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Categorical perception of facial expressions by 7-month-old infants

Eleni Kotsoni, Michelle de Haan¶§, Mark H Johnson§

Université Catholique de Louvain, Place de l'Université 1, 1348 Louvain-la-Neuve, Belgium; e-mail: e.kotsoni@psychology.bbk.ac.uk; ¶ Institute of Child Health, University College London, 30 Guilford Street, London WC1N 1EH, UK; § Centre for Brain and Cognitive Development, Birkbeck College, 32 Torrington Square, London WC1E 7JL, UK

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Abstract. Recent research indicates that adults show categorical perception of facial expressions of emotion. It is not known whether this is a basic characteristic of perception that is present from the earliest weeks of life, or whether it is one that emerges more gradually with experience in perceiving and interpreting expressions. We report two experiments designed to investigate whether young infants, like adults, show categorical perception of facial expressions. 7-month-old infants were shown photographic quality continua of interpolated (morphed) facial expressions derived from two prototypes of fear and happiness. In the first experiment, we used a visual-preference technique to identify the infants' category boundary between happiness and fear. In the second experiment, we used a combined familiarisation – visual-preference technique to compare infants' discrimination of pairs of expressions that were equally physically different but that did or did not cross the emotion-category boundary. The results suggest that 7-month-old infants (i) show evidence of categorical perception of facial expressions of emotion, and (ii) show persistent interest in looking at fearful expressions.

1 Introduction

Facial expressions are a mechanism through which internal emotional states and intentions become available as external signals. The meanings attributed to different facial expressions are very similar between individuals and across diverse cultures, suggesting that genetic and/or environmental constraints predispose humans to develop common emotion categories. From the first months of life, infants are able to discriminate between some facial expressions (reviewed in de Haan and Nelson 1998; Walker-Andrews 1997), showing that they are sensitive to variations in the facial features that to adults denote expression. However, few studies have focused on the question of *how* infants perceive expressions and whether the way they do so is similar to or different from adults. Adults show categorical perception of facial expressions, meaning that they perceive a qualitative difference in how similar expressions look depending on whether or not they are in the same category. The purpose of this study is to examine whether categorical perception of facial expressions is a basic characteristic of perception of expressions that is present from the earliest years of life.

Categorical perception occurs when continuous stimulation that reaches the senses is sorted out by the brain into discrete, distinct categories; that is, when equal-sized physical differences between stimuli are perceived as larger or smaller depending on whether the stimuli are in the same category or different ones (Harnad 1987). A classic example is the perception of colour: adults do not perceive a continuous change in colour with a continuous change in the wavelength of light but, instead, they perceive a discontinuity at the category boundary and a switch from one colour category to another (Bornstein et al 1976; cited in Cohen et al 1979). Categorical perception is typically assessed by comparing identification (categorising stimuli with verbal labels, such as 'red' or 'green') and discrimination (deciding whether pairs of stimuli are the same or different). Categorical perception is said to occur when two conditions are

met: (a) a set of continuously varying stimuli are given one verbal label (eg 'yellow') on one side of a 'boundary' and another verbal label on the other side (eg 'green'), and (b) discrimination is superior for pairs of stimuli that cross the boundary (yellow versus green) than for equally different pairs that fall within one category (eg two different shades of green).[1]

In recent years, advances in computing have allowed investigation of categorical perception not only of percepts that vary along a single dimension, such as colour, but also of higher level, complex categories that vary along multiple dimensions, such as faces. The principle is very simple: to create interpolated (morphed) images between two expressions, the values of features in one picture are gradually moved towards their values in the other picture. The results of studies using such stimuli indicate that adults show categorical perception of facial expressions of emotion: when shown a continuum between a pair of expressions they give one verbal label (eg 'anger') on one side of a boundary and another verbal label (eg 'fear') on the other, and their discrimination of pairs of expressions is superior if the members of the pair cross the boundary than if they do not. Thus, while faces normally show a wide range of expressions, adults perceive expressions as belonging to discrete categories (Etcoff and Magee 1992; de Gelder et al 1997; Young et al 1997).

An important question for understanding the development of recognition of expressions is the extent to which hardwired constraints in visual-processing mechanisms and experience in processing facial expressions contribute to the emergence of categorical perception of expression. On the one hand the observations that infants show categorical perception of colour early in development and that there are colour-sensitive cells in the brain have been used as evidence that categorical perception of colours stems from built-in constraints in the early stages of visual processing. On the other hand, there is strong evidence that experience modifies phoneme boundaries in the categorical perception of speech (Liberman et al 1957). With respect to faces, the observation that infants can discriminate among different facial expressions might be consistent with experience-independent mechanisms. However, the observation that adults show categorical perception not only of facial expression but also of facial identity shows at least some aspects of categorical perception of faces must be dependent on experience (Beale and Keil 1995).

One way to investigate the relative importance of built-in constraints and experience in the development of categorical perception of facial expressions is to determine when categorical perception first emerges. Even very young infants, within the first months of life, are able to discriminate the features of the face that to adults denote facial expressions. For example, 3-month-olds can discriminate happy and sad faces from surprised faces (Young-Browne et al 1977) and smiling faces from frowning faces (Barrera and Maurer 1981), and 4-month-olds can discriminate happy from fearful expressions (Nelson and Ludemann 1986). However, it is not until 6 – 7 months of age that infants begin to recognise that an expression remains the same despite discriminable differences in 'irrelevant' information such as the intensity of the expression, the age or gender of the model, and so on. For example, Nelson et al (1979) familiarised 7-month-olds to two different models posing happy expressions, and then showed infants a new model posing a happy expression and a fearful one. Infants looked longer at the fearful expression than at the happy one, suggesting they recognised the happy expression as familiar despite the change in model. Thus, by 7 months of age, infants are able to

[1] According to the original definition, categorical perception referred to cases in which within-category discrimination did not occur at all. More recently the definition has been broadened by some to include cases where within-category discrimination is present but inferior to between-category discrimination (Harnad 1987; Young et al 1997). We adopt the broader definition, although our results are consistent even with the stricter one.

discriminate between some expressions and see similarity between two different faces posing the same expression. However, it is important to note that whether or not infants demonstrate these abilities varies depending on factors such as the age of the infant, the expression pair tested, and the method of assessment (reviewed in de Haan and Nelson 1998). Thus, in order to investigate whether infants perceive the different expressions as different points on a continuum or as discrete categories we specifically chose the age and expression pair that has been most frequently studied in the past, 7-month-olds' perception of happy and fearful expressions (de Haan and Nelson 1998; Kestenbaum and Nelson 1990; Nelson and Dolgin 1985; Nelson et al 1979). Demonstration of categorical perception at this early age would allow some limits to be placed on the nature and amount of experience required for development of this phenomenon.

The purpose of the present experiments was to determine whether infants' early emotion categories are structurally similar to those in adults. Specifically, we tested infants' categorical perception of a facial expression using a morphed continuum between happy and fear. In order to demonstrate categorical perception in infants, we designed an infant version of the two-step 'identification – discrimination' procedure.[(2)] In experiment 1 we identified the infants' category boundary using a visual paired-comparison procedure, rather than a verbal-labeling procedure. In experiment 2 we used a visual familiarisation test to assess whether infants were better at discriminating pairs that crossed this boundary than pairs that were equal morphed steps apart but did not cross the boundary.

2 Experiment 1

Our purpose in the first experiment was to identify the infants' emotion-category boundary between happiness and fear. Because we could not ask the infants to verbally label the stimuli for identification, as adults do, we devised a visual-preference test for identification. Previous studies show that at 7 months of age infants show a consistent spontaneous looking preference for fearful faces compared with happy ones (de Haan and Nelson 1998; Nelson and Dolgin 1985; Nelson et al 1979). We used this known preference to identify the infants' category boundary. In a series of presentations, infants were shown a prototypical happy face paired with faces of varying degrees of a happy/fearful 'mix'. If infants perceive both faces as showing the same (happy) expression, they should look at each picture in the pair for an equal length of time; however, if they perceive the difference between them, they should look longer at the fearful face. The point in the continuum where the infants' preference for the fearful face emerged could thereby be identified as their category boundary between happiness and fear.

[(2)] In classical studies of categorical perception there is a strict order from discrimination to classification. The rationale is that discrimination should come first because: (i) it does not require verbal labeling which is known to influence classification, and (ii) starting with identification, whatever the procedure, encourages the organism to set up processing categories which will have an impact on subsequent discrimination tasks. However, these reasons did not apply in the present study since: (a) the infants were preverbal, and (b) the identification and discrimination phases were completed by different infants. Thus, we had no reason to conduct the discrimination phase first; however, there were advantages to conducting it second. In studies with adults, it is easy to test discrimination between many pairs of stimuli along the continuum and then determine later (based on the subsequent identification phase) which of these pairs crossed the boundary and which did not. However, this is not feasible with young infants due to their limited attention spans. In order to keep the discrimination phase as brief as possible for infants, we conducted the identification phase first to find the category boundary, and then for the discrimination phase specifically chose one pair that did and one pair that did not cross the boundary. This allowed us to obtain the critical comparisons (discrimination between pairs within or across the boundary) with the minimal number of test pairs (2).

2.1 *Method*

2.1.1 *Subjects.* Sixteen 7-month-old human infants were tested (eight boys and eight girls; *M* age—215 days or 31 weeks). One additional infant was tested but excluded owing to side bias (more than 85% of overall looking time exclusively spent looking to one side of the test screen).

2.1.2 *Stimuli.* The stimuli were created by a morphing technique (for details, see: http://www.asahi-net.or.jp/~FX6M-FJMY/mop00e.html). The term *morphing* is a short form of *metamorphosing* and indicates the use of computer software to calculate and draw multiple frames between two key forms. Morphed images have made it possible to explore categorical perception effects with multidimensional stimuli, such as faces. The principle is very simple: to create interpolated (morphed) images between two expressions, the values of features in one picture are gradually moved towards their values in the other picture. The features of one image are defined by a number of nodes. Each node is a corresponding point between the two images: a node to the right corner of the right eye corresponds to the node of the right corner of the right eye in the second image. The nodes are connected by elements forming the different parts of the face, such as the nose, the eyes, the mouth, etc. For this experiment, two different female identities were selected from the Ekman and Friesen (1976) series. The pictures were full-face frontal views with the hair visible, and measured 15.5 cm by 11 cm (identity A) and 16 cm by 10.5 cm (identity B). For both of the faces, the nodes were connected by elements defining the eyes, the eyebrows, the nose, the mouth, the chin, the neck, and the hairline. Then, we created a continuum between a 100% happy expression and a 100% fearful expression that consisted of six different faces (including the 100% anchor points) with a 20% gap between each one of them (see figure 1).

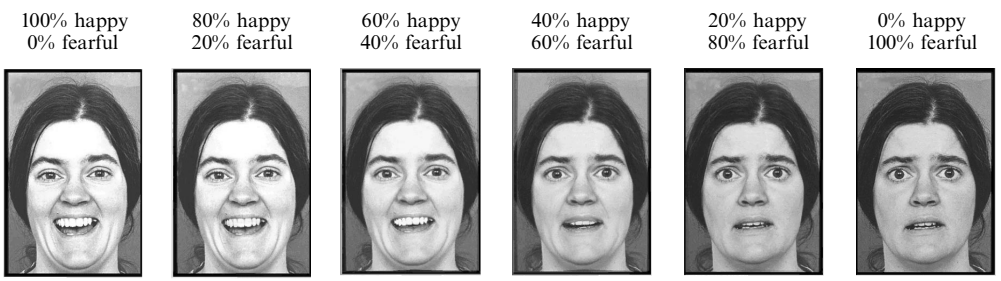

Figure 1. An example of one of the two morphed continua from happy to fearful used in experiments 1 and 2.

2.1.3 *Procedure.* The visual-preference test consisted of ten trials during each of which a pair of stimuli was shown consisting of the 100% happy face paired with one of the five remaining happiness–fear blends in the continuum (eg a 60% happy–40% fearful face). The five unique pairs were each presented twice, with the position of the stimuli changed from left to right across presentations. The order of presentation was random with the constraints that the 100% happy face was never at the same (left or right) location on more than two consecutive trials and that the same pair of faces was never presented on two consecutive trials. Half of the subjects were tested with identity A, and the other half with identity B.

Infants were tested in a modified version of the portable visual-preference apparatus used by Fagan (1970). This apparatus allows presentation of visual stimuli to an infant seated in the caregiver's lap without the caregiver being able to view the stimuli. The experimenter observed the infant through a peephole in the centre of the presentation screen and timed how long the infant looked at each face of the pair. The baby's

attention was attracted to the centre and then the stimuli were presented. Each trial began when the infant first looked at one of the faces and ended 10 s later. The baby was judged to be looking at a stimulus when the reflection of the stimulus was visible over his or her pupil. A second experimenter timed the 10 s trial intervals, recorded the infant's looking times, and inserted and removed the appropriate stimuli in position between trials, so that the first experimenter was not aware of the exact stimuli being presented on a given trial.

2.2 *Results*

The looking time for each face on each of the ten test trials was first converted to a proportion by dividing the looking time for each face by the total looking time for the trial, and then the proportion of looking time for each face was averaged across its two presentations.

To determine the point in the continuum at which the preference for fearful faces emerged, we performed one sample *t*-tests for each trial type comparing looking time for the more fearful face of the pair with the chance level of 0.50. The results showed that infants did not look longer at the 80% happy – 20% fearful or the 60% happy – 40% fearful faces than would be expected by chance. In contrast, *t*-tests showed that for the remaining faces (60% fearful – 40% happy, 80% fearful – 20% happy, and 100% fearful), infants showed a preference for the fearful face by looking significantly longer at it than would be expected by chance (figure 2).

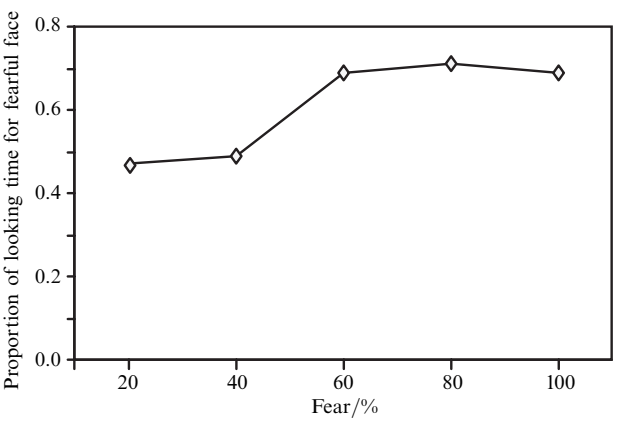

Figure 2. Experiment 1: The average proportion of looking time for varying levels of fear when paired with a 100% happy face.

An ANOVA of the looking times for the more fearful face of each pair, with Face (20% fearful, 40% fearful, 60% fearful, 80% fearful, 100% fearful) as the within-subjects factor and Identity (A, B) as the between-subjects factor showed only a main effect of Face ($F_{4,60} = 7.45$, $p < 0.0001$). A posteriori tests between all possible pairs of faces showed that they could be divided into two groups: 20% fearful and 40% fearful versus 60% fearful, 80% fearful, and 100% fearful.

3 Experiment 2

The results of experiment 1 suggest that the infants' category boundary between happiness and fear lies between the 40% fearful – 60% happy and 60% fearful – 40% happy faces. To further examine the nature of this boundary, we next investigated infants' discrimination of pairs of expressions that did or did not cross it. If babies have categorical perception we expect their discrimination performance to be better when presented with a pair of faces that cross the category boundary compared with when they are presented with a pair that does not. Previous experiments report that, following habituation or

familiarisation to fearful faces, infants usually do not show novelty preferences for new expressions owing to their persistent interest in looking at the fearful expression (Nelson at al 1979). Thus, we expected that babies familiarised to fearful expressions might show weaker novelty preferences owing to the interactive effects on their looking times of their tendency to look at fear and their tendency to look at novelty.

3.1 *Method*

3.1.1 *Subjects.* The participants were thirty-two 7-month-old infants (sixteen boys and sixteen girls; *M*—age 217 days or 31 weeks), none of whom had participated in the first experiment.

3.1.2 *Stimuli.* The stimuli were the same as those used in experiment 1.

3.1.3 *Procedure.* The testing apparatus and general procedure were the same as in experiment 1. The test was divided into two parts:

Familiarisation. The familiarisation phase consisted of four 10 s trials during each of which two pictures of the same expression were presented simultaneously to the infant. Half of the infants saw the 60% fearful – 40% happy face (the 'habituate to fear' group) and the other half saw the 60% happy – 40% fearful face (the 'habituate to happy' group). Within each of these groups, half the infants saw identity A and half saw identity B.

Discrimination. Immediately following familiarisation, infants were tested with two types of test pair: one pair crossing the category boundary, and one pair within the emotional category. The pair crossing the category boundary was the same for all subjects: the 60% fearful – 40% happy face paired with the 60% happy – 40% fearful face. The pair within the category depended on the expression used during the familiarisation phase. For the infants familiarised with the 60% happy – 40% fearful face, the within-category test pair was this same face paired with the 80% happy – 20% fearful face. For the infants familiarised with the 60% fearful – 40% happy face, the within-category test pair was this picture paired with the 80% fearful – 20% happy face. The order of the two trial types was counterbalanced across infants, and each trial was presented twice in succession with a left – right reversal.

3.2 *Results*

Babies' looking times during the familiarisation trials were analysed in a two-way mixed ANOVA with Trial (1, 2, 3, 4) as the within-subjects factor and Face (fearful, happy) as the between-subjects factor. There was a main effect of Trial ($F_{3,90} = 3.29$, $p < 0.05$) which occurred because babies' looking times decreased over the four presentations. There was no main effect or interaction with Face.

The looking time for each face on each of the two test trials was first converted to a proportion by dividing the looking time for each face by the total looking time for the trial, and then the proportion of looking time for each face was averaged across its two presentations. Figure 3 illustrates the mean looking time during the test trials following habituation to the happy or fearful face.

We predicted that, if babies have categorical perception, they would be worse at discriminating pairs of faces that lie within the same emotion category than pairs of faces that cross the category boundary. The first part of this prediction was tested by comparing the babies' looking time for the novel face on the within-category test pair with the level of looking expected by chance (0.5). Babies showed no evidence of discrimination whether they had habituated to happy faces ($t_{15} = 0.89$, $p > 0.1$) or to fearful faces ($t_{15} = -0.14$, $p > 0.1$). The second part of the prediction was tested by comparing the looking time for the novel face in the cross-boundary test pair with that expected by chance (0.5). Babies looked longer at a novel expression that crossed the category boundary following familiarisation to the happy expression ($t_{15} = 4.15$, $p < 0.05$) but not following familiarisation to the fearful one ($t_{15} = 0.35$, $p > 0.1$).

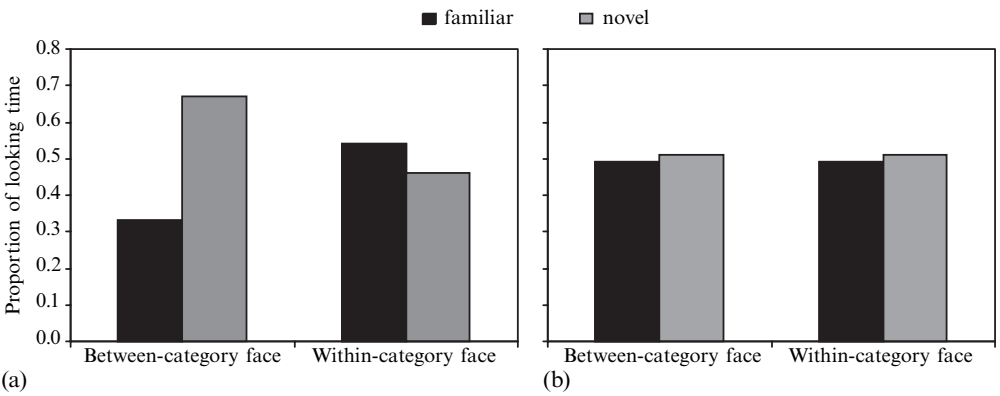

Figure 3. Experiment 2: the average proportion of looking time during the test trials following habituation to (a) a happy or (b) a fearful face.

Why did babies fail to show a novelty preference for the cross-category expression following habituation to fear? One explanation is that babies did not encode the expression during familiarisation. However, the fact that there was a significant habituation, or decrease in looking times across familiarisation, argues against this explanation. A second explanation is that the category boundary may be asymmetrical. We identified the boundary by using the 100% happy face as an anchor and comparing it with varying degrees of fear. It is possible that the boundary we identified was thus most sensitive in the direction of happy to fear and thus babies showed between-category discrimination only in that direction. This possibility could be tested by conducting additional experiments in which the category boundary is identified by using the 100% fearful face as an anchor and comparing it with varying degrees of happiness. If the boundary is identified at a different point in the continuum, closer to the happy anchor, it would support the view that an asymmetrical boundary contributed to the present results. A third likely explanation is that the babies' spontaneous preference for fearful faces and their preference for novel faces were in conflict in the cross-category happy–fearful test pair. Because babies of this age are known to show a spontaneous preference for fearful expressions (about 0.70 looking at fearful faces when paired with happy faces, as assessed in experiment 1), testing against a chance level of 0.5 may not be appropriate. In fact, when the babies' 52% looking at the novel happy face following habituation to fear is compared with their typical level of looking at a happy face without familiarisation to fear (30%—experiment 1), it is apparent that the 52% looking at the novel happy face in fact represents an increase over their spontaneous level of looking ($t_{15} = 5.76$, $p < 0.01$). This suggests that babies were able to discriminate the cross-category pair but that their persistent preference for the fearful face interacted with the novelty preference for the happy face during the test trial so that they were drawn to look at both faces.

4 Discussion

The purpose of these experiments was to investigate whether young infants, like adults, show categorical perception of facial expressions of emotion. Infants aged 7 months old were tested with a series of faces morphed from a fearful to a happy expression to determine whether: (a) they showed an identifiable emotion-category boundary between the expressions, and (b) they were better at discriminating pairs of expressions that crossed the boundary than those that did not. The results provide evidence in support of categorical perception: infants showed a reliable category boundary and, following familiarisation to one expression, they were able to discriminate it from another expression that crossed the boundary, but showed no evidence of discriminating it

from another expression that did not cross the boundary. These results demonstrate that categorical perception of the facial expressions fear and happiness emerges early in life and does not require years of experience to develop.

In experiment 1, the infants' attention did not gradually increase as faces became more fearful. Instead, their preference for looking to fearful expressions emerged suddenly in full strength at a particular level of fear. This was true for both of the two different facial identities tested, and therefore was not due to an idiosyncratic aspect of an individual face. This result supports the interpretation that the infants perceived a discontinuity in the expression information in spite of the physical continuum. In other words, the relation between perception and the morphing continuum was not linear but behaved as a threshold function. Since the continuum we created was based on a 20% gap between each picture, the boundary we found corresponds to a range of 20% distance between the two expressions. Further experiments could identify more precisely where, within this range, the boundary is located.

The results of experiment 2 showed that, following habituation to a happy face, infants were able to discriminate the happy face from a face that crossed the boundary with fear, but not from a face that fell within the happy category. This pattern suggests that babies show categorical perception of happy faces. However, following habituation to a fearful face, infants showed no evidence of discrimination either across the category boundary or within it. This difference in discrimination following habituation to a happy face compared with habituation to a fearful face cannot be explained by a difference in the infants' looking times during familiarisation, as there were no significant differences in looking during familiarisation between the two groups. One interpretation is that infants show true categorical perception of happy faces but not of fearful faces. This interpretation would be consistent with reports of categorical perception of facial identity that show that categorical perception effects are stronger the more familiar the face (Beale and Keil 1995). In the same way, categorical perception effects may emerge first for the happy expression because it is likely to be the most frequently seen and thus most familiar expression to young infants. Other possibilities are that the difference in discrimination performance is due to an asymmetrical category boundary that we identified in only one direction or that it is an artifact of infants' pre-existing preference for fearful faces (see the discussion of experiment 2 in section 3.2). Further studies which examined other expressions that vary in familiarity to young infants at different ages and that identify the category boundaries in both directions can provide additional evidence on these points.

A recent event-related-brain-potential study of the temporal course of categorical perception of facial identity provides an explanation for why adults, and possibly also infants, find between-category differences easier to detect than within-category ones (Campanella et al 2000). Between-category differences in identity influenced brain activity over right occipito-temporal areas as early as 150 ms after stimulus onset, while within-category differences emerged later in processing. The authors suggested that discrimination of within-category differences is more complex because, while different images within the same category are physically different, they give rise to similar configural representations of the face. Thus, in order to make a within-category discrimination, the brain has to 'overcome' the identity similarity of the two images in order to notice their physical differences. Similarly, in the present study, infants may not appear to discriminate facial expressions within the same category because, even though the two images are different, they give rise to a similar configuration of facial expression in the brain.

The babies' persistent interest in the fearful faces is consistent with several previous studies indicating that babies tend to show a persistent interest in looking at fearful expressions, even following habituation to fear (eg Nelson and Dolgin 1985; Nelson et al

1979). Investigators have speculated that infants' interest might be due to the relative novelty of the face. However, this cannot be the only influence as younger babies, to whom the fearful expression is presumably even more novel, do not show this effect (Ludemann and Nelson 1988). Another possibility is that infants are just beginning to perceive the meaning of the fearful expression at this age and respond to this signal with increased vigilance. This interpretation is supported by studies showing that infants of this age also show increased visual attention to the mother in response to vocal expressions of fear (Mumme et al 1996) and that infants as young as 4 months of age vary their behavioural responses according to the affective meaning of each expression (Serrano et al 1992, 1995). This may reflect the beginnings of infants' social referencing—their use of other people's interpretations of an event to form their own understanding of that event (Feinman 1982). Klinnert et al (1983) proposed a four-level sequence of development leading to the ability to engage in social referencing: first the infant develops the ability to discriminate among emotional expressions, then this is followed by a gradual recognition of the meaning of various expressions, then by emotional responsiveness, and, finally, by referencing of expressions and regulation of behaviour. In the case of the present study, one could argue that the infants are just beginning to perceive the meaning of the fearful expression and this leads to a persistent interest on their part in looking at it. Further investigation is needed to validate such an interpretation. This emergence of infants' reaction to fearful faces and voices in particular might be related to the development of the amygdala and/or its cortical connections, as the amygdala is known to be involved in recognition of fear by adults (Morris et al 1996).

If infants are able to perceive happy expressions categorically, are they doing so on the same basis as adults? Is this generalised across other categories of facial expression, such as anger, surprise, or disgust? The results of these experiments do not allow us to identify the physical basis of the categorical perception—whether it is based on the configuration features denoting the expression or on particular features, etc. One way this issue has been addressed is by studying babies' ability to recognise that an expression is the same even when posed by different models. Because babies, by 7 months of age, are able to perceive constancy in expression across changes in identity, they must be attending to expression-relevant information in the faces (reviewed in de Haan and Nelson 1998). Whether the emergence of categorical perception is coincident with the emergence of the ability to recognise a particular expression across differences in expression-irrelevant information could be tested in future experiments by using a wider range of facial expressions. A second way the question what physical information babies use to discriminate and recognise expressions has been addressed is by examining the influence of inversion on babies' abilities. Even though upright and inverted faces contain the same basic physical information, inverting a face impairs adults' perception of it. This effect is thought to be due to disruption of encoding of configural information. Similarly, inversion causes babies' preference for prototypical fearful faces compared with happy faces (de Haan and Nelson 1998) and their ability to categorise expressions (Kestenbaum and Nelson 1990) to disappear. Together, these results suggest that, at least by the age of 7 months, babies' recognition of happy and fearful expressions is not merely based on simple discrimination of local differences in pattern information, but on perception of the configuration of emotional information in the face.

Since categorical perception of emotional expressions begins to emerge early in life, does this mean that it is necessary for the normal development of recognition of facial expressions of emotion? Recent work indicates that categorical perception of facial expressions is not observed in individuals with autism (de Gelder et al 1997). Interestingly, the deficit in categorical perception seen in autism is independent of the

individual's ability to recognise and verbally label expressions (de Gelder et al 1997). This suggests that even if categorical perception of emotional expressions normally facilitates development of emotion concepts, alternative developmental trajectories are possible. The present results showing that categorical perception of facial expressions normally emerges early in life may provide an additional tool for early detection of developmental abnormalities in the perception of emotional information.

Data from the visual and the auditory modalities indicate that the processes of categorisation are available very early in life, and that these processes are remarkably like those that characterise the processes of categorisation in adults. These results are the first to show that this is also the case for complex, multidimensional visual stimuli, such as facial expressions of emotion. Categorical perception may in fact reflect a more general mechanism of infant perception and that, as for facial identity in adults, experience can serve to establish categorical perception for any frequently experienced category. These early perceptual categories may facilitate subsequent development of children's conceptual understanding of categories, such as emotional expressions, with experience serving to fine-tune the category boundaries. These results are consistent with the proposal that the ability to recognise facial expressions of emotion represents a selective adaptation resulting in the creation of specialised neurocognitive systems that subserve this ability and may require little experience to initially develop (Nelson 1993).

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