MECHANISMS IN INFANT FACE PROCESSING

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ABSTRACT. For the past few years, Mark Johnson and I have been exploring early infant preferences for looking at faces and face-like stimuli (Morton and Johnson, 1991). At the time we started this work, the dominant experimental methodology was the infant control procedure. Maurer (1985) considered this technique to be more sensitive than the preference techniques used by other workers. Earlier, she had found that two-month olds looked significantly longer at a schematic face than control stimuli but failed to demonstrate any such preference with one-month old infants.

Infant Control Procedure

Since only Maurer and Barrera (1981) had previously found any preference for faces compared with scrambled faces with infants younger than four months, we decided to replicate and extend their study (Johnson, Dziurawiec, Bartrip and Morton, 1992). The stimuli were life-sized white heads outlined on a grey background. They are shown in Figure 1. Of the non-face stimuli, *Config* had three squares, intended to correspond, roughly speaking, to two eyes and a mouth. The other two stimuli used the elements of the schematic face arranged in a different configuration. In both of these cases, the symmetry of the stimulus was maintained. The infants sat on their mothers' laps about 90cm from a rear projection screen. Once the infant's attention had been attracted, one of the four stimuli was shown on the screen and the presentation terminated once the infant looked away. This is the procedure recommended by Cohen (1976) and Maurer (1985). The infant's behaviour was recorded on video-tape and scored blind. We used three groups of infants, with mean ages of 5 weeks (n=14), 10 weeks (n=15) and 19 weeks (n=15).

The data are shown in Figure 1. There were no significant differences for the 5-week-old group. For the 10-week-old group, the amount of time spent looking at the scrambled face was significantly different from all other stimuli (Wilcoxan: p=0.05 for

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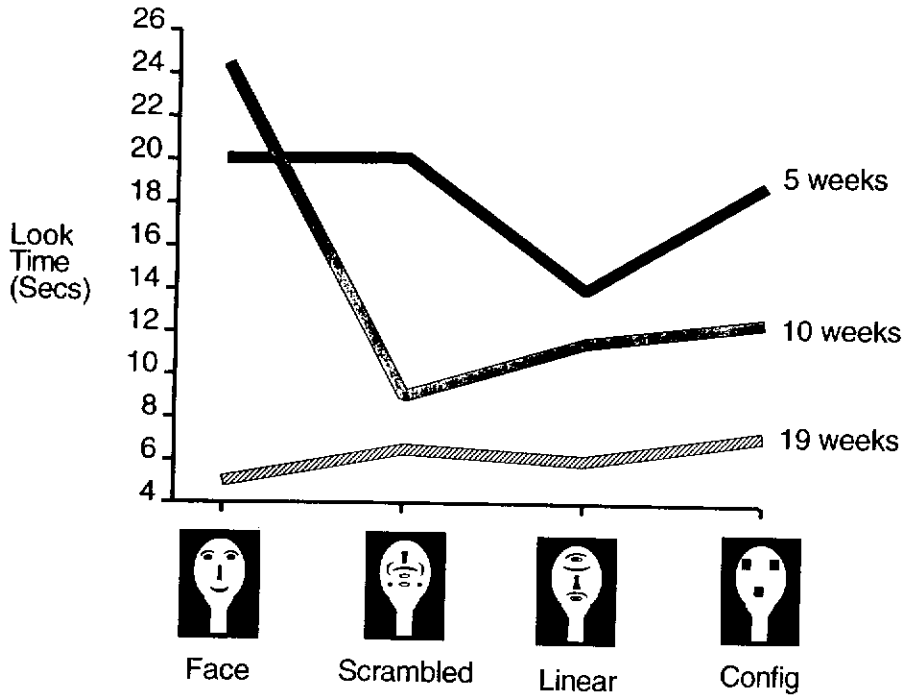

Figure 1. Data for Infant Control Experiment. (Mean look times for each of the three stimuli for 5-, 10- and 19-week-old infants. For both the 10- and 19-week-old groups, there was a significant effect of stimulus on mean look time. From Johnson, Dziurawiec, Bartrip and Morton, 1992).

Config; p>0.01 for *linear* and *scrambled*). With the 19-week-old group, the face was preferred less than the other three stimuli. Our suspicion is that this group found the static schematic face too dull (see Johnson, Dziurawiec, Ellis and Morton, 1991).

Newborn Abilities

The data using the infant control technique seemed to conflict with Goren, Sarty and Wu (1975) who published a study which involved newborn infants, with a median age of 9 minutes, tracked a moving schematic face, scrambled faces and a blank head outline. Using both head and eye movements, they showed that these infants were more interested in the schematic face than they were in the other stimuli. On the surface, this result contradicted the work with infant control procedure. We decided to replicate this experiment because of its far-reaching theoretical implications. As we did so, we discovered that Dziurawiec and Ellis had carried out a replication that they were having difficulty publishing! Suzanne Dziurawiec then joined our group, carried out yet another replication and both studies were included in the same paper (Johnson et al,

1991). The first study included refinements of data collection and analysis over the earlier Goren et al (1975) experiment. The infants were, however, much older, with a mean age of 37 minutes. The three stimuli used are shown in Figure 2.

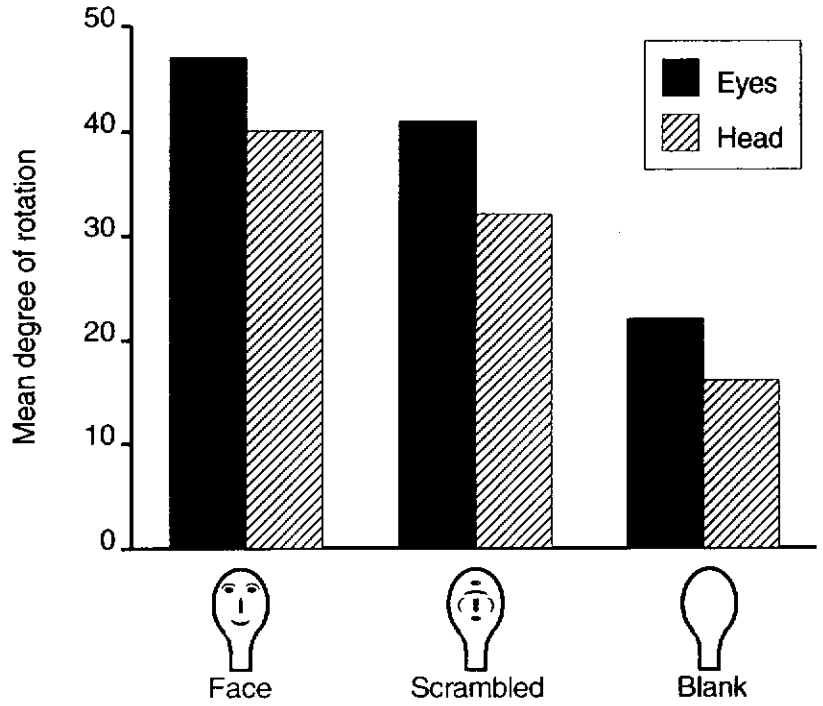

Figure 2. Data from the Goren replication showing the extent of newborn eye and head turns in following the stimuli (from Johnson, Dziurawiec, Ellis and Morton, 1991). (Newborn infants follow the face farther than the other stimuli.)

The technique involved the infant lying on its back on the experimenter's lap. The stimuli were on one side of a paddle. When the baby's head was aligned to midline, one stimulus was presented at approximately 20cm from the infant's face. The experimenter was blind to the precise nature of the stimulus. The stimulus was moved slowly to one side at a rate of about 5° per second. The infant's eye and head turning were recorded on video-tape and the extent of turning was estimated by blind judges against a protractor which surrounded the infant and was visible on the video recording. This procedure was repeated until the infant followed the stimulus. The procedure was then followed to the opposite side. The data, shown in Figure 2, replicated the Goren et al (1975) study. For both head and eye turning, the infants turned more to the face than the scrambled stimulus and more to the scrambled stimulus than the blank. In a second study, different stimuli were used. These are shown in Figure 3.

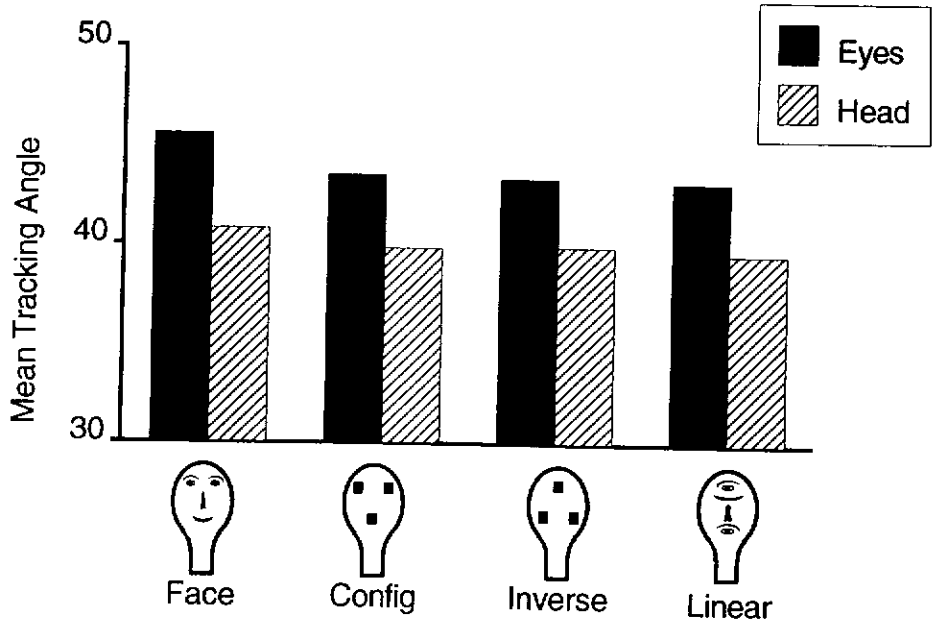

Figure 3. Data again showing that newborn infants aged 15-69 min follow a face farther than other stimuli. (This applied only with eye movements. From Johnson, Dziurawiec, Ellis and Morton, 1991, Experiment 2.)

In this case, the response to the face was significantly different from *linear* and *inverse* but only marginally different from *Config*. This was only true for eye movements.

There were now three studies showing that newborn infants prefer a schematic face to control stimuli. How are we to interpret this? Our preference is that, from before birth, infants possess some information about the structural characteristics of faces. One reason for supporting such an idea is that it is well established that the chick has such an innate endowment Johnson, Bolhuis, and Horn (1985), Johnson and Horn (1986), Johnson and Horn (1988). According to one referee of Morton and Johnson (1991), this is an idea "that has been bandied about for over 30 years, and which has been rejected by most in the field of developmental psychology for nearly 20." The alternative is that the preference for faces over control stimuli is due to the sensory properties of the stimuli. One formulation is that "infants are predisposed to attend to stimuli that are readily visible ... face-like patterns are fixated preferentially because they contain large [low spatial frequency], high-contrast features that are arranged symmetrically" (Kleiner and Banks, 1987, p.594). And this conclusion was put forward also by Kleiner (1987)

for newborn infants and her conclusions were disputed by Morton, Johnson and Maurer (1990). The issues are also discussed in Johnson and Morton (1991) and Morton and Johnson (1991). I will restrict myself here to one observation. The only reasonable sensory theory is the linear systems model (Banks and Ginsberg 1985: Banks and Salapatek 1981). This model predicts infants' preferences for visual stimuli on the basis of the energy in the stimulus at frequencies that newborn infants are sensitive to. According to Atkinson, Braddick and French (1979) newborns are most sensitive to frequencies between 0.2 and 0.5 cycles per degree. Energy in that range, according to the model, will be most effective in attracting and holding the infants' attention. In Figure 4 we show the amplitude spectra of *face* and the scrambled stimulus used in Figure 2.

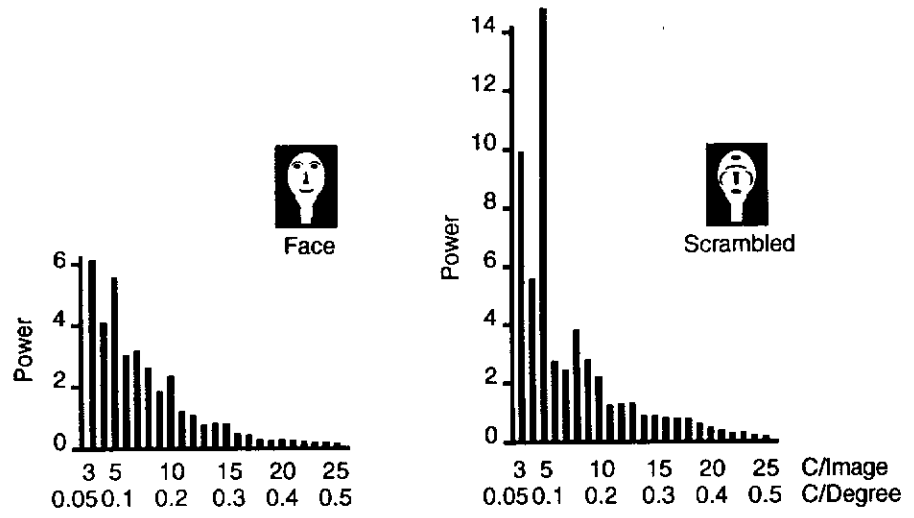

Figure 4. Power spectra of two of the stimuli shown in Figure 2. The units of power are arbitrary.

We have not been able to find any function of these power spectra that would give an advantage for *face* over *scrambled.* Whilst it is clear that the linear systems model predicts very accurately the interest that infants will have in other stimuli, we conclude that there is, in addition, structural information that is innate to the human infant. We have called this structure CONSPEC.

CONSPEC and CONLERN

The theory that Mark Johnson and I have put forward (Johnson and Morton, 1991, Morton and Johnson, 1991) is that there are two mechanisms operating to control infants' attention with respect to faces. One of them, CONSPEC, I have already mentioned. CONSPEC constrains structural information concerning the visual characteristics of conspecifics. In addition, this information is available without the organism requiring exposure to specific stimuli. By *structural* we mean that the information is concerned with the relative spatial location of elements within a pattern. For our purposes it would be sufficient for CONSPEC to specify only three blobs, similar to the stimulus we have called *Config*. The second mechanism is called CONLERN. This refers generically to mechanisms devoted to learning about conspecifics. These may be modular, stimulus-specific mechanisms or may be general mechanisms. Which they are for any species is an empirical question. CONSPEC merely refers to the functional class.

The theory proposes that CONSPEC is active in controlling attention from birth but that its effects die away during the second month of life. During this time, CONLERN has been acquiring information about faces (a very dominant stimulus in a human infant's environment) and by ten months or so this mechanism is able to control attention. We have proposed that CONSPEC is sub-cortical and CONLERN cortical, partly because such proposals seem to fit in with facts about the maturation of connections from the cortex to systems concerned with visual attention (see Johnson, 1990). However, the psychological theory is in no sense dependent upon this attempt to find neurophysiological correlates. The theory, then, is represented diagrammatically in Figure 5 where the lines are meant to indicate the potency of the two mechanisms at particular ages.

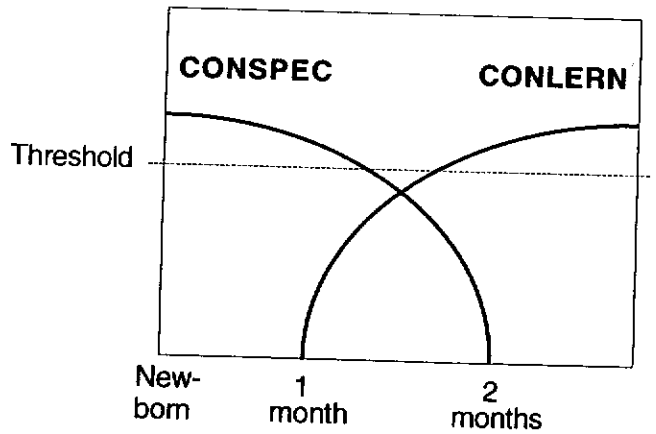

Figure 5. Theory concerning the relative influence of CONSPEC and CONLERN over the first two months of life. Only those structures above threshold will be active.

CONSPEC is above threshold at birth and below threshold at two months whereas CONLERN is below threshold until two months. The prediction from this is that CONSPEC could be active at one month, which could not be the case for any explanation which relied on a single mechanism. The theory also proposes that CONSPEC is maximally sensitive to the stimuli in the periphery and that the tracking technique used by Goren et al (1975) and in the replications thereof capitalized on this. CONLERN, on the other hand, would be more sensitive to foveal stimuli, as in the infant control procedure. We checked the predictions from this model in a further experiment (Johnson et al 1991, Experiment B).

In this experiment we took infants at 5-, 10- and 19-weeks of age. The infants sat on their mothers' lap in front of a screen. Once an infant's attention had been drawn to the screen the stimulus was projected and then the chair on which the mother was seated began to rotate slowly. The infants turned their heads to maintain fixation on the stimulation and we measured the angle of turn at the moment of disengagement. The stimuli and data are given in Figure 6. The results were clear. At 5 weeks of age, infants turned further to the face than to the other stimuli (T-Tests gave - *Config*, P=0.015; *linear*, P=0.008; *Scram*, P=0.029).

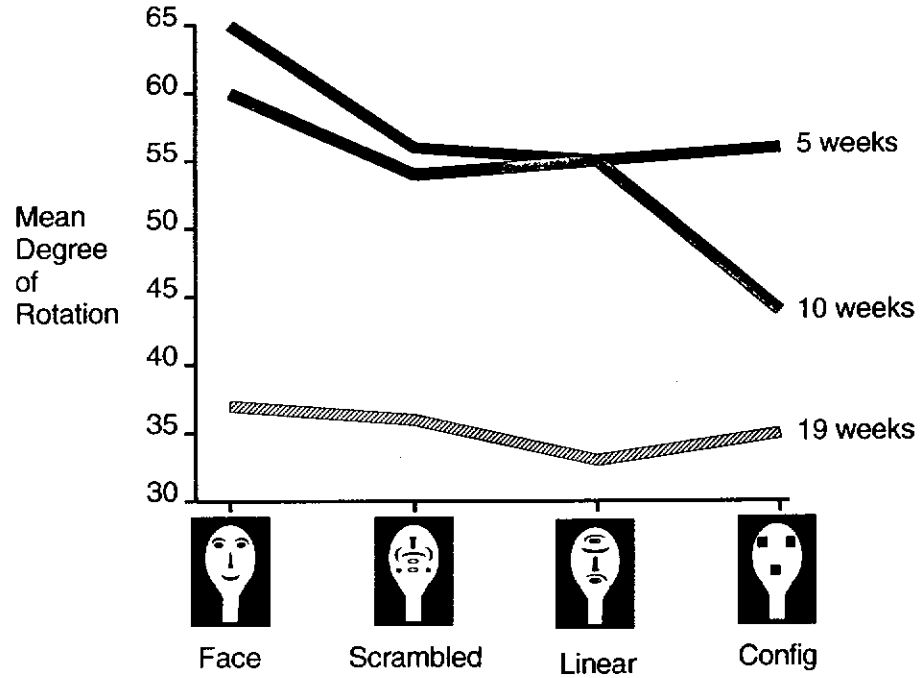

Figure 6. Data showing the extent to which infants will turn their head to maintain fixation. (Only for the youngest age group was the face followed farther than the other stimuli. From Johnson, Dziurawiec, Ellis and Morton, 1991, Experiment 3.)

Recognition of Mother

The two mechanisms, CONSPEC and CONLERN, are concerned with differentiating faces from other stimuli. But what about distinguishing one face from another? A number of experiments, recently, have tested newborn responses to individual faces. The best controlled of these experiments is one by Bushnell, Sai, and Mullin (1989). They used infants of an average age of 1.7 days. The infants were presented with two faces, about 30cm away and about 30cm apart. One of the faces was the baby's mother and the other was that of another woman who had just given birth who was "judged to be broadly comparable in terms of hair colour and facial complexion" (Bushnell et al 1989, p.6). Careful controls were carried out to check that the infant response could not be influenced by smell, and the women were instructed to keep their faces immobile and to refrain from vocalisation of any kind. The infants fixated on their mothers' face for an average of 60% of the time. This was clearly significant. There are a number of issues here but it seems clear that this performance cannot be accounted for in terms either of CONSPEC or CONLERN. Accordingly, we have been exploring recognition of mother in collaboration with Scania de Schonen and her colleagues.

The results presented below are preliminary. The basic design of the experiments follows that of Bushnell et al (1989). With the newborns (run in Marseille) there were two groups. For one group the target faces were fully visible. For the other group both women wore scarves around their heads in such a way that their hair was concealed and the outline of their face was blurred. We refer to this as the "internal" condition.

Meanwhile, in London, infants of 20-, 40-, 60-, 90-, 120- and 150 days ran through three conditions. The first two were as with the newborns and the third condition involved mother and stranger wearing white plastic masks designed so that the internal features were completely obscured but the face outline and hair were fully visible. This condition we called "external". For each condition there were two presentations with mother on the left in one presentation and on the right for the other. This was to avoid untoward distortions of the data from side preferences. The newborns were 3 or 4 days old and were tested in hospital. For the newborns these presentations lasted 16 seconds and for the other infants they lasted 20 seconds. The preliminary data are given in Figure 7.

In this we have presented the relative interest in mothers' face. This is computed by subtracting the amount of time spent looking at the other face from the amount of time spent looking at the mother. First of all, we can look at the newborn data. With full face, there was a massive preference for looking at mother. However, when the women were wearing scarves the infants did not distinguish between them. Thus, we conclude, that infants had not, as a group, learnt about the mothers' internal features.

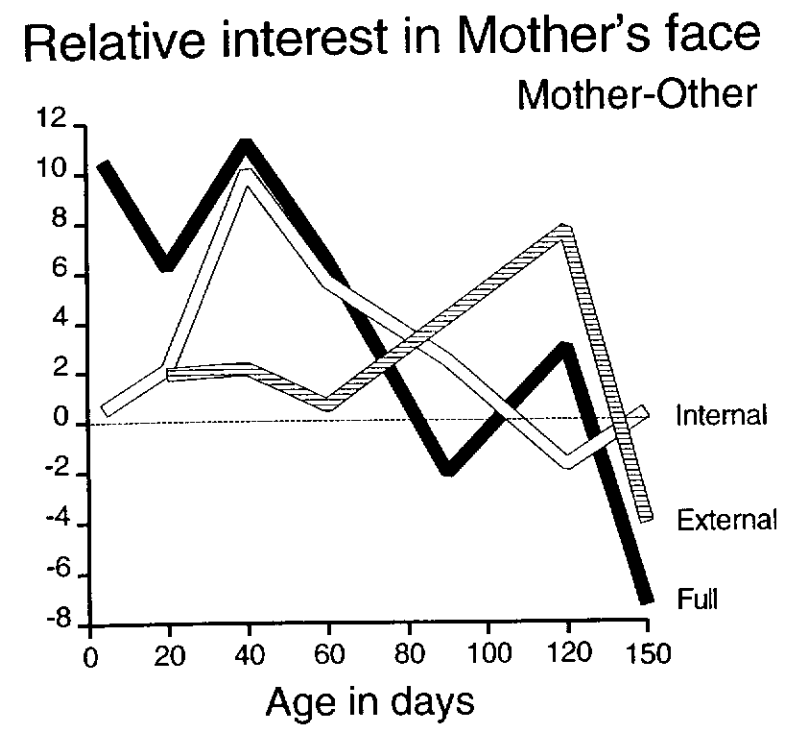

Figure 7. Data showing preference for mother's face over that of another woman. In the "internal" condition both women wore tightly fitting head scarves and for the "external" condition they wore white rigid face masks. The newborn infant groups were run in Marseille, the older infants in London (unpublished data).

We turn now to the older infants. It seems that at 20 days there is still no change in the pattern of interest. However, by 40 days the infants are taking much more interest in their mother when the internal features of her face are visible. There is no selective interest in the external features of mother, however, until at least 90 days. This interest reaches a peak at 120 days and by 150 days some very complicated things are happening which cannot easily be summarized.

These data constitute a replication and extension of Bushnell et al (1989). One condition, newborns with external features only, remains to be done. If 4 day old infants respond to mother in the external condition then we would require two extra mechanisms in addition to CONSPEC and CONLERN. If, however, they do not respond to mother in the external condition then we may be able to make do with just one more. In any case we seem to have the need for at least three different mechanisms concerned with conspecific faces.

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