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ABSTRACT

This experiment examined developmental changes in the ability of infants to learn conceptual categories regarding the human face. A total of 108 infants, aged 18, 24, and 30 weeks, were habituated to (1) the same face in the same orientation, (2) the same face in differing orientations, or (3) different faces in different orientations. All subjects were then tested for generalization of habituation with a familiar face in a novel orientation and a novel face in a novel orientation. Results for both fixation times during post-habituation trials and dishabituation to the test stimuli indicated little conceptual categorization at 18 weeks, possibly the beginnings of such categorization at 24 weeks, and evidence for responding at two different categorical levels (both that of a "specific face regardless of orientation" and "faces in general") at 30 weeks of age. These results suggest that concept acquisition ability may be present at a much younger age than had previously been believed. (Author/MS)

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CONCEPT ACQUISITION IN THE HUMAN INFANT[1]

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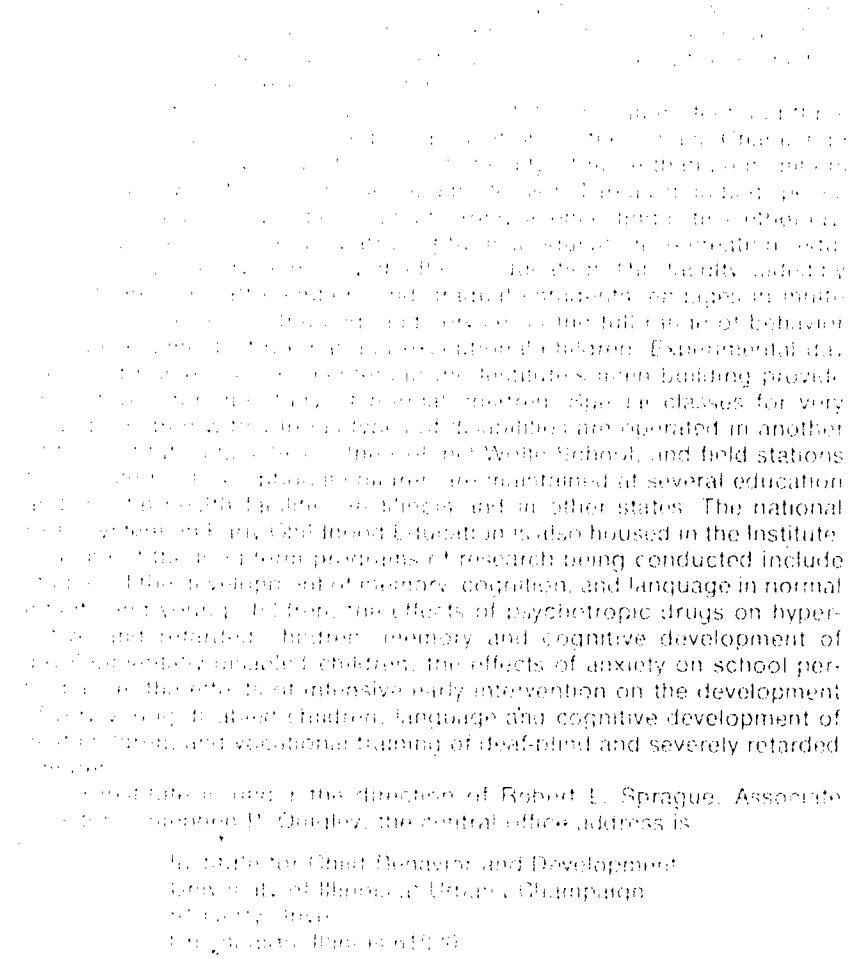

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The present experiment was designed to examine developmental changes in the ability of infants to learn conceptual categories. The categories all dealt with the human face and were at three different levels of abstraction.

The typical procedure for demonstrating concept learning requires at least two phases. In an initial acquisition phase, Ss learn to respond similarly to (or are habituated to) a number of different stimuli, all of which are members of the same general class or category. A test phase follows in which concept acquisition is inferred from greater generalization to a novel member of the same category than to a member of a different category. For example, in one condition of their experiment, Faikender, Wright, and Waldren (1974) habituated toddlers to pictures of animals and then found more generalization of habituation among females to pictures of other animals than to pictures of fruit. The fact that the generalization occurred to an animal which had not been seen before indicated that the Ss were basing their response on some abstract category or concept.

Habituation and related novelty preference techniques are ideally suited to investigating generalization and discrimination of visual stimuli in young infants (Cohen and Gelber, 1975) and a few studies have even examined generalization to what could be called the same conceptual category: for example, responding to the same pattern regardless of orientation (McGurk, 1972; Schwartz, 1975) or to male versus female faces (Cornell, 1974; Fagan, 1976). However, the only study investigating developmental changes in infants ability to categorize at different levels of abstraction was reported by Cornell (1974) and his results must be treated as somewhat tentative. He attempted to show that infants would generalize either to the

same facial photograph, to a photograph of the same person in a novel orientation, or to photographs of females versus males in general. Unfortunately in all three conditions infants might have been responding to the same common feature such as length or shape of hair, and it was not clear whether or not the infants could discriminate the same sex test stimulus from the ones presented during familiarization. Also infants were run for the same number of trials rather than to a criterion of habituation, and there was some evidence that the decreased generalization in some conditions may have resulted from a lack of habituation rather than from an inability to acquire the concept.

The present study attempted to correct these deficiencies. One hundred and eight infants were tested in all, with 18 males and 18 females at 18, 24, and 30 weeks of age. Within each age and sex category, infants were randomly assigned to one of three conditions described below. Each infant was brought individually into our testing laboratory and placed on his or her mother's lap in an enclosed area facing a 4' x 4' white display screen. The screen was approximately 26' from the infant's eyes. A closed circuit television camera facing the infant through a 2" hole in the center of the screen was used to record fixations. Every trial began with a blinking light 5" to the right of the camera hole. As soon as the infant fixated the light, it went off and was replaced by a 12 x 8 inch slide five inches to the left of the hole. The infant was allowed one unrestricted look per trial. As soon as he or she turned away, the slide went off and the blinking light reappeared to begin the next trial. Fixation times were recorded in an adjacent control room by an observer watching the infant's

face on a television monitor. The reliability of this technique is extremely high with better than 98% agreement between two independent observers.

The design of the experiment as well as the stimuli used in each condition are presented in Table 1. All Ss received a 24 x 24 black and white checkerboard pattern on the first and last trials. These checkerboards provided both a warm up stimulus at the beginning of the experiment and a test at the end to determine if looking time generally decreased during the course of the session. Following the first checkerboard, infants entered the habituation phase of the study in which they were repeatedly given either one or more stimuli (depending upon the condition) until their mean fixation times on three consecutive trials reached a criterion of less than 50% of the mean of their first three looks. The post habituation phase included three more trials with the same stimuli to test whether habituation had actually occurred. All stimuli in habituation and post habituation were color photographs of adult females in a 3/4 profile side orientation.

In Condition 1 infants were repeatedly shown exactly the same photograph (female 1 in orientation 1). In Condition 2 the slide changed from trial to trial, but it was always the same female person in different side orientations. (For example, it may have been female 1 looking to the upper left on trial one, looking to the lower right on trial 2, looking to the upper right on trial 3, etc.). Condition 3 was identical to Condition 2 except that the photographs were of different females in different side orientations on each trial. Finally two test trials were given, one with

female 1 and one with a totally novel female. However, for the first time, both faces were looking straight ahead. Order of presentation of the test trials and the choice of female 1 and female N were counterbalanced.

Two sets of predictions were made; one set for those infants capable of acquiring the relevant concept in each condition, and a second set for those incapable of doing so. Infants able to acquire the concepts should respond quite differently in each condition. In Condition 1, the infants were habituated only to "the same face in the same orientation". Thus a change in either face or orientation should be sufficient to produce dishabituation. In terms of the present experiment, therefore, we predicted that in Condition 1, infants would dishabituate to, or look longer at both test stimuli than at the last post habituation stimulus. In Condition 2, the same face was presented in varing orientations. If infants were acquiring the relevant concept, they should habituate to "the same face regardless of orientation", and dishabituation should occur only to the novel face. In other words, only the fixation time to $F_{N.}$ should be higher than the last post habituation trial. Finally in Condition 3 both the faces and orientations were varying from trial to trial. Habituation should be to "female faces in general", and there should be no dishabituation to either test stimulus.

Infants unable to acquire the appropriate concepts should respond quite differently. Prior research from our laboratory has shown that infants as young as 14 weeks of age will dishabituate to the same face in a novel orientation. Even if they cannot respond to the more abstract concepts of "the same face regardless of orientation", or "female faces in general", they should be able to discriminate different orientations. Thus the prediction for these infants is that all three conditions should be equivalent to

Condition 1, since all involved habituation to side views and tests with front views, and in all conditions the infants should dishabituate to both test stimuli.

Most of the results were straightforward. In all analyses involving fixation times raw scores were converted to logs to reduce the variance and normalize the distributions. Looking times to the initial and final checkerboard patterns did not differ significantly, although younger S looked longer than older ones ($F_{2,72} = 15.33$, $p < .001$). Therefore, infants at all ages did not decrease their fixation times over the course of the experiment and were generally attentive throughout.

A comparison of the first three habituation trials with the three post habituation trials indicated that in all three conditions and at all three age levels infants habituated (i.e., looked significantly less during post habituation than during the beginning of the habituation phase ($F_{1,72} = 233.65$, $p < .001$). A significant conditions effect was also obtained ($F_{2,72} = 4.69$, $p < .02$) with infants' overall fixation times somewhat longer in Conditions 2 and 3, than in Condition 1.

Somewhat unexpectedly, even though infants looked longer during habituation in the conditions involving changing stimuli, (Conditions 2 and 3) no significant difference was found either over age or over conditions in the mean number of trials needed to reach the habituation criterion. ($\bar{X} = 9.6$).

In order to test the major predictions of the study, separate analyses of variance were run at each age comparing the last post habituation trial, P_3, and the two test trials, F_1. and F_N. At 18 and 24 weeks the analyses produced significant Trials effects ($F_{2,48} = 9.36$, $p < .01$, and $F_{2,48} = 7.52$, $p < .01$) but no Conditions effect or Conditions x Trials

interaction. At both ages the results indicated that across conditions infants were looking significantly longer at the two test stimuli than at the post habituation stimulus.

The story was quite different at 30 weeks of age. No reliable main effect of either Conditions or Trials was found, but the interaction between Conditions and Trials was significant ($F_{4,48} = 3.26$, $p < .02$) indicating that the three conditions did have a differential effect on fixation times to the test stimuli. Figures 1, 2, and 3 show these effects along with the results of one tailed t-tests comparing the post habituation stimulus with each of the test stimuli.

As can be seen from Figure 1, at 18 weeks, infants in all three conditions tended to look longer at both test stimuli than at P_3. Differences between P_3 and either $F_{1.}$ or $F_{N.}$ were significant in Condition 1, were of borderline significance in Condition 2, but were not quite significant in Condition 3. The problem in Condition 3 resulted from one atypical infant who looked 13 seconds at P_3 and only 2 seconds at $F_{1.}$ and $F_{N.}$. When his data were removed, performance in Condition3 approximated that of Condition 2.

As shown in Figure 2, at 24 weeks the results were essentially the same as for 18 weeks. In all three conditions infants looked longer at the two test stimuli than they did at the last post habituation stimulus.

The Conditions x Trials interaction at 30 weeks of age is shown in Figure 3. In Condition 1 these older infants looked significantly longer at both test stimuli than at P_3, while in Condition 2 they looked longer only at the novel face, and in Condition 3 they looked the same or less at

both test stimuli than at P_3.

The present results with 30 week old infants were precisely what was predicted for Ss who were capable of abstracting or differentiating appropriate conceptual categories regarding the human face. Furthermore, the data indicated that at this age infants can acquire a variety of categories ranging from a particular orientation of a face, to a particular face regardless of orientation, to faces (or at least female faces) in general. By contrast, infants at the younger two ages responded similarly in all conditions. They seemed to be sensitive to a change from a side to a frontal orientation, but not to the invariant features of a particular face or of faces in general.

The procedure used in this study represented an improvement over the one used by Cornell (1974). Since all infants in the present experiment were habituated to a criterion, one can be reasonably confident that at all ages infants had encoded whatever information about faces they were able to encode. The fact that all three ages infants dishabituated to both test stimuli in Condition 1 indicated that the infants were able to discriminate the habituation from the test stimuli. Also the fact that the 30 week old infants responded differently in the test following each habituation condition indicated that the infants could not be basing their responses on the same distinctive features in all conditions.

The present results were quite similar to those reported recently by Fagan (1976). He tested only 29 week old infants and found them capable of generalizing either to the same face in a novel orientation, or to same sex faces when he presented multiple examples of these faces during a

familiarization period. Comparison of 30 week olds, under conditions 1 and 3 in the present study produces the same conclusion. Only when multiple examples of faces were presented during habituation did the 30 week old infants generalize to both faces in the test. However, unlike Fagan who found that one example of an individual's face was sufficient to produce generalization to another orientation of the same face, comparing 30 week old infants in the present experiment under Conditions 1 versus 2 suggests multiple examples facilitate generalization to the same face in a different orientation as well.

One might be tempted to argue that the reason the 18 and 24 week old infants in the present study looked longer at both test stimuli under all conditions was that they simply preferred to look at faces in a frontal orientation than at the same faces in a side orientation. Data from an unpublished study in our laboratory do not support that argument. Fourteen, 18, 22, and 26 week old infants were habituated either to a frontal or side view of a face and then tested with the opposite view. Although at all ages the infants did dishabituate when the orientation was changed, neither overall fixation time nor amount of dishabituation was related to the type of orientation the infants were viewing.

Finally while the present experiment demonstrates concept acquisition at 30 weeks of age, one should not interpret the findings with younger Ss to mean that infants under 29 or 30 weeks are incapable of acquiring a concept or of abstracting the relevant categorical information from a set of changing stimuli. McGurk (1972), for example, found that 26 week old infants could generalize to the same shape in a different rotation, given previous experience with the shape in a variety of other rotations and a study on shape constancy

by Day and McGenelle (1974) suggests that infants as young as 6 or 7 weeks of age may be able to abstract the invariant properties of a cube that changes orientation from trial to trial.

Thus, it does not appear to be too fruitful to attempt to search for the earliest age at which an infant can form any concept or category. More meaningful developmental questions might be what types of concepts can be acquired at different ages, what are the minimum number of examples needed to form those concepts, and how does that minimum number change over age? These are some of the questions we intend to pursue in our future research.

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Footnote

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CONCEPT ACQUISITION IN THE HUMAN INFANT

EXPERIMENTAL DESIGN

CONDITIONS	PRETEST	HABITUATION	POST-HAB.	TEST	POST-TEST
I	CHECK.	$F_{11}, F_{11}, F_{11}, \ldots$	F_{11}, F_{11}, F_{11}	$F_{1.} F_{N.}$	CHECK.
II	CHECK.	$F_{11}, F_{12}, F_{13}, \ldots$	F_{17}, F_{13}, F_{19}	$F_{1.} F_{N.}$	CHECK.
III	CHECK	$F_{11}, F_{22}, F_{33}, \ldots$	F_{77}, F_{88}, F_{99}	$F_{1.} F_{N.}$	CHECK.

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F_{11} refers to Face 1 in side orientation 1, F_{22} to Face 2 in side orientation 2, etc. $F_{1.}$ and $F_{N.}$ refer to Faces 1 and N in frontal orientations.

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Figure Captions

Figure 1. Log fixation times by 18 week old infants to the last post habituation trial (P_3), and test trials with the familiar face in a frontal orientation ($F_{1.}$), and a novel face in a frontal orientation ($F_{N.}$), following either habituation to the same face in the same orientation (Condition I), the same face in varying orientations (Condition II), or different faces in varying orientation (Condition III).

Figure 2. Log fixation times by 24 week old infants to the last post habituation trial (P_3), and test trials with the familiar face in a frontal orientation ($F_{1.}$), and a novel face in a frontal orientation ($F_{N.}$), following either habituation to the same face in the same orientation (Condition I), the same face in varying orientations (Condition II), or different faces in varying orientation (Condition III).

Figure 3. Log fixation times by 30 week old infants to the last post habituation trial (P_3), and test trials with the familiar face in a frontal orientation ($F_{1.}$), and a novel face in a frontal orientation ($F_{N.}$), following either habituation to the same face in the same orientation Condition I), the same face in varying orientations (Condition II), or different faces in varying orientation (Condition III).

Figure 1

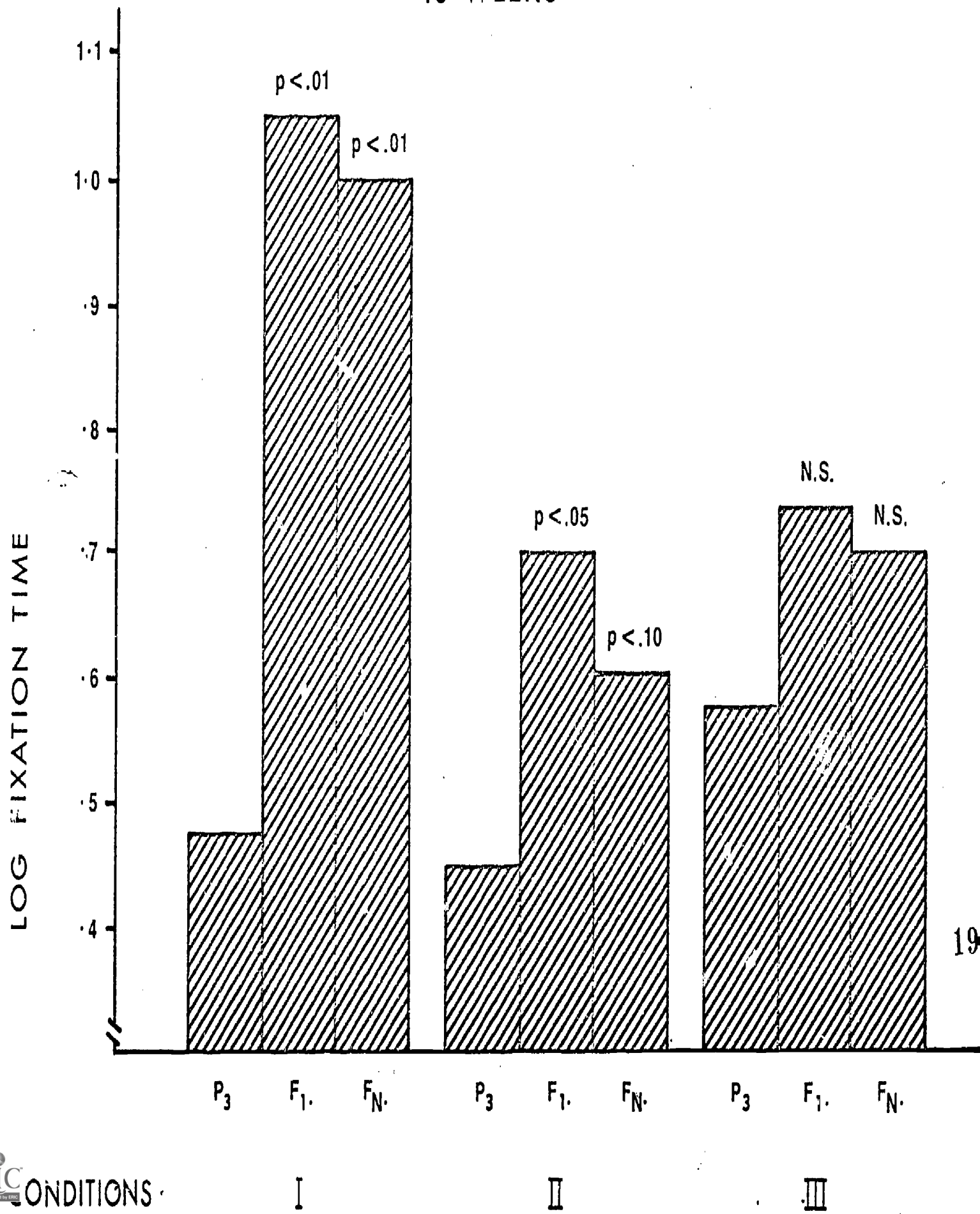
18 WEEKS
LOG FIXATION TIME
1·1
1·0
·9
·8
·7
·6
·5
·4
p <.01
p <.01
p <.05
p <.10
N.S.
N.S.
P3
F1.
FN.
P3
F1.
FN.
P3
F1.
FN.
CONDITIONS
I
II
III

Figure 2

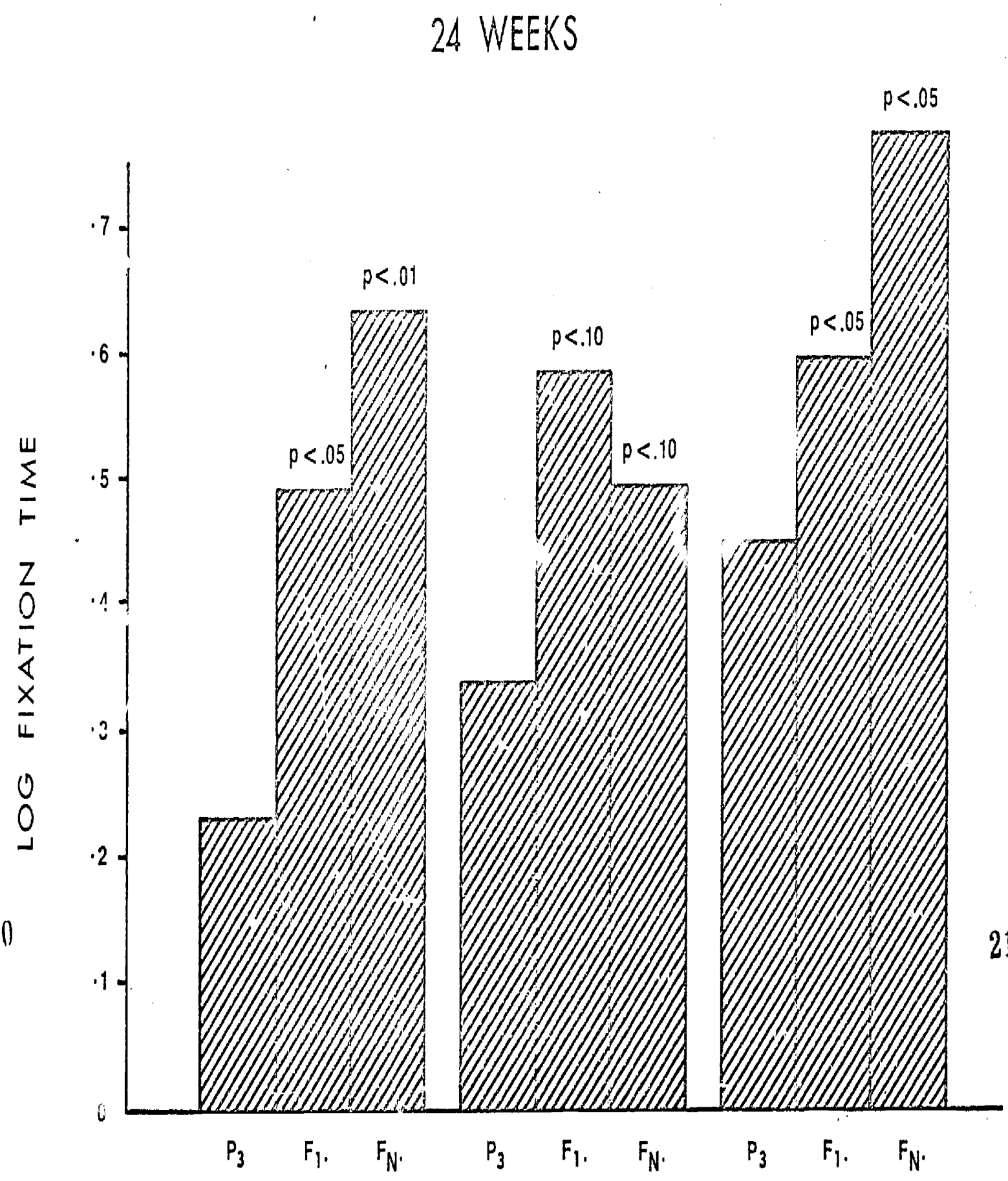
24 WEEKS
p<.05
p<.01
p<.10
p<.05
p<.05
p<.10
LOG FIXATION TIME
·7
·6
·5
·4
·3
·2
·1
0
P3
F1.
FN.
P3
F1.
FN.
P3
F1.
FN.
CONDITIONS
I
II
III

Figure 3

30 WEEKS