Generalization and dishabituation of the orienting response to a stimulus of lower intensity

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An experiment was carried out to investigate generalization and dishabituation of the GSR orienting response by a tonal stimulus of lower intensity than the habituating stimulus. Subjects were 84 young adult male twins. These were divided into two groups, one twin being assigned to each. One group received 32 auditory stimuli at 95 dB intensity with an interstimulus interval of 33 sec. The other group differed only in that the 22nd stimulus was at 65 dB. It was found that the quieter stimulus produced a significantly larger GSR response than did the control group stimulus in the same position. Significant dishabituation of the responses to the subsequent stimuli was also found. No concomitant changes in basal GSR were found. The results were discussed in terms of the habituation theories of Sokolov (1960, 1963) and of Groves and Thompson (1970). It was felt that the best explanation was directly in terms of expectancy rather than of any neurophysiological theory.

The work reported in this paper deals with habituation of the electrodermal response. This has often been taken (Sokolov, 1963) as a measure of the orienting response. A large number of theories of habituation have been put forward (see Lynn, 1966). These can be divided in several ways, but perhaps the most striking difference is between those theories which put forward a model at the neuronal level and those which emphasize the importance of gross cortical mechanisms. Groves and Thompson (1970) provide an example of the former, while the theory of Sokolov (1960) exemplifies the latter.

Sokolov suggests that, on stimulation of a sensory organ, signals are directly sent to both the cortex and the arousal center in the reticular formation. A comparator in the cortex checks against a library of images of past stimulation to see if any incoming stimulus is novel. If not, a signal will be sent to the reticular formation inhibiting an orienting response which would otherwise occur automatically. Habituation is thus explained by changes in the comparator on repeated application of the same stimulus.

It may be that different types of habituation take place in different ways. Sokolov has restricted his theory to the orienting response. Groves and Thompson, on the other hand, imply that the theory which they have developed at the spinal level can be generalized to include all types of habituation. They suggest that habituation is due to self-generated inhibition in the neurons of S-R pathways. Dishabituation is seen as resulting from a separate sensitization process in the "state" system.

Both types of theory are able to deal with simple habituation where the same stimulus is presented repeatedly. Particular problems arise, however, when generalization of habituation is considered. Generalization has been shown to occur along several types of dimension. Geer (1969) found generalization to different frequencies of a tonal auditory stimulus. Here it could be argued that different receptors in the ear with overlapping sensitivities were activated at different frequencies, so that a neuronal model could account for the data. However, generalization has also been demonstrated along more complex stimulus dimensions such as the semantic (McCubbin & Katkin, 1971; Sokolov, 1963; Zimny, Pawlick, & Saur, 1969). Sokolov is able to explain all these results by attributing extra powers of categorization and selection to the cortical comparator.

The theories also differ in their explanations of dishabituation. This phenomenon involves the re-emergence of habituated responses following the interpolation of a different stimulus into the habituation stimulus sequence. Sokolov explains this in terms of changes in the comparator. The image of past stimulation within the stimulus chain is altered, so that the next few stimuli will not fit the image as well as the stimuli before dishabituation. Groves and Thompson suggest that there are two separate processes of habituation and sensitization and that dishabituation results from the excitation of sensitizing neurons which give additional activation to the responses.

In the present study, the generalization of habituation to a stimulus of lower intensity than the habituated stimulus is examined. Sokolov (1963) reports this phenomenon, finding that a stimulus of lower intensity, but otherwise the same, introduced into a chain of auditory stimuli, produces a larger

Table 1
Analyses of Variance for Differences Between the Two Groups on Skin-Conductance Response Magnitude for Stimuli 21 to 25

Stimulus Number	Experimental Group Mean	Control Group Mean	F Ratio (1,82)	Significance p <
21	.555	.409	1.62	n.s.
22	.985	.470	19.27	.0002
23	.945	.520	11.41	.002
24	.735	.385	4.07	.05
25	.490	.580	.86	n.s.

Note. Stimulus 22 is the stimulus of lower intensity in the experimental group. Means are also given, units being square root conductance in micromhos.

orienting response than the louder habituated stimuli. This quieter stimulus also dishabituated the responses to subsequent presentations of the louder stimulus. He does not, however, use any statistical tests in his experiments so that we are in doubt about the reliability of the phenomenon.

METHOD

Subjects
All 84 male subjects were twins from the twin register compiled by J. Kasriel at the Institute of Psychiatry. Of the total sample, 42 of the twins were monozygotic and the remainder dizygotic. The mean age of the subjects was 24.18 years, with a standard deviation of 6.32 years.

Apparatus
Skin resistance was measured with an apparatus built in the department and described elsewhere (Venables & Martin, 1967, Model b1). One modification was that the consistency of the current flow was maintained by the use of a transistor in place of R1. Electrodes were Ag AgCl and of a diam of 9.04 mm. Electrode placement was bipolar to the first and second fingertips of the left hand. The electrolyte was a saline lubricating jelly (Johnson & Johnson, Ltd.). The skin resistance was recorded on a Mingograf EEG polygraph and on magnetic tape for subsequent computer analysis. Tonal stimuli were generated by an audio oscillator (SG65A Advance) and were presented binaurally through stereophonic headphones. The intensity of the quieter tone was adjusted with a variable resistance placed between the oscillator and the headphones.

Design
All subjects received 32 stimuli, each of 1 sec duration, with a constant interstimulus interval of 33 sec. All stimuli were sinusoidal and at a frequency of 1,000 Hz. For all subjects, the first 21 stimuli were at an intensity of 95 dB (re 20 N/cm²). For the remaining 11 stimuli, the subjects were divided into an experimental and a control group with 42 subjects in each. Of the twin pairs, one was assigned to each group. The experimental group received a stimulus of only 65 dB for Stimulus 22, the remaining 10 stimuli again being at 95 dB. The control group continued with the 95-dB stimulus throughout.

The subjects were tested in a soundproof room, seated in a comfortable chair in the dark. While the electrodes were being fixed on the subject, the procedure was explained to him. The subject was completely instructed about the stimulus paradigm. He was asked to keep his eyes closed during the experiment but otherwise to sit back, relax, and do nothing.

Analysis
The skin-resistance record on magnetic tape was analyzed on a Linc-8 computer, using a system of programs developed by L. Law (Martin, Levy, & Slubicka, 1975). A response to the stimulus was defined as any response whose onset occurred within 5 sec of stimulus onset. These were measured in resistance and transformed into square root of change in conductance. Basal resistance at the point of onset of each stimulus was also measured and transformed into square root conductance units.

RESULTS

The analysis of variance comparing electrodermal response magnitude of the experimental and control groups on Trials 21 to 25 is given in Table 1. It will be remembered that Trial 22 is the stimulus of lower intensity in the experimental group. The effect is shown graphically in Figure 1. It can be seen that the quieter stimulus itself produces a significantly larger response (p < .0002) than the habituated louder control stimulus. Thus incomplete generalization of habituation to a stimulus of lower intensity is clearly demonstrated. The response to the usual loud tone is dishabituated for the next two tones (23 and 24) but shows no significant difference from the 25th tone onward.

Analysis of variance for the same effect and trials with basal conductance is given in Table 2. There is no significant difference between the groups for this variable, so that the hypothesis that dishabituation is caused by a separate tonic sensitization effect is not supported by these results.

DISCUSSION

Selective habituation along an intensity dimension has thus been demonstrated. Habituation to a loud tone fails to generalize completely to a softer tone.
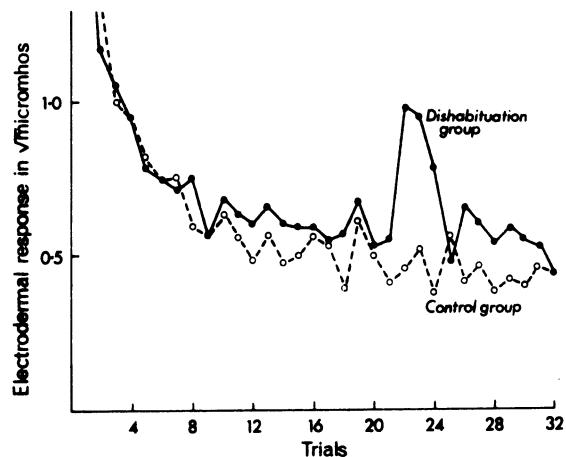

Figure 1. Generalization to and dishabituation by a stimulus of lower intensity. All stimuli are at an intensity of 95 dB except for Stimulus 22 in the experimental group, which is at an intensity of only 65 dB.

The effect is strong enough to exceed the countervaling effect where we would expect responses to quieter stimuli to be smaller. The dishabituating effect of the quieter tone is also demonstrated, the response to the habituated stimulus being significantly larger following presentation of the quieter tone. The latter is therefore able to act as a dishabituating stimulus.

Groves and Thompson could explain this generalization effect in the same way as their explanation of generalization to different tonal frequencies. It may be that there are cells in the auditory cortex which respond selectively to weak tones but not to strong ones. There is something unsatisfactory, however, about this type of explanation. It would be difficult to identify these cells without categorization in terms of the stimulus. As this categorization is, in essence, a psychological one, the neurological intervening variables (the cells) can have only descriptive and not predictive power. With regard to a theory of habituation, they are not independently testable and cannot therefore validate the theory.

Groves and Thompson's theory suggests that basal conductance should be a causative factor in dishabituation and therefore should produce a more significant difference over the relevant groups than response magnitude. This is clearly not supported by the present experiment.

Sokolov's (1960) theory does predict the results of the present experiment. However, this predictive power may be slightly misleading. Insofar as it deals with an orienting response, it would be rather odd if we did not get such responses to unexpected or novel stimuli. Indeed, if this did happen, our most natural interpretation would be either that the organism did not detect the stimulus, or that the responses we were measuring were not orienting responses. Either way, Sokolov's theory would escape a proper test. In the orienting response and its various measures we have a method of measuring central state and changes in state independently of verbal report and which can be controlled by the information content of the stimulus paradigm. It is this aspect of the orienting response that is important. As a physiological descriptive theory of this process, Sokolov's theory is redundant.

Table 2
Analyses of Variance for Differences Between the Two Groups on Basal Skin Conductance for Stimuli 21 to 25

Stimulus Number	Experimental Group Mean	Control Group Mean	F Ratio (1,82)	Significance
21	4.019	4.028	.006	n.s.
22	4.041	4.019	.033	n.s.
23	4.152	4.045	.512	n.s.
24	4.057	4.051	.001	n.s.
25	4.105	4.029	.340	n.s.

Note. Stimulus 22 is the stimulus of lower intensity in the experimental group. Means are also given, units being square root of micromhos.

It is felt that the best explanation of the results, and those of other experiments involving generalization and dishabituation of the orienting reaction, is directly in terms of expectancy. Although categorization of this expectancy variable is difficult, problems associated with it are not solved by the substitution of physiological or neural metaphors.

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