Startle responsiveness after habituation to different intensities of tone¹

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The likelihood of startle response to different intensities of tone (96, 102, 108, 114, and 120 dB) was evaluated in rats, before and after a series of exposures to either 108- or 120-dB tones. Responsiveness following habituation was less at each test intensity for Ss exposed to 120-, as compared to 108-dB tones. These results were contrasted with other reports which have led to the potentially misleading generalization that habituation is faster or more pronounced, the weaker the stimulus intensity.

Reviews of the literature on habituation generally include some assertion that the rate or degree of habituation is inversely related to the intensity of the stimulus employed. Thus Humphrey (1933) stated: "now it seems to be admitted that an intense stimulus is followed more slowly by adaptation than a lighter one" (p. 149). Harris (1943) cited an experiment by Danisch (1921) as corroborating the findings of Jennings (1906), to the effect that "weaker stimuli are followed by quicker habituation" (p. 391). Most recently, Thompson & Spencer (1966) have proposed the following as one of several known "parametric characteristics of habituation": "*The weaker the stimulus, the more rapid and/or the more pronounced is habituation. Strong stimuli may yield no significant habituation* [p. 19, italics theirs]."

These assertions are all based upon observations from an experimental procedure in which a given S is repetitively presented with the same stimulus intensity. Then, the more intense the stimulus, the more repetitions it may take to reach some criterion of unresponsiveness to that stimulus intensity, or the less change may be observed in the probability or amplitude of the response to that stimulus intensity (e.g., Oldfield, 1937; Prosser & Hunter, 1936; Thompson & Spencer, 1966).

It is likely to be the case that the more intense a stimulus the more probable or the more vigorous is the response to that stimulus. It might thus be concluded from the previous studies cited that, the more intense a test stimulus presented, the less likely will a prior training series have rendered that stimulus ineffective, independent of the intensity employed during training.

However, since the term "habituation" is frequently employed as a theoretical construct, similar to "conditioning" or "learning" the generalization, that habituation is more pronounced the weaker the stimulus, is likely to be interpreted as implying a very different conclusion. That is, it might be expected that a variety of testing procedures would reveal less responsiveness to a stimulus as a result of prior exposures to weak as compared to intense values of that stimulus.

Unless it is kept in mind that generalizations concerning stimulus intensity and degree of habituation, have been based upon a restricted set of observations in which differences in training and testing intensity have been confounded, the generalizations are apt to be misleading.

To evaluate differential changes in responsiveness that may be attributed to the history of intensities experienced, it is obviously necessary to arrange separate training and testing phases in which Ss are exposed during the habituation series to different stimulus intensities, but are then tested with a common intensity or common series of intensities. The present experiment was designed to allow such an evaluation, in the case of the startle-response in the rat and different intensities of tone.

METHOD

The Ss were 48 male albino rats of the Sprague-Dawley strain, selected to weigh between 350 and 400 g, and ranging in age between 90 and 120 days.

Six stabilimeter devices were housed in a ventilated, 24 x 48 x 18-in. chamber. Each stabilimeter consisted of a 3.5 x 5.5 x 6.5-in. Plexiglas and wire mesh cage, supported by four compression springs and by a universal joint at the center of the base. Cage

movement was translated (with an approximate 4:1 mechanical advantage) to displacement of a loud-speaker coil by means of separate lever arms from each corner of the base. Movement-induced voltages in the speaker coil were amplified, and a selected amplitude was arranged to produce a relay closure, which in turn could operate an electromechanical counter and an event recorder. The sensitivity of each circuit was adjusted so that relay closure occurred approximately 50% of the time when a .5-g weight was dropped onto the stabilimeter from a height of 1 in. A startle response was recorded as a relay-activating cage movement during the 300-msec interval following onset of each tone.

A 15-in. Altec, high-frequency, loud-speaker was located in the rear of the chamber and was employed to provide presentations of a 4000 Hz, 50-msec tone, every 8 sec during stimulus exposure periods. The intensity of the tones, which varied according to the experimental plan, was calibrated with a General Radio Model 1551-C Sound Level Meter with a scale setting of 20 k Hz. The microphone was placed within each stabilimeter cage and the cages positioned to yield comparable readings in each. The intensities of the tones, as designated, however, do not make allowance for switching-transients which were observable in oscilloscopic recording of the microphone output as an approximately 10% elevation in the wavefront of the stimuli. The background noise level was 80 dB.

An S was placed in each of the six stabilimeters and after 30 min, Ss were given 20 exposures to each of five tone intensities (96, 102, 108, 114, and 120 dB). The several intensities were presented in an irregular order with the restrictions that each intensity followed itself and every other intensity equally often, and that the occurrence of each intensity was distributed approximately evenly over the total sequence of 100 tone presentations. Following a 1-min delay, Ss were given either 300 or 700 exposures to either 108- or 120-dB tones. These four treatments will be referred to as: 108-300, 108-700, 120-300, and 120-700. One min following the selected habituation treatment, Ss were given a final 20 exposures to each of the five intensities in a manner identical to the pre-treatment procedure.

Two separate replications were conducted with each treatment, creating a total of 12 Ss in each of the four groups. During one replication of the 108-300 and 120-300 conditions, one of the stabilimeters malfunctioned, leaving 11 Ss in these groups from which data were collected.

RESULTS AND DISCUSSION

Figure 1 shows the mean percentage startle responses of the four groups at each of the five test intensities, before and after the different habituation treatments. Analysis of the pre-habituation data revealed a highly reliable overall increase in startle frequency

Fig. 1. Mean percentage startle responses at each of five tone intensities, before and after habituation, for each of four groups, receiving either of two tone intensities (108 or 120 dB) and either of two numbers of stimulations (300 or 700) during habituation.

with increasing intensity of the test stimulus ($F = 145.81$, $df = 4/168$, $p < .001$), and no significant differences among the groups.

During the treatment phase (not shown in Fig. 1), all groups showed a decreasing frequency of startle, with repeated exposures to the selected tone intensity. Of primary interest, however, was performance following the separate habituation treatments, when each group was again presented with the same sequence of test intensities.

Figure 1 indicates that for all groups post-habituation responding was lower than the pre-habituation levels. An increase in startle frequency with increasing test intensities was still evident ($F = 64.09$, $df = 4/168$, $p < .001$) and 700 habituation exposures resulted in a lower overall frequency of startle than did 300 exposures ($F = 4.74$, $df = 1/42$, $p < .05$).

Most important is the fact that at each test intensity, and following either 300 or 700 habituation trials, the groups habituated with 120-dB tones responded less than the groups habituated with 108-dB tones. The overall effect of stimulus intensity during habituation was highly reliable ($F = 11.27$, $df = 1/42$, $p < .005$). The only statistical significant interaction involving the effects of stimulus intensity during habituation was an habituation intensity by test intensity by number of habituation trials interaction ($F = 2.44$, $df = 4/79$, $p < .05$), which reflected the diminished difference between the 108- vs 120-dB groups, that may be seen in Fig. 1, when overall response level was rendered very low at the weakest test intensities following 700 habituation trials.

These findings clearly indicate that exposure to the more intense, 120-dB stimulus, during habituation produced a greater decrease in startle responsiveness than did exposure to the 108-dB stimulus.

According to the design of previous studies (e.g., Danisch, 1921; Oldfield, 1937; Prosser & Hunter, 1936; Thompson & Spencer, 1966) the probability of startle of the 120-dB groups at a 120-dB test intensity would simply have been compared with the probability of startle of the 108-dB groups at a 108-dB test intensity. The points representing such a comparison following 300 and 700 habituation trials have been circled for identification in Fig. 1. As may be seen, in agreement with previous studies, there was less frequent post-habituation responding associated with the 108-dB intensity than with the 120-dB intensity. It is also

clear, however, that this fact is attributable to the differences in test intensity, rather than the differences in habituation intensity, involved in the comparison. When the groups habituated with the different intensities were both tested at 120-dB, the 120-dB group startled less frequently ($t = 3.05$, $df = 44$, $p < .005$) and when they were both tested at 108-dB, again the 120-dB group startled less frequently ($t = 2.51$, $df = 44$, $p < .01$).

A useful metric by which to express the degree or rate of habituation, resulting from various treatments, might be found in the change in stimulus intensity associated with a specified probability of responding, such as the common "threshold" or 50% level. Conditions of the present experiment were not arranged so as to insure a distribution of response probabilities that would allow an accurate post-habituation "threshold" estimation for each S. Yet, Fig. 1 grossly indicates a greater change in threshold for the groups habituated with 120-dB than with 108-dB tones.

There is probably little surprise-value in such findings. It is, nonetheless, important that students of habituation acknowledge the separate influences of the conditions under which habituation is produced and the conditions under which habituation is evaluated, and that generalizations made concerning the effects of various parameters upon habituation are not potentially misleading, by virtue of ignoring these separate influences.

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NOTE

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