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DURATION AND SPONTANEOUS ACTIVITY

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Habituation of GSR to repeated stimulation with tones of either 2- or 20-sec. duration was investigated with college students. Subsequent to habituation, stimulus durations were reversed immediately for half the Ss and after a number of additional trials for the remaining Ss. Speed of habituation did not vary with stimulus duration but was significantly related to "spontaneous activity" as defined by spontaneous fluctuation scores. Orienting to the reversal in stimulus duration was indicated by an overall increase in latency and an increase in response duration for Ss changed from a 2- to a 20-sec. stimulus.

This experiment was undertaken to study the course of habituation and to determine the relevance of certain variables. First, one aspect of Sokolov's (1960) explanation of habituation was investigated. Sokolov conceptualizes a stimulus in two parts—onset and prolongation. He has hypothesized that the prolongation of a stimulus produces unconditioned inhibition, which becomes conditioned to the onset of the stimulus, thereby producing response decrement and habituation. Thus, habituation is explained as conditioning in which stimulus onset acts as a CS and stimulus prolongation as a US for inhibition. During habituation, conditioned inhibition accrues to stimulus onset, thus causing the response decrement characteristic of habituation. This formulation suggests stimulus prolongation or duration as a relevant variable in habituation. It might be expected that greater prolongation would facilitate the development of conditioned inhibition, thereby producing faster habituation. In order to investigate this hypothesis, habituation of the GSR as a function of stimulus duration was studied.

Second, Sokolov has also reported that, once habituated, Ss will orient to changes in the temporal characteristics of the stim-

ulus experienced during habituation. In an attempt to replicate this finding the durations of the stimuli were varied subsequent to habituation.

Finally, a number of investigators have shown that, within a given response mode, "spontaneous activity" is strongly related to reactivity to stimulation (Johnson, 1963; Lacey & Lacey, 1958). Since this finding is particularly true with respect to measures of skin resistance, the relation between spontaneous activity and habituation was investigated. (In this paper spontaneous activity refers to fluctuations in a given response mode that are apparently unrelated to environmental stimulation.)

METHOD

Subjects

The Ss were 40 introductory psychology students.

Apparatus

Skin resistance was recorded continuously through a Fels Dermohmeter connected to an Esterline-Angus Recorder. Zinc-zinc sulphate electrodes 1 cm. in diameter were attached to the sole and top of the foot. A constant amount of electrode jelly was injected beneath the electrode through a small hole in the center of the back of the electrode. The hole was then covered with tape.

The stimulus used in the habituation sequence was a pure tone of 1,000 cps generated by a Grason-Stadler Audio-Frequency Oscillator and delivered through a speaker placed approximately 5 ft. in front of S. The intensity of the tone was 94-db. SPL measured at the position of S's head. The duration of the tone, which was controlled electronically, was either 2 or 20 sec. The intertrial interval was varied randomly.

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Procedure

The Ss were seated in a comfortable chair facing the speaker, which was hidden by a drape. They were told of the measurements to be taken but no mention of the tone was made. First, the GSR electrodes and then equipment for recording finger volume and dilation of the temporal artery were attached to S. The data from the latter recordings will not be reported at this time. The Ss were left alone in the sound-controlled testing room while Es and recording equipment were in an adjoining room. A one-way vision window connected the rooms.

The Ss were randomly assigned to conditions so that 20 Ss started the experiment with a stimulus of 2-sec. duration and 20 with a stimulus of 20-sec. duration. These groups may be called the short- and long-stimulus groups. The stimuli were presented repeatedly until Ss reached an habituation criterion of three successive trials on which no response occurred. A failure to respond was scored for any fluctuation under 1,000 ohms. At this point the stimulus durations were reversed for 20 Ss. Half the Ss ($N = 10$) who were habituated with a 2-sec. stimulus were changed to a 20-sec. stimulus. This may be called a short-to-long reversal. Likewise, half the Ss ($N = 10$) who were habituated with a 20-sec. stimulus were changed to a 2-sec. stimulus, a long-to-short reversal. The remaining 10 Ss in the short- and long-stimulus groups were given 30 additional trials before reversing the stimulus durations. These latter Ss may be called the delayed reversal group and the former, the immediate reversal group. Subsequent to the experiment all Ss filled out the Taylor Anxiety Scale (Taylor, 1953).

It should be noted that E's decision as to when the habituation criterion occurred did not always agree with that resulting from a more scrupulous scoring of the data at a later date. Occasionally, therefore, the reversal stimulus was administered a few trials after the criterion was met, but in any case it was always administered after a succession of at least three failures to respond.

Use of a constant intertrial interval for long- and short-duration stimuli would confound stimulus duration with interstimulus interval (the interval between onset of any two successively presented stimuli). Of necessity the interstimulus interval would be longer for a long-duration stimulus. In order to control for this, the short-duration group was run under two intertrial interval conditions. Half of these Ss ($N = 10$) were run with an intertrial interval of 10-40 sec.—the same as that for all Ss in the long-duration group. The remaining half ($N = 10$) were run with an intertrial interval of 30-60 sec. so that the interstimulus intervals were similar to those of the long-duration group. Of the 10 Ss in each intertrial interval condition, five were in the immediate and five in the delayed reversal groups.

Spontaneous activity scores were defined in terms of the number of spontaneous fluctuations of 1,000 ohms or greater, occurring in the 2 min.

just prior to the first habituation trial. These scores could be obtained for 35 Ss.

The response measures obtained for all Ss were frequency, latency, and magnitude of response. The magnitude was defined in terms of the absolute difference in resistance between the onset of the response and the point of lowest resistance within 20 sec. of stimulus onset. The analyses of the data were performed with this difference score as well as with a log conductance change score. Since the results were essentially the same with both measures, the data are reported in terms of the difference score. Latency was defined as the time elapsing between the point of stimulus onset and the point of pen deflection which indicated onset of the response.

In addition, base level values were obtained on the first two trials for all Ss and over the first 33 trials for a select group of Ss. A base level value was defined as the absolute resistance recorded at the point of onset of a given stimulus. For those Ss who responded when stimulus duration was reversed, response duration was scored for the following three responses: (a) the initial response in habituation, (b) the last response before reversal, and (c) the response on the reversal trial. Response duration was defined as the time elapsing between onset of the response and its point of lowest resistance. The skin resistance records were all scored by a person who had no knowledge of the purpose of the experiment.

RESULTS

Stimulus Duration and Habituation

Speed of habituation, defined in terms of the number of trials to a criterion of three successive failures to respond, showed no effect of stimulus duration. The median number of trials to criterion was 14.5 for the 2-sec. group and 15.5 for the 20-sec. group. The probability was 95% that the medians fell within the confidence intervals of 5-20 and 10-22, respectively. There was also no effect of stimulus duration on the number of trials to the first failure to respond. (The medians were 6 for both groups.) An analysis of variance indicated that magnitude of response was unrelated to stimulus duration, while a plot of the data indicated the same for the latency and frequency measures. Similar analyses showed no effect of the two different intertrial intervals used in running the short-duration group.

Stimulus Duration and Reversal

When the stimulus durations were reversed, 49% (18/37) of all Ss responded.

(Three Ss who failed to meet the habituation criterion within the experimental period were not included in the reversal condition.) The frequency of response did not vary between the immediate and delayed groups; nine of the 19 Ss in the immediate reversal group and nine of the 18 Ss in the delayed reversal group responded. Therefore the Ss from both groups were considered together in the following analysis.

In order to ascertain whether those Ss who did respond on the reversal trial were orienting to the change in stimulus duration or merely to the onset of the stimulus, as during habituation, the latency and duration of the reversal response were analyzed. To put the reversal trial in the context of the experiment, the reversal response was compared to the initial response in habituation and to the last response before reversal. The mean duration and latency of these three responses are presented in Table 1.

As indicated in the table, response duration was related to stimulus duration on the reversal as well as initial trials ($F = 18.807$, $df = 2/32$, $p < .001$). The change from a short to a long stimulus occasioned a significant increase in response duration when comparing the reversal response with the last response ($t = 4.24$, $df = 9$, $p = <.01$). The opposite change from a long to a short stimulus had no effect on response duration. On the initial trial the long stimulus also elicited a significantly longer response duration ($t = 3.85$, $df = 16$, $p < .01$). These values did not differ significantly from those elicited by the long stimulus on the reversal trial.

TABLE 1
MEAN DURATION AND LATENCY (IN SECONDS)
OF THE REVERSAL RESPONSE AND THE INITIAL
AND LAST RESPONSES IN HABITUATION

Response	Short-to-long reversal		Long-to-short reversal	
	Duration	Latency	Duration	Latency
Initial	8.1	2.5	17.0	2.5
Last	6.9	3.2	7.9	3.8
Reversal	16.3	4.9	6.2	5.3

The increase in latency shown in the table was significant overall ($F = 18.565$, $df = 2/32$, $p < .001$) and did not vary with stimulus duration. The changes in stimulus duration, both from long to short as well as from short to long, resulted in a significant increase in response latency when comparing the reversal response with the last response ($t = 3.77$, $df = 17$, $p < .01$). Response latency also increased significantly from the initial response to the last response ($t = 3.88$, $df = 17$, $p < .01$). An analysis of response magnitude failed to indicate any effect of stimulus duration.

Spontaneous Activity

Unlike stimulus duration, spontaneous activity was directly related to speed of habituation. On the basis of their spontaneous activity scores, Ss were divided at the median, those above termed labiles and those below, stabiles, after the designation of Lacey and Lacey (1958). The median number of trials to the habituation criterion was 5.5 for the stabiles and 19.0 for the labiles. This difference was significant as indicated by a median test ($p < .02$). The probability was 95% that the medians fell within the confidence intervals of 3-15 and 15-36, respectively. The median number of trials to the first failure to respond was 4 for the stabiles and 8 for the labiles. A median test of this difference was also significant ($p < .005$). The 95% confidence intervals for these medians were 3-6 and 6-11, respectively.

Labile-stabile differences were analyzed on the first two trials of habituation. With respect to latency of response, labiles responded significantly faster than stabiles ($F = 4.699$, $df = 1/32$, $p < .05$). There were no significant differences between labiles and stabiles with respect to magnitude of response and base level values. Rank order correlations of spontaneous activity with base level were .29 ($p < .10$) on Trial 1 and .35 ($p < .05$) on Trial 2. The data were ranked such that these correlations indicate the extent to which increased spontaneous activity is related to decreased base level.

To further study the effect of spontaneous activity on amplitude and percentage response during habituation, a subgroup of Ss who had received at least 33 trials was selected; 20 Ss, 10 labiles and 10 stabiles, met this criterion. Percentage response was directly related to spontaneous activity. In Figure 1 the mean percentage response is plotted in blocks of four trials, excluding the first trial on which all Ss responded. The mean was obtained by averaging the percentage response values attained by individual Ss in blocks of four trials.

An analysis of these data indicated that habituation was occurring in both groups ($F = 9.212$, $df = 7/126$, $p < .001$) but that the labiles consistently responded at a higher frequency than the stabiles ($F = 12.324$, $df = 1/18$, $p < .005$). Labiles and stabiles did not differ significantly with respect to magnitude of response over the first six trials, although both groups did exhibit significant habituation ($F = 24.040$, $df = 5/90$, $p < .001$). Only the first six trials were analyzed because of the subsequent low frequency of response in the stable group.

In addition, the base level data of these Ss indicated slightly lower values for the labile Ss. When only the first two trials were considered, the p values were less than .05 ($F = 5.082$, $df = 1/18$) but were between .05 and .10 when all 33 trials were considered ($F = 4.319$, $df = 1/18$).

Habituation

In the data reported thus far, habituation has been characterized by a decrease in magnitude and percentage response. In addition, the latency of response showed a significant tendency to increase during habituation. This was indicated by (a) the previously described increase in latency from the initial to the last response for those Ss responding on the reversal trial, and (b) by a test of the increase in latency from the first to the last response of all Ss in the delayed reversal group ($t = 2.59$, $df = 19$, $p < .02$).

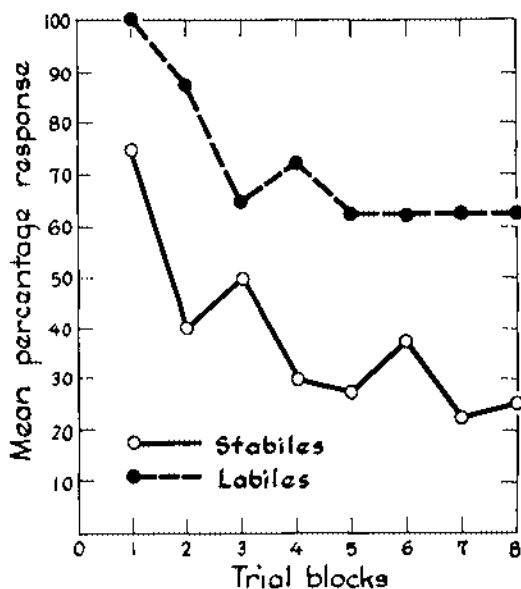


FIG. 1. Mean percentage response in habituation. (Trials 2-23 averaged in blocks of four.)

Taylor Anxiety Scale

The Taylor Anxiety Scale (TAS) scores showed low, nonsignificant correlations with all of the following variables: number of trials to the first failure to respond ($r = .19$), number of trials to the first three successive failures to respond ($r = .23$), magnitude of the first response ($r = .16$), base level values before the first and second trials in habituation ($r = .03$ and $-.10$, respectively), and spontaneous activity scores ($r = .28$).

DISCUSSION

Stimulus Duration and Habituation

The results of this experiment fail to support one implication of Sokolov's (1960) explanation of habituation. Within the limiting parameters of this experiment, stimulus duration did not appear as a particularly relevant variable in habituation per se. Further, the hypothesis that a long stimulus would result in faster habituation than a short one was not confirmed. In his recently translated book (1963), Sokolov states that a stimulus of very short duration may elicit no response or a response that habituates quickly, while a very long stimulus may also habituate

quickly. This might explain our results, except that a stimulus of 2-sec. duration would not be considered extremely short and, furthermore, it did not produce particularly fast habituation.

Keen, Chase, and Graham (1964) reported no difference in habituation to stimuli of 2- and 10-sec. duration when using a frequency of response measure. They recorded heart rate changes in newborns over 15 trials and did report that initially the longer stimulus produced a longer period of acceleration which habituated quickly. This is similar to the longer response duration elicited by the longer stimulus in our experiment. Thompson and Welker (1963) reported no difference in within-session rate of habituation to stimuli of .1- and 2.0-sec. duration, although the 2-sec. stimulus elicited a greater degree of response overall. They used auditory stimuli and scored spatial orientation in cats on a 4-point scale. They further reported that over a number of sessions long-term habituation occurred to the .1-sec. stimulus but not to the 2-sec. stimulus. On the other hand, Bridger (1961), observing the startle response in neonates, reported that a long auditory stimulus produced faster habituation than a short one. Coppock and Chambers (1959) suggested that the amplitude of the unconditioned GSR to a .5-sec. shock showed some tendency to habituate more slowly than that to a 3.0- or a 15-sec. shock.

This variety of results may be in part related to the intensity of stimulation. In the Bridger (1961) and Coppock and Chambers (1959) experiments, which utilized strong startling stimuli (shock and startle-producing auditory stimuli), slower habituation was reported for short-duration stimuli. In this experiment and the others reported (Keen et al., 1964; Thompson & Welker, 1963), milder nonstartle-producing stimuli were used and rate of habituation was not related to stimulus duration. This suggests that rate of habituation may vary with stimulus duration only under conditions of more intense stimulation.

The interpretation of Thompson and Welker's finding with respect to long-term

habituation is somewhat complicated by the fact that for any given *S* stimulus durations were alternated from one session to the next. The results of the present experiment suggest that the shifts from a short to a long stimulus may have resulted in a relatively greater degree of orientation than the shifts from a long to a short stimulus. Thus, the apparent effect of stimulus duration on long-term habituation may be in part due to the alternation of stimuli. The relation between stimulus duration and long-term habituation could be determined more clearly by testing *Ss* with the same stimulus duration at each session.

Stimulus Duration and Reversal

The results of the reversal condition in this experiment show that 49% of the *Ss* responded to an alteration in the temporal pattern of the stimulus. In order to ascertain whether these *Ss* were orienting to the change in stimulus duration, or merely to the onset of stimulation, as in habituation, the latency and duration of the reversal response were compared with those of the last response before reversal. If these *Ss* were responding on the reversal trial as if it were merely another habituation trial, no differences would be expected between the reversal response and the response preceding it. Since the reversal in duration could not be noted for at least 2 sec., a longer latency would be expected if these *Ss* were orienting to the change in duration rather than to stimulus onset. A comparison of the latency of the reversal response with that of the last response before reversal showed a significantly longer latency for the reversal response. This suggests that these *Ss* did orient to the change in duration.

Further, if these *Ss* were orienting to the reversal in stimulus duration, it could be expected that the short-to-long reversal would occasion an increase in response duration. This is suggested by the direct relation between stimulus duration and response duration found on the initial trial in habituation. The short-to-long reversal did produce a significant increase in the duration of the reversal response as com-

pared to the last response, suggesting again that these Ss oriented to the change in stimulus duration. With respect to the opposite reversal, long to short, there was no decrease in response duration. This could be expected since the durations of the last response before reversal were sufficiently short so that a further decrease would have been unlikely.

Thus, the comparison of the reversal response with the last response prior to reversal revealed an overall increase in latency and an increase in response duration on the short-to-long reversal. On this basis it may be concluded that those Ss who did respond on the reversal trial were orienting to the change in stimulus duration. These results are in line with Sokolov's report that Ss will orient to an alteration in the stimulus duration (1960).

Spontaneous Activity

The finding that speed of habituation varied with spontaneous activity supports in greater detail the general finding that more GSR stabiles adapt during a sequence of stimuli than do labiles, as has been reported by Johnson (1963) and Mundy-Castle and McKiever (1953). The greater percentage response on the part of the labile Ss is consistent with the significant correlations between the number of spontaneous fluctuations and orienting responses recorded by Stern, Steward, and Winokur (1961).

The finding that spontaneous activity was unrelated to magnitude of response is consistent with the findings of Wilson and Dykman (1960), but discrepant with those of Johnson (1963). Perhaps the medical students of the former experiment and the psychology students of this experiment were less apprehensive and therefore less responsive than the helicopter pilots who viewed the procedures of Johnson's experiment as a medical examination. This finding also differs from that of Silverman, Cohen, and Shmavonian (1959) and may result from either or both the more sensitive measure of spontaneous fluctuation used by Silverman and the more stressful situation employed in his experiments.

The weak negative relation between spontaneous activity and base level is similar to that generally reported in the literature (Lacey & Lacey, 1958; Martin, 1960).

The shorter latency of response found for labile Ss is consistent with the findings of Lacey and Lacey (1958) and Sternbach (1960).

Taylor Anxiety Scale

The lack of significant relations between the TAS scores and the variables mentioned is similar to that recorded by Johnson (1963) and Wilson and Dykman (1960).

Spontaneous Activity and the Orienting Reaction

Apparently spontaneous activity in skin resistance is closely related to repetitive orienting such that greater spontaneous activity implies a greater likelihood of continued orienting. Given individual differences in spontaneous activity, the implications of this relationship depend on the significance of orienting. According to Sokolov, the functional significance of the orienting reaction lies in the optimal state for perception of stimuli created by its component responses (1963). Berlyne (1960) has suggested that many of the responses included in the orienting reaction are a part of the "intensive aspect of attention." A related suggestion proposed that the GSR component of orienting facilitates registration of the stimulus event (Bagshaw, Kimble, & Pribram, 1965; Kimble, Bagshaw, & Pribram, 1965).

Thus, the orienting reaction could be considered one type of attention response in that it prepares and focuses the organism for optimal perception. This should facilitate perception of both the stimulus complex which aroused the orienting reaction and whatever situational change might follow. This suggests that the orienting reaction might be important in situations in which one stimulus is a signal for another, as in learning, for example. In this regard, Sokolov has reported that the case of classical conditioning is closely related to the occurrence and strength of the orienting reaction elicited by the CS (1963). Since

repetitive orienting is directly related to spontaneous activity, it would be expected that more labile Ss would, by virtue of orienting more frequently, show better classical conditioning than more stable Ss. Such findings have been reported by Stern et al. (1961) and Martin (1960). Thus, the relation between spontaneous activity and orienting apparently implies that labile Ss are more often in a state optimally conducive to stimulus perception than are stable Ss. That this is important in learning is suggested by the classical conditioning data.

REFERENCES

- BAGSHAW, M. H., KIMBLE, D. P., & PRIBRAM, K. H. The GSR of monkeys during orienting and habituation and after ablation of the amygdala, hippocampus and inferotemporal cortex. *Neuropsychologia*, 1965, **3**, 111-119.
- BERLYNE, D. E. *Conflict, arousal, and curiosity*. New York: McGraw-Hill, 1960.
- BRIDGER, W. H. Sensory habituation and discrimination in the human neonate. *Amer. J. Psychol.*, 1961, **117**, 991-996.
- COFFOCK, H. W., & CHAMBERS, R. M. GSR conditioning: An illustration of useless distinctions between "types" of conditioning. *Psychol. Rep.*, 1959, **5**, 171-177.
- JOHNSON, L. C. Some attributes of spontaneous autonomic activity. *J. comp. physiol. Psychol.*, 1963, **56**, 415-422.
- KEEN, R., CHASE, H. H., & GRAHAM, F. Twenty-four-hour retention by neonates of a habituated heart-rate response. *Amer. Psychologist*, 1964, **19**, 457. (Abstract)
- KIMBLE, D. P., BAGSHAW, M. H., & PRIBRAM, K. H. The GSR of monkeys during orienting and habituation after selective partial ablations of the cingulate and frontal cortex. *Neuropsychologia*, 1965, **3**, 121-128.
- LACEY, J. I., & LACEY, B. C. The relationship of resting autonomic activity to motor impulsivity. In H. C. Solomon, S. Cobb, & W. Penfield (Eds.), *The brain and human behavior*. Baltimore: Williams & Wilkins, 1958. Pp. 144-209.
- MARTIN, I. Variations in skin resistance and their relationship to G.S.R. conditioning. *J. ment. Sci.*, 1960, **106**, 281-287.
- MUNDY-CASTLE, A. C., & MCKIEVER, B. L. The psychophysiological significance of the galvanic skin response. *J. exp. Psychol.*, 1953, **46**, 15-24.
- SILVERMAN, A. J., COHEN, S. I., & SHMAYONIAN, B. M. Investigation of psychophysiological relationships with skin resistance measures. *J. psychosom. Res.*, 1959, **4**, 65-87.
- SOKOLOV, E. N. Neuronal models and the orienting reflex. In M. A. B. Brazier (Ed.), *The central nervous system and behavior*. New York: The Josiah Macy, Jr., Foundation, 1960. Pp. 187-276.
- SOKOLOV, E. N. *Perception and the conditioned reflex*. Oxford: Pergamon Press, 1963.
- STERN, J. A., STEWARD, M. A., & WINOKUR, G. An investigation of some relationships between various measures of galvanic skin response. *J. psychosom. Res.*, 1961, **5**, 215-223.
- STERNBACH, R. A. Some relationships among various "dimensions" of autonomic activity. *Psychosom. Med.*, 1960, **22**, 430-434.
- TAYLOR, J. A. A personality scale of manifest anxiety. *J. abnorm. soc. Psychol.*, 1953, **48**, 285-290.
- THOMPSON, R. F., & WELKER, W. I. Role of auditory cortex in reflex head orientation by cats to auditory stimuli. *J. comp. physiol. Psychol.*, 1963, **56**, 996-1002.
- WILSON, J. W. D., & DYKMAN, R. A. Background autonomic activity in medical students. *J. comp. physiol. Psychol.*, 1960, **53**, 405-411.

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