Heart rate and skin conductance responses to signal and nonsignal stimuli*

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Heart rate and skin conductance were recorded from human Ss while they listened to a mixed series of two tone stimuli. Ss were required either to count or to give a motor response to one stimulus (the signal stimulus) and to ignore the other stimulus. Skin conductance responses were larger for signal stimuli than for ignore stimuli, and the motor response Ss gave larger responses than the counting Ss, for both types of stimuli. The accelerative component of the heart rate response was greater for signal stimuli, and this finding, together with those findings from reaction time studies, is discussed in relation to the conceptual distinction between imperative and warning stimuli.

Heart rate (HR) and skin conductance (SC) components of the orienting response (OR) have been described as a decrease in HR (Graham & Clifton, 1966) and as an increase in SC or decrease in resistance. While several studies (e.g., Uno & Grings, 1965) have examined the relative response magnitudes and habituation rates of these components of the OR to stimuli varying in intensity, few attempts have been made to examine the effect of the importance, or signal value, of stimuli on the OR. According to Lynn (1966), the OR to signal stimuli is slow to habituate and is larger than that to nonsignal stimuli. Korn & Moyer (1968) failed to find differential habituation rates for electrodermal responses following instructions to attend or not to attend to a series of tone stimuli. However, the magnitude of the SC response (SCR) to the first stimulus of the series was greater for those Ss who had been instructed to attend. The present study was designed to examine further the relative effect of signal and nonsignal stimuli on the OR. It was predicted that both SCRs and HR responses (HRRs) would be greater for signal than for nonsignal stimuli and that responses to signal stimuli would be slower to habituate.

SUBJECTS

Forty right-handed male undergraduate students served as Ss. They were recruited from an introductory psychology course at the University of Illinois.

APPARATUS AND PROCEDURE

Ss reported individually for the experiment and were seated in a high-backed easy chair, which was placed in a partially soundproofed air-conditioned room. A Beckman R-411 Dynagraph, located in an adjacent room, and Beckman electrodes were used to provide continuous recording of the S's heart beats and skin resistance. Heart beats were also recorded on a Hewlett-Packard 3960 FM tape recorder. Measures of skin resistance were obtained by using a constant current of 10 microamps, imposed on the index and middle fingers of the left hand, the electrodes (1 sq cm in area) being placed on the volar surfaces of these fingers.

Each S was presented with a mixed series of 30 high-frequency tones (1,000 cps, 1 sec duration, 80 dB) and 30 low-frequency tones (400 cps, 1 sec duration, 80 dB). Interstimulus interval (between 25 and 45 sec), and the order of presentation of high and low stimuli were varied randomly. Twenty Ss, assigned randomly to the pressing group (P), were instructed to press a button, placed in their right hands, as soon as possible following one tone stimulus, but to ignore the other tone. The other 20 Ss (Group C) were instructed to count the number of presentations of one tone but to ignore the other. For half the Ss in each group, the tone requiring a response (the SIG tone) was the high tone, and the tone that the Ss were instructed to ignore (the IGN tone) was the low tone. The reverse was the case for the other Ss. Before the experiment started, two presentations of each tone were given to insure that the S could differentiate between the tones.

SCORING

SCRs

Skin resistance in kilohms was obtained at the onset of each stimulus and at the point of maximum response following the stimulus (see Coles, Gale, & Kline, 1971, for a description of the response criteria). These values were converted to micromhos, and measures of the SCR for each of the 60 stimuli were obtained by taking the difference between the poststimulus conductance value and the value at stimulus onset.

HRRs

Second-by-second analysis of HR was provided by an IBM 1800 computer for the 20 sec following each stimulus. In contrast to handscoring methods, this procedure involved starting the analysis at the first complete heart beat following stimulus onset instead of the actual onset of the stimulus.

RESULTS

The Ss in the P group responded correctly to SIG and IGN stimuli. Those in the C group reported having heard between 29 and 31 SIG stimuli.

Analysis of SCRs

All response values were divided by the maximum response given by the S to either SIG or IGN stimuli to yield range-corrected response scores for each S. This procedure is similar to that advocated by Lykken & Venables (1971) except that the method described by them involves dividing by the maximum response that *can* be elicited from the S using a startle stimulus. For SIG and IGN trials separately, the 30 range-corrected response scores were reduced to 6 by averaging in blocks of five trials. An analysis of variance on the resulting data indicated that the P group showed significantly larger responses than the C group [$F(1,38) = 17.61$, $p < .001$] and that responses to SIG stimuli were significantly larger than those to IGN stimuli [$F(1,38) = 37.38$, $p < .001$]. Responses tended to increase in magnitude during the session [$F(5,190) = 3.09$, $p < .05$]. Breakdown analysis for P and C groups separately indicated that the difference between responses to SIG and IGN stimuli was significant for both groups. For Group C, responses to IGN stimuli were low and constant over the session, while those for SIG stimuli increased in magnitude [$F(5,95) = 3.88$, $p < .01$]. Breakdown analyses for SIG and IGN stimuli separately indicated that the P group showed larger responses than the C group to both types of stimuli. Responses to SIG stimuli increased in magnitude during the session [$F(5,190) = 4.14$, $p < .01$] while those to IGN did not change [$F(5,190) = 1.73$, $p > .05$].

Analysis of HRRs

The second-by-second HR values were averaged in blocks of five trials to yield six HRR curves for both SIG and IGN stimuli for each S. An analysis of variance on this data indicated that HR was higher for SIG than for IGN stimuli [$F(1,38) = 48.52$, $p < .001$]. HR changed significantly following a

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stimulus (in an acceleration-deceleration-acceleration pattern) but this HRR did not change over trial blocks. Breakdown analyses for the two groups separately indicated that the difference in HR between SIG and IGN stimuli was significant for both groups. The HRR curve, averaged over all trials and both groups, showed maximum acceleration at the third second-by-second HR value and maximum deceleration 5 sec later. Values for these accelerative and decelerative components of the HRR were obtained by subtracting the third and eighth second-by-second HR values from the first value. Analyses of variance on the data representing the two components indicated that SIG stimuli were associated with greater accelerations than IGN stimuli [$F(1,38) = 5.20$, $p < .05$], but there was no change or differential change in this component during the session. There were no differences between groups or stimuli with respect to the decelerative component.

DISCUSSION

In contrast to earlier investigations of the effects of the signal value of stimuli on the OR (e.g., Korn & Moyer, 1968), the present study involved a within-S, within-session design. One implication of this type of design is that, particularly for the P group, where a quick decision as to whether to respond or not was required, persistent orientation to both types of stimuli might be expected. However, while this explanation may account for the failure to obtain habituation, there is no reason to expect the magnitude of the SCR to increase during the session.

Although the prediction concerning habituation rates has not been confirmed, differences in responses to SIG and IGN stimuli have been demonstrated. SIG stimuli were associated with larger SCRs, higher HRs, and greater cardiac accelerations than were IGN stimuli. These differences cannot be attributed to the fact that a motor response was required from the P group: when the data for the C group were considered separately, the differences still obtained. It could be argued that the physiological responses to SIG stimuli were responses to the motor or counting responses to these stimuli. However, if this was the case, a difference between P and C groups would be expected. The only difference between groups was in SCR magnitude, and this difference was significant for *both* SIG and IGN stimuli.

Graham & Clifton (1966) argued that cardiac *acceleration* is part of the defensive reaction, while *deceleration* is related to the OR. Since responses to SIG and IGN stimuli differed in the degree of acceleration, the results obtained here suggest that it is *this* component of the HRR that is related to the OR. However, this conclusion is tempered by a consideration of the procedures used to give a stimulus signal value. According to Lynn (1966), this may be accomplished by either requiring the S to make a response to the stimulus (as in the present study) or by requiring the S to attend to the stimulus. In the former case, the stimulus becomes an "imperative" stimulus, while in the latter case, the term "warning" stimulus seems more appropriate. There is a wealth of evidence from reaction time studies that warning stimuli are associated with deceleration (e.g., Lacey & Lacey, 1964). Thus, the present results suggest that the conceptual distinction between warning and imperative stimuli may be paralleled by differences in the form of the HRR.

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