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ABSTRACT

Habituation and dishabituation to a simple geometric stimulus were examined for a sample of 36 5-month old subjects. All subjects viewed successive presentations of a standard stimulus, and, following a retention interval, a single presentation of the standard and a novel stimulus in the test phase. During the interpolated interval, repeated presentations of another, different stimulus were shown to subjects in the Retroactive Inhibition Condition, while those in the Control Condition were given auditory stimulation. Analyses of visual fixation scores indicated that habituation occurred to the standard stimulus and that response within conditions to this stimulus in the test phase was in directions predicted by the interference theory of forgetting. Visual responses of subjects in the Retroactive Inhibition Condition appeared to have been dishabituated by presentations of a stimulus during the retention interval, whereas those of subjects in the Control Condition evidenced continued habituation to the standard. The between-conditions comparison on the test of the standard stimulus, however, only approached significance. (Author)

A TEST OF HABITUATION IN HUMAN INFANTS AS AN ACQUISITION PROCESS IN A RETROACTIVE INHIBITION PARADIGM[1]

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The purpose of the present research was to explore the correspondence between habituation, as it occurs in the human infant, and learning or memory phenomena. The hypothesized similarity is not a new proposal. Reference throughout the literature to learning, schema or cognitive structure, and attention indicate that many investigators view overt habituation as index of some form of learning or, at the least, a suitable vehicle by which to study variables demonstrated to affect acquisition and retention.

Habituation is defined generally as the decrement of response resulting from repeated stimulation (Harris, 1943). Controls for fatigue and sensory adaptation are required in order to determine the course of responding as a function solely of exposure to the stimulus. Procedures to induce habituation, therefore, are not unlike those used in studies of learning wherein material to be acquired is presented repeatedly. Behaviorially, the habituated autonomic or sensory system shows minimal response to subsequent presentations of the same stimulus, but demonstrates activation to a novel stimulus. Such differential behavior typically has been interpreted in terms of response to familiar vs. unfamiliar stimuli. An explanation rephrased in terms of learned vs. unlearned stimuli does not alter conclusions.

Resemblances to the learning process also are emphasized in the detailed operational definition for habituation recently proposed by Thompson and Spencer (1966). Nine empirically derived, parametric characteristics of behavioral habituation are specified. Each has reference to or can be rephrased in terms of phenomena of learning and relevant variables: e.g., spontaneous recovery, massed vs. distributed practice effects, etc.

Data on response habituation are available for cardiac, respiratory, and visual systems (e.g., Caron & Caron, 1968, Clifton, Graham, & Hatton, 1968; Engen & Lipsitt, 1965; Schaffer & Parry, 1969). Decrements in response to repeated presentations of a stimulus were not found in only a comparatively few studies (Haith, 1966; Haith, Kessen, & Collins, 1969; Meyers & Cantor, 1966, 1967), but these results appear to emphasize the effect of stimulus complexity (cf. Ames, 1966) and the importance of regularity of presentations. Thus they are not firmly out of line with the bulk of the literature. In essence, these latter studies demonstrate that decrements in response do not occur to short, random presentations of a stimulus during a rather limited interval, nor do rapid decrements occur to stimuli whose attributes would be described as high in complexity. Within an interpretation of habituation as a type of learning, these results are not surprising. Short, irregular presentations of a task within a brief period would not be expected to provide a reasonable situation for learning. Nor would assimilation of complex material be anticipated to proceed at the same pace as that for more simple tasks.

In view of past work and current interest in the phenomenon of habituation, an experiment was designed to investigate whether habituation may be subject to the laws of interference demonstrated for verbal and, in some instances, motoric learning. According to the interference theory of forgetting, decrement in response after acquisition can be explained by one or both of two kinds of interference: proactive and retroactive inhibition, respectively presumed to be caused by responses learned prior to or after the criterion behavior (Adams, 1967). This statement can be rephrased in terms of overt habituation as a manifestation of learning of the stimulus. That is, interference to this learning or retention may occur in the form of immediately prior or subsequent stimulation of the same sensory organs, and responding would be affected accordingly. A "decrement" in an habituated response would be simply an increased response to a familiarized stimulus.

To test the relevance of the interference theory, an experiment was conducted to examine visual habituation in a retroactive inhibition design. Following repeated visual presentations of the standard stimulus in Phase I, a different visual stimulus was shown to Ss of the Retroactive Inhibition Condition during the retention interval (Phase II), while auditory stimulation was provided for the Control Ss. After this interval, all Ss were tested on the standard stimulus. To help eliminate interpretations of fatigue and sensory adaptation, a novel visual stimulus also was presented at the test phase, in alternate order with the standard across conditions. Given that learning of the stimulus does occur as the result of exposure to an event, differential responding in the Retroactive Inhibition and Control Conditions at the test phase is predicted from the interference theory of forgetting: (a) Retroactive Inhibition Ss will show increased responding to the standard stimulus, as compared to their last trial of Phase I. (b) Control Ss are expected to show no forgetting and thus response to the standard at the test phase will be similar to that on the last trial of Phase I. (c) Between-group comparison of test results should indicate the degree of interference generated by the experimental manipulation of Phase II.

Method and Procedure

Subjects

The Ss in the final sample were 36 male infants whose average age was five months (range: 4 months, 6 days--5 months, 19 days). Half of the Ss participated in the Retroaction Inhibition Condition and half in the Control Condition. Assignment to prerandomized experimental groups was determined by the order in which appointments occurred.

With the exception of three infants, surnames of Ss were obtained from local newspaper birth announcements. The parents of each were invited, first by mail and then by telephone, to participate in the study. Fifty-eight per cent of those reached by phone agreed to let their sons serve as subjects. Taxi, parking, and baby sitting fees were reimbursed when these were incurred.

Seventy-two infants were tested to obtain 36 Ss with complete data. Primarily, infants were not included in the sample because of crying (20), sleeping (5), and nonattendance to one or both of the test phase stimuli (5). Others were excluded because of errors in testing procedure (3), distractions which invalidated the test sessions (2), and unreliable scoring on the last trial (1). When an infant was eliminated from the sample for one of the above reasons, the next child to be tested was assigned to the same condition as a replacement.

Apparatus and Stimuli

All Ss were tested in a standard infant seat placed so that the infant's eyes were about 24 inches from a back-projection screen that was mounted at one end of a curtain-enclosed area. The opposite end of this chamber-like arrangement remained open, and one parent was seated here, behind the infant, throughout each testing session.

A TV camera, placed at a small opening beneath the screen, provided an almost head-on view of the S. Use of the camera permitted observation of the infant on a monitor outside the test room by the E, as well as a recording of each session on video tape.

The stimuli were geometric forms used in combinations within conditions: a red circle, 4 3/4 inches in diameter; a green equilateral triangle, sides measuring 5 1/2 inches; and a black cross, the bars of which were 1 7/8 inches wide and 5 3/4 inches long. All measurements refer to projected size. Empty slots in the projector cartridge permitted presentations of light that on the screen appeared similar to, though were not matched to, the white background of the stimuli slides. These presentations will be referred to hereafter as "blank slides."

The stimuli were projected on the screen by a Kodak Carousel slide projector positioned at the window of an adjacent room. The projector was programmed to advance every 30 seconds after the cycle was started, and to automatically stop after 15 positions. A print-out counter, operated by a hand switch, was used to record visual fixation times. Fixations were scored after the session from the video tape. Total accumulated fixation times, to a tenth of a second, were registered on the counter tape for each slide presentation. The counter was incorporated into the programming equipment so that its activation was not possible prior to the start of the projector cycle or during interstimulus intervals. With the exception of the TV camera, all equipment was located outside the test room.

Procedure

Each infant was placed in the infant seat by the parent. A brief adaptation to the surround was permitted while the E discussed the general nature of the experiment. If the S was to participate in the Control Condition, the parent was given a nursery rhyme book and told to which cues on the screen reading should start and stop. The infant was positioned then before the screen, the curtains drawn to eliminate distractions of fixtures in the room, and the session was started.

Each S saw one of the sequences of stimuli shown in Table 1. The

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Insert Table 1 about here

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intertrial interval, in all cases, was that time required to advance the projector, and, accordingly, it reduced by .9 seconds the actual time of each presentation on the screen. The only difference between sets of stimuli for the two Conditions was the content of the retention interval, Phase II. Infants in the Retroactive Inhibition Condition saw a new stimulus. Each S in Control heard his mother's voice during a blackout period created by insertion of five opaque squares in the projector cartridge. The mother continuously read selections of her choice from a nursery rhyme book. The blank slide presentation used in the Control Condition was a cue to stop reading and a device to redirect the *S*'s visual attention to the screen. The interpolated reading was intended to provide some nonvisual stimulation that would be adequate to keep the *S* in the test situation. The variability between mothers in selections or in reading styles cannot be estimated. The rhyming nature of the material, however, tended to limit even the most creative mothers to a "sing-song" recitation.

Scores of fixation time were collected from the video tapes after the sessions. Fixations were recorded as the times the infant's eyes were turned in the direction of the stimulus. A reliability measure was obtained by a second observer independently scoring from the tapes at a later time.

Results and Discussion

The data consisted of total fixation times on each stimulus trial. Interobserver reliability of .89 was determined by computing a correlation coefficient for 12 of the first 15 *S*s, five in the Retroactive Inhibition Condition and seven in Control. This result is comparable to the consistently high reliabilities for this measure reported for total samples.

The data of Phase I were examined for decrement in response by a 2(Conditions) x 3(Stimulus Groups) x 6(Trials) analysis of variance for repeated measures. Significant main effects were found for Trials, $F = 2.49$, $df = 5/150$, $p < .05$, and for Stimulus Groups, $F = 4.90$, $df = 2/30$, $p < .025$. The Trials effect is similar to that found in most studies of habituation. Means on this factor decreased across trials with the exception of that for the last trial which showed a slight increase over Trial 5. The slope of the Trials effect can be extrapolated from Figure 1 where the trial data are plotted separately for

Insert Figure 1 about here

the two Conditions, which did not differ significantly from each other. The stimuli effect is shown in Figure 2 to provide an orientation for

Insert Figure 2 about here

other results pertinent to this factor. As can be seen, the effect was produced by the generally low response to the green triangle.

Before examining the Test Phase data, the nature of visual fixations to the stimuli shown during Phase II to Ss in the Retroactive Inhibition Condition must be established. To test for response recovery on presentation of a different stimulus, the difference between Trials 6 and 7 was analyzed in a 3(Stimulus Groups) x 2(Trials) repeated measures analysis of variance. Partitioning by Stimulus Groups was maintained because of stimuli effects found for Phase I. Only a significant Trials effect, $F = 9.89$, $df = 1/15$, $p < .01$ was found, reflecting higher responding on Trial 7.

Response across trials to the stimuli of Phase II was examined and compared with that for the standard stimuli of Phase I in a 3(Stimulus Groups) x 2(Phases) x 6(Trials) analysis of variance with repeated measures on the last two factors. The Stimulus Groups x Phases interaction was significant, $F = 4.41$, $df = 2/15$, $p < .05$, as was the Trials effect, $F = 5.84$, $df = 5/75$, $p < .0005$. The two-way interaction was a function of increased responding to the second stimulus following exposure to the triangle, a reversal of the trend in the other two Stimulus Groups.

The data of Phase II for the Retroactive Inhibition Condition can be summarized as follows. Significantly increased responding to presentation of the new stimulus on Trial 7 as compared to that for the standard stimulus on Trial 6 suggests that the decrement obtained over the first six trials is evidence of habituation rather than fatigue or sensory adaptation. Following response recovery, or dishabituation, visual fixations to the stimulus of Phase II declined. Whether or not the decrement in Phase II can be called habituation in part depends on eliminating such alternate explanations as fatigue. An analysis assessing this possibility is reported later in this section. The Stimulus Groups x Phases interaction found in Phase II bears on the stimuli effects in Phase I. That is, the relevant data reflect differential responding to a particular stimulus, the green triangle, rather than, say, the neurophysiological condition of the Ss in the subgroup. When shown another stimulus, the Ss in those cells responded at about the same level as others in the same Condition.

To answer the major question of this research, whether or not differential responding will occur to the standard stimulus as a result of treatments in Phase II, responding to the standard stimulus on the sixth trial and in the Test Phase was compared. These data as well as response to the novel stimuli are included in Figure 1. A 2(Conditions) x 3(Stimulus Groups) x 2(Test Phase Orders) x 2(Trials)repeated measures analysis of variance revealed no significant effects. However, since the direction of the results had been hypothesized *a priori*, and in order not to overlook any fragile effects missed by insensitivities in the analysis of variance (cf. Abelson, 1962), the data were re-examined. That is, the data were combined for each Condition and analyzed (using one-tailed t-tests) for effects in the specific directions predicted by the interference theory of forgetting. In the Retroactive Inhibition Condition, the analysis of difference scores between performance on Trial 6 and the presentation of the standard stimulus after Phase II was significant (t = 1.95, *df* 17, $p < .05$), reflecting longer fixations on the Test Phase presentation of the standard. Analysis of difference scores for these presentations of the standard in the Control Condition did not produce a significant result (t = 1.29, $.10 < p < .20$). Comparison of difference scores for the two Conditions was in the predicted direction, but only approached significance (t = 1.55, $.05 < p < .10$).

The findings relative to the possible interference effects of visual stimulation in Phase II may be summarized as follows. One-tailed *t*-tests yielded results which supported two of the three *a priori* predictions posed by the interference theory of forgetting. Subjects in the Retroactive Inhibition Condition, after exposure to interpolated visual stimulation in Phase II, responded to presentation of the standard stimulus with longer fixations than those on Trial 6. Subjects in the Control Condition, who did not experience interpolated visual stimulation, responded to the test presentation of the standard at about the same rate as that on Trial 6. However, comparison of the two Conditions was only suggestive of the retroactive inhibition effect which can be caused by interpolated learning.

To explore for the possibility of fatigue or sensory adaptation as alternative explanations for the decrements in response to repeated stimulation, Trials 1, 2, 6, and 14 were compared, without regard to type of stimulus involved. A 2(Conditions) x 4(Trials) repeated measures analysis of variance yielded a significant Trials effect, $\underline{F} = 4.00$, $\underline{df} = 3/102$, $\underline{p} < .025$. The relevant means were 6.58, 5.16, 3.43, and 5.60 for Trials 1, 2, 6, and 14 respectively. The Newman-Keuls method of comparing means indicated that Trial 1 was significantly different from Trial 6, $\underline{p} < .05$, but that no other means differed significantly from each other. Since this result suggested that responding on the last trial of the stimuli sets was not significantly lower than that for the first two trials, it was concluded that fatigue was not responsible for response decrements within the series.

The pattern of results obtained in the present study suggest some merit in further consideration of habituation as an acquisition process. The data indicate the possibility that, for this age group at least, some sort of memory of the external environment may accrue as a function of repeated exposures over a short time period. Full support for a memory interpretation is precluded because the difference between the Retroactive Inhibition and Control Conditions only approached significance. An aspect of the research design, however, may account for attenuation of the retention interval manipulation. Two orders of stimuli, test/novel and novel/test, were used in the Test Phase to provide an opportunity to assess the presence of fatigue if other analyses were not conclusive. This arrangement also may have provided a situation capable of generating unintended interference in the Control Condition, however. That is, in the novel/test order the novel stimulus was inserted between the manipulation of Phase II and the test of the standard stimulus, and thus possibly served to dishabituate those Ss. Post hoc examination of Test Phase data indicated that two of the three Control groups may have been affected by such dishabituation.

This same examination of the data also indicated varied response to the triangle. In general, responding to that stimulus appeared to be a function of order, the stimulus with which it was combined in the Test Phase, and its role as the test or the novel stimulus. No ready explanation is available to account for the peculiar influence of this stimulus, but the differential response that it evoked exerted some effect on the results of the research.

The data offer some support for several of the parametric characteristics of habituation outlined by Thompson and Spencer (1966): decreased response to repeated applications of the stimulus; recovery of the habituated response or dishabituation; and habituation of dishabituation with repeated presentations of the dishabituatory stimulus. Trend analyses used to examine the significant Trials effects (Miller, 1970) were not adequate methods to verify the decrements in response as a negative exponential function of the number of stimulus presentations. The linear trend was prominent in the data, but the presence of other significant components suggests that a negative exponential equation may provide the best fitting curve as specified by Thompson and Spencer (1966). The relevance of the other characteristics of habituation described by these authors to the responding of human infants needs to be examined also, and the retroactive inhibition paradigm appears to offer a basic design for such studies. Future research on habituation should be designed not only for parametric investigation of the pheuomenon itself, but also for study about its potential as an index of cognitive ability and development during infancy.

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Footnote

1. This study is based on a thesis submitted by the first author to the University of Minnesota as partial fulfillment of requirements for the Master's degree. The research, conducted while the first author was an NICHD Trainee at the Institute of Child Development, was supported by National Institute of Child Health and Development Grant C900-4157. Portions of this paper were presented at the 78th Annual Convention of the American Psychological Association, Miami Beach, September, 1970.

Table 1
Experimental Design

Conditions	Phase I Habituation		Phase II Retention Interval		Test Phase	
Retroactive Inhibition	one 30-sec. presentation	six 30-sec. presentations	six 30-sec. presentations		one 30-sec. presentation	one 30-sec. presentation
E-1	blank slide	circle	cross		circle	triangle
E-2	blank slide	circle	cross		triangle	circle
E-3	blank slide	triangle	cross		circle	triangle
E-4	blank slide	triangle	cross		triangle	circle
E-5	blank slide	cross	circle		cross	triangle
E-6	blank slide	cross	circle		triangle	cross
Control	one 30-sec. presentation	six 30-sec. presentations	150 seconds	one 30-sec. presentation	one 30-sec. presentation	one 30-sec. presentation
C-1	blank slide	circle	voice	blank slide	circle	triangle
C-2	blank slide	circle	voice	blank slide	triangle	circle
C-3	blank slide	triangle	voice	blank slide	circle	triangle
C-4	blank slide	triangle	voice	blank slide	triangle	circle
C-5	blank slide	cross	voice	blank slide	cross	triangle
C-6	blank slide	cross	voice	blank slide	triangle	cross

Figure 1. Mean fixation time for Trials 1-6 and presentation of the test and novel stimuli.

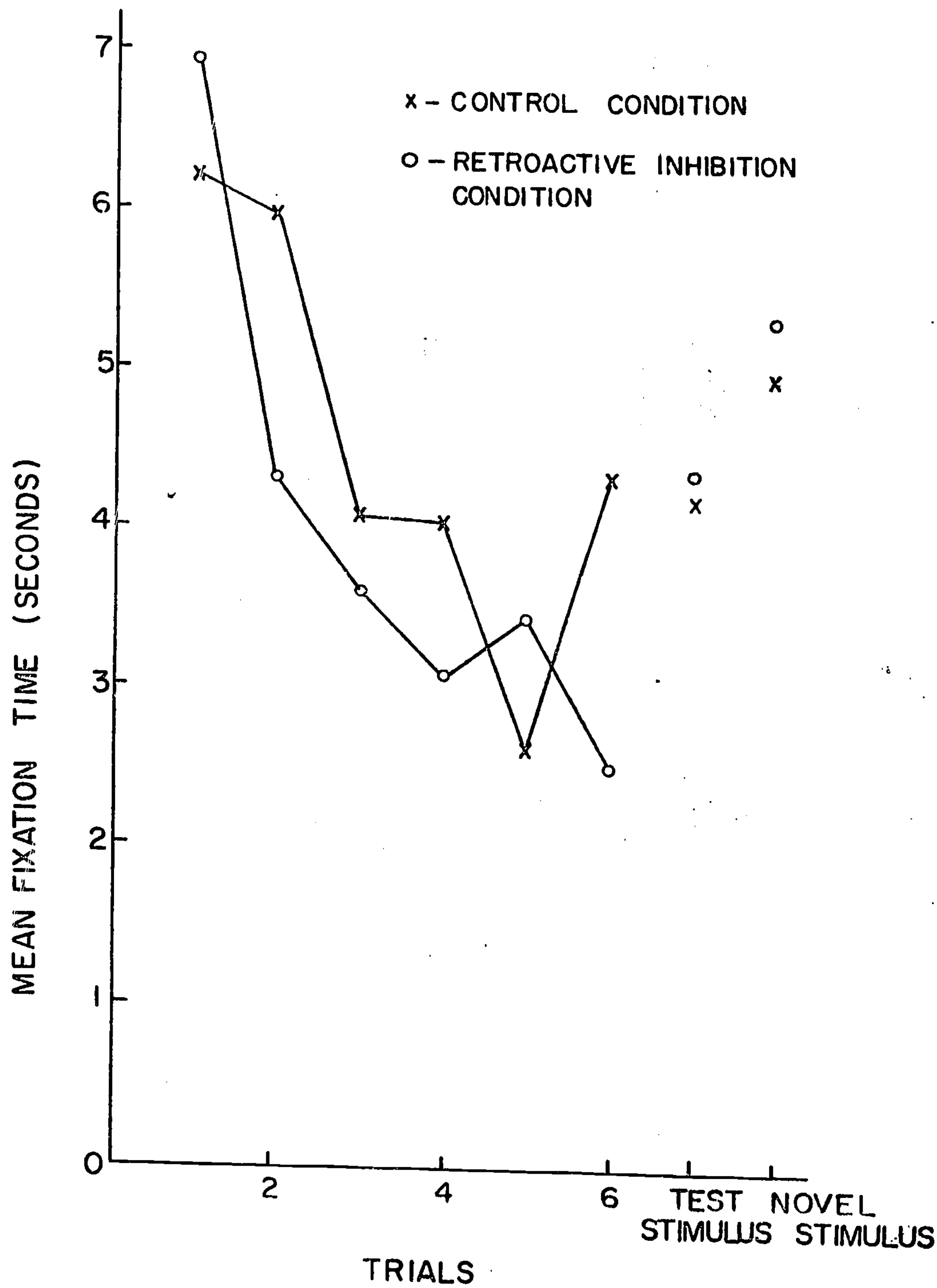

Figure 2. Mean fixation time plotted for the different stimuli presented in Phase I.