant as a "social organism" (Rheingold, 1969), must learn to recognize and discriminate social and emotional signals not only on his mother's face but on others' as well. The purpose of this experiment was to determine whether the three-month-old infant can also discriminate between smiling and frowning expressions acted out by a female stranger. The procedure was identical to that of Experiment 4 except that the expressions were posed by a stranger. Thus, by comparing the results of this experiment with the results of Experiment 4, one may also find out if infants can discriminate facial expressions acted out by the mother more easily than facial expressions acted out by a stranger.

Method

Subjects

The subjects were 28 three-month-old infants (14 boys and 14 girls). The mean age was 91 days, the range 86 to 98 days. An additional 12 babies were tested but replaced for the following reasons: six infants (2 boys and 4 girls), all in the frowning condition, because of crying; three (2 girls and 1 boy) because of sleepiness; one because of experimental error; one because the infant was premature; and one because of an extremely large number of trials and unusually large fluctuations in the visual fixations (this baby,

however, showed strong recovery to the novel expressions in the recognition test).

Apparatus and Stimuli

The apparatus was the same as the one used in Experiments 1 to 4.

The stimuli were color slides of the smiling and the frowning face of a female adult who served as one of the strangers in previous experiments. These pictures are shown in Figure 3. The two photographs of the expressions were taken under identical conditions of illumination, background, and exposure time. The woman was encouraged to imagine situations which would make her happy (for the smiling face) or angry (for the frowning face). The projected size of the faces was, as before, life-size. The checkerboard used in previous studies was also used here.

Procedure and Experimental Design

The procedure and experimental design of this study were identical to those in Experiment 4. Half of the infants were habituated to the smiling face (S) and the other half to the frowning face (F). After the infant met the criterion of habituation he was tested with the new facial expression, the familiar facial expression, and the checkerboard (C). Half of the infants had an SFFSCC test sequence, and the other half an FSSFCC sequence.

As in previous studies, two persons observed the baby on every trial. The interobserver reliability is shown in the last column of table 5. The mean correlation was .99 and the range .97 to .99.

Results

Table 5 shows the habituation and recognition data for every baby. The data are grouped by sex and expression.

Habituation data

Analyses of Variance were calculated on the number of trials to reach habituation, the criterion of habituation and the total looking time during habituation. Sex and expression (smiling or frowning) were the factors. No main effects or interactions of sex and expression were found on any of the habituation measures.

Recognition test

Twenty-one out of the 28 infants looked longer at the face with the novel expression than at the face with the habituated expression. The mean looking time for the novel expression was 71.65 sec. and for the habituated expression it was 45.74 sec. An Analysis of Variance on the recognition data was calculated using sex and expression (whether the infant was habituated to the smiling face or the frowning face) as the between factors and novel vs. familiar expression as the within factor. This analysis showed only one significant main effect: longer looking at the novel than at the familiar expression ($F = 14.753$, $df = 1, 24$; $p < .01$).

Twenty-three out of 28 infants looked longer at the checkerboard (a new stimulus presented at the end of the recognition test) than at the habituated face. This difference was clearly significant ($t = 3.61$, $df = 27$, $p < .001$).

Table 5

Experiment 5

Habituation to facial expressions posed by a stranger

	Subjects	Habituation			Recognition test			Interobserver
		No. trials to Habituation	Criterion of Habituation (sec)	Total Looking (sec)	Time looking (sec) at Novel	Familiar	Checkerboard	r
Males	# to frowning							
	2	7	219.2	686.7	260.2	307.25	171.0	.99
	3	9	23.45	262.5	24.9	36.05	87.2	.98
	11	7	182.1	1195.5	64.0	24.05	32.4	1.00
	28	14	25.85	154.1	71.55	28.1	146.6	1.00
	35	8	99.85	322.7	19.1	14.85	109.6	.99
	44	18	18.25	319.6	15.45	5.45	58.85	1.00
	45	7	119.1	112.4	60.55	14.1	30.15	1.00
	X =	10	137.57	464.79	73.68	61.58	91.96	
	sd =	4.12	112.4	361.74	85.45	108.81	52.2	
	# to smiling							
	19	14	70.0	261.6	13.7	14.4	7.95	.97
	4	14	142.2	1072.5	98.95	100.25	203.4	.96
	8	8	87.6	327.7	71.75	10.55	28.55	1.00
	22	8	106.25	361.5	122.1	72.05	120.65	1.00
	38	14	86.85	717.3	62.0	39.0	49.75	1.00
	40	17	65.25	937.0	40.25	36.45	137.7	1.00
	41	11	30.75	177.4	18.0	21.25	45.65	1.00
	X =	11.85	85.41	550.71	60.96	40.56	84.81	
	sd =	3.44	42.65	355.37	40.41	33.42	70.69	
Females	# to frowning							
	11	9	41.4	144.2	43.8	43.2	23.8	.96
	24	10	78.0	469.8	81.95	45.15	85.95	1.00
	27	17	11.1	251.2	28.55	8.15	56.3	1.00
	32	8	164.05	542.1	69.55	35.9	78.2	1.00
	34	7	145.7	404.8	45.95	19.45	109.15	1.00
	48	13	29.85	160.1	57.5	13.0	99.4	.99
	51	7	91.15	290.9	292.16	142.38	186.65	1.00
	X =	10.14	83.42	309.01	95.64	41.95	91.15	
	sd =	3.67	54.28	141.54	87.93	45.79	50.76	
	# to smiling							
	6	20	41.8	439.8	41.45	27.15	21.95	.97
	21	14	55.05	789.2	30.6	19.7	72.55	.87
	29	13	127.0	836.0	94.35	84.95	245.3	.95
	30	13	111.15	588.9	121.45	46.65	320.95	1.00
	31	13	23.6	123.4	19.7	7.1	14.55	.99
	46	9	134.25	682.0	57.6	16.4	47.3	1.00
	50	8	128.35	428.8	29.1	37.15	81.35	1.00
	X =	12.86	88.74	555.44	56.32	37.01	114.85	.97
	sd =	1.89	46.88	247.17	37.98	25.22	119.48	.05

Discussion

In this experiment, three-month-old infants showed evidence of discriminating smiling and frowning expressions acted out by a female stranger and of recognizing the facial expression they saw during habituation. These findings extended the findings of Experiment 4 in which infants showed these abilities with pictures of the mother.

This study extended La Barbera et al.'s (1976) findings to a younger age. La Barbera and her associates found evidence of discrimination between happy and sad expressions (posed by a female stranger) in four- and six-month-olds. This study also extended Browne et al.'s (1977) results to other expressions: Browne and her associates found evidence of discrimination of surprised and happy expressions in three-month-old infants.

Interestingly enough, in this experiment, as in previous experiments using faces of strangers, boys did not behave differently from girls during the habituation trials nor during the recognition test. This supports again the notion proposed in Experiment 4 that sex differences appear only when the mother's face is the stimulus, or one of the stimuli, and that these differences may reflect different experiences the two sexes have with the mother in the natural environment.

Although the data from the habituation measures and recognition test showed no evidence that infants perceived the socio-emotional meaning associated with the smiling and with the frowning expressions, other pieces of evidence seem to indicate otherwise. (a) There was more fussing and crying when infants were habituated to the frowning

expression than when they were habituated to the smiling one, and (b) of the seven infants who did not show recovery to the novel expression in this experiment, five of them had the smiling face in the habituation trials; that is, these five babies continued looking at the smiling face during the recognition test. These observations suggest that at least some infants "preferred" to look at the smiling face rather than at the frowning face, regardless of which face they were habituated to.

Comparison between the results of Experiments 4 and 5

The habituation and recognition data of the infants who saw the facial expressions acted out by the mother were compared to the data of the infants who saw the facial expressions acted out by a female stranger. First an Analysis of Variance was calculated on each of the three habituation measures. For each analysis, person (mother-stranger), condition (smiling-frowning) and sex were the factors. No main effects or interactions were found on the number of trials or on the criterion of habituation. The analysis of the total looking time, however, showed an interaction between person and expression ($F = 4.705$, $df = 1, 40$, $p < .05$)[5] This interaction is shown in Figure 4. An analysis of this interaction using Tukey's procedure for post hoc comparisons, showed that infants habituated to the smiling face looked longer at it during habituation when the person conveying the

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5 The Anova with the transformed scores also showed an interaction between sex and expression ($F = 4.691$, $df = 1, 40$; $p < .05$); this interaction however was not significant with the raw numbers ($F = 3.534$; $df = 1, 40$; $p > .05$).

expression was the stranger than when the person was the mother (q = 3.79, df = 4, 40; $p < .05$). Infants habituated to the frowning face looked at it equally long when the expression was acted out either by the mother or by the stranger.

Next, an Analysis of Variance on the recognition data from both experiments was calculated. Person and sex were the between factors and stimulus (novel vs. familiar expression) was the within factor. No main effects were found. However, there was an interaction between person, sex and stimulus (F = 7.882, df = 1, 44, $p < .01$). This interaction is shown in Figure 5. It appears that this interaction is basically the result of the strong sex differences obtained when the mother acted out the expressions and the somewhat greater difference between looking at the novel vs. the familiar expression on the mother's face than on the stranger's face.

Although the Analysis of Variance did not show a main effect of person a X^2 analysis indicated that a relatively greater number of infants showed evidence of discrimination (looked longer at the novel than at the familiar expression) when the mother acted out the expressions than when the stranger did ($X^2(1) = 4.57$, $p < .05$). In addition, a X^2 analysis also showed that of the infants who started either Experiment 4 or 5, a relatively greater number of them failed to complete the experiment when the expressions were acted out by the stranger than when they were acted out by the mother ($X^2(1) = 5.18$, $p < .05$).

Figure 4. Interaction between the facial expression infants were habituated to and the person posing the expressions, using the data from the total fixation time during habituation

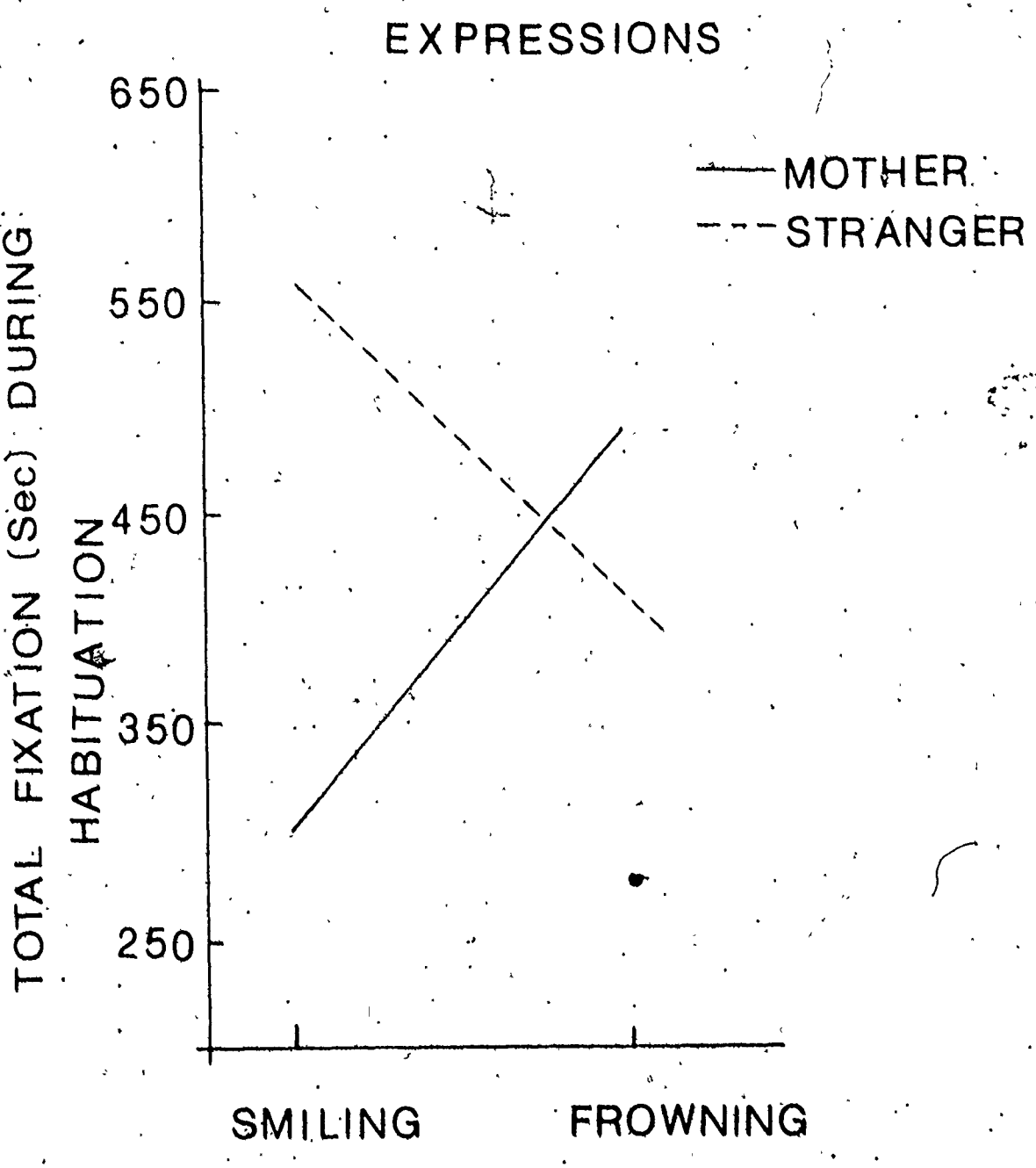
EXPRESSIONS
650
550
450
350
250
TOTAL FIXATION (Sec) DURING HABITUATION
MOTHER
STRANGER
SMILING
FROWNING

Figure 4

Figure 5. Interaction between the person posing the facial expressions, sex, and the test stimulus, using the data from the recognition test

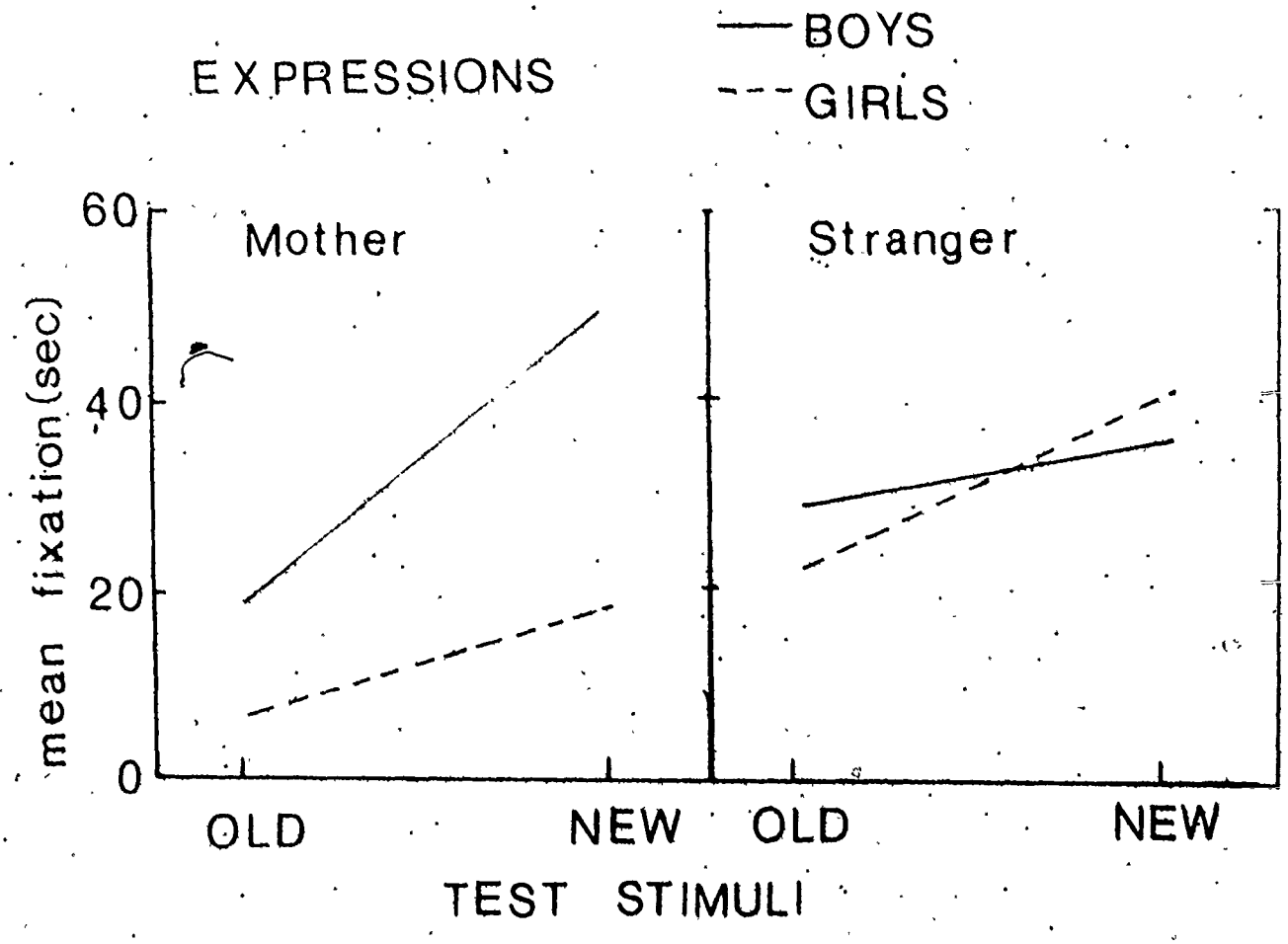
EXPRESSIONS
BOYS
GIRLS
Mother
Stranger
mean fixation (sec)
60
40
20
0
OLD
NEW
OLD
NEW
TEST STIMULI

Figure 5

General discussion of the discrimination of facial expressions

The combined data of Experiments 4 and 5 show that when the face was smiling during the habituation trials infants looked longer at the stranger's face than at the mother's face, but when the face was frowning infants seemed to look equally long at the photographs of the mother and of the stranger. This finding suggests that some infants habituated faster to the smiling expression on the mother's face than on the stranger's. (Note, however, that the same comparison between Experiments 1 vs. 2 and 3 did not show such a difference). When the face was frowning infants seemed to habituate to the mother's face as slowly as they did to the stranger's. This may suggest that infants in general may have perceived the frowning expression as novel, regardless of whether it was acted out by the mother or a stranger.

Was the discrimination of facial expressions on the mother's face better or, perhaps, easier than the discrimination of facial expressions on a stranger's face? There is some evidence from Experiments 4 and 5 which suggests that infants exposed to the facial expressions posed by the mother might have found the discrimination task easier than infants exposed to the facial expressions posed by the stranger. First, the number of infants who showed evidence of discriminating facial expressions was significantly greater when the mother acted out the expressions than when the stranger did. Second, although in the recognition data of the two experiments combined there was no main effect of person (posing the expressions) the difference between looking at the smiling and the frowning expressions on the mother's face tended to be larger (40.16 sec) than the equivalent

difference on the stranger's face (15.91 sec). In any event, this evidence is consistent with Gibson's (1969) hypothesis that differentiation of new features on familiar objects may be easier than differentiation of new features in new objects.

Did infants perceive social meaning in the facial expressions? In the discussion of Experiment 4 the investigator suggested that infants might have perceived not only physical differences between the two facial expressions, but also some of the social meaning conveyed by smiling and frowning faces. The main reason for this suggestion was that infants fussed more in the frowning than in the smiling condition. In Experiment 5 there was further evidence supporting that suggestion. Of the 6 babies who did not complete the experiment because of crying, all were in the frowning condition. Of those infants who remained in the experiment the ones in the frowning condition fussed more than the infants in the smiling condition. Finally, of the seven infants who did not show recovery to a face with novel expression, five were in the smiling condition and only two in the frowning. In other words, babies habituated to a smiling face, tended to continue looking at a smiling face, rather than at the novel frowning face. In Experiment 4, the only baby who did not show recovery to the novel expression was also in the smiling condition during habituation.

In conclusion, Experiments 4 and 5 suggest that three-month-old infants can discriminate a smiling from a frowning face acted out by their own mothers or by a female stranger. Infants, however, may discriminate facial expressions more easily on the mother's face than on a stranger's face. Infants must process some of the internal

features of the face to discriminate one facial expression from another. The finding of these two experiments also support previous suggestions that by three months of age boys and girls may behave differently if one of the faces presented as the stimulus is the the mother's. These experiments show that although the habituation paradigm is very effective for assessing recognition and discrimination of smiling and frowning faces, the visual data from the habituation trials and recognition test alone seem to be insufficient to establish whether infants perceived the social and sometimes emotional meaning of facial expressions. Observations of infants' "state" during the experimental session and of other behaviors such as smiling and vocalizing, in addition to visual fixations, may contribute to establishing whether or not infants perceive the social meaning of some facial expressions.

Chapter 5

Discrimination of faces and facial expressions without training in the laboratory

Experiment 6: Preference study

In the pilot study, infants were given a preference test before the familiarization period to determine if they could discriminate photographs of faces without having previous experience with photographs in the laboratory. Some infants were shown photographs of the mother's face paired with that of a female stranger's face; other infants were shown photographs of two female strangers' faces; in either case, the picture were presented twice for a fixed duration each time. Infants showed no evidence of discrimination of faces, not even if one of the faces in a pair was the face of the infant's own mother.

In Experiment 1, infants were again given a visual preference test, to determine whether they would discriminate a photograph of the mother's face from that of a stranger's. This time, however, the photographs were presented singly (rather than in pairs), in the center of the visual field, and each photograph was shown until the infant was judged to look away from it. In other words, the procedure used for timing the presentation of the stimuli was similar to the "infant control procedure" developed by Horowitz (see Horowitz, 1975 for details), in which the timing of a trial starts when the infant is judged to start looking, and stops when he is judged to look away. In contrast to the results of the pilot study, infants in Experiment 1

showed evidence of discrimination between the photograph of the mother and the photograph of a female stranger.

It is possible that if the infant is shown photographs of strangers using the visual preference procedure used in Experiment 1, he will also look at one face longer than at the other; this would imply that he can discriminate between faces of strangers even without extensive experience with either of them. Thus, one of the purposes of this experiment was to determine whether or not the three-month-old infant could also discriminate photographs of strangers in a visual preference test like that of Experiment 1. This visual preference test provides no extensive exposure to either stimuli before testing, but nevertheless allows the infant some control of the experimental situation.

The second purpose of this experiment was to investigate whether or not the three-month-old infant would show evidence of discrimination of some facial expressions, posed by either the mother or a stranger, without having previous exposure to one of the pictures. La Barbera et al.'s (1976) results with the visual preference paradigm suggest that this might be possible at least by four months, and Experiments 4 and 5 suggest that three-month-old infants discriminate a frowning expression from a smiling expression, after they have been habituated to either one of the facial expressions. In this experiment the same question was investigated using the visual preference paradigm.

The third objective of this study was to test again three-month-old infants with a visual preference paradigm on the

discrimination between the mother's face and a stranger's face, in order to see if the preference for the mother's face, found in Experiment 1, would be replicated when a variety of stranger's faces were presented. The presence of several stimulus conditions may facilitate the discrimination between the mother and strangers and perhaps may even result, as in Fagelow's (1977) study, in longer looking at a stranger's face than at the mother's.

Finally, the checkerboard used in all the habituation studies reported in this dissertation was also presented to infants in this experiment in order to determine whether or not infants would prefer (i.e., look longer at) faces to a non-facial stimulus. If infants preferred the checkerboard over the faces, it could be argued that in the recognition test of the previous studies infants looked longer at the checkerboard than at a familiar face because the checkerboard was a highly preferred stimulus and not because it was just a novel one.

In summary, then, in this experiment infants were tested to determine whether or not they would show evidence of discriminating (without any prior exposure) photographs of strangers, facial expressions posed by either the mother or a stranger, the mother's face from that of a stranger's, and photographs of faces from a non-facial pattern.

Method

Subjects

The subjects were 16 three-month-old infants (8 boys and 8 girls). Their mean age was 89.13 days, the range was 87 to 95 days.

One other baby was tested but did not complete the experiment because of crying.

Apparatus and Stimuli

The apparatus was the same as the one used in Experiments 1 to 5. The stimuli were color slides of smiling and frowning faces of the mother and of strangers, and of a black and white checkerboard. There were three faces of female strangers (the same as the ones used in Experiments 3 and 5); these faces are shown in Figure 2. The faces of stranger A and of the mother of each baby were presented both smiling and frowning (the smiling and frowning faces of stranger A had been used in Experiment 5; see Figure 3). In summary, each baby saw four smiling faces (the mother's and three strangers'), two frowning faces (the mother's and stranger A's), and the checkerboard. The projected size of the stimuli was the same as in the previous experiments.

Procedure and Experimental Design

Each baby saw the seven pictures, each presented twice. The first block of seven pictures was presented in a random order; the second presentation was simply the reversed order of the first. The random order varied for every infant.

Each picture was presented in the center of the visual field, as in the habituation studies reported earlier. The picture was on the screen until the infant was judged by the observers to look away from the screen. The timing of a trial started when the infant was judged to start looking at the picture and ended when he was judged to look away. The intertrial intervals lasted about 5 sec each; during this time the observers recorded the length of the fixation and advanced the

slides. The procedure for controlling the presentation of the stimuli was the same as in the habituation experiments.

The interobserver agreement was calculated as before using the Pearson Product-Moment correlation. The mean correlation was .99 (range: .96 to .99).

Results

Table 6 shows the individual data of this experiment. Because this experiment was designed to test a number of discriminations, namely, infants' discrimination of facial expressions posed by the mother and by a stranger, infants' discrimination between the mother's face and a stranger's face, infants' discrimination between faces of strangers and infants' discrimination between faces and a checkerboard, the data were analyzed in two separate ways. One analysis tested whether or not infants would discriminate between faces of two strangers (Strangers R and MH in Figure 2) and the checkerboard. The other analysis tested whether or not infants would discriminate the mother's face from a stranger's face (the stranger in Figure 3) and a smiling face from a frowning face either posed by the mother or by the stranger. For the first analysis a 2 x 3 Analysis of Variance was calculated with sex and stimulus (two faces and the checkerboard) as the factors. This analysis showed no main effects or interactions. For the second analysis, a 2 x 2 x 2 Analysis of Variance was calculated, using sex, person (mother-stranger), and expression (smiling-frowning) as the factors. Although there were no main effects there was a significant interaction between sex and person ($F = 6.89$, $df = 1, 14$, $p < .05$). As Figure 6 shows, girls looked longer at the

Table 6

Data from the Visual Preference Study: Experiment 6

Time (sec) spent looking at the stimuli

	Subjects	Mother Smiling	Mother Frowning	D Frowning	D Smiling	R Smiling	M Smiling	Checker-board	$\bar{X}$ strangers Smiling	Interobserver Reliability
male	2	75.48	55.63	20.8	17.68	64.9	18.06	26.5	33.75	1.00
	3	108.35	102.15	20.68	22.08	42.9	106.1	60.53	57.03	1.00
	7	42.48	100.75	18.85	29.78	29.43	19.23	64.2	26.15	1.00
	9	12.18	68.23	54.85	16.05	50.1	35.2	51.48	33.78	1.00
	10	130.8	20.38	24.28	44.53	4.43	55.35	113.6	34.77	1.00
	14	10.4	9.3	23.3	13.0	8.25	29.48	8.63	16.91	.96
	15	26.6	21.73	11.93	15.53	25.3	24.85	32.7	21.89	1.00
	17	6.3	8.93	10.5	11.43	25.75	28.7	14.35	21.96	1.00
		$\bar{X}$ = 51.57	48.39	23.15	21.26	31.38	39.7	46.52	30.78	
		sd = 47.92	39.02	13.74	11.04	20.5	29.23	34.06	12.50	
female	1	66.55	32.25	21.48	36.5	73.6	38.3	39.95	49.47	.96
	4	25.35	97.35	104.05	134.85	136.9	313.38	358.33	195.04	1.00
	5	9.68	20.3	59.05	81.18	63.6	139.45	24.88	94.74	1.00
	6	11.33	21.89	22.15	24.7	9.65	54.63	6.26	29.66	.98
	11	12.15	21.05	9.58	15.45	21.25	44.55	15.05	27.08	1.00
	12	13.13	21.15	35.65	47.38	38.05	23.08	33.73	36.17	.99
	13	32.63	132.05	34.58	66.15	17.2	24.53	44.58	35.96	1.00
	16	6.25	9.6	15.45	55.7	17.35	27.78	42.23	33.61	1.00
		$\bar{X}$ = 21.63	44.46	37.75	57.74	47.2	83.21	70.63	62.72	
		sd = 18.73	44.75	30.85	37.81	43.05	100.43	117.04	57.74	
	TOTAL									
		$\bar{X}$ = 36.85	46.42	30.45	39.5	39.29	61.46	58.58	46.75	
		sd = 38.59	40.61	24.27	32.85	33.58	74.90	84.19	43.60	

Figure 6. Interaction between sex and person. (Experiment 6).

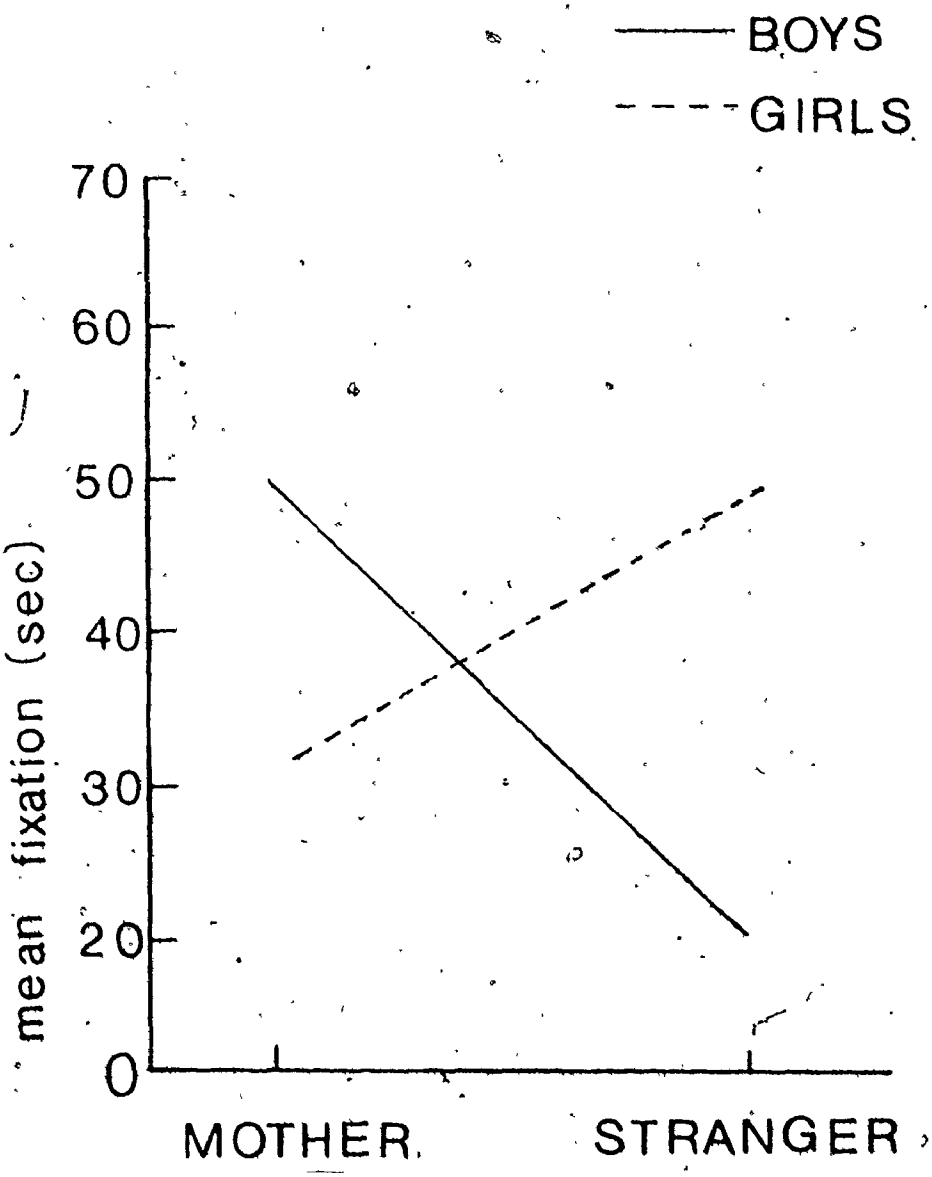
BOYS
GIRLS
70
60
50
40
30
20
0
mean fixation (sec)
MOTHER
STRANGER

Figure 6

stranger's face than at the mother's, whereas boys looked longer at the mother's face than at the stranger's. An analysis of this interaction using Tukey's procedure did not show specific differences. In addition, there was a marginal interaction between sex, person and expression ($F = 4.50$, $df = 1, 14$, $p < .05$). This interaction is shown in Figure 7. Girls tended to look longer at the frowning face of the mother than at her smiling face; moreover, girls tended to look longer at the smiling face of the stranger than at her frowning face. In contrast, boys tended to look at the smiling face as long as at the frowning face, regardless of whether the expressions were posed by the mother or by the stranger.

Discussion

The main finding in this study was that boys looked longer at the mother's face than at the stranger's face, whereas girls looked longer at the stranger's face than at the mother's. Regardless of the direction of the preference, this finding suggests that both boys and girls discriminated the mother's face from that of a stranger. This finding replicated the results of the preference test in Experiment 1 in that infants in that experiment also showed evidence of discrimination between the two faces. However, in contrast with the results of Experiment 1, in which infants of both sexes looked longer at the mother's face than at the stranger's face, boys and girls in this study differed in the direction of their preference. The finding with girls is consistent with Bigelow's (1976) finding with real faces. In her study, infants of both sexes looked longer at a stranger than at the mother.

Figure 7. Interaction between sex, person, and expression. (Experiment 6).

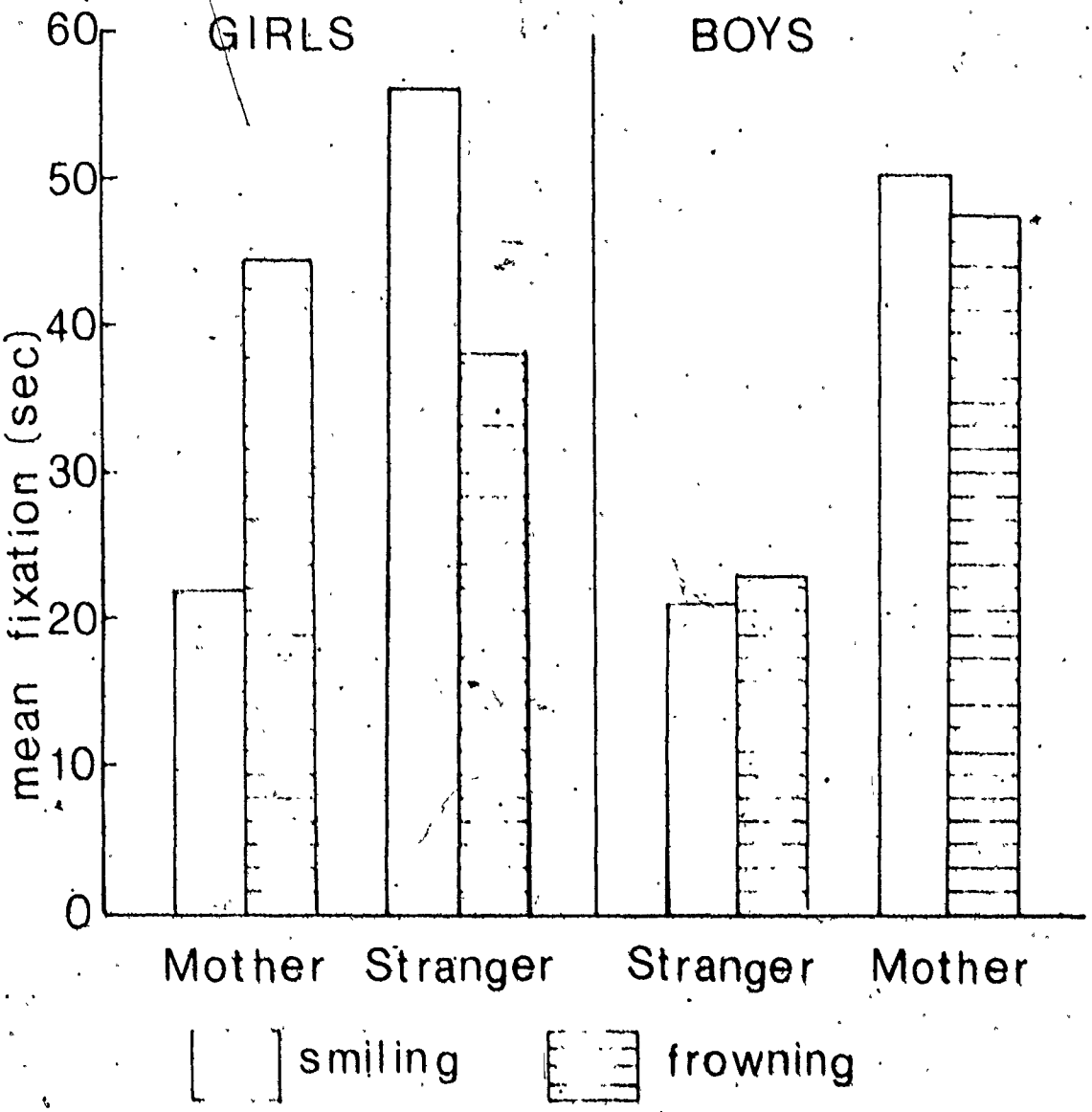
GIRLS
BOYS
60
50
40
30
20
10
0
mean fixation (sec)
Mother
Stranger
Stranger
Mother
smiling
frowning

Figure 7

One reason why the infants in Bigelow's study and the infant girls in this study looked longer at the stranger's face than at the mother's, may be because of different experiences with the mother's face. Bigelow's babies saw real faces which may be more easily discriminated than photographs. Moreover, since the mother's face was not different from what the infants had seen every day at home, and since at least by two-and a half-months infants seem to prefer novel stimuli to familiar ones (Fagan, 1970), Bigelow's infants may have simply looked longer at the face which appeared novel to them than at the one they had seen previously. With respect to the results for infant girls in this study, if girls have had more experience with the mother's face than boys in the natural environment (as suggested in previous chapters), they may recognize the mother's face more readily than boys, especially if her face is contrasted to the faces of several strangers. Infant girls might have benefited from the presence of several faces of strangers by the contrast between the familiar face and other faces. The presence of several faces of strangers may account for the differences between the results of this and of Experiment 1.

Infants did not show consistent differences in the time they looked at the smiling faces of two strangers. This finding suggests that the infants did not seem to be attracted by one specific feature of the face, by some salient physical cues, even if they could discriminate between the faces. Yet, as shown in Experiments 2 and 3, infants clearly show evidence of discrimination between strangers after habituation.

The fact that infants seem to show evidence of discrimination, in a preference test, between the mother's face and a stranger's face but not between two strangers suggests that (a) infants were already somewhat familiar with the mother's face before they came to the laboratory and (b) experience with specific faces, e.g., the mother's, as in children (Chance et al., 1967; Diamond and Carey, 1975) and in adults (Yarmey, 1971), may facilitate recognition of faces.

When infants were shown the smiling and frowning pictures of the mother and stranger A, girls seemed to discriminate between the smiling and frowning expressions when either the mother or the stranger posed the expressions. Boys did not seem to show evidence of discrimination of the expressions posed either by the mother or by the stranger, even though they clearly show evidence of those discriminations after habituation (Experiments 4 and 5).

The trend toward the discrimination of facial expressions by the girls suggests that girls may perceive the changes of facial configuration which take place from smiling to frowning (and vice versa) in photographs, with virtually no previous experience with pictorial material.

It is puzzling that infant girls showed some evidence of discrimination between facial expressions in a preference test, i.e., without prior training. One possibility is that the sex differences in the discrimination of facial expressions in this study may reflect experiential effects of some kind as suggested previously. Studies of mother-infant interaction in the natural environment offer some indirect support for this suggestion. For example, mothers of three-

month-old infants tend to spend more time in face-to-face interaction with infant girls than with infant boys (Judd & Lewis, 1975; Lewis, 1972; Moss, 1967). If infant girls have more knowledge about the mother's face than boys do, it is likely that such knowledge includes a smile. An infant boy, in contrast, may not have sufficient experience with the mother's face to distinguish one expression from another.

Finally, in this experiment infants looked as long at faces as at the checkerboard. If infants have an "innate" preference for faces as some investigators have suggested (e.g., Goren, 1976), infants should have looked longer at the faces than at the checkerboard, but they did not. This result is consistent with the results of the checkerboard group in the pilot study (see Appendix 1) in which infants also looked equally long at a checkerboard and at the mother's photograph. This result is an excellent example of one of the limitations of the visual preference paradigm: that often times infants do not show differential looking between stimuli even though it is very likely that they can discriminate between them. If the three-month-old can discriminate between faces which have many attributes in common (e.g., sex, feature arrangement, size) without previous training, it is very likely that they could discriminate between stimuli which differ in multiple dimensions, e.g., a color photograph of a face versus a black and white checkerboard. In any event, the fact that infants looked at the checkerboard as long as they looked at faces suggests that in the habituation experiments infants looked longer at the checkerboard than at a habituated face because the

checkerboard was a new stimulus, and not because of any initial preference for the checkerboard.

In summary, in this experiment infants showed no evidence of discriminating between faces of strangers without previous experience with one of them, but they seemed to discriminate between a stranger's face and the mother's. Like several previous experiments, this result suggests that infants (a) learn something about the mother's face in their real world; (b) are able to transfer what they learn about the three-dimensional face to its picture; and (c) recognize something about the mother's face in the picture. Infant girls seemed to discriminate between facial expressions acted out by either the mother or a stranger, but infant boys seemed not to. The sex differences found here are consistent with almost all experiments reported so far in this dissertation in that such differences only appeared when the mother's face was one of the experimental stimuli. Finally, the fact that infant girls tended to discriminate facial expressions here suggests that they processed some of the internal features of the face.

Chapter 6

Scanning of photographed faces

Experiment 7

If the three-month-old infant can recognise and discriminate faces and facial expressions, it is important to know what information about a face he is using to do so. The purpose of this study was to determine what features of a photographed face the three-month-old infant looks at when the photograph is presented for a short period of time. The answer to this question may provide useful information for our understanding of face perception and processing and perhaps for our better understanding of how the young infant perceives and processes objects in general.

Since the 1940's psychologists have been interested not only in studying infants' discrimination of faces or face-like designs but also in studying what facial features infants attend to at what age. Specifically, early studies were designed to investigate what part(s) of the face was a necessary condition to elicit smiles in the infant. To do so, investigators presented out-outs of face-like arrangements with either some of the features missing or covered. Two- to four-month-old infants smiled at out-outs containing dots in the place of eyes, or at the eyes in a real face (with the lower part of the face covered) as much as they smiled at a out-out with all the facial features or at the uncovered face of the experimenter. Infants apparently did not notice the absence of the mouth. In addition,

infants did not smile at out-outs without eyes at two to four months of age (Ahrens, 1954; Buhler & Hetzer, 1928; Kaila, 1932--cited in Freedman, 1964; Spitz & Wolf, 1946). When the mouth of the investigator was moving, Ahrens (1954) observed that three-month-old infants attended to the opening and closing movements of it but they did not smile at it.

Recently, Caron, Caron, Caldwell and Weiss (1973) tested systematically four- to six-month-old infants, using habituation as the paradigm, visual fixation as the response measure and schematic drawings of a face-like pattern as the stimuli. Four-month-olds showed evidence of discrimination between a normal schematic face and a schematic face with distortion of the eyes or of the hairline. However, they showed no evidence of discriminating a normal facial arrangement and arrangements with distortions in the nose and mouth. In contrast, five- to six-month-olds clearly differentiated both types of distortions (of the upper and lower part of the face-like pattern) from the normal face-like pattern.

It should be pointed out that, as mentioned above, Ahrens observed that when the real face is presented and the mouth is in motion, infants as young as three months seem to look at the mouth. Thus, the fact that with face-like cut-outs or motionless faces infants under five months of age seem to attend mostly to the eyes should not be interpreted to mean that infants do not look at the mouth at all, nor that infants are incapable of directing their attention to the lower part of the face.

Caron et al.'s findings are very important for they represent the first systematic evidence of what parts of the face the infant may process in order to discriminate one facial arrangement from another. The limitation of Caron et al.'s findings is that we do not know whether infants will process the same features when they see a real face or a photograph of it as when they see a face-like pattern.

Other investigators have studied what features of the face infants look at most by using Corneal Reflection Photography. They have filmed one of the infant's eyes and reflections off it of infrared lights to determine the location and duration of the infant's visual fixations on a specific stimulus or on part of it. The location of the reflections on the pupil varies systematically as the infant shifts his gaze (Haith, 1969; Maurer, 1975).

With this technique, Bergman, Haith and Mann, (1971 or Haith, Bergman and Moore, 1977), Donnee, (1973, or Hainline, 1978) and Maurer and Salapatek, (1976) have studied scanning of real or photographed faces in one-, two- and two- and-a-half-month-old infants. At one month of age infants spent very little time looking at the face and when they did so, they spent much more time on the edges of the face than on its internal features. In contrast, at two months infants looked at the face they were shown most of the time, and their fixations were mainly concentrated on the area of the eyes, even though infants seemed to scan the entire face (Hainline, 1978; Haith et al., 1977; Maurer and Salapatek, 1976). These findings with one- and two-month-olds were true for the scanning of real faces as well as for the scanning of a photograph of a face.

The scanning data with slightly older babies (10-11 weeks in Hainline's study and 9-11 weeks in Haith et al.'s) are inconsistent. Haith and associates found that 9-11 week-olds looked at the face most of the time, much like the 8-week-olds, but scanned the inside features of the face even more. In contrast, Hainline (1978) found that although 10-11-week-olds, like the 7-8 week-olds, looked less at the edges of the face than the 4-5 week-old infants, they looked at the internal features (presumably eyes, nose and mouth) as little as the younger infants did and significantly less than the 7-8 week-olds.

The most obvious difference between the two studies was that Haith et al. used real faces whereas Hainline used a photographed face and a face-like design. Thus, it is possible that the nature of the faces might have accounted for the difference in findings with the two-and-a-half-month-old infants. Hainline explained the older infants' behavior by saying that they had had enough experience with real faces so that the two-dimensional face presented to them was no longer realistic enough to be responded to as a real face. Alternatively, if the two-and-a-half month old infant has had sufficient experience with real faces, one would also expect that he would perceive similarity between real faces and photographs.

It is difficult to infer from the scanning data in two-and a half-month-olds what features of the face the three-month-olds perceive and perhaps process to discriminate between faces and facial expressions. It is difficult to infer so because, in all the studies reported in this dissertation, photographed rather than real faces were used and because the findings of the only scanning study in which a

photograph of a face was used (Brinline's study) are in conflict with the findings using real faces (Haith et al.'s study). Since there are no scanning data on three-month-olds, this experiment was aimed to provide such data. In addition, this experiment may clarify whether or not the three-month-old infant scans a face as infants in Donnee's study did with a photograph, or as infants in Haith et al.'s study did with a real face.

Method

Subjects

Forty of the babies who participated in the pilot study also participated in this experiment. Of the films of 40 infants, 10 were randomly chosen with the limitations that (a) the quality of the film was good, i.e., the infant's pupil was clearly visible; (b) the reflection of the lights (see below) on the pupil was clearly defined; and (c) that within the fixed exposure time the infant spent more than 50% of the time looking on the face[6]. The final sample consisted of 13 three-month-old infants.

Apparatus

The apparatus consisted of a large chamber, which is shown in Figure 8. The infant sat in an infant seat inclined at 45°. He faced a black wooden panel parallel to the seat. In the middle of the panel was a vertical strip (10 cm x 3 mm) of 8 red miniature lights. Black mesh screens (90 x 60 cm) with the stimulus attached to them were

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6 The films of three other babies who did not reach this criterion were also analyzed in order to compare their scanning on the various facial features to the scanning of the infants who did look at the face more than 50% of the time.

manually slid into position in front of the black panel at 33 cm from the infant's eyes. Behind the black panel were a 16 mm movie camera, 5 infrared reference lamps (Bausch & Lomb microscope illuminators) and 3 timers. The camera was loaded with high speed Kodak infrared film, and was aimed at the left eye of the infant. The reference lights, also aimed at the left eye, were fitted with Corning 7-69 and Kodak Wratten (87C) filters which transmitted light of about 860 to 960 nm, i.e., they were almost invisible to an adult and harmless to the infants' eyes. The timers controlled the length of the trials and intertrial intervals. Two 15 WAC lamps, located to the side and slightly behind the infant, illuminated the stimulus. A cassette tape recorder, located under the infant seat, furnished white noise throughout the experimental session. The noise level was 73-76 Db.

Stimuli

The stimuli were three color photographed faces of women. Each face was smiling and the photograph was cut out around the contour of the hair. Each face measured approximately 17 x 23 cm, subtended a visual angle of 34° 42' (vertical) by 28° 18' (horizontal), and the left edge of the picture was 3° from the center of the visual field.

The three faces were randomly chosen from a pool of women whose photographs were used in the pilot study (see Appendix 1). Figure 9 shows one of the faces.

Procedure

After the pilot study was over, the baby was shown one of the three large faces for 30 sec if he was content and showed no signs of fatigue. While the baby looked at the picture, his eye movements were

Figure 8. Apparatus used in Experiment 7 and in the Pilot study

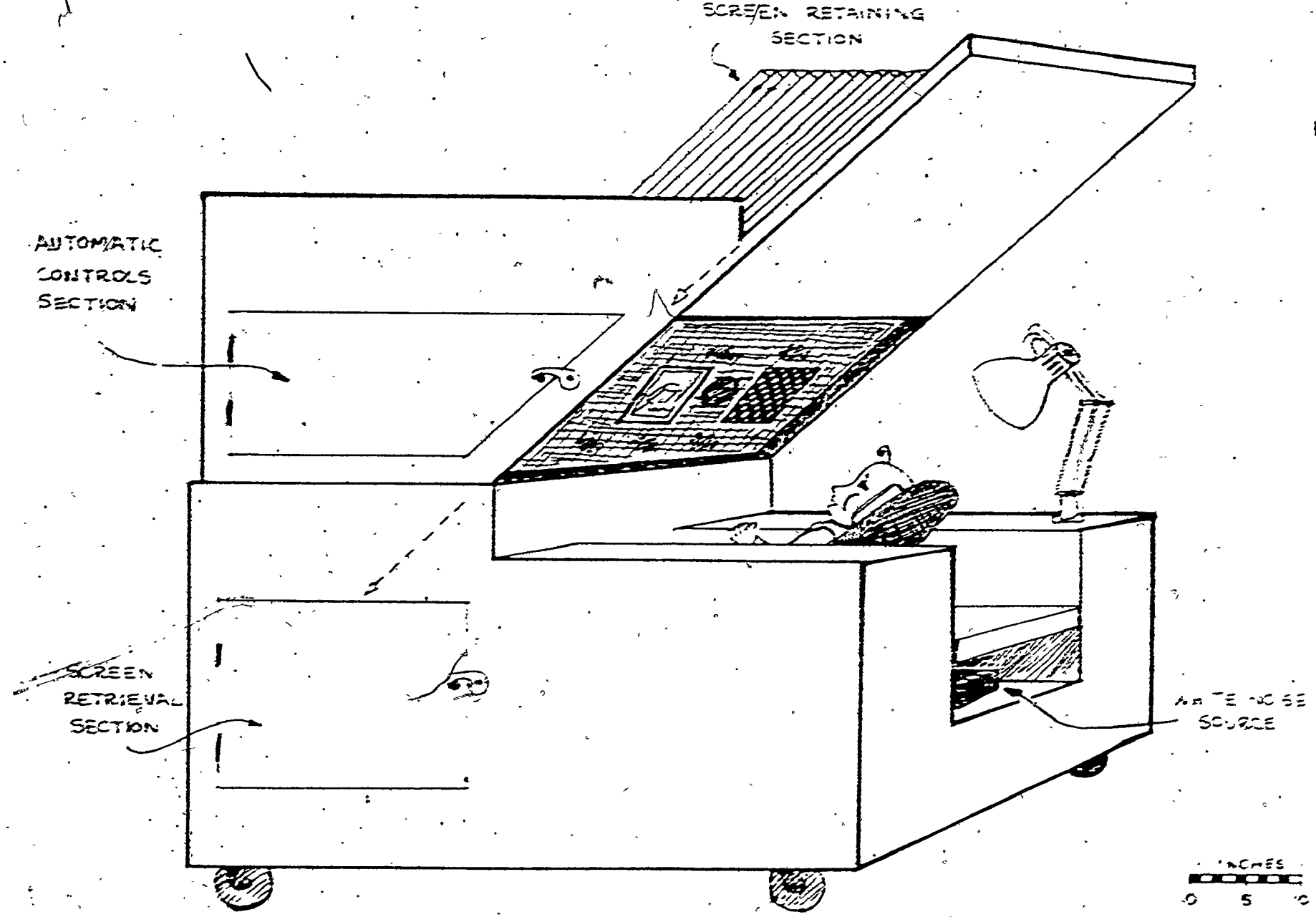
SCREEN RETAINING SECTION
AUTOMATIC CONTROLS SECTION
SCREEN RETRIEVAL SECTION
INCHES
0 5

Figure 9. One of the pictures used in Experiment 7. The originals were in color.

filmed four frames per sec. Infants were randomly assigned to one of the three faces.

Corneal Reflection Photography was used to determine where the baby was looking in the visual field. The left eye of my eight-year-old daughter was filmed with the reflections off it of the infrared lights while she looked at specified features of each of the three faces (e.g., hairline, eyes, mouth, nose, chin, right and left edge) or while she looked at the black background off the face. The purpose of this film was to have a prototype or model of how the lights reflected off the pupil as different parts of the face were being fixated; this model was then compared to the infant's films. No perceptible differences were found in the location of the reflections off the pupil for fixations on the same features of the three faces.

Before the infants' films were scored the experimenter trained herself with the film of the eight-year-old child. First, the experimenter drew the exact position of the reflection points on the pupil for each area of the face looked at. Second, the film was observed repeatedly and studied, frame by frame, with the help of the drawings until accuracy of visual fixation judgments reached 90%. Finally, when the experimenter was able to judge the fixation points better than 90% of the time without the help of the drawings, she began to score the infants' films frame by frame (8 frames in a sec). Depending on the clarity of the film and the eyes' activity, the time required to score a film varied from 30 to 60 min.

A second observer was trained and also scored all the films. The interobserver agreement was calculated for each infant by comparing

the number of frames scored by the two observers in eight specific areas. The mean correlation was .94, the range, .91 to .99.

Results and Discussion

The number of frames scored by the first observer was transformed to sec. Table 7 shows the amount of time each infant spent looking at each of the facial features. The most striking result was that all infants, even the ones that spent less than 50% of the time looking at the faces, concentrated their visual fixations on the area of the eyes. In fact, the mean time infants looked at the eyes alone was higher than the mean time they looked at all the other features combined. The hairline/top border was the next most looked at feature of the face, even though infants looked at it only a third of the total time they looked at the eyes. In addition, the mouth and the left and right borders of the photographed face were next in the mean group data. However, it should be noted that of the 8 babies who looked at the mouth (5 did not look at it at all), 7 of them looked at it more than at the hairline.

That infants looked at the eyes longer than at any other feature is consistent with Haith, Bergman and Moore's (1977) and Maurer and Salapatek's (1976) findings with two- and two- and a half-month-old infants, using real faces. These investigators found that infants looked longer at the internal features of the face, mainly the eyes, than at the borders.

The consistency of the results of this experiment with previous findings with real faces suggests that the life-sized color photographs in this study may have been perceived as real faces. In contrast, the

Table 7

Data from Experiment 7: Visual fixations on each feature of the face (sec)

Subjects	Top Hairline	Eyes*	Mouth	Chin Border	Side Borders	Total on Face	Off Face	Non-Scorable	Total	% on Face
21	1.15	8.30	3.0	2.15	1.15	16.15	2.30	4.45	23.30	.69
22	3.30	8.00	3.45	1.30	0.30	19.15	4.30	1.45	25.30	.76
23	7.15	8.45	0.0	0.0	2.45	18.45	0.0	6.30	22.15	.73
41	8.00	8.45	0.0	0.0	2.15	19.30	3.45	6.45	29.30	.65
44	7.30	12.15	1.0	1.45	4.0	26.30	0.45	1.15	28.30	.93
58	0.30	22.15	1.45	0.30	0.30	26.30	1.45	1.30	29.45	.89
67	0.0	16.15	1.45	1.15	1.15	20.30	2.30	2.45	25.45	.80
72	6.15	11.30	0.0	0.0	2.0	19.45	5.45	2.15	27.45	.71
73	0.0	11.45	3.15	0.0	4.0	19.0	5.45	3.3	28.15	.67
75	0.0	12.0	1.45	3.45	2.0	19.3	2.15	7.0	28.45	.68
24	2.3	4.45	0.0	0.0	2.15	9.30	0.45	9.30	19.45	.48
25	0.30	7.00	2.00	1.30	0.45	11.45	1.00	11.45	25.30	.43
56	0.30	5.45	0.0	0.0	1.30	7.45	16.30	4.15	28.30	.26
(1)										
n=10										
$\bar{X}$ =	3.34	11.84	1.8	.98	1.95	20.34	3.73	3.6	26.73	.75
sd =	3.45	4.42	1.75	1.16	1.31	5.32	1.91	2.29	2.55	.10
n=13										
$\bar{X}$ =	2.79	10.41	1.53	.85	1.8	17.88	3.54	4.68	26.18	.67
sd =	3.2	4.72	1.66	1.08	1.22	5.65	4.22	3.24	3.05	.18

* Scanning of the nose could not be reliably scored (changes between eye-nose or mouth-nose were too small to be detectable.)

(1) excluding infants who looked at the face less than 50% of the time.

data of this experiment are in conflict with Hainline's (1978) findings with 10 to 11 week-old infants; these infants (according to Hainline) looked longer at high contrast areas, e.g., the borders of the photographed face, than at the internal features of the face. Hainline's results are puzzling and difficult to interpret, particularly in light of the previous findings with real faces and the findings of the experiment reported here with photographed faces.

There were many methodological differences between this and Hainline's experiment. For example, in Hainline's experiment each infant was exposed to a photograph of a face and to a face-like design in three conditions: silent, with voice and with a tone sound; in this study infants were exposed to only a silent photographed face. Moreover, the faces used in this experiment were perhaps perceived as more similar to real faces than the faces used by Hainline, because the expression of the faces in this study (smiling) was perhaps more natural than the expressionless face used by Hainline. In addition, the photographed face used by Hainline was that of a brunette female whose hair produced a sharp contrast with the bright background. Although the faces in this study were brunette too, they were pasted on a black screen; this diminished the high contrast transition between the edge of the face and the background; it also diminished the flatness cues produced by the rectangular borders of the cardboard which were present in Hainline's experiment. Yet the methodological differences between the two studies cannot explain why the face used by Hainline resulted in very little internal looking by her 10 to 11 and 8 to 9-week-olds but not by her 6-week olds.

Ahrens (1954) observed that when the face is still the eyes are more attractive to infants than the mouth even at five to six months of age. In addition, when an adult was talking to the two-and a half-month-old infant, Haith et al. (1977) found that he still looked at the eyes much more than at any of the other facial features. In fact the infants tended to look at the eyes even longer when the adult was talking than when he was silent. The infant's attention to the eyes was also shown in Bloom's (1973) work with four-month-old infants. She found that infants increased their vocalizations when the experimenter was wearing eye glasses with a cut-out pattern of eyes pasted on the glasses and with the eyes looking toward the infant. In contrast, infants did not increase their vocalizations when the experimenter was wearing eye glasses with cut-out eyes whose gaze was directed away from the infant, even though in both conditions the experimenter was talking and smiling at the infants.

In older infants, Barrera (1975) found that one- and two-year-olds looked significantly longer at photographs of smiling faces of the mother or strangers when the eyes were open than when they were closed. All these findings (Ahrens', Haith et al.'s, Bloom's and Barrera's) suggest that the physical characterization of the facial features (e.g., color, contrast, contour, movement, brightness) were not the only characterization controlling the infants' attention. If the physical characterization of the facial features were alone responsible for attracting the attention of the infant, then changes in the mouth --like talking-- should attract more attention to it, yet that did not happen in Haith et al.'s study.

In our culture, it is well established that eye-to-eye contact plays a very important role in social interactions among adults (Argyle, 1975; Cook, 1970). In infants, some investigators have proposed that eye-to-eye contact is the first social interaction the infant engages in (e.g., Vine, 1971), an important "meeting event" or an antecedent for social learning (Bloom, 1971), and an important antecedent for the development of attachment, i.e., an emotional bond between the infant and his caretaker, typically the mother, (Robson, 1967; Robson, Pedersen & Moss, 1969; Bowlby, 1969; Vine, 1971). Thus, it is reasonable to suggest that as early as two months (Haith, 1978; Haith et al., 1977; Maurer & Salapatek, 1976) infants may look longer at the eyes because they already have learned to perceive the social meaning conveyed by the eyes of other human beings.

If an infant of two to three months looks longer at the eyes than at any other facial features, does it mean that for the infant the eyes are the facial features which provide most of the information about a face?

Yarbus (1967) hypothesized that the amount of attention directed towards specific features of a picture depends on whether such features provide essential and useful information. Several investigators have tested Yarbus' hypothesis with adult subjects (e.g., Loftus, 1972; Loftus and Bell, 1975; Mackworth and Morandi, 1967). Typically, one sample of subjects is asked to judge a picture by indicating what are the parts or features of the picture considered the most informative. Another sample of subjects is exposed to the picture while their eye movements are being measured. The main finding

from this work is that adult subjects indeed seem to concentrate their fixations on the parts of the pictures which were considered by other adults as the most informative areas. However, the fact that adults look at some parts of a picture more than at others, does not mean that they only process the features they fixate most.

The problem with studies of eye movements in infants, like the one reported here, is that we do not know whether the infant fixates the features because they are informative or whether the features are informative because the infant fixates them, or whether the infant fixates them because of a number of other reasons. If the infant looks at a feature(s) one may assume that he may also processes it (them); however, the fact that some features are looked at longer than others does not necessarily imply that those are the only features processed. The infant can look longer at a feature than at another simply because that particular feature has acquired social meaning, not because he is processing it all the time he is looking at it.

The question of whether or not the eyes are the features which provide most of the information about a face may have to be qualified by specifying what kind of information one is referring to. It is reasonable to propose that the eyes, as discussed above, may provide the basic information for social interaction. However, the eyes alone may not provide sufficient information to discriminate one face from another, nor may the provide necessary information.

That the hairline was the next most looked at feature is consistent with Caron et al.'s (1973) results with four-month-old infants. Caron et al. found, that at four months infants

differentiated distortions of the hairline and of the eyes in a face-like pattern from a normally arranged pattern, presumably because they looked at and processed the entire upper part of the face.

The non-scorable column in Table 7 refers mainly to those instances in which observers could not determine where the infant was looking within the face, because the reflections of the infrared lights appeared as a line across the pupil rather than as specific points. This was the case when the infant engaged in eye movements from one feature to another, i.e., when the infant was scanning the face. Thus, at least some of the non-scorable data may be taken as evidence that the infants were scanning the entire face rather than only one feature.

Although the faces for the scanning study were presented at the end of the pilot study, the infants who participated in this study did not show signs of fatigue. Rather, the presentation of the large face elicited in the majority of the babies a high amount of looking time. One possible reason for the infants' interest in this face was that the picture was larger than the pictures used in the pilot study and was presented singly, rather than in pairs.

In summary, the scanning data reported here are consistent with the previous findings in the literature with infants under four months of age: Infants look longer at the area of the eyes than at any other feature. That the infants look longer at the eyes may mean that the eyes are the facial features which might have acquired some social meaning to infants when they interact with other people. Moreover, the existent data on the scanning of a face should not be interpreted to mean that the eyes are the only feature infants process at two and

three months of age; infants may perceive and process the entire facial configuration but still prefer to look at the eyes.

Chapter 7

Summary and Conclusions

This chapter summarizes the main research findings reported in Chapters 2 to 6 and their implications for the infant's perceptual, cognitive, cortical and social development. Experiments 1 to 3 provide evidence which suggests that three-month-olds can discriminate a photograph of one face from a photograph of another. When one of the faces was the mother's, infants showed evidence of discriminating faces both in a preference test and after habituation to the mother's face. These findings extend Bigelow's results (1977) by showing that babies can discriminate between the mother's face and a stranger's face even when the faces are presented two-dimensionally rather than three-dimensionally.

When the faces were of strangers, infants showed evidence of discriminating one photograph from another only after habituation to the photograph of one of the strangers. Infants discriminated between strangers regardless of whether the strangers were judged (by adults) to be similar or dissimilar to each other. This finding extends the results of Cohen et al. (1977) to a younger age --three months-- and hence it represents the first systematic evidence of discrimination and recognition of faces of strangers in infants under four-and-a-half-months of age.

Experiments 4 and 5 provide evidence which suggests that three-month-old infants can discriminate a photograph of a frowning face from

a photograph of a smiling face when the expressions are posed either by each infant's own mother or by a stranger. Yet more infants completed the experiment if the expressions were posed by the mother, than if the expressions were posed by a stranger. If infants were habituated to either the mother's or the stranger's frowning face, they were more likely to cry (and in many cases the experimental session was consequently stopped) than if they were habituated to the smiling face. The discrimination of facial expressions in Experiments 4 and 5 extend previous findings (e.g., by La Barbera et al., 1976) to a younger age, and to other facial expressions (Browne, et al., 1977). In addition, these experiments provide the first suggestion that infants as young as three-months might associate different meanings to smiling and frowning faces.

In Experiments 1 and 4 the infants were habituated to the mother's face and in Experiments 2, 3 and 5 infants were habituated to a stranger's face. In Experiments 1 and 4 sex differences were evident whereas in Experiments 2, 3 and 5 they were not. In Experiment 6, the preference study, infants were presented with photographs of the mother's face and of a stranger's face and again sex differences appeared. Typically, when sex differences were evident the boys, in general, looked at the faces longer than the girls; in addition, in the preference test of Experiment 1 girls showed evidence of discriminating the mother's face from a stranger's face more readily than boys. Also, in Experiment 6 girls tended to show evidence of discriminating facial expressions on either the mother's or a stranger's face in the preference study, but boys did not. The sex differences found in all

the habituation experiments in which the mother was a stimulus, and the lack of sex differences found in the experiments with strangers, suggest that sex differences reflect differences in social experiences prior to the laboratory visit.

Finally, in Experiment 4 infants looked at the eyes of a color photograph much longer than at any of the other features of the face, even though they seemed to scan the entire face. The fact that infants looked at the eyes more than at any other feature does not mean that the eyes were the only feature they processed. Infants may have processed the entire face but preferred to look at the eyes. Evidence from other studies (Barrera, 1974; Bloom, 1974; Haith et al., 1977) supports the hypothesis that infants are attracted to the eyes because the eyes acquire socio-emotional meaning at a very early age.

What can one infer from these data about the three-month-old's cognitive, perceptual, cortical and social development?

With respect to perceptual development, the evidence from the preference test in Experiment 1 suggests that the infants perceived some similarity between the mother's three-dimensional face and a two-dimensional representation of the same face. Infants did so after having very little experience with pictorial material. Although similar evidence has been found with faces of strangers at five-and-a-half months of age by Dirks & Gibson (1977), and with geometric designs at six months of age by Fagan (1977), the results of Experiment 1 suggest that the infant can do so at a younger age, at least if the mother's face is used.

These results provide some support for J.J. Gibson's (1971) hypothesis that the mechanisms involved in the perception of two-dimensional objects are similar to those involved in the perception of three-dimensional objects.

With respect to the perception of a face, Experiments 4 and 5 suggest that infants must have looked at, and perhaps processed, at least some of the internal features of the face in order to discriminate between expressions. This must be so because the external features of the face were identical for the two facial expressions.

With respect to cognitive development, the findings reported here suggest that memory for complex patterns such as faces is functioning at least by three months of age. Some investigators (Bond, 1972; Olson, 1974) have also hypothesized that infant's perception and memory systems may be qualitatively similar to those of children and adults, but that the efficiency of visual processing may improve with experience and development. Other investigators (e.g., Gibson, 1969; Greenberg, Uzgiris, & Hunt, 1970) have also proposed that the infant's perceptual and cognitive systems improve with experience and development. Although the three month-olds studied in this dissertation made discriminations traditionally expected only in older infants, the results reported here cannot tell us whether or not the behavior of these infants was equivalent to the behavior of older infants. In fact, some of the data suggest that three-month-old infants need more experience with faces than older infants do in order to discriminate photographs of strangers. For example, in the pilot study infants did not show evidence of discriminating strangers with

the familiarization-novelty paradigm, a paradigm which typically does not provide as much experience with stimuli as does the habituation paradigm. Yet, five-and-a-half-month-olds have shown evidence of discriminating strangers with the familiarization-novelty paradigm (e.g., Fagan, 1972). Although this dissertation provides no direct evidence on whether or not memory improves with development, the fact that some discriminations were evident only after extensive exposure in the laboratory suggests that at least recognition of faces improves with experience in three-month-olds. A similar phenomenon has been observed in children (Chance et al., 1967; Diamond & Carey, 1974) and in adults (Bahrick, Bahrick & Wittlinger, 1975; Carmody, 1971).

With respect to the recognition process, some of the results reported here suggest that there may be two stages of recognition in early infancy, depending on the infant's previous experience with the object in question: an early stage in which he shows a preference for familiar objects and a later stage in which the infant shows a preference for novel objects.

With regard to the infant's cortical development, the findings of this dissertation suggest that the area of the brain responsible for processing and integrating complex arrays, including faces, is functioning at least by three months of age. Several lines of evidence suggest that the inferotemporal lobe is one of those areas. For example, adults who have suffered cortical lesions on the right temporal lobe show marked deficits in recognizing faces and nonsense figures, and in recalling geometric drawings (e.g., De Renzi & Spinnler, 1966; Hecaen & Angelergues, 1962; Kohn & Dennis, 1974;

Milner, 1968). With similar tasks normal adults recognize faces and geometric patterns presented on the left half of the visual field more accurately or faster than those presented on the right half (e.g., Ellis & Shepherd, 1974; Geffen, Bradshow & Wallace, 1971; Moscovitch, 1976). This perceptual asymmetry has been interpreted as evidence that faces are mainly processed by the right temporal lobe.

Milner (1968) has suggested that the visual deficits found in human adults with lesions in the right temporal lobe are similar to the visual deficits found in monkeys after inferotemporal lesions (Mishkin, 1968). On the basis of this similarity, Gross, Bender & Rocha-Miranda (1974) have proposed that in man and in monkey the inferotemporal cortex appears to be involved in higher order perceptual and cognitive processes underlying visual recognition. If this is true in human adults, the findings on the discrimination and recognition of faces and facial expressions reported here suggest that the inferotemporal cortex is functioning at least by three-months of age.

With respect to the infant's socio-emotional development, the findings reported here indicate that by three months of age the infant recognizes his mother. Some investigators have indicated that perceptual recognition is a necessary condition for the development of attachment (Bowlby, 1969; Schaffer, 1971). Recognition of the mother's face, however, may be a necessary but not sufficient condition for attachment. At least one investigator (e.g., Wahler, 1967) has suggested that differential responding toward the mother at three months of age indicates that the infant already is attached to his mother, i.e., he has developed an emotional bond with his mother.

However, other evidence from this thesis suggests that this may not be the case. Specifically, infants' shift from a visual preference for the mother to a preference for a stranger within the same experimental session (Experiment 1) suggests that at three months infants are not yet attached to their mothers, insofar as they do not show strong resistance to habituation to the mother's face nor strong resistance to changing their preference.

It is possible, however, that, as some investigators have suggested (e.g., Carter, 1974), looking may not be an index of attachment. If this is the case, the findings reported here cannot tell us very much about attachment. Infants might already be attached to their mothers, but this research could not explore that because looking was used as the response measure. It is also possible that, as suggested above, infants might still not be attached to the mother at three months, and that they only recognize her as different from others.

Finally, the findings on the discrimination of facial expressions suggest that by three months of age, some infants already perceive some socio-emotional meaning conveyed by smiling and frowning faces.

In conclusion, the findings reported in this thesis suggest that by three months of age the infant already shows memory for complex patterns such as faces, recognizes his mother's face even when only limited visual cues are present, and generalizes his knowledge of a three-dimensional face to a picture of the same face, at least when the mother's face is used. In addition, the findings suggest that by three

months of age, the infant can recognize smiling and frowning faces, discriminate between them, and even perceive some of the social meaning associated with those expressions. The most general implication of these findings is that the areas of the brain responsible for processing and integrating complex arrays like faces may be functioning at least by three months of age.

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Appendix J

Face discrimination and recognition before and after familiarization in the laboratory

A Pilot Study

This study preceded the experiments reported in this thesis. The purposes of this first experiment were the following: First, it investigated whether or not the three-month-old infant would show any evidence of recognizing faces and discriminating between them. Second, it investigated whether infants would discriminate photographs of some faces more easily than photographs of other faces; specifically, whether infants would discriminate a photograph of the mother's face from a photograph of a stranger more readily than photographs of strangers from each other. In other words, it investigated whether or not prior experience in the natural environment with the mother's live face would facilitate the discrimination of a photograph of the mother's face from the photograph of a female stranger's face. And third, it studied whether the infant would transfer his knowledge of a live three dimensional-face to a picture of the same face. That is, whether he would perceive similarity between the real three-dimensional representation of his mother's face and a two-dimensional representation of it: her picture.

To investigate these questions both the visual preference and the familiarization-novelty paradigms were used. The visual preference

paradigm tested whether infants could recognize the mother's face and whether they would discriminate between the mother's face and a stranger's face, the mother's face and a non-facial pattern (a checkerboard) and between two strangers' faces without any previous experience with the stimuli in the laboratory. The familiarization-novelty paradigm was used to test for the same abilities after the infants were exposed to one of the pictures in the laboratory.

Method

Subjects

The subjects were 56 three-month-old infants, 25 girls and 31 boys. The mean age was 91 days, the range was 84 to 98 days. An additional 17 subjects were tested but excluded from the analysis because of ruined film (n=8), side preference (n=4; more than 90% of visual fixations on one side), or incomplete data (n=4; 1 because of crying; 2 because of looking away from the stimuli 90% of the time; and 1 because of experimental error).

Apparatus

The apparatus consisted of a large chamber which is shown in Figure 8 and described in Experiment 7.

Stimuli

The stimuli were 12.6 x 18 cm black and white checkerboards and color prints of women. They were mounted in pairs on black screens 33 cm from the infants' eyes. At this distance the visual angle of each picture was $20^{\circ}05'$ x $28^{\circ}36'$. The distance from the center of the visual field to the inner edge of each stimulus was $19^{\circ}5'$.

Figure 10. Examples of some of the faces used in the pilot study. The originals were color.

Figure 11. A copy of the checkerboard used in the pilot study.

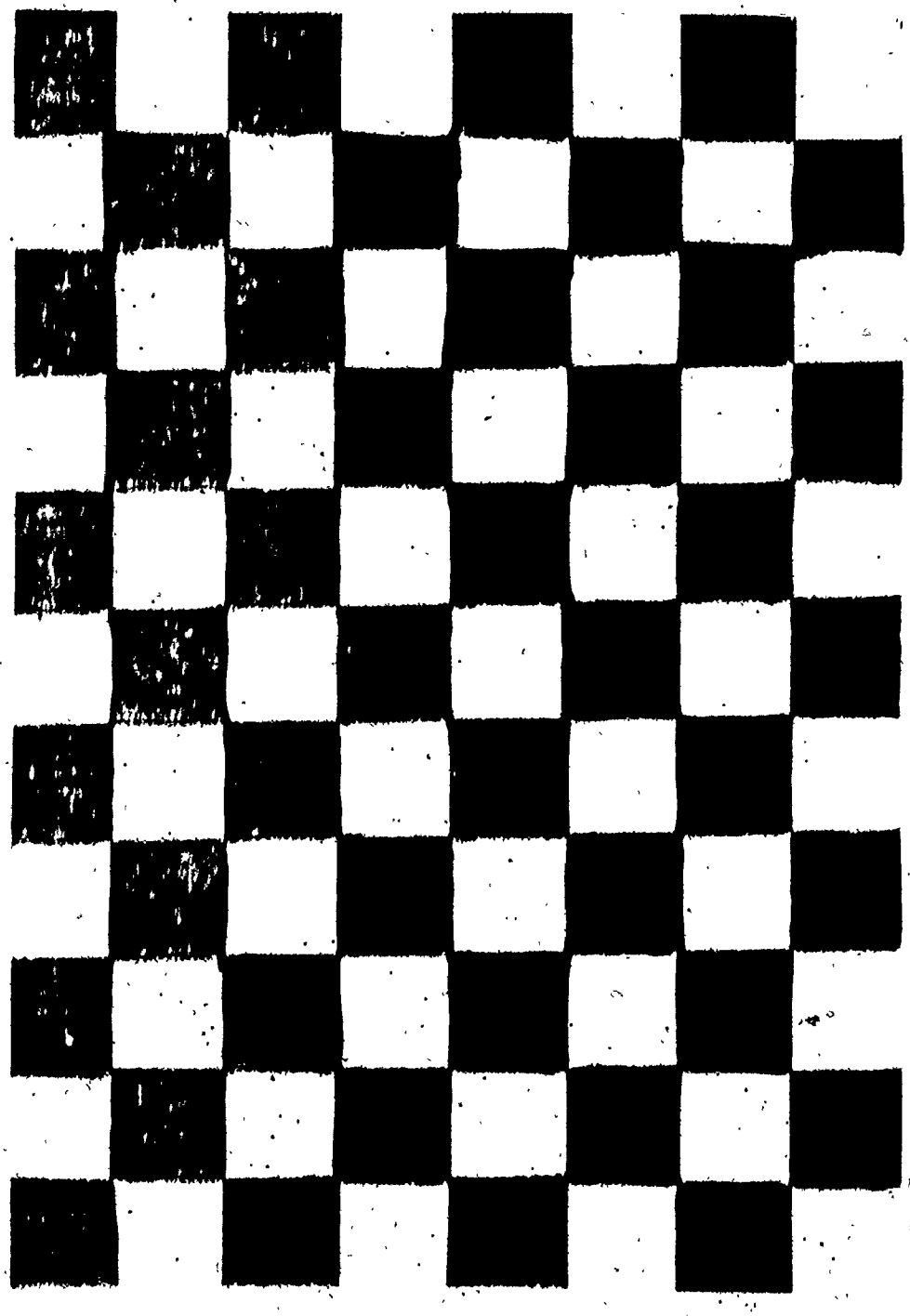


Figure 11

The women in the photographs were mothers of infants that participated in the experiment; some mothers served as strangers for other infants. Before the photograph of each woman was taken she was encouraged to look at the camera and smile naturally, showing her upper or lower teeth or both. All photographs were taken under standard conditions of illumination and background. The range of light reflected by the photographs was 1.20 1.70 log ft L (BBC Exposure Meter). Figure 10 shows some examples of the photographed faces.

Each checkerboard contained 88 squares arranged in 8 columns and 11 rows. Each square was 2"x2". The range of light reflected by the squares was 1.65 (black squares) to 1.95 log ft L (white squares). Figure 11 shows a copy of the checkerboard.

Experimental Design

Table 8 shows the experimental design. There were 8 groups of infants and all groups had three conditions: a visual preference test, a familiarization period and a recognition test. Each test consisted of two 20-sec trials. On each trial the infant was shown a pair of pictures. The pictures were counterbalanced for left-right position within each test. The familiarization period consisted of a 100-sec long trial. Intertrial intervals lasted 1 sec.

In the main group, the mother group, the infant was tested with pictures of the mother and a stranger before and after he was familiarized to the mother's face. In the two strangers group the infant was tested with pictures of two strangers before and after he was familiarized to one of the strangers' faces. In the stranger group the infant was tested with pictures of the mother and a stranger before

and after he was familiarized to the stranger's face. And finally, in the checkerboard group the infant was tested with pictures of the mother and a checkerboard before and after he was familiarized to a checkerboard. There were 14 infants (8 boys and 6 girls) in the mother group, 12 (7 boys and 5 girls) in the two strangers group, 14 (8 boys and 6 girls) in the stranger group and 16 (8 boys and 8 girls) in the checkerboard group.

Procedure

After the experimenter explained the procedure to the parent(s), either the mother or the experimenter placed the baby in the infant seat and adjusted the seat so that the baby's left eye was in the field of the camera, at 11 cm from the stimuli. At the beginning of a session and during the intertrial intervals the room was dark except for the minilamps and lights located centrally; during the trial the pod lights were off and the two lamps behind the infant illuminated the stimuli.

Data analysis and scoring

The data consisted of films of each infant's left eye with the reflections of the reference lamps superimposed on the pupil. The location of these reflections relative to the center of the pupil changed systematically as the infant changed his fixation (see Maurer, 1976, for a detailed explanation of this technique).

To score the data, first the left eye of my eight-year-old daughter was filmed in the apparatus as she fixated specific points in the visual field. Then, for every point she fixated the experimenter drew her pupil with the reflection off it of the reference lights,

After several training sessions the experimenter scored all of the infants' films by comparing each frame to the drawings made previously and then deciding on each frame whether the baby was looking towards the stimulus on the left, the stimulus on the right or off the stimuli. A second observer randomly selected the films of ten babies and independently scored them. Both observers scored the films without knowing the identity of the pictures. Pearson Product-Moment correlations were calculated for the number of frames scored on each side by the two observers. The mean correlation for the fixations on the left was .91 (range: .86 1.00), for the fixations on the right was .97 (range: .86 1.00). The number of frames scored by the first observer were transformed into seconds (6 frames per sec).[1]

Results

Tables 9 to 12 show individual data for each group during the visual preference test, familiarization period and recognition test.

Visual Preference Test Data

For each baby a score for each stimulus was calculated by taking the mean of the two trials. The visual preference data showed that although most babies looked at one picture longer than at the other, the direction of this preference was not consistent across babies in any of the groups.

[1] The total looking time in the entire experiment was probably underestimated by the exclusion of unscorable frames. Unscorable frames were those in which the observers could not determine the direction and location of a fixation because of the poor quality of the film, physical obstruction by the infant's hand or because of saccades or visual fixations which appeared as blurs across the pupil due to rapid head movements.

Table 9

Data from the mother group of the pilot study
(duration of looking time in sec.)

Mother Group

Subjects	Visual Preference Test		Familiarization to Mother		Recognition Test	
	Time looking at		Looking time during		Time looking at	
	Mother	Stranger	1st half	2nd half	Stranger	Mother
1	13.75	5.75	19.25	16.00	2.5	14.75
12	12.75	7.25	21.25	30.75	10.0	18.5
20	16.5	15.75	32.50	15.75	6.75	4.5
34	20.25	17.25	24.00	11.00	24.0	2.5
37	14.0	9.5	24.00	25.75	11.0	12.5
42	46.75	18.25	35.50	41.0	28.25	5.5
43	14.5	21.5	11.00	29.00	11.0	1.5
47	18.0	20.75	35.00	12.00	19.25	14.5
80	5.25	20.5	26.50	26.50	16.25	8.25
91	10.0	22.75	15.25	8.00	6.75	5.25
67	7.25	8.75	18.75	16.75	15.75	14.75
71	5.75	11.0	32.25	18.00	5.75	8.25
74	14.25	10.5	31.75	29.75	17.25	22.25
78	11.0	7.25	28.00	11.25	13.75	10.0
N=14						
$\bar{x}$	12.86	14.16	29.71[a]	24.82	14.88[b]	9.29
sd	4.54	6.06	6.99	9.39	8.58	5.15

a: $t_{13} = 1.86$, $p < .05$ (one tail)

b: $t_{13} = 1.78$, $p < .05$ (one tail)

Data from the two stranger group of the pilot study
(duration of looking time in sec)

Subjects	Visual Preference Test		Two Strangers Group Familiarization to Stranger 2		Recognition Test	
	Time looking at Stranger 1	Stranger 2	1st half	2nd half	Time looking at Stranger 1	Stranger 2
59	5.25	23.0	15.25	14.50	8.75	16.0
62	20.0	15.0	18.00	44.50	17.5	15.75
63b	8.0	10.75	9.75	23.75	.75	27.75
64	17.75	12.5	44.00	46.25	18.0	0.0
81a	10.5	5.5	18.50	18.00	9.25	5.25
85	21.75	21.0	12.50	12.50	7.0	13.00
86	21.25	10.5	28.25	24.50	8.25	18.00
87	11.75	15.25	22.25	26.50	18.5	8.5
88	17.25	17.75	11.75	15.25	10.0	16.0
89	19.25	7.75	16.50	12.75	8.5	3.75
90	4.5	18.75	40.25	35.00	13.0	12.0
91	12.0	20.75	16.50	16.00	22.75	14.25
N 12						
X	13.27	14.79	21.13	23.46	11.52	12.52
sd	5.75	5.58	9.89	8.26	9.71	7.40

Table 11

Data from the stranger group of the pilot study
(duration of looking time in sec)

Subjects	Visual Preference Test		Stranger Group Familiarization to Stranger		Recognition Test	
	Stranger	Mother	1st half	2nd half	Stranger	Mother
14	26.75	38.5	43.25	40.0	9.75	21.25
15	29.25	3.5	38.75	39.0	10.75	12.25
16	17.25	12.75	31.25	20.25	4.5	12.75
22	10.75	3.75	26.25	27.25	0.0	25.0
30	7.5	12.5	12.75	0.0	5.25	9.0
12	15.75	16.75	22.5	29.75	19.25	7.75
13	14.25	16.75	24.0	23.5	13.25	14.0
15	20.75	13.5	23.5	32.25	16.25	3.5
61	5.25	20.5	37.25	28.25	9.25	12.0
64	18.25	16.25	36.0	35.25	13.5	16.25
56	11.0	11.25	40.25	36.25	20.25	25.0
69	13.75	14.25	19.25	42.0	6.25	6.5
70	14.5	13.75	37.0	33.75	7.75	21.75
71	6.0	14.25	23.75	22.25	4.0	7.0
N =	16					
$\bar{X}$ =	15.71	12.1	29.84	29.30	10.43	13.86
sd =	9.04	6.75	8.96	10.78	5.37	7.06

Table 12

Data from the Checkerboard group of the pilot study
(Duration of Checking Time in sec)

Subjects	Visual Preference Test		Familiarization to Checkerboard		Recognition Test	
	Checker	Mother	1st half	2nd half	Checkerboard	Mother
2	15,0	17,0	21,5	16,0	2,75	0,25
19	10,0	17,0	15,0	21,75	4,0	24,5
25	15,75	1,75	27,25	25,0	15,5	10,5
24	11,5	4,5	19,75	18,75	8,25	10,5
31	14,0	11,5	10,0	21,0	9,5	11,75
36	4,0	21,25	11,5	21,75	23,5	2,75
40	17,0	8,0	27,5	11,0	17,5	1,0
45	15,0	15,25	18,0	41,0	24,0	14,0
49	4,0	16,5	16,0	24,5	8,5	20,0
52	9,5	11,5	28,25	19,0	17,25	5,5
53	1,0	10,0	15,5	12,0	6,25	5,75
57	14,5	16,75	19,75	26,0	12,5	12,0
65	18,5	18,5	42,5	41,25	25,25	8,75
68	5,75	17,0	18,5	20,0	6,25	24,25
71	7,0	12,0	11,5	26,75	4,5	12,75
76	12,25	11,0	25,5	22,25	7,75	18,25
	N = 16					
	X = 11,21	15,72	26,5	21,25	11,58	11,14
	sd = 4,97	8,49	8,9	9,47	7,51	8,51

$t_{15} = 1,96$, $p = .05$ (one tailed)

Familiarization Data

In each group, the familiarization data were analyzed for evidence of habituation (i.e., decrement of looking time) to a repeated stimulus. Thus, how long infants looked during the first half of familiarization was compared to how long they looked during the second half.

Babies familiarized to the mother's face looked significantly less during the second half of the familiarization trial than during the first half ($t = 1.86$, $df = 11$, $p < .05$, one-tailed test). The means for the first and second halves were 29.71 sec and 24.82 sec. Babies familiarized to a stranger's face showed no decrement of their looking time during familiarization. This was true in both groups in which infants were exposed to a stranger's face. The means in the two strangers group were 11.11 sec and 12.46 sec, and in the stranger group were 29.00 sec and 20.1 sec for the first and second halves. Finally, infants familiarized to the checkerboard looked significantly less during the second half of the trial than during the first half ($t = 1.94$, $df = 15$, $p < .05$) one-tailed test). The means for the first and second halves were 26.5 sec and 21.25 sec.

Recognition Test Data

During the recognition test infants familiarized to the mother looked significantly longer at the novel face (a stranger's) than at a familiar one (the mother's) ($t = 1.78$, $df = 11$, $p = .05$, one-tailed). The mean looking time at the novel face was 10.80 sec and at the familiar face 9.20 sec. Yet, only 9 of 14 babies looked longer at the novel face of a stranger than at the familiar face of the mother.

Infants familiarized to a stranger's face and then tested with two strangers looked equally long at the two faces: the novel stranger and the "familiar" stranger. Infants familiarized to a stranger's face and tested with the mother's face as the "novel" stimulus tended to look longer at the novel stimulus than at the stimulus they were familiarized to in the laboratory, yet, this result was not significant ($t = 1.50$, $df = 11$, $p < .05$ one tailed test). Finally, infants familiarized to a checkerboard and tested with the mother's face as the "novel" stimulus looked no longer at one stimulus than at the other stimulus.

In this study the three-month-old infant seemed to recognize the face of his mother in a picture after a short exposure in the laboratory, and he appeared to habituate to it. In addition, the infant seemed to discriminate the mother's face from that of another female, after a short familiarization trial with the mother's face. In a preference test, the infant did not seem to recognize the mother's pictured face, nor did he seem to discriminate it from that of a stranger. In addition, the three-month-old infant did not seem to discriminate between photographs of strangers, either before or after a short exposure to one of the photographs. Finally, although the infants seemed to habituate to a checkerboard during the familiarization period, they looked equally long at the checkerboard and at the photograph of the mother either before or after familiarization.

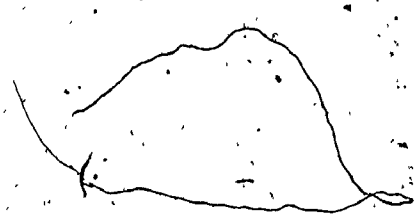
The preference test data on the discrimination between the mother and a stranger is inconsistent with Bigelow's (1977) results.

with infants of the same age) her infants looked longer at a stranger's face than at the mother's face. The main difference between the two studies was that Bigelow used real faces presented singly whereas in this study the faces were photographed and presented in pairs. The fact that infants did not show evidence of such discrimination in this experiment might have been due to one or to several of the following possibilities: the presentation of the pictures in pairs rather than singly (so that side bias might have affected the results), the nature of the faces: printed and smaller than life size (so that the mother's face was not easily recognized), insufficient exposure to the pictures and fixed duration of the trials, (so that the infants did not have sufficient time to recognize the pictures).

There are several reasons why the recognition data on the discrimination of the mother's face from a stranger's face should be taken cautiously. First, in the recognition data the "t" value obtained from the analysis of looking at the novel and at the familiar face in the mother's group was just equal to (not greater than) the score equivalent to .05 alpha level of a one-tailed test. Second, the simultaneous presentation of photographs required that the infant look at one side and then the other side of the visual field in order to see both pictures. However, the infants did not alternate between the pictures as much as one might have hoped. In fact, 24 infants had to be excluded from the study because they looked on one side more than 90% of the time. Moreover, an independent analysis of side bias in the remaining infants showed that infants looked significantly longer at the right side of the visual field than at the left, regardless of the

stimuli (Barrera, Dalrymple & Wilcoxon, 1978) this finding is consistent with previous reports of right-side bias, e.g., Cohen, 1972). Thus, infants' side bias may have weakened the effect of the stimuli in the mother group and masked it in other groups.

Several questions emerge from this study. Why did infants show no evidence of discrimination during the preference test? Why did they show weak evidence of discrimination between the mother's face and a stranger's face? Would infants show discrimination between strangers with a different paradigm? These questions motivated most of the experiments reported in this dissertation. In addition, further evidence of the discrimination of the mother's face from a stranger was needed to support the results in this experiment. One of the purposes of Experiment 1 was to replicate those results using a paradigm which appeared to be much more effective for assessing memory in young infants: the habituation paradigm.



Appendix 2

Table 11

The mean ratings of pairs of faces by the panel of undergraduate student judges.

Pair	Mean	Pair	Mean	Pair	Mean	Pair	Mean
B-G	4.7	C-M1	6.1	B-B	6.9	B-A	7.6
D-C	5.1	M1-M1	6.1	M1-M	6.9	B-M1	7.6
D-G	5.1	C-M1	6.1	DY-D	6.9	B-M1	7.6
B-M1	5.4	DY-B	6.4	A-B	6.9	C-B	7.6
G-A	5.6	B-B	6.6	C-DY	7.0	DY-A	7.6
B-M	5.6	M1-A	6.4	B-G	7.1	DY-M1	7.7
G-M1	5.9	C-A	6.6	C-C	7.1	DY-B	7.7
B-M1	6.0	B-M1	6.6	M1-B	7.1	D-M1	7.7
C-M	6.0	B-A	6.7	C-B	7.1	DY-B	7.7
D-A	6.0	A-M1	6.7	M-G	7.4	D-B	7.9
C-M1	6.1	D-B	6.9	M-M1	7.4	D-M	8.0

Appendix 4

Table 14

Readings of brightness density of 10 faces on four areas of the face.

Areas	Faces									
	M	N	MN	O	R	RY	MI	G	A	G
Forehead	.81	1.07	.85	.81	.86	.85	.84	.94	.80	.91
Left Cheek	.69	.79	.68	.64	.68	.61	.67	.71	.76	.68
Right Cheek	.79	.80	.86	1.36	.86	.97	.69	.97	1.23	1.01
Chin	.88	.94	.90	.91	.91	.82	.88	1.04	.84	.81