Development of Face Perception

ANNIE VINTER *University of Bielefeld*
JACQUES LANARÈS and PIERRE MOUNOUD
University of Geneva

In this paper, we will examine the development of face perception mainly in infancy and analyze to what extent it does reveal a specific process. For that reason, data drawn from object perception as well as from perception of one's own face will be also examined. Studying face recognition in infancy is a complex enterprise because several different abilities intervene in this phenomenon: the modes of visual exploration, the categorization ability, the ability to detect invariances ... . Moreover, the methodological paradigms that investigators have at their disposal are different enough to generally lead to divergent conclusions. For this reason, we will firstly analyze the various methods used to study face perception in infants. There are at least four of them: the habituation paradigm, the preferential looking paradigm, the scanning studies and the imitation studies. Data obtained with these methods will then be closely examined, in relation to the main distinctions suggested by the investigators in that field: holistic/analytic perception; internal/external bias; featural/prototypical. Finally, we will try to offer an overall view of face recognition development which integrates data from the various stages of development.

I FACE PERCEPTION IN INFANCY: METHODS AND GENERAL DATA ON EARLY DEVELOPMENT

I.1 Methods

Face recognition in infancy has been investigated above all by means of two experimental paradigms: the habituation paradigm and the preferential looking paradigm. Faces are probably the most salient pattern stimuli infants are confronted with from the beginning of life. The face is a particularly rich stimulus, in terms of brightness, contour density, contrast, complexity. It can move as a whole or only with regard to its parts (the eyes, the mouth, the tongue). It is also a potential source of multimodal information, visual, auditory (the voice), tactual (kiss, bite, etc ...). A special pool of attraction for infants, faces are equally meaningful sources of information about character, personality, mood, feelings ... for the adult. Adults are also remarkably accurate in face recognition. This accuracy seems to be based on the detection of particular features, such as the vertical positioning of the mouth and of the eyes (Haig, 1985).

Together with the fact that very specific deficits in face perception and recognition can be observed in brain-damaged patients, this particular attraction that faces exert from infancy to adulthood has provoked a lot of studies of how infants, children or adults encode or recognize faces. Both reasons are also responsible for the fairly common idea in this domain, although not empirically well established, that faces are 'special', i.e. that a face-specific process exists (Yin, 1970a, 1978). Processes underlying face recognition are supposed to be different from those responsible for the recognition of other objects (Scapinello & Yarmey, 1970; Yarmey, 1971). Yin (1970b) showed that faces are better recognized than houses in upright presentation but less well in inverted presentation. Face recognition, at least in adults, is based on holistic-social strategy encoding, which means that adults pay attention to the whole face and equally code the face according to some social experience, whereas feature analysis is the more common strategy for recognizing objects (Yin, 1978). The distinction highlighted here is between a holistic and analytic (or featural) mode of perception, or between an undifferentiated and a differentiated perception (Werner, 1957). This distinction is also used by some authors for characterizing hemispheric specialization, the left hemisphere being more specialized for an analytic and fragmentary mode of perception, the right hemisphere for a holistic and unitary mode (Sperry, 1974; Morais, 1982). Yin (1978) in fact considers face-specific processes to be localized in the right hemisphere.

Interestingly, as far as development is concerned, face perception has been described as evolving from a piecemeal to a configurational mode of representation during childhood (Carey, 1982; Carey & Diamond, 1977), as well as during adolescence in a self-face recognition task (Mounoud & Vinter, 1984). But a similar trend has also been found in infancy by investigating perception of part-whole relations in objects (Bower, 1966; Miller et al., 1976) whereas a reverse trend, going from integral to separable dimensions, has been identified in object perception in children (Shepp, 1978; Kemler, 1983). This suggests firstly that either face or object recognition development are more complex than a shift with age from an analytic to a holistic perception, or vice-versa, and secondly that normal development does not give convincing evidence to the idea of the specificity of face perception processes. Habituation studies are essentially aimed at studying the generalization ability of the baby, and also at investigating discrimination abilities. The rationale of the method is that confronting a baby with the same stimulus several times will regularly decrease his looking time. A stimulus presented when the habituation criterion is reached (usually when looking time is half the time of the first presentation) will increase the baby's looking time if the stimulus seems new to him. The second method essentially used to study discrimination abilities is the preferential looking method. It is assumed that some visual characteristics of the stimulus are attractive to the baby. Consequently, if he spends more time looking at one stimulus rather than the other, it is concluded that he is able to distinguish between them.

These methods are very different one from the other. Whereas in a habituation study, the stimulus to be discriminated is presented subsequently to the familiarized stimulus, in a preferential looking study the stimuli to be discriminated are presented simultaneously. This implies that the first method is more similar to an evocation task, the second to a recognition task. That is, that perception of the whole is required more in the first than in the second task whereas perception of differences or isolated features may underlie performance in the second. It might thus be easier, for infants at certain ages, to resolve a task with an habituation paradigm rather than with a preferential looking technique, or vice-versa. For instance, La Barbera et al. (1976) found that 4-month-old infants are able to discriminate between two facial expressions by using a preferential looking technique, while Caron et al. (1982), using an habituation technique, failed to obtain any discrimination between facial expressions at the same age. Infants, at this age, might be able to differentiate two facial expressions on the basis of particular features, which ability is more easily revealed by a preferential looking technique. Within the same perspective, the degree of similarity of faces is a very important factor when a subject has to judge whether two faces are identical or not. If the selected faces are rather different, an isolated feature may be sufficient to allow a non-identity judgment. On the contrary, if they are highly similar, analysis of the whole configuration of the face is required. The degree of similarity of faces may thus be determinant in revealing one form of perception or the other.

A third method used to study face recognition consists of monitoring and analyzing eye movements. These scanning studies allow the determination of where the baby looks and on which regions of the stimulus he spends more time.

Finally, even if it has never been used to study face recognition, we may mention imitation of facial gestures as a potential method for indicating which features of the face, together with their movements, are discriminated by the infant. The basic assumption is that in order to reproduce a facial gesture, the subject must possess a representation of the face which at least includes the part of the face involved in this movement. This implies that this method is not suitable at certain ages, namely when the infant is discovering the features of the face (i.e. is constructing a representation of the face), but is adequate when this knowledge has been achieved.

Whichever method is used, faces themselves, as stimuli in an experiment, can be presented in at least four different ways: animate or immobile live face, moving or static schematic face. Animate live faces are clearly the most natural and representative stimuli but, with schematic face displays, specific features and feature combinations can be varied systematically to assess the infant's sensitivity to them. Both the methods and the kind of representation of the face selected must be carefully considered in order to understand the results obtained. In the next paragraph, general data on early aspects of face recognition will be reviewed. They show, for instance, that imitation, as a method, is adequate mainly in the study of the neonatal period.

I.2 General Data on Early Aspects of Face Perception

From a very early age, infants respond differently to animate real faces and inanimate objects. A 6-week-old infant fixates a toy and follows it with his gaze when it is moving, but, when interacting with his mother, his attention follows a cycle of alternating interest and withdrawal, as if expecting a response from her (Brazelton et al., 1974). In fact other studies have shown that infants from 6 to 16 weeks become distressed and upset when facing their unresponsive mother (Fogel et al., 1979), but are not disturbed by other unmoving stimuli (Tronick et al., 1975). This expectancy of 'responsiveness' also seems higher with regard to the child's own mother than with regard to strangers. Four-week-old infants look significantly less at their immobile mother's face than at the passive face of a male or female stranger, as if they felt discomfort seeing a non-responsive mother (Maurer & Salapatek 1976).

A mother moves her head, makes different facial gestures, adopts different facial expressions, speaks and sings, and from birth, infants seem sensitive to this kind of information. Imitation studies have demonstrated that newborns or 1-month-old infants are able to reproduce three different facial gestures (tongue protrusion, lip protrusion, mouth opening-closing) as well as the lateral head movement, and to discriminate between, and imitate, three different facial expressions: happiness, sadness and surprise (Maratos, 1973, 1982; Meltzoff & Moore, 1977; Field et al., 1982; Fontaine, 1982; Vinter, 1983). Although facial imitations appear most differentiated, infants during the first month of life also reproduce two hand movements, the hand opening-closing and the sequential finger movement (Meltzoff & Moore, 1977; Vinter, 1983). These data indicate that from birth infants have a sufficient knowledge of some facial and manual features and their movements to guide and match their own movements. This innate body-representation is clearly fairly general but rather precise as far as the face, and more particularly the mouth region is concerned. Nevertheless we shall mention that some investigators have failed to obtain imitation of almost all the models outlined above in the first months of life, but several methodological shortcomings characterize these studies (Hayes & Watson, 1979; Koepke et al., 1984; MacKenzie & Over, 1984; See Meltzoff & Moore, 1983 and Vinter, 1983 for methodological comments).

Up to now, data are lacking for an understanding of what features or combination of features infants are responding to when they imitate. Vinter (1986) has shown that movement is an essential property in eliciting facial and manual imitations at birth. It might be interesting to know to what extent the 'face-ness' of the model plays a role in this phenomenon and whether, for instance, the presence of features such as the eyes or the nose are also important in eliciting facial imitations, i.e. to what extent this ability at birth is based on a holistic or featural perception of the face. People are also responsive to infants by speaking to them. Do young infants expect the visual appearance of a face to be associated with auditory stimulation? The literature on auditory-visual coordination cannot be reviewed here because it is slightly off the subject, but it turns out that newborns, 1-month-old and 4-month-old infants expect a face and a voice to share a common spatial location (Aronson & Roosenblum, 1974; Vinter et al., 1984). Three-month-olds also expect mouth movements and the voice to be synchronized as shown by Dodd (1973), and Spelke and Cortelyou (1981). More surprisingly, very young infants are able to mimic the mouth and hand movements associated with speech, what Trevarthen (1979) calls 'pre-speech' activity.

Thus, from the data presented so far, it can be assumed that newborns or

1-month-old infants possess a schema of the face in which some internal features are represented and which integrates different sensory modalities. This conclusion appears, at least partially, to contradict data more directly related to face recognition. From these other studies, it seems that the face, as a particular combination of different features, is distinguished from face-like stimuli only at around 4 months. It is true that newborns eye-track more a moving schematic face than other similar stimuli (Goren et al., 1975) and that 2-week-old infants look preferentially at a human face (Fantz, 1966), but, as Carey (1981) points out, differences between stimuli in terms of contrast, complexitity ... might very well be responsible for this preference. In fact, Haaf and Bell (1967) report that the more the stimulus is face-like, the longer 4-month-olds look at it, whereas younger infants look preferentially at the more complex stimulus.

To assess to what extent faces are discriminated from face-like stimuli, differential responses of infants to regular faces in upright position and inverted or scrambled faces, or faces with features missing, have been compared. To differentiate between a regular face and a scrambled face, infants must be able to pay attention to the internal features of the face.

Watson (1966) reports that smiling and fixation time peak at 11 weeks for upright faces but not for disoriented faces. It has been confirmed that 3 1/2-month-olds prefer upright faces to inverted faces (MacGurk, 1970; Fagan, 1972). They also distinguished a normal face from a scrambled face, smile more at the regular face than at a scrambled face or at a blank face or a face without eyes (MacCall & Kagan, 1967; Haaf, 1977). These studies with scrambled faces suggest that infants need to be around 4 month-old before they can represent some internal features of the face. However, a more recent study reveals that at already 2 months, but not at 1 month, infants can discriminate a regular schematic face from two different scrambled arrangements and prefer to look at the natural face (Maurer & Barrera, 1981). They are also able to discriminate between symmetrically and asymmetrically scrambled faces. The authors suggest that differences in periods of time infants are exposed to the stimuli – longer in the last study – may be responsible for the differences in the results. If we remember that smiling at the human face appears between 2 and 3 months and is elicited by a Gestalt in which some internal features are represented (Spitz, 1957), it makes sense to think that infants do discriminate between natural and scrambled faces before 4 months.

The next step is to discover the salient aspects of the face that attract the baby, and, also at what age he is able to perceive the features of the face in detail.

I.3 Face Perception in Infancy: What Features are Perceived?

I.3.1 Discrimination of external/internal features

It has been shown that 4-month-olds do not notice modifications in the mouth-nose configuration but in that of hairline-eyes, suggesting that the lower part of the face is not discriminated. Changes in nose and mouth are noticed later, at 5 months

(Caron et al., 1973). The upper half of the face seems to become meaningful as a human face before the lower half does. Haaf, Hull-Smith, and Smitley (1983) reported that ten-week-old infants respond to qualitative variations among stimuli (number of elements in facelike patterns) rather than to differences in pattern configuration, whatever the technique may be (fixed trials or infant-control procedures). Habituated with a live face, 5 month-olds do not dishabituate when presented with a photograph of the same person or of a person of the same sex, same hairstyle and haircolor, but dishabituate with a photograph of a person of a different sex, hairstyle and haircolor (Dirks & Gibson, 1977). On the contrary, Spelke (1975) found that 4 and 51/2 month-olds look longer at the new person during the test even if she is of the same age, sex and coloring as the woman to whom they were habituated.

The first two studies suggest that discrimination between faces at 4–5 months is based on gross features like hairstyle or haircolor; the face as a whole, as a unique combination of different internal features (eyes, mouth, nose ...) and external contour are still not discriminated. Spelke's study does not support this view but the crucial point might be that the degree of dissimilarity between the habituated and the new person is still high enough to allow a recognition based on a partial encoding of the faces.

Other studies support the view that 5-month-olds do not encode the face as a unique configuration of particular features. Four-and 5-month-olds are able to discriminate between highly dissimilar faces, – a man from a woman (Fantz, 1972; Cornell, 1974), a woman from a baby (Miranda & Fantz, 1974; Cohen et al., 1977) – and between 3/4 views of highly dissimilar men (Fagan, 1976), probably thanks to an encoding of gross features, but they fail to distinguish between highly similar men (Fagan, 1976). It is at around 7 months that they become able to make such fine discriminations, although they still have difficulties in differentiating between highly similar inverted faces (Fagan, 1979). It is also at around 8 months that the 'reaction of fear to a stranger' is traditionally described (Spitz, 1957). Such a reaction presupposes that each new face can be encoded in details in order to assess its degree of familiarity, whatever may be its similarity or dissimilarity with familiar faces.

Thus recognition of faces in early infancy seems to evolve from an analytical or featural level to a holistic or configurational level. Such a trend also characterizes the processing of part-whole relations in object perception, although the shift is more precocious in the latter case (Bower, 1966; Cornell & Strauss, 1973; Miller, 1972; Miller et al., 1976). These studies, which have a gestaltist flavor, have investigated whether or not infants respond equally to a compound figure and to the sum of its elements. It turns out that at less than 4 months, infants perceive the whole as equivalent to the sum of its parts, but after 4 months, they respond differently to a unique configuration (the whole) and to the set of its individual elements.

I.3.2 Discrimination of facial expressions

The discrimination of facial expressions might also be a valid indicator of the ability to process internal features of the face but the data are again not consistent with regard to the age at which infants are supposed to differentiate between facial expressions. We have already mentioned the Field et al. study (1982) which shows that neonates discriminate between various facial expressions and imitate them. Barrera and Maurer (1981) demonstrated that 3-month-old infants differentiate their mother's smile or a stranger's smile from frown. They can also discriminate a happy from a surprise – but not from a sad – expression (Young-Browne et al., 1977). Interestingly, McGrath (1983) reported that 3-month-olds can discriminate upright as well as upside down photographs of happy, surprised, and angry expressions. This may suggest that discrimination of facial expressions at this age is based on some unspecified physical difference between the stimuli. Four-month-olds prefer a joy expression to an anger or neutral expression but do not show any preference for one of these latter (La Barbera et al., 1976). Schwartz, Izard, and Ansul (1985) confirmed that 5-month-olds are able to discriminate between fear, sadness and anger expressions, and suggested that the paired-comparison novelty technique may underestimate the infant's ability to detect differences among stimuli of different social or emotion-signal value.

Caron, Caron and Myers (1982) failed to obtain any discrimination between facial expressions at 4 months; on the contrary, 51/2-month-olds differentiate a surprise from an happy expression following habituation to happy faces but not the reverse, and 7-month-olds are able to differentiate between happy and surprise expressions. Caron *et al.* (1982) argued that younger infants might have made a differentiation between facial expressions on the basis of alterations of isolated facial features, such as a contrast between wide and narrow eyes, for instance. On the contrary, in their study, they tried to assess the infant's ability to discriminate between facial expressions on the basis of a change in some kind of facial gestalt rather than in a single isolated element. These authors examined more precisely this issue in a recent study (Caron et al., 1985) and reported that even 7-month-olds were more responsive to differences in isolated features (in particular, toothiness of the mouth) than to change in emotional expressions *per se*. It appears that prior to 9 months infants have difficulty extracting emotional information from static displays. The authors suggested that by using static stimuli, the actual ability of the infant to recognize facial expressions may well be underestimated.

I.3.3 Detection of invariances

The 6-7-month-olds are not only able to differentiate between very similar faces but they are also able to detect abstract invariances in faces (Harris, 1983). One of these abilities is that of shape constancy. Six 1/2-month-olds recognize the same face in different orientation: they respond to a man as familiar even if they were habituated to another position of this man. They equally detect an invariant orientation of different faces, by responding to a position as familiar even if the face presented during test is different from that presented during the familiarization exposure (Fagan, 1976). Cohen and Strauss (1979) confirmed the ability of 7-month-old infants to conceive the invariance of a face with different orientations. Infants aged less than

30 weeks, on the contrary, dishabituated when they were shown the same woman used during familiarization in a novel pose.

Shape constancy with objects different from faces seems to operate earlier, by around 3 months. In a study by Bower (1966), 2-month-olds were conditioned to turn their heads in response to a rectangle slanted 45° relative to their line of sight and tested under conditions of same or different projective and objective shape objects. They responded equally to conditions in which the stimulus had the same objective shape as the conditioned stimulus. Studies by Day and McKenzie (1973), Caron, Caron and Carlson (1979), using a somewhat different technique, support the hypothesis that shape constancy is present by around 3 months. Seven-month-olds seem capable of treating different instances of the same class of faces as similar to one another, and of conceiving a face as an exemplar of a category. Fagan (1976) reported that 7-month-olds responded to invariant sexual facial characteristics by identifying a face as familiar even if another example of that same-sex face had been presented during familiarization. He has defined the conditions under which such a capacity to construct a 'male faces' category can be detected (Fagan, 1979). Infants must have been shown several exemplars of this category to be able to transfer habituation to a novel face of the same category. For instance, if they were presented with only one male face during familiarization, then they dishabituated equally in response to a novel man as to a woman. Cohen and Strauss (1979) have reported similar results.

Some authors have tried to analyze the processes upon which categorization can be based. One of these processes is that of averaging. Ten-month-olds were habituated with faces varying in the length of nose and in the distance between the eyes. They then perceived as familiar a face containing the average of these values of length of nose and distance between the eyes (Strauss, 1979). Thus infants would extract a prototype by averaging the different faces. Counting constitutes another important process for categorization and seems likely to occur when feature values are discontinuous, such as form, color ... (Harris, 1983).

I.3.4 Why are external features detected before internal features?

(a) *Externality effect:* Part of the data reviewed so far suggest that development of face recognition may be dependent on the ability to scan the internal features of the face. Indeed scanning studies tend to confirm this link. Scanning studies show that 1-month-old infants pay attention to the external contours of a real face (hairline) whereas 2-month-olds scan also the internal features, more particularly the eye region (Bergaman et al., 1971; Maurer & Salapatek, 1976; Hainline, 1978). This 'externality effect' is also obtained with a compound pattern (Salapatek, 1975; Haith et al., 1977), and is equally present at birth: newborns prefer curved lines to straight lines but do not discriminate between them when the lines are internal elements of a compound figure (Fantz & Miranda, 1975). This 'externality effect' has been reexamined these last years and it appears to be influenced by at least three different parameters, whether it refers to faces or to physical objects (Banks & Salapatek, 1983).

The size of the internal figure relative to the compound figure constitutes one of these parameters. One-month-old infants have a bias for processing the largest figure in the field (Milewski, 1976, 1978). The presence of relative motion is a second parameter. Girton (1979) showed that 1-month-old infants discriminate an eyes substitution in a schematic face with moving eyes. Coherently, infants at 1 month discriminate changes of the internal figure when it flickers or is moved within the external figure, but not when both move together or when the component is static (Bushnell, 1979). With respect to this finding, we may point out that, in the imitation studies, the 'internal feature' of the face (the mouth) is in motion and that the presence of movement appears to be an important determinant for eliciting imitations (Vinter, 1986). Finally the salience of the internal figure or element is important. If it is a bull's eye or a checkerboard, highly prefered stimuli, it can be discriminated even at 1 month (Ganon & Schwart, 1980). Maurer (1983) discovered a similar effect in the scanning of a schematic face which, according to her, constitutes a more salient stimulus than a real face. Newborns and 1 month-old infants scan the internal elements of the schematic face for at least half the time. Hence, if we remember that infants, in real life, are confronted with animate and moving faces and not with static displays, it is very likely that, from the beginning of life, they attend to internal features of the face as well as to the external contours, but are more attracted by these contours.

(b) *Processing of visual frequencies*: Neurophysiological data on the resolution power of the infant's visual system may be very important for an understanding of what is called the 'externality effect', and of why gross features of the face are discriminated by the infant before fine details. The visual system of the newborn is immature specifically with respect to the processing of spatial frequency bands. Sensitivity to middle and high spatial frequencies undergoes a marked development during the first months of life. Indeed, a one-month-old baby is sensitive to a 1c/deg sine wave grating whereas a three-month-old also responds to 5c/deg gratings (Marq et al., 1976; Atkinson, 1977). It appears then that during development low spatial frequency channels are operating before higher spatial frequency channels. These findings have direct implications for face perception in infancy. Firstly, details of a visual stimulus cannot be perceived when only low frequencies are available. Therefore, the development of higher frequency channels than those operating at birth might partially explain improvement in face perception, although this hypothesis has not yet been experimentally tested. Secondly, the role of spatial frequencies in face perception has been investigated in psychological (Tieger & Ganz, 1979; Woodhouse, 1976) and neuropsychological (Sergent, 1982) studies. It turns out, from these studies, that a face can be recognized on the basis of low frequencies, but that some discriminations require middle and high spatial frequencies. In other words, information contained in low spatial frequencies might be sufficient to discriminate very dissimilar faces. This discrimination might be made on the basis of the contour and may explain the 'externality effect'. But processing of internal details of the face requires middle and high spatial frequencies. Moreover, when a visual stimulus is projected, low spatial frequencies are available first and it seems that the right cerebral hemisphere best deals with this kind of information. This might explain some aspects of the right hemisphere superiority in face perception, but also suggests than when higher spatial frequencies are necessary, both hemispheres must be involved.

II FACE PERCEPTION IN CHILDHOOD AND ADOLESCENCE

Data presented in the previous sections show that face perception undergoes a complex development in infancy. Part of the ability to discriminate the features of faces, present at birth, seems to disappear later. Moreover, a shift from a piecemeal to a configurational strategy in encoding faces characterizes the first year of life. Thus face perception seems to undergo a first reconstruction process soon after birth. The processing of faces that underlies abilities such as neonatal imitation or pre-speech, is certainly different from that which develops during the first year of life. But development of face perception appears to be still more intriguing when childhood and adolescence are considered, whether it refers to the faces of others or to one's own face.

II.1 *Recognition of Faces of Others*

This development has been extensively investigated by Carey and Diamond (1977; Diamond & Carey, 1977; Carey, 1981; 1983) and by Flin (1980, 1985a). In some experiments, the child was shown some photographs of familiar or unfamiliar faces and is told that he would have to recognize them later. Photographs were then presented in pairs during recognition trials. Simultaneous matching tasks were also used, in which the child had to judge whether or not two photographs of faces differing in expression, pose, clothing … , depicted the same person. One aspect of Carey and Diamond's results shows a steady improvement in the recognition of unfamiliar faces between 6 and 10 years. This result has been equally observed in other studies (Goldstein & Chance, 1964; Kagan & Klein, 1973; Blaney & Winograd, 1978; Flin, 1980; Grusser et al., 1985). A similar improvement is also obtained with the simultaneous matching task, which perhaps requires a more abstract encoding of faces (Salz & Siegel, 1967; Benton & Van Allen, 1973; Carey *et al.*, 1980). But this improvement is limited to the case of upright faces. When confronted with inverted faces, no significant increase in encoding familiar faces is observed between 6 and 10 years (Carey & Diamond, 1977; Carey et al., 1980). Flin (1985a) confirmed that the developmental trend is less pronounced with inverted faces than with upright faces, but observed nevertheless an improvement in acuracy between 7 and 11 years in recognition of inverted faces. There is also relatively little develomental change between 5 and 10 years in the recognition of highly familiar faces (Diamond & Carey, 1977), although efficiency in encoding familiar faces seems to increase between 4 and 6 (Goldstein & Mackenberg, 1966; Chance et al., 1967).

But more interestingly, Carey and Diamond have tried to understand which process underlies face recognition at different ages. They have found that young children based their recognition judgments essentially on salient piecemeal features: when two different persons matched in paraphernalia (hat, eyeglasses ...) were presented, 6 and 8 year-olds judged them to be the same person. This attention to accessories and other extraneous features to the face declines with age. On the contrary, by around 10 years, children attended to the total configuration of facial features. Thus between 6 and 10 years, there is a shift in unfamiliar faces recognition from a featural to a holistic representation. It means that a qualitative change, not only a quantitative change, in face recognition takes place between 6 and 10 years. Finally, these authors observed a very intriguing further development during adolescence: a decline in performance by around 14-15-16 years. A similar U-shaped development in unfamiliar face recognition has been found by Flin (1980), although there are some differences in the exact ages at which the decline in performance is observed. But Flin (1985a) criticized Carey's position according to which there is a shift in unfamiliar faces recognition from a featural to a holistic representation. The tendency of young children to select incorrectly paraphernalia cues as a basis for identity judgments might be dependent on the level of difficulty of the task, in particular on the degree of similarity of the faces paired in each trial. According to Carey (1979, 1983), maturation might strongly contribute to the shape of the developmental course of face encoding, in two different ways: first, limits in performances of children aged less than 9–10 years may be explained by an immaturity of some aspect of neural substrate; second, temporary regression in face encoding may be due to a maturational event associated with puberty. In relation to this suggestion, we may point out that a U-shaped-development is not specific to faces recognition at early adolescence, but can be also observed with picture recognition (Flin, 1985b) or voice recognition (Mann et al., 1979).

II.2 *Self-recognition*

Mounoud and Vinter (1981, 1983, 1985) have studied the development of recognition of one's own face, by using a deforming mirror which, due to the bending of its surface, can make the face fat or thin. The subject had to adjust the position of the mirror until it reflects his 'objective' image. A non-linear progression, in terms of precision and stability of the images selected by the children, has been shown between 3 and 15 years. In short, 4 and 5-year-olds as well as 11-12-13 year-olds chose imprecise and unstable images, while 3, 6 and 14 year-olds chose precise and stable images. Between 7 and 10–11 years, children selected less precise or stable images than 6 year-olds but more precise than 4 and 5 year-olds or 12–13 year-olds. Mounoud and Vinter suggested that a choice of precise and stable images is mediated by a configurational or holistic perception whereas a featural perception may be responsible for the selection of imprecise and unstable images. This implies that recognition of one's own face evolves from a featural to holistic and to a combined or intermediary kind of perception from 4 to 10 years, and then again from a featural to a holistic perception between 11 and 14 years. But we must point out that a reverse shift, from a holistic to a featural representation, can also be described between 2–3 and 4 years. Although the exact ages at which the shift takes place differ in the Carey and Diamond studies and in the Mounoud and Vinter studies (it could be suggested that recognition of one's own face develops faster than that of others'), a similar transition, at least apparently, from a piecemeal to a holistic perception between 4 and 10 years is described in both studies. We may wonder if this trend reveals a general evolution of the child's cognitive abilities, which would equally be apparent in a non-face perception task.

II.3 *Object perception*

Interestingly, a reverse trend is more often obtained in tasks such as classification of objects, conservation of properties, concept-learning task ... , according to Shepp (1981, 1983) or Kemler (1983). Three and 4-year-olds tend to produce similarity-based classification for instance, which means that they treat the objects as undifferentiated wholes and relate them according to overall similarity. On the contrary, older children (around 10 years) produce dimensionally based classifications, which means that they treat stimuli as analyzed sets of dimensional components. These results would suggest that face recognition is a special process if we had no doubt that what is called analytic or featural perception on the one hand, configurational or holistic perception on the other, are diversely defined by the authors and do refer to different psychological processes. For Kemler (1983), the holistic perception involves undifferentiation whereas it seems clearly not the case for Carey. It is rather the piecemeal mode of perception which implies undifferentiation to the extent that the identity of the whole is confused with the presence of single and isolated features. We would like to suggest that the undifferentiated/differentiated distinction, in addition to the analytic/holistic distinction, could help to interpret face perception development.

II.4 *Specificity of Face Perception Processes?*

Most of the evidence in favor of the specificity of faces comes from the neuropsychological pathology, in particular from cases of prosopagnosia (i.e.) patients unable to recognize people (and sometimes themselves) by their face. The specificity of the deficit for face recognition in comparison with recognition of other objects has led authors to assume the existence of a special cortical area responsible for face information processing. Some experimental data with animals support this hypothesis. Perrett et al. (1982) for example have shown that some cells in the monkey's temporal lobe respond uniquely to faces (20% of the 500 cells tested).

But the thesis of face specificity can also be contested by detailed analysis of clinical cases, as well as by experimental data. Firstly, it has been suggested that several different kinds of prosopagnosia exist (Hécaen, 1981; Bruyer, 1983; Bruyer et al., 1983; Assal & Lanares, 1985), which does not offer any support to the thesis of a unique function associated with a unique cortical location. It is possible to observe patients who present a major deficit in the recognition of other kinds of stimuli, such as birds (Bornstein, 1962), or cows (Assal & Favre, 1984), or a similar deficit in recognition of the faces and cars (Lhermitte et al., 1973). And, from Benton & Allen (1973), it is also known that deficits in face recognition may be more important with regard to familiar faces than unfamiliar faces. Moreover, some aspects of the face, such as its expressions, may be adequately perceived while the particular face is not recognized (Lanares & Assal, 1984). Secondly, data from split-brain subjects in face recognition tasks and from normal subjects in tachitoscopic studies show that both hemispheres are probably involved in face recognition processes (Levy et al., 1972; Sergent, 1982). Face information is probably processed by immediately extracting the low spatial frequencies (major role of the right hemisphere), and secondly the high spatial frequencies (major role of the left hemisphere).

Thus, it seems that face perception cannot be reduced to a question of specificity, and, it does not seem satisfactory to postulate a unitary function for face perception. We rather think that information conveyed by the face can undergo different processings, and that the nature of the processing is the result of the interaction of several variables, such as task demands and conditions, stimulus characteristics, brain potentiality, etc. Further research is required to demonstrate these interactions in early development.

III IN SEARCH OF A GENERAL INTERPRETATION

A complex image of face perception development emerges from this review. Very early in life, infants behave differently in front of inanimate objects and humans. They seem to expect the latter to be 'responsive', to act through gestures or sounds. More astonishing still, newborns and 1-month-old infants are able to imitate some facial gestures and expressions, to conceive that a face and a voice should share a common spatial location and to mimic the lip and hand movements of a speaking person. These behaviors indicate that, at birth, infants possess an intermodal face schema (and more generally body schema), in which internal features are represented. But many of these behaviors disappear in the first months of life, and a 3-month-old appears less efficient, in some respect, in face encoding. Before 4 months of age, infants progressively (re)discover some features of the face. The hairline is the first which becomes meaningful for them, probably due to a preference for scanning external contours. Some isolated features are sufficient to allow a discrimination between upright and inverted faces, between regular and scrambled faces, and probably to permit a rudimentary discrimination between facial expressions. Between 4 and 6 months, infants' perception of the face becomes more holistic; a face begins to be represented as a unique combination of features. Differentiation between highly similar faces is then possible. Later, face perception develops towards a categorical form of perception.

Face perception is thus initially based on a syncretic perception at birth, then on a featural perception, and then on a holistic perception. Similar shifts are repeated during childhood and adolescence: from a syncretic to a featural perception between 2 and 4 years, and then from a piecemeal to a holistic perception between 4 and 6 years and again between 12 and 14 years according to Mounoud and Vinter's studies. The second shift is located between 6 and 10 years in Carey and Diamond's studies.

How can we understand this complex development? Firstly it appears necessary to define stages in development, i.e., periods in which discontinuity predominates. The first discontinuity appears during the neonatal period, which can be considered as the first stage, or more likely, as the achievement phase of a first stage. We call this stage sensori-motor stage (Mounoud 1979, 1981; Mounoud and Vinter, 1981). A second one, the perceptivo-motor stage, is constructed from birth until around 18–24 months. The third stage, the conceptuo-motor stage, characterizes the period between 2 and 9–10 years and finally the semiotico-motor stage takes place between 10–11 and 16–18 years. The onset of a stage is determined by a maturational process which makes possible the use by the child of a new code in order to represent reality as well as himself. By means of the code, the child constructs particular knowledge about objects or himself. The nature of this knowledge, called representation, is dependent on the nature of the code available to him (sensorial, perceptive, conceptual or formal).

Within each stage, face perception undergoes a new (re)construction, which can be described by using the holistic-analytic and the undifferentiated-differentiated dichotomy. The development sequence we will propose is rather speculative but can be supported by some of the data presented above. For a set of reasons that cannot be specified here (see Mounoud and Vinter, 1981; Vinter, 1983, 1985), it is likely that undifferentiated and holistic representations qualify the neonatal period and make possible global behaviors such as imitation of facial gestures or pre-speech activity. These representations, called sensorial, allow some kind of discrimination of facial features without their being related to objective faces by the newborn. This step is repeated by around 2 years and 10 years; this may clarify why a holistic perception again characterizes children at these periods. With the onset of the perceptive code, abilities related to face recognition disappear and are reconstructed at a higher level. The construction process takes place in 3 steps. *Firstly*, the infant (re)discovers some isolated features of the face (the hairline, the eyes), these being sufficient to permit a recognition of the whole face. Representations are analytic (isolation of features) but still undifferentiated (confusion between the whole and the parts). Performances of infants aged between 2 and 5–6 months in face encoding belong to this phase. This step is repeated at around 4–5 years and 12–13 years according to Mounoud and Vinter's studies and also corresponds to the phase Kemler, unfortunately, calls holistic. It equally corresponds to the period of piecemeal perception of the face in Carey and Diamond's study although it seems to last between 6 and 9 years in this study. *The second step* is characterized by holistic and differentiated representations: the face is conceived of as a unique combination of features. Precise discriminations between similar faces are possible. Discrimination of facial expressions can be based on a perception of the expression per se. It occurs between 7 and 10 months. It is repeated by around 6 years and 14 years according to Mounoud and Vinter, 10 years according to Carey and Diamond. *Finally*, during the third step, representations become analytic and differentiated. Infants are able to establish equivalences between faces, to categorize them in the sense that, while being perfectly able to discriminate between them, they are simultaneously able to conceive of two faces as identical with respect to isolated features. We would expect this step to be achieved during the second year of life and not at around 10 months as some of Fagan's studies suggest it to be. It exactly corresponds to the phase of analytic thought described by Kemler or Shepp and which appears by around 9–10 years. By around the same age, Mounoud and Vinter have also shown recognition of one's own face to be analytic and differentiated.

Thus this theoretical sequence finds some empirical support, and in particular, allows us to understand some paradoxes such as the fact that a holistic perception can occur at different ages or that a shift from a holistic to an analytic perception and the reverse can simultaneously be observed in development. But the relatively poor agreement between studies with respect to the exact ages at which these shifts take place raises some theoretical problems which require further investigation in order to be better understood. Accurate task analysis of the different studies seems to be strictly necessary for an understanding of the eventual divergences.

REFERENCES

ATKINSON, J., BRADDICK, O., MOAR, K., (1977) 'Development of Contrast Sensitivity Over the First Three Months of Life in the Human Infant.' *Vision Research*, 17: 1037–1044.

ARONSON, E., ROSENBLOOM, S. (1971) 'Space Perception in Early Infancy: Perception within a Common Auditory-visual Space.' *Science*, 172: 1161–1163.

ASSAL, G., FAVRE, C., ANDERES, J.P. (1984) 'Non reconnaissance d'animaux familiers chez un paysan.' *Revue Neurologique*, 140: 580–584.

ASSAL, G., LANARES, J. (1985) 'Face Recognition.' Paper presented at the meeting of the European Brain and Behavior Society: Zurich.

BANKS, M.S., SALAPATEK, P. (1983) 'Infant Visual Perception.' In P.H. Mussen (Ed.), *Handbook of Child Psychology Vol. II. Infancy and Developmental Psychobiology*. New York: Wiley.

BARRERA, M.E., MAURER, D. (1973) 'Recognition of Mother's Photographed face by Three-month Old Infant.' *Child Development*, 52: 714–716.

BENTON, A.L., VAN ALLEN, M.W. (1973) 'Manual: Test of Facial Recognition.' Neurosensory center publication n° 287. Department of Neurology, University Hospitals, Iowa city, Iowa.

BERGMAN, T., HAITH, M.M., MANN, L. (1971) 'Development of Eye Contact and Facial Scanning in Infants.' Paper presented at the meeting of the society for Research in Child Development, Minneapolis, April.

BLANEY, R.L., WINOGRAD, E. (1978) 'Developmental Differences in Children's Recognition Memory for Faces.' *Developmental Psychology*, 14: 441–442.

BOWER, T.G.R. (1966) 'Heterogenous Summation in Human Infants.' *Animal Behavior*, 14: 395–398.

BORNSTEIN, B., SROKA, H., MUNITZ, H. (1969) 'Prosopagnosia With Animal Face agnosia.' *Cortex*, 5: 164–169.

BRAZELTON T.B., KOSLOWSKI B., MAIN M. (1974) 'The Origin of Reciprocity in mother-infant Interaction.' In M. Lewis & L.A. Rosenblum (Eds.), *The Effect of the Infant on its Caregiver*. New York: Plenum Press.

BRUYER, R. (1983) '*Le visage et l'expression faciale*.' Bruxelles : Pierre Mardaga.

BRUYER, R., LATERRE, C., SERON, X., FEYEREISEN, P., STRYSTEIN, E., PIERRARD, E., RECTEM, D. (1983) 'A Case of Prosopagnosia with Some Preserved Covert Remembrance of Familiar Faces.' *Brain and Cognition*, 2: 257–284.

BUSHNELL, I.W.R. (1979) 'Modification of the Externality Effect in Young Infants.' *Journal of Experimental Child Psychology*, 28: 211–229.

CAREY, S., DIAMOND, R., WOODS, B. (1980) 'The Development of Face Recognition. A Maturational Problem?' *Developmental Psychology*, 16: 257–269.

CAREY, S. (1981) 'The Development of Face Perception.' In G. Davies., H. Ellis & J. Sheperd (Eds.), *Perceiving and Remembering Faces*. London: Academic Press.

— (1982) Face Perception: 'Anomalies of Development.' In S. Strauss & R. Stavy (Eds.), *U-shaped Behavioral Growth.* New York: Academic Press.
CAREY, S., DIAMOND, R. (1977) 'From Piecemal to Configurational Representation of faces.' *Science,* 195: 312–313.
CARON, A.J., CARON, R.F., CALDWELL, R.C., WEISS, S.J. (1973) 'Infant Perception of the Structural Properties of the face.' *Developmental Psychology,* 9: 385–399.
CARON, R.F., CARON, A.J., MYERS, R.S. (1982) 'Abstraction of Invariant Face Expressions in Infancy.' *Child Development,* 53: 1008–1015.
— (1985) 'Do Infants see Emotional Expressions in Static Faces?' *Child Development,* 56: 1552–1560.
CHANCE, J., GOLDSTEIN, A.J., SCHICHT, W. (1967) 'Effects of Acquaintance and Friendship on Children's Recognition of Classmates Faces.' *Psychonomic Science,* 7: 223–224.
COHEN, L.B., DELOACHE, J.S., PEARL, R.A. (1977) 'An Examination of Interference Effects in Infants' Memory for Faces.' *Child Development,* 48: 88–96.
CORNELL, E.H. (1974) 'Infants' Discrimination of Photographs, of Faces Following Redundant Presentations.' *Journal of Experimental Child Psychology,* 18: 98–106.
CORNELL, E.H., STRAUSS, M.S. (1973) 'Infants' Responsiveness to Compounds of Habituated Visual Stimuli.' *Developmental Psychology,* 9: 73–78.
DAY, R.H., MCKENZIE, B. (1973) 'Perceptual Shape Constancy in Early Infancy.' *Perception,* 2: 315–320.
DIAMOND, R., CAREY, S. (1977) 'Developmental Changes in the Representation of Faces.' *Journal of Experimental Child Psycholcgy,* 23: 1–22.
DIRKS, J., GIBSON, E. (1977) 'Infants' Perception of Similarity Between People and their Photographs.' *Child Development,* 48: 124–130.
DODD, B. (1979) 'Lip Reading in Infants: Attention to Speech Presented in- and out-of-Synchrony.' *Cognitive Psychology,* 11: 478–484.
FAGAN, J.F. (1972) 'Infants' Recognition Memory for Faces.' *Journal of Experimental Child Psychology,* 14: 453–476.
— (1976) 'Infants' Recognition of Invariant Features of Faces.' *Child Development,* 47: 627–638.
FANTZ, R. (1966) 'Pattern Discrimination and Selective Attention as Determinants of Perceptual Development From Birth.' In A Kidd and J. Rivoire (Eds.), *Perceptual Development in Children.* New York: International University Press.
FANTZ, R., MIRANDA, S. (1975) 'Newborn Infant Attention to Form of Contour.' *Child Development,* 46: 224–228.
FIELD, T.M., WOODSON, R., GREENBERG, R., COHEN, D. (1982) 'Discrimination and Imitation of Facial Expressions by Neonates.' *Science,* 218: 179–182.
FLIN, R.H. (1980) 'Age Effects in Children's Memory for Unfamiliar Faces.' *Developmental Psychology,* 16: 373–374.
— (1985a) 'Development of Face Recognition: An Encoding Switch? *British Journal of Psychology,* 76: 123–134.
— (1985b) 'Development of Visual Memory: An Early Adolescent Regression.' *Journal of Early Adolescence,* 5: in press.
FOGEL, A., DIAMOND, G.R., LONGHORST, B.H., DEMOS, V. (1979) 'Alteration of Infant Behavior as a Result of "Still-face" Perturbation of Natural Behavior.' Paper presented to the Society for Research in Child Development, San Francisco, March 1979.
FONTAINE, R. (1982) 'Conditions d'évocation des conduites imitatives chez l'enfant de 0 à 6 mois.' Doctoral thesis of the University of Paris.
GANON, E.C., SWARTZ, K.B. (1980) 'Perception of Internal Elements of Compound Figures by One-month Old Infants.' *Journal of Experimental Child Psychology,* 30: 159–170.
GIRTON, M.R. (1979) 'Infants' Attention to Intrastimulus Motion.' *Journal of Experimental Child Psychology,* 28: 416–423.
GOLDSTEIN, A.L., CHANCE, J.E. (1964) 'Recognition of Children's Faces.' *Child Development,* 35: 129–136.
GOREN, C.C., SARTY, M., WY, P.Y.K. (1975) 'Visual Following and Pattern Discrimination of Face Like Stimuli by Newborn Infants.' *Pediatrics,* 56: 544–549.
GRUSSER, O.J., SELKE, T., ZYNDA, B. (1985) 'A Developmental Study of Face Recognition in Children and Adolescents.' *Human Neurobiology,* 4: 33–39.
HAAF, R.A. (1977) 'Visual Responses to Complex Facelike Patterns by 15 and 20 Week-old Infants.' *Developmental Psychology,* 13: 77–78.
HAAF, R.A., BELL, R.Q. (1967) 'A Facial Dimension in Visual Discrimination by Human Infants.' *Child Development,* 38: 893–899.
HAAF, R.A., HULL-SMITH, P., SMITLEY, S. (1983) 'Infant Response to Facelike Patterns Under Fixed-trial and Infant Control Procedures.' *Child Development,* 54: 172–177.

HAIG, N.D. (1984) 'The Effect of Feature Displacement on Face Recognition? *Perception*, 13: 505–512.
HAINLINE, L. (1978) 'Developmental Changes in the Scanning of Face and Non-face Patterns by Infants.' *Journal of Experimental Child Psychology*, 25: 90–115.
HAITH, M.M., BERGMAN, T., MOORE, M.J. (1977) 'Eye Contact and Face Scanning in Early Infancy.' *Science*, 198: 853–855.
HARRIS, P.L. (1983) Infant Cognition.' in P.H. Mussen (Ed.), *Handbook of child psychology*, Vol. II. *Infancy and Developmental Psychobiology*, New York: Wiley.
HAYES, L.A., WATSON, J.S. (1981) 'Neonatal Imitation: Fact or Artifact? *Developmental Psychology*, 17: 655–660.
HECAEN, H. (1981) 'The Neuropsychology of Face Recognition.' In G. Davies., H. Ellis., and J. Sheperd (Eds.), New York: Academic Press.
KAGAN, J., KLEIN, R.E. (1973) 'Cross Cultural Perspectives on Early Development.' *American Psychologist*, 28: 947–961.
KEMLER, D.G. (1983) 'Holistic and Analytic Modes in Perceptual and Cognitive Development.' In T.J. Tighe & B.E. Shepp (Eds.), *Perception, Cognition and Development: Interactional Analysis.* Hillsdale, N.J: Lawrence Erlbaum.
KOEPKE, J.E., HAMM, M., LEGERSTEE, M. (1983) 'Neonatal Imitation: Two Failures to Replicate.' *Infant Behavior and Development*, 6: 97–102.
LA BARBERA, J.D., IZARD, C.E., VIETZE, P., PARISI, S.A. (1976) 'Four and Six month- Old Infants' Visual Responses to Joy, Anger, and Neutral Expressions.' *Child Development*, 47: 535–538.
LANARÈS, J., ASSAL, G. (1984) 'Prosopagnosia and Facial Expression Recognition.' Paper presented at the European Workshop on cognitive Neuropsychology, Bressanone, January 1984.
LEVY, J., TREVARTHEN, C., SPERRY, R.W. (1972) 'Perception of Bilateral Chimeric Figures Following Hemispheric Disconnexion.' *Brain*, 95: 61–78.
MCCALL, R.B., KAGAN, J. (1967) 'Attention in the Infant: Effects of Complexity, Contour, Perimeter, and Familiarity.' *Child Development*, 38: 939–952.
MCGRATH, S.K. (1983) 'Infants' Recognition of Facial Expressions.' Paper presented at the biennial meetings of the SRCD, April 1983, Detroit.
MCGURK, H. (1970) 'The Role of Object Orientation in Infant Perception.' *Journal of Experimental Child Psychology*, 9: 363–373.
MCKENZIE, B., OVER, R. (1983) 'Young Infants Fail to Imitate Facial and Manual Gestures.' *Infant Behavior and Development*, 6: 85–89.
MANN, V.A., DIAMOND, R., CAREY, S. (1979) 'Development of Voice Recognition: Parallels with Face Recognition.' *Journal of Experimental Child Psychology*, 27: 153–165.
MARATOS, O. (1973) 'The Origin and the Development of Imitation During the First Six Months of Life.' Doctoral Dissertation of the University of Geneva.
— (1982) 'Trends in the Development of Imitation in Infancy.' In T.G. Bever (Ed.), *Regressions in Mental Development: basic phenomena and theories*. Hillsdale : Lawrence Erlbaum.
MARG, E., FREEMAN, D.N., PELTZMAN, P., GOLDSTEIN, P.J. (1976) 'Visual Acuity Development in Human Infants: Evoked Potentials Measurements.' *Invest. Ophthal. Visual sci.*, 15: 150–153.
MAURER, D., BARBERA, M. (1981) 'Infants' Perception of Natural and Distorted Arrangements of a Schematic Face. *Child Development*, 52: 196–202.
MAURER, D., SALAPATEK, P. (1967) 'Developmental Changes in the Scanning of Faces by Young Infants.' *Child Development*, 47: 523–527.
MELTZOFF, A.N., MOORE, K.M. (1977) 'Imitation of Facial and Manual Gestures by Human Neonates.' *Science*, 198: 75–78.
— (1983) 'The Origins of Imitation in Infancy: Paradigm, Phenomena, and Theories.' In L.P. Lipsitt & C.K. Rovee-Collier (Eds.), *Advances in Infancy Research*, Vol. II, Norwood, N.J.: Ablex.
MILEWSKI, A. (1976) 'Infants' Discrimination of Internal and External Pattern Elements.' *Journal of Experimental Child Psychology*, 22: 229–246.
MILLER, D.J. (1972) 'Visual Habituation in the Human Infant.' *Child Development*, 43: 481–493.
MILLER, D.J., RYAN, E.B., SINNOTT, J-P., WILSON, M.A. (1976) 'Serial Habituation In Two-, Three-, and Four-month-old Infants.' *Child Development*, 47: 341–349.
MIRANDA, S.B., FANTZ, R.L. (1974) 'Recognition Memory in Down's Syndrome and Normal Infants.' *Child Development*, 45: 651–660.
MORAIS, J. (1982) 'The Two Sides of Cognition.' In J. Mehler., E.C.T. Walker & M. Garett (Eds.), *Perspectives on Mental Representations.* Hillsdale: Erlbaum.
MOUNOUD, P. (1979) 'Développement cognitif: construction de structures nouvelles ou construction d'organisations internes.' *Bulletin de Psychologie*, 36: 107–118.
— (1984) 'A Point of View on Ontogeny.' *Human Development*, 27: 329–334.

MOUNOUD, P., VINTER, A. (Eds.) (1981a) *'La reconnaissance de son image chez l'enfant et l'animal.'* Paris et Neuchatel: Delachaux et Niestlé, 1981a.
MOUNOUD, P., VINTER, A. (1981b) 'Representation and Sensori-motor Development.' In G. Butterworth (Ed.), *Infancy and Epistemology*. Brighton, Sussex: The Harvester Press.
— (1984) 'Un point de vue sur le problème de l'image de soi à l'adolescence.' *Bulletin de Psychologie*, 1984, 36: 45–62.
— (1985) 'A Theoretical Developmental Model. Self Image In Children.' In V.L. Shulman., L.C.R. Restaino-Baumann., & L. Butler (Eds.), *The future of Piagetian Theory: The neo-piagetians*. New York: Plenum Press.
PERRETT, D.I., ROLLS, E.T., CAAN, W. (1982) 'Visual Neurones Responsive to Faces in the Monkey Temporal Cortex.' *Experimental Brain Research*, 47: 329–342.
PIAGET, J. (1946) *La formation du symbole chez l'enfant*. Paris et Neuchatel: Delachaux et Niestlé.
SALAPATEK, P. (1975) 'Pattern Perception in Early Infancy.' In L. Cohen & P. Salapatek (Eds.), *Infant perception*. New York: Academic Press.
SALTZ, E., SIGEL, I.E., (1967) 'Concept Overdiscrimination in Children.' *Journal of Experimental Psychology*, 73: 1–8.
SCAPINELLO, K.F., YARMEY, A.D. (1970) 'The Role of Familiarity and Orientation in Immediate and Delayed Recognition of Pictorial Stimuli.' *Psychonomic Science*, 2: 329–331.
SCHWARTZ, G.M., IZARD, C.E., ANSUL, S.E. (1985) 'The 5-month-old's Ability to Discriminate Facial Expressions of Emotion.' *Infant behavior and Development*, 8: 65–77.
SERGENT, J. (1982) 'About Face: Left Hemisphere Involvement in Processing Physiognomies. *Journal of Experimental Psychology: Human Perception and Performance*, 8: 1–14.
— (1982) 'The Cerebral Balance of Power: Confrontation or Cooperation'?. *Journal of Experimental Psychology: Human Perception and Performance*, 8: 253–272.,
SHEPP, B.E., (1978) 'From Perceived Similarity to Dimensional Structure: A New Hypothesis about Perceptual Development.' In E. Rosch & B.B. Lloyd (Eds.), *Cognition and Categorization*, Hillsdale, N.J.: Lawrence.
SPELKE, E.S. (1976) 'Infant's Intermodal Perception of Events.' *Cognitive Psychology*, 8: 553–560.
SPELKE, E.S., CORTELYOU, A. (1981) 'Perceptual Aspects of Social Knowing: Looking and Listening in Infancy.' In M.E. Lamb & L.R. Sherrod (Eds.), *Infant Social Cognition*. Hillsdale, N.J.: Erlbaum.
SPERRY, R.W. (1974) 'Lateral Specialization in the Surgically Separated Hemispheres.' In F.O. Schmitt & F.G. Worden (Eds.), *The neurosciences: Third study program*. Cambridge, Massachussets: MIT Press.
SPITZ, R. (1957) *La première année de la vie de l'enfant*. Paris: PUF.
STRAUSS, M.S. (1979) 'Abstraction of Prototypical Information by Adults and 10-month-old Infants.' *Journal of Experimental Child Psychology: Human Learning and Memory*, 5: 618–632.
TIEGER, T., GANZ, L. (1979) 'Recognition of Faces in the Presence of Two Dimensional Sinusoidal Masks.' *Perception and Psychophysics*, 26: 163–167.
TREVARTHEN, C. (1979) 'Neuroembryology and the Development of Perception.' In F. Falkner & J.M. Tanner (Eds.), *Human Growth: a Comprehensive Treatise*. New-York: Plenum Press.
TRONICK, E., ADAMSON, L., WISE, ALS, H., BRAZELTON, T.B. (1975) 'Infant Emotions in Normal and Perturbated Interactions. Paper Presented at the Meeting of the Society For research in Child Development.' Denver, April 1975.
VINTER, A. (1983) 'Imitation, représentation et mouvement dans les premiers mois de la vie.' Doctoral Dissertation of the University of Geneva,
— (1985) *L'imitation chez le nouveau né*. Paris et Neuchatel: Delachaux et Niestlé.
— (1986) 'Role of Movement in Eliciting Early Imitations.' *Child Development*, 57, in press.
VINTER, A., DENOBILI, G., PELLEGRINETTI, G., CIONI, G. (1984) 'Auditory-visual Coordination at Birth: Does it Imply an External World for the Newborn?' *Cahiers de Psychologie Cognitive*, 4: 309–322.
WERNER, H. (1957) 'The Conception of Development from a Comparative and Organismic Point of View.' In D. Harris (Ed.), *The Concept of Development*. Minneapolis: University of Minnesota Press.
WOODHOUSE, J.M. (1976) 'The Application of Contrast Sensitivity to Studies on Image Detection and Recognition.' PhD Thesis, University of Cambridge.
YARMEY, A.D. (1971) 'Recognition Memory for Familiar "Public" Faces: Effects of Orientation and Delay.' *Psychonomic Science*, 24: 286–288.
YIN, R.K. (1970a) 'Face Recognition: A Special Process?' Unpublished Doctoral Dissertation, MIT, Cambridge.
— (1970b) 'Face Recognition by Brain Injured Patients: A Dissociable Ability.' *Neuropsychologia*, 8: 395–402.
— (1978) 'Face Perception: A Review of Experiments with Infants, Normal Adults, and Brain-injured

Persons.' In R. Held., H.W. Leibowitz & H.L. Teuber (Eds.), *Handbook of Sensory Physiology* (Vol. VIII). Berlin: Springer Verlag, pp. 593–608.
YOUNG-BROWNE, G., ROSENFELD, H.M., HOROWITZ, F.D. (1977) 'Infant Discrimination of Facial Expressions.' *Child Development*, 48: 555–562.

ABSTRACT

This paper examines the development of face perception mainly in infancy and analyzes to what extent it does reveal a specific process. For that reason data drawn from object perception as well as from perception of one's own face will also be examined. Studying face recognition in infancy is a complex enterprise because several different abilities intervene in this phenomenon: the modes of visual exploration, the categorization ability, the ability to detect invariances, etc. Moreover the methodological paradigms that investigators have at their disposal are different enough to generally lead to divergent conclusions. This is why it is important to review the various methods used to study face perception in infants: the habituation paradigm, the preferential looking paradigm, the scanning studies and the imitation studies. Data obtained with these methods are closely examined in relation to the main distinctions suggested by the investigators in that field: holistic/analytic perception; internal/external bias; featural/prototypical processing. Finally an overall assessment of face recognition development is offered in view of the various data obtained.

RÉSUMÉ

Cet article examine l'évolution de la perception des visages dans la toute première enfance, et essaie de déterminer dans quelle mesure il s'agit d'un processus spécifique. Pour ce faire, on prend aussi en considération des données provenant de recherches sur la perception des objets ainsi que sur la perception du visage propre. L'étude de la reconnaissance des visages dans la première enfance est une entreprise très complexe à cause des différentes compétences qui interviennent dans ce phénomène : modes d'exploration visuelle, catégorisations, capacité à détecter des invariants, etc. En outre les méthodologies disponibles sont suffisamment distinctes pour conduire en général à des conclusions divergentes.
C'est pourquoi il importe de passer en revue ces diverses méthodes d'investigation basées sur l'habituation, la préférence, le balayage du champs visuel, et l'imitation. Les données obtenues grâce à ces méthodes sont évaluées en fonction des distinctions faites par les spécialistes : perception globale/analytique, influences internes/externes, traitement des traits distinctifs/des prototypes. Finalement une vue d'ensemble de l'évolution de la perception des visages est présentée à la lumière des données recueillies.

Pierre Mounoud is 'Professeur ordinaire' in the Faculty of Psychology and of Educational Sciences at the University of Geneva, Switzerland (Département de Psychobiologie expérimentale et appliquée). He is the author of numerous publications on the cognitive development of the child, with a special emphasis on the construction and organization of internal representation at various stages of development (e.g. *Structuration de l'instrument chez l'enfant*).

Annie Vinter is associated with the Istituto Scientifico Stella Maris, Pisa, and with the Zentrum für interdisziplinäre Forschung, University of Bielefeld. She published *L'imitation chez le nouveau né* (1985) and is the author or co-author of several articles in developmental psychology.

Jacques Lanarès is a researcher at the Faculty of Psychology and of Educational Sciences, University of Geneva.