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REPORT

Newborns learn to identify a face in eight/tenths of a second?

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Abstract

A number of recent studies have shown that newborns prefer to look at mother's face rather than at the face of a stranger. This preference can be seen as the result of familiarity with the mother's face, stemming from a greater number of encounters with mother's face. A schema theory can deal with this kind of recognition. Recent work with verbal stimuli has shown that newborns are sensitive to primacy and recency as well as simple familiarity. A pilot and one complete experiment were carried out to examine whether primacy and recency operated with faces as well. Results indicated that primacy, but not recency, was effective. The results show very rapid learning, learning that may outpace the capacity of any extant model of perceptual learning.

A number of recent studies have shown that human infants, only a few hours of age, have learned to identify mother's face (Bushnell, Sai, and Mullin, 1989; Field, Cohen, Garcia, and Greenberg, 1985; Pascalis, de Schonen, Morton, Deruelle, and Fabre-Grenet, 1995; Walton, Bower, and Bower, 1992). There can be no argument that this is very rapid learning. Unlike mother's voice (e.g., Mills and Melhuish, 1974), there is no possibility of prenatal exposure to mother's face. Walton and Bower (1993) suggested that the requisite learning could be accomplished by a very simple process, the process of schema formation as outlined by Kagan (1984). An analogous process in the mind of the baby could explain this very rapid learning. In essence it was proposed that newborns store in memory a composite of faces presented to them. That composite is modified by each new presentation of a face. The more frequently presented a face is, the more the composite will resemble that face. It seems reasonable to assume that the mother's face will be the most frequently presented face. Hence the continuously updated composite will closely resemble mother's face. Walton and Bower tested this hypothesis by serially presenting newborns with a list of 4 faces. The newborns were then presented with a composite of these 4 faces and a composite of 4 previously unseen faces. The newborns preferred to look at the composite of the 4 previously seen faces. Since newborns prefer the familiar in experiments such as these (e.g., Meltzoff and Borton, 1979) (habituation experiments are a different matter), this result was taken as support for the hypothesis. In habituation experiments the aim is to find a presentation in which the subject will prefer a novel presentation at some point in time. Thus, Pascalis and de Schonen (1994) were able to demonstrate that, after repeated presentations of a face, newborns would look more at a novel face when the familiar face was presented with a novel face. Pascalis *et al.* (1995) found that newborns did prefer to look at the face of mother who of course is not novel. These authors seem to believe that the newborn's basic preference is for novelty and that the preference for mother's face is surprising and strange. They present an operant learning explanation of why newborns might look at mother's face. The operant learning explanation had been dismissed by Walton *et al.* (1992), the explanation certainly would not apply to other experiments which have found a preference for the familiar, e.g. Meltzoff and Borton (1979) or Kaye and Bower (1994), that involved stimuli with no operant history. We do not deny that what looks like a novelty preference can be induced in habituation experiments. Whether the preference found in these experiments is true preference or a temporary phenomenon due to exploration we can not at present decide. It would seem from the work of Langlois and Roggman (1990) that adults show a

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similar preference for the composite of a set of faces over any of the individual faces. It thus seemed possible that the same mechanism was operating throughout the lifespan.

At least for the newborns, this model would imply that there was no individuation of faces. Even for adults, the implication is that attractiveness is a function of averageness. With infants, the only measures available are measures linked to attractiveness, e.g., looking time, which would imply experimental difficulties in demonstrating individuation. This line of thought was brought to an abrupt halt by results presented by Kaye (1992). Kaye presented newborns with lists of speech sounds (nonsense syllables). She found no preferences between syllables on first presentation. However, within the second presentation of the same list she found that both primacy and recency affected preference, with items presented at the beginning of the list being listened to longer than items presented at the end of the list, which were in turn listened to longer than items presented in the middle of the list. This serial position effect implies both individuation and a source of preference that is different from preference that can be attributed to a composite effect. If all we had, in effect, was a composite effect there would be no preferences linked to order of presentation. It is assumed that all components contribute equally to a composite and that all are therefore similar to and different from the composite to the same extent. No position specific effect can thus be anticipated. It is possible that faces (visible stimuli) and syllables (audible stimuli) are dealt with in separate modules (Fodor, 1983) with different principles of operation (see, e.g., Crowder, 1986; Greene and Crowder, 1984). Before accepting this hypothesis, it seemed worthwhile checking to discover whether primacy and recency effects could occur with a list of faces. It is, of course, possible that primacy, recency and a composite effect could all be produced by a list of faces. Since there is evidence for the last of these, the composite effect, this paper focused on the first two. The following pilot study was, therefore, performed. It should be emphasized that it was intended as a pilot only, done only to see whether it was worthwhile investing the time and effort in a full-fledged experiment.

Pilot

Method

Participants

Participants were 5 full-term newborns, 3 uncircumcised males and 2 females, between the ages of 7 and 54 hours ($M = 30.25$, $SD = 8.10$), who were born without complication at a large county hospital, weighed at least 2500 g at birth, had Apgar scores of 8 or greater at 1 and 5 min., and had no problems identified in their routine physical examination. Informed consent was obtained from the mother of each newborn prior to participation. All the mothers were of low socioeconomic status, and the criteria for invitation to participate included documented prenatal care for the mother, no history of maternal drug or cigarette use, no current or prenatal diseases, and no medication during delivery. There were no newborns recruited for this experiment who failed to complete it.

Materials

The faces of 5 blond females were captured live through a video camera (Panasonic PV 330), and then were digitized using Framegrabber hardware and its associated software (Progressive Peripherals and Software). All women were of north European descent, aged 23–30. The images were saved onto the hard drive of an Amiga 2000 computer (Commodore). Each female face was captured with a neutral facial expression to eliminate the possibility that newborns would prefer one facial expression over another. Faces were captured in HAM 320×200 resolution in 4096 colors, then reformatted to 640×200 resolution in 16 colors using Pixmate graphics software (Progressive Peripherals and Software). Faces were aligned for digitizing so that pupils and the middle of the upper lip were matched to places marked on the monitor. The luminance of the female images was 8.0 footcandles. The faces were presented on a 13" color video monitor and were 17 cm high.

Design and Procedure

The 5 faces were loaded as files on an Amiga computer. The files were presented sequentially with order counterbalanced across newborns. Using an operant sucking procedure (Walton *et al.*, 1992), newborns first entered a fixed operant phase in which by sucking they could present each face to themselves for 0.8 seconds. The newborns then began a free operant phase in which they controlled how long they viewed each stimulus. The newborns could cycle through the stimuli in the free operant phase as many times as they wished during the experiment depending on the individual neonate's rate of sucking.

The newborns completed the trial in a quiet test room within the newborn nursery between the hours of 2:00 p.m. and 5:00 p.m. in a gap between scheduled feedings. All participants were run by two experimenters who monitored the state of the infant. If both agreed that the infant was quietly alert (eyes open, focusing and tracking; no fussing), the experiment was begun. The experimenters monitored the infant during the experiment from different angles of view. If either experimenter thought the infant had closed his eyes or was looking away from the screen, there was a facility in the software to pause the experiment until the infant's state and attention could be restored. Had it proved impossible to restore state and attention, the infant would have been removed from the experiment and data discarded. It should be noted that this facility was not used at all in either of the experiments reported in this paper.

The newborns were held with 'liberated neck' (Amiel-Tison and Grenier, 1986) 25 cm from the monitor. The presentation of faces in the monitor was controlled by the Amiga computer. Faces were loaded as files into the computer. The presentation of files was controlled by the newborn by way of a pacifier connected via an Omega pressure transducer to the computer. The operant was a positive pressure suck at < 10 cycles per second (cps). The background screen was plain blue. The newborn's first three sucks generated bullseyes with audible beeps, each lasting 0.2 seconds. These trials were intended to orient the newborn toward the monitor. The next suck began the fixed phase. That suck elicited the first presentation of file 1. File 1 was presented for 0.4 seconds and could not be interrupted. The next suck after the 0.4 seconds elicited a second presentation of file 1. That presentation could not be interrupted. The next suck after the second presentation of file 1 elicited file 2 for 0.4 seconds, uninterruptible. The next suck after the 0.4 seconds elicited a second uninterruptible presentation of file 2. The next suck after the 0.4 seconds elicited the first uninterruptible presentation of file 3. This process continued until all 5 files had been presented for 0.8 seconds. The next suck began the free phase of the experiment, with the first presentation of file 1. File 1 and all subsequent files were presented for 0.4 seconds. If a second suck occurred during the presentation of file 1, a new presentation of file 1 began and continued for 0.4 seconds unless it was in turn interrupted. Each suck elicited file 1 until an inter-suck interval (ISI) of more than 1 second occurred. The next suck after such an interval elicited file 2, which was presented until the next ISI > 1 second occurred; the next suck after that eliciting file 3, and so on. After the last file loaded had elicited an ISI of > 1 second, the computer returned to file 1 and continued as before until the experimental duration of 300 seconds elapsed. By sucking and pausing appropriately, the newborns could view each stimulus for as long as they wished.

As well as controlling the experiment, the computer was responsible for the first stage of data analysis. The basic data recorded were an analogue of first-look durations during the first free operant cycle (Lewis, Kagan, and Kalafat, 1966). For first-look durations, the computer measured total presentation time of a stimulus from its first occurrence until its termination by an ISI of greater than 1 second. It should be noted that the same looking time could be generated by different sucking patterns. With a 400-ms stimulus presentation, a 2-s looking time could be generated by 5 sucks each 400 ms apart, followed by an ISI of greater than 1 second. The same looking time could be generated by 9 sucks each 200 ms apart, followed by an ISI of greater than 1 second. If the newborn sucked at a slower rate so that the background screen was presented in between presentations of the same stimulus (slower than one suck/400 ms but faster than one suck/second), then presentations of the blue screen were not included in looking time. Save for the circumstances mentioned above, the computer was solely responsible for recording data in this experiment. It can thus be assumed that the reliability of these measurements is, for all practical purposes, perfect. Since the experiment would have been stopped had the infant ceased to look at the computer screen (see above), the times given can be taken as true looking times.

Results

First look durations on the first free presentation of each face were used (Lewis *et al.*, 1966). Longer looks were taken as a measure of preference. We assumed that newborns prefer the familiar (DeCasper and Fifer, 1980; Meltzoff and Borton, 1979; Walton *et al.*, 1992). A preference for a face in the free presentation would thus indicate that the newborns had formed a representation so that the face had become familiar. The results are shown in Figure 1. As can be seen, there was a strong primacy effect, $F(4, 16) = 17.213$, $p < 0.001$. There was no effect of face.

Discussion

Figure 1 indicates a strong primacy effect operating in the conditions of this pilot experiment. There was no sign of a recency effect. The absence of a recency effect argues against the validity of the observed primacy effect. The conditions of this pilot experiment were such that artifacts could have produced the result. The first obvious artifact is that the first face presented in the fixed phase, the presumed beneficiary of primacy, was also the first face presented in the free operant phase.

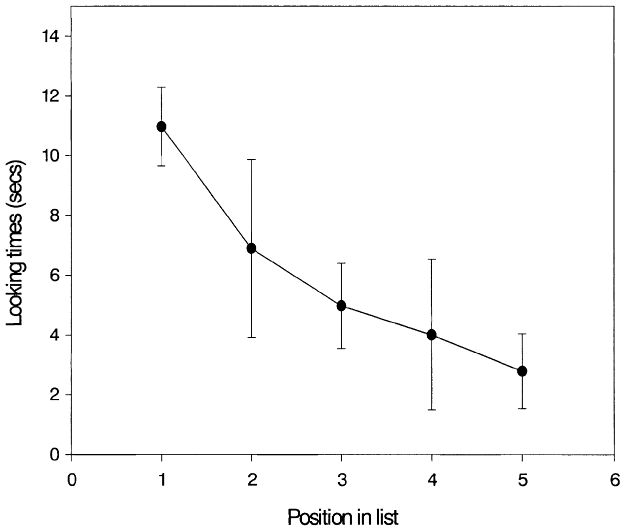

Figure 1 *Results of pilot experiment. First look duration in free looking as a function of position in the fixed list. The points represent the mean looking times in seconds; vertical lines depict standard deviations.*

We must presume that newborns will be struck by and will enjoy the fact that they have total control over the stimulus presentation (Bower, in press; Watson, 1966). They may, therefore, suck more to explore the contingency and thus present the first stimulus more often to be looked at. The primacy effect would thus be an artifact of contingency exploration.

The next experiment sought to control this artifact by introducing two changes. The first stimulus presented in the free phase was a novel stimulus, a 1–3 kHz tone. (A tone, rather than a novel visual stimulus, was chosen because prior work (Bower, in press) has shown that simple sound stimuli elicit much more responding than simple visual stimuli, i.e., much more contingency exploration.) The tone was completely under the subject's control. It was hoped that the contingency exploration would be completed with the tone so that the response to the faces would be free of this artifact. As a further control, the order of faces in the fixed presentation was changed in some of the free presentations so that the primary face in the fixed list was not invariably primary in the free list.

Experiment 1

Method

Participants

Participants were 16 full-term newborns, 8 uncircumcised males and 8 females, aged 7 to 54 hrs. ($M = 32.4$, $SD = 8.0$). Criteria for participation were the same as for the pilot experiment. There were no newborns recruited for this experiment who failed to complete it.

Materials

The materials used were the same as for the pilot experiment.

Design and Procedure

Four of the five faces used in the pilot experiment were loaded into the computer. A 1–3 kHz tone was also loaded. Computer limitations meant that we could not use five faces. During the fixed phase each face was presented for 0.8 seconds. Four infants saw the faces in the order ABCD, four in the order BCDA, four in the order CDAB, and four in the order DABC. The first stimulus presented in the free phase was the tone. After that the infants could view the faces. The order of faces in free presentation was counterbalanced with respect to their presentation order in the fixed phase. Thus, of the four infants who saw the faces in the fixed presentation in the order ABCD, one saw them in the free phase in the order ABCD, one saw them in the order BCDA, one saw them in the order CDAB, and one saw them in the order DABC. All of the fixed orders were counterbalanced in the same way.

The procedure was identical to that of the pilot experiment.

Results

The tone elicited a mean first listen of 1.83 seconds ($SD = 1.39$). The results for the faces are shown in Figure 2. A two-way ANOVA with repeated measures was used to analyse the data (see Table 1). As can be seen in Figure 2, there was a strong effect of order in the fixed list, with primacy producing more looking during the first free operant cycle, $F(3, 36) = 10.919$, $p < 0.001$. There was no significant effect of order in the free list, $F(3, 36) = 0.58$, p = 0.639 (see Figure 3), nor was there any interaction between fixed and free orders,

Table 1 *Analysis of Variance for Experiment 1.*

Source	d*f*	*F*
Order in free list	3	0.580
Order in fixed list	3	10.919*
Interaction	9	0.531
error	36	(9.006)

Note. Values enclosed in parentheses represent mean square errors.
* $p < 0.001$.

$F(9, 36) = 0.531$, $p = 0.842$. Post hoc testing indicated that the first face in the free list was significantly preferred over the second face ($t = 2.9$, df = 15, $p = 0.011$, with Bonferroni correction $p = 0.022$). The face presented second in the fixed list was not significantly preferred over the face presented third ($t = 1.796$, $df = 15$, $p = 0.093$, with Bonferroni correction $p = 0.19$). No further post hocs were done since they would clearly have been a waste of time.

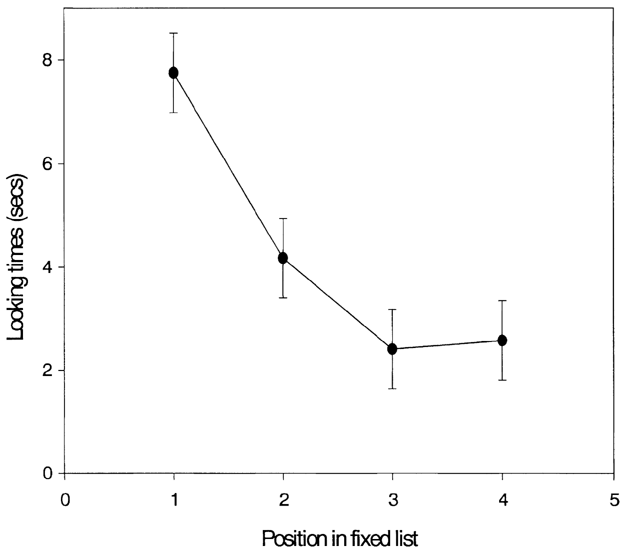

Figure 2 *Effect of order in fixed list in Experiment 1. This figure shows first look duration in free looking as a function of position in fixed list. The points represent the mean looking times in seconds; vertical lines depict standard errors of the means.*

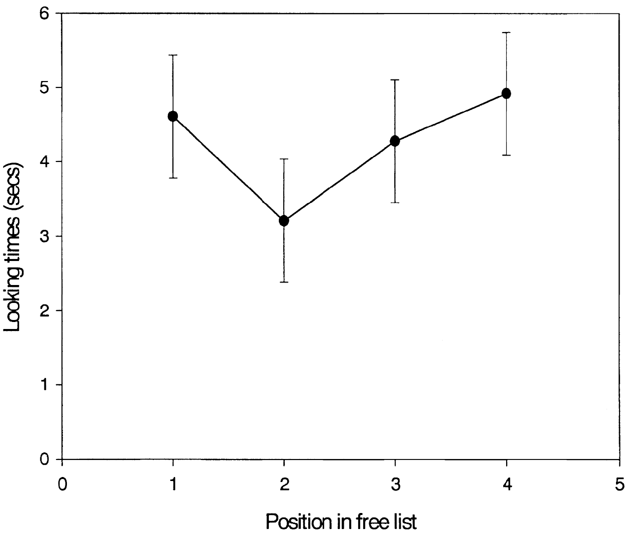

Figure 3 *Effect of order in free list in Experiment 1. This figure shows first look duration in free looking as a function of order of presentation in the free list. The points represent the mean looking times in seconds; vertical lines depict standard errors of the means.*

General discussion

The results provide striking evidence of the effectiveness of primacy in producing newborn preference for a face. We are assuming that primacy produced very rapid learning so that the first presented face was more familiar than any of the other faces. A reviewer of this paper has suggested that primacy has its effect as a result of novelty preference with the newborns forgetting the first presented face by the time it is re-presented in the free phase. In the pilot experiment, there is more time between presentation of the second face in the fixed list and its re-presentation in the free list than there is between the presentation of the first face in the fixed list and its re-presentation in the free list. On the novelty preference model face two should have been preferred and it was not. In Experiment 1, this hypothesis would have to predict a significant interaction effect between fixed and free order. There was no interaction effect. It should be noted that in neither the pilot nor the experiment was there any evidence for recency. Primacy and recency together would have been very clear evidence of individuation. A primacy effect such as that shown here must coexist with the composite effect (Walton and Bower, 1993). The two together indicate that newborn learning, simple visual learning, is a more complex process than we have previously thought, with at least two learning processes going on simultaneously. One of these, the primacy effect, is truly surprising. The evidence presented here indicates that newborns could learn to identify a face after a presentation of only 0.8 seconds. They could retain a representation of that face across the presentation of other faces and a tone. So far as we know, there is no extant theory of perceptual learning that can account for learning as rapid and persistent as this. The learning was persistent. There was no effect of order in the free list and no interaction between the orders of the fixed and the free lists.

These results may explain why newborns in many studies prefer to look at mother's face. In the hospitals that we work in, and indeed in all of the hospitals we are familiar with, the mother's face is the first unmasked, ungoggled face seen by the newborn. These hospitals are following the recommendation of Klaus and Kennell (1982). Mother's face, thus, benefits from the primacy effect shown in the experiment described above. A reviewer of this paper has reported that in some UK hospitals procedures are such that the father's will be the first face seen by the baby. On the reasoning presented here, in these hospitals, the newborn should show a preference for father's face rather than mother's face, an effect that was tested for and definitely not found by Walton, Bower and Bower (1992).

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