Newborn visual attention to repeated exposure of redundant vs "novel" targets*

STEVEN FRIEDMAN

Boston University, Boston, Massachusetts 02115

This study was designed to test the proposition that habituation in the newborn human is specific to repetition of a single impinging stimulus. Using a group (3) by sex (2) by trials (8) repeated measures factorial design, 120 newborn infants were repeatedly presented with a single visual target (2 x 2 or 12 x 12 black and white checkerboard) or exposed to a series of different targets, and the infants' visual fixation time was measured. Infants exposed to the multiple target series had a significantly greater mean visual fixation time than did infants repeatedly presented with a single target. However, all groups of infants displayed response decrement in fixation time with repeated target exposure. In addition, infants receiving the multiple target series displayed differential visual fixation to the stimuli, with, in general, targets of greater redundancy (i.e., those having a higher degree of spatial repetition and duplication of elements) being most "preferred." These results suggest that young human infants are receptive and responsive to stimulus change in the immediate visual environment.

Response decrement to repetitive stimulus presentation is described as "perhaps the most ubiquitous phenomenon in animal behavior [Harris, 1943, p. 385]." A number of studies with the human newborn have reported relatively short-term changes in responsiveness attributable to repeated stimulus exposure in various modalities (e.g., audition—Bartoshuk, 1962; Clifton, Graham, & Hatton, 1968; olfaction—Engen & Lipsitt, 1965; vision—Friedman, 1972).

This habituation process, in which an originally "novel" stimulus loses its capacity to maintain significant interest, may provide a useful technique for studying the perceptual capacities of the young organism. Using a habituation-recovery paradigm, one can repeatedly expose the organism to specific stimulation until a decrement in responsiveness is displayed, at which time a change in the stimulating agent may be introduced. If a recovery of response is demonstrated to the "new" stimulus,

one can rule out adaptation of sensory receptors and/or effector fatigue as producing the decrement (Thompson & Spencer, 1966). Moreover, such response recovery indicates that the organism has the capacity to detect (i.e., discriminate) the novel stimulus event. Such a habituation process has been demonstrated using visual patterns with the 3½-4-month-old human infant (e.g., Caron & Caron, 1969; Pancratz & Cohen, 1970) and, more recently, with the newborn human (Friedman, 1972). In this latter study, Friedman reported that a waning of the visual fixation response of the human neonate can be observed with repeated exposure of a checkerboard target, with response recovery being displayed when a stimulus change is introduced.

Since the habituation process has been described as specific to a single stimulating agent (e.g., Sokolov, 1963; Thorpe, 1963), the question explored in the current study was whether the visual response decrement displayed by the newborn is specific to a successively repeated target or occurs also with presentation of a series of different visual stimuli. If the former is the case, the habituation effect could not be attributable to the effect of visual stimulation, *per se*, but would be specific to repetition of a single visual pattern. If the latter is the case, then the decrement may be attributable to either oculomotor fatigue or possibly to a generalized response decrement to the whole class of stimuli employed.

METHOD

Subjects

The Ss were selected randomly from a population of apparently normal

human newborn infants from the Boston City Hospital nursery. They were awake and alert at the time of observation (which was between 7:30 and 9:00 a.m., prior to the morning feeding). Selected for this study were 120 infants (60 male and 60 female), who ranged in age from 17 to 96 h (mean = 53 h). An additional 19 infants were excluded due to vehement crying (16) or drowsiness (3) during the course of a session.

Stimuli

The stimulus targets employed are represented in Fig. 1. Each target was nonglossy, achromatic, and measured 15.2 x 15.2 cm excluding the base. No attempt was made to vary the targets systematically along a single dimension. Rather, the targets were constructed so as to be distinctly different from each other, while exhibiting "high attention value" within the limits imposed by using black and white patterns of equal size. As can be observed in Fig. 1, only one target possesses a circular configuration (No. 6) and only two targets have white elements on a black field (Nos. 3 and 7). Targets 4, 5, and 9 are checkerboards of varying degrees of redundancy (2 x 2, 6 x 6, and 12 x 12, respectively). Each target was inserted against the side of the infant's crib, which was covered with embossed light-blue plastic material.

Response Measure

The dependent variable, visual fixation time, was defined as the time during which the infant oriented his eyes toward the target. Judgment of time on target made by two independent Os, using cumulative stopwatches, yielded Pearson product moment correlations of +0.97 and +0.85 for 190 and 202 min of observation, respectively, in previous studies (Friedman, Nagy, & Carpenter, 1970a; Friedman, 1972). Additional inter-O reliability with a new O yielded a correlation of +0.87 for 109 min of observation. Reliability coefficients for individual Ss in the sample ranged from 0.64 to 0.99. Since judgments of time on target made by the two Os were highly consistent, the observations of one O (the author) served as the data.

Design

A group (3) by sex (2) by trials (8) factorial design with repeated measures on one factor (trials) was employed (Winer, 1962) with 20 Ss per cell (N = 120). Each of the three groups contained 40 infants, 20 of each sex. Two of the three groups were repeatedly presented with either a 4-square (2 x 2) or a 144-square (12 x 12) checkerboard target for

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Fig. 1. Stimulus targets employed.

eight successive 60-sec trials. The third (or novelty) group was successively exposed to each of the 10 targets represented in Fig. 1 for 60 sec.¹ For all three groups, trials were separated by a 5-10-sec intertrial interval, during which time the target was removed. For the novelty group, the order of exposure of the 10 targets (as indicated in Fig. 1) was initially randomly assigned and constant for all Ss. However, the starting point of target presentation was varied systematically (i.e., some infants began with Target 1, some with Target 2, etc.).

Procedure

Details of the procedure used in the present study are given elsewhere (Friedman et al., 1970a; Friedman, 1972). In brief, cumulative stopwatches were used in recording visual fixation time, and a photographic timer indicated the completion of a 60-sec trial. Targets were inserted against the side of the crib at approximately 19 cm from the infant, who was placed on his right side.

RESULTS

Response Decrement Effects

Figure 2 graphically displays the mean visual fixation time of each group over the eight trials of target presentation.

In order to determine if response decrement was displayed by the 40 Ss receiving presentation of the multiple target sequence, a simple sex (2) by trials (10) repeated measures ANOVA was computed. Although neither the

sex main effect ($F = 0.29$; $df = 1/38$) nor the Sex by Trials interaction ($F = 1.61$; $df = 9/342$) was significant, there was a significant trials (decrement) main effect ($F = 2.58$; $df = 9/342$; $p < .01$). This decrement effect reflects the fact that Ss exposed to the novel target sequence did display response decrement over the course of the 10 presentations.

In addition, the sequence of target presentation (i.e., whether S began the series with Target 1, 2, . . . , or 10) did

not differentially influence the infant's visual fixation time to the stimuli.

Tests for differences between the visual response of the two groups receiving a single visual target (i.e., 2 x 2 or 12 x 12 checkerboard) over trials were examined in a group (2) by sex (2) by trials (8) repeated measures ANOVA (Case II; Winer, 1962). A significant trials (decrement) effect ($F = 8.33$; $df = 7/532$; $p < .001$) and Group by Sex by Trials interaction ($F = 2.97$; $df = 7/532$; $p < .01$) were obtained. (See Friedman & Carpenter, 1971, for details regarding this interaction.) All other main effects and interactions in this analysis were nonsignificant.

Since the visual response of Ss receiving the 2 x 2 and 12 x 12 targets did not differ, these groups were combined and compared with the response of the novelty Ss. Since the 2 x 2 and 12 x 12 groups were given 8 trials of target exposure rather than 10, as in the novelty group, this ANOVA compared the initial 8 trials of the novelty group against the 8 trials of the other two groups. An unweighted means solution was employed (see Winer, 1962) since this analysis involves unequal group size (i.e., $N = 80$ for redundant group; $N = 40$ for novelty group). Results of this group (2) by sex (2) by trials (8) repeated measures ANOVA revealed a significant group main effect ($F = 6.24$; $df = 1/116$; $p < .025$), reflecting the greater mean looking time of the novelty group as compared with Ss receiving repetition of the 2 x 2 or 12 x 12 checkerboards. The trials (or

Fig. 2. Mean visual regard of 2 x 2, 12 x 12, and novelty groups as a function of repeated target exposure. Each trial lasted 60 sec.

Table 1
Summary of Results of Duncan Range Test of Differences Among Targets

	Shortest Significant Range $\alpha = .05$
Mean	53.86	54.05	54.82	55.51	55.62	56.12	56.80	57.42	57.58	57.68	
Face 53.86	—	0.19	0.96	1.65	1.76	2.26	2.94*	3.56†	3.72†	3.82†	2.52
Black-Δ 54.05	—	—	0.77	1.46	1.57	2.07	2.75*	3.37*	3.53†	3.63†	2.66
Vertical Stripe 54.82	—	—	—	0.69	0.80	1.30	1.98	2.60	2.76*	2.86*	2.74

* $p < .05$ † $p < .01$

decrement) main effect was also significant ($F = 7.98$, $df = 7/812$; $p < .001$), with all other main effects and interactions being nonsignificant.

Analysis of Fuss Behavior

During the course of a session, some infants displayed fussy behavior (i.e., agitation, crying, gross movements, and general arousal). When the number of Ss in each group showing such behavior was compared, it was found that 8 Ss fussed in the 2 x 2 group, 18 Ss fussed in the 12 x 12 group, while only 3 Ss displayed such behavior in the novelty group. A chi-square analysis of the above data was significant ($\chi^2 = 15.92$; $df = 2$; $p < .001$). A further analysis, comparing only the 2 x 2 and 12 x 12 groups, revealed that more infants fussed in the latter than in the former group ($\chi^2 = 4.62$; $df = 1$; $p < .05$).

Neonatal Target Preferences

Possible differential visual fixation by the 40 novelty Ss to the 10 targets (i.e., pattern "preferences") was examined in a target (10) by position (10) by sex (2) ANOVA. Results revealed that both the target and position main effects were significant ($F = 2.43$ and 2.44 , respectively; $df = 9/200$; $p < .025$). This latter position effect reflects response decrement in fixation time (i.e., the later in the series the target appeared, regardless of its composition, the lower the looking time). In addition, since the Position by Target interaction was not significant ($F = 1.07$; $df = 81/200$), the position of a target in the sequence did not alter this waning of fixation time.

The target main effect reflects differential fixation by the neonates to the 10 targets. In order to make specific comparisons of fixation time among the 10 targets, a Duncan new multiple range test (Edwards, 1960) was computed (see Table 1). The results of this analysis revealed that

while responses to the bull's-eye, horizontal stripes, 6 x 6, and 12 x 12 targets were not significantly different from each other, they did receive a significantly higher mean looking time than did either the facial stimulus or the black target with triangles. Furthermore, the 6 x 6 and 12 x 12 targets were significantly "preferred" to the vertically striped stimulus. No other differences were significant.

To determine the degree of "agreement" among the neonates in their ranking of the 10 targets (as determined by their differential visual fixation time), a Kendall test of concordance (Siegel, 1956) was computed. Results, computed separately by sex, revealed that whereas males "agreed" among themselves regarding the order of target preference, females did not ($\chi^2 = 21.60$; $df = 9$; $p < .02$ for males; $\chi^2 = 7.56$; $df = 9$ for females). A further and curious finding was that the infants sneezed more in the presence of those targets receiving relatively high fixation times (Pearson $r = +0.78$; $df = 9$; $p < .01$).

DISCUSSION

Response Decrement Effects

The present findings indicate that although human newborn infants repeatedly exposed to a series of *different* targets displayed visual response decrement, their mean visual fixation time was significantly greater than that of infants repeatedly presented with the *same* target. These results confirm earlier research (e.g., Friedman, 1972), indicating that the human newborn is perceptually responsive to stimulus change in the immediate visual environment.²

The current findings, however, are not altogether consistent with the fundamental characteristic of habituation which requires that the decrement process be specific to a single impinging stimulus (e.g.,

Thorpe, 1963). The current data indicate that the newborn's visual fixation time to patterned targets is reduced with experience viewing the stimuli, regardless of their composition. This decrement, displayed by the novelty group, may be accounted for in terms of some oculomotor fatigue with repeated visual stimulation or possibly to a generalized response decrement to the whole class of patterned stimuli employed. Since the targets do share common elements, the latter interpretation may well be tenable.

Arousal Effects

Arousal effects, as manifested in fussing and possibly in sneezing behavior, seem to be related to attentive processes in the neonatal period. The current study showed that infants receiving repetitive exposure of a single target (particularly the 12 x 12 stimulus) had a greater tendency to engage in fussy behavior than did infants receiving the series of different targets. A similar finding has also been recently reported with 3½-month-old infants (Caron, Caron, & Caldwell, 1971). In addition, a greater amount of sneezing occurred in the presence of those "novel" targets receiving relatively high fixation times. Anderson and Rosenblith (1968) reported that sneezing occurs in response to photic stimulation in some newborns, and this behavior may reflect an excitatory process.

Pattern Preferences

The results of the current study confirm the findings of Fantz (1963, 1966), Stechler (1964), and Miranda (1970) in regard to the existence of pattern preferences in the neonate. Since the 10 targets employed were not varied along a single dimension, it is difficult to delineate the properties of the stimuli which were "attractive" to the infants.

It appears, however, that patterns with a higher degree of internal redundancy and regularity (i.e., Nos. 1, 5, 6, and 9) were most "attractive", as reflected in relatively high attention times. It is possible that scanning and visual exploration of these highly repetitious patterns permits an increase in retinal stimulation. In this regard, Haith (1968) has reported that it may be such retinal stimulation, occurring when the eyes of the infant cross an edge or contour in the visual field, which "keeps the infant in the proximity of the contour [p. 6]."

Based on the current data, it seems as if an external environment of highly spatially redundant yet regularly changing stimulation may be most effective in producing a relatively high degree of maintained visual "interest" in the environment, as well as a calm and visually alert infant. However, habituation seems to occur when change in this highly redundant stimulation is minimal or absent—resulting in off-target (i.e., avoidance?) behaviors, accompanied by negative affective response (e.g., crying). Further systematic study may provide information on the relationship of the habituation process to the parameters of the environment which maintain and fail to maintain the infant's visual attention as well as to the concomitant affective response produced by such stimulation.

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NOTES

1. Data for the two repetition groups were collected prior to that for the novelty group. The former groups received 8 trials rather than 10, since the investigator was initially interested in the visual responses of these two groups on only 8 repeated exposures (see Friedman & Carpenter, 1971, for detailed discussion of the visual behavior of these two repetition groups).

2. It is possible that the group receiving the different targets (i.e., novelty group) was simply more alert and attentive than the repetition groups, irrespective of differences in target configuration. This possibility seems highly improbable since all groups were tested at the same time of day and did not differ significantly in postnatal age or in amount of medication the mother received during labor (see Friedman, 1971, for details). In addition, the same S selection criteria were used in choosing all 120 infants who were included in the study (i.e., quiet awake, eyes open, and alert).

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