Locus of control and the autonomic responses associated with a visual orienting task

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Heart rate and electrodermal responding were recorded while 48 subjects viewed eight discrete presentations of a visual orienting stimulus. Subjects were split into Internals and Externals according to scores on the Locus of Control scale (Rotter, 1966). A beat-by-beat analysis of the heart-rate data collapsed over all eight stimulus trials indicated that Externals exhibited a significant decrease in heart rate in response to the stimulus, whereas Internals exhibited no significant change in heart rate. A further analysis of the heart-rate results during the first stimulus trial indicated that Internals displayed a heart-rate response consisting of an initial increase in heart rate followed by a significant decrease in heart rate 4 heart beats after the initiation of the stimulus. In contrast, Externals displayed a large and significant decrease in heart rate during the 1st heart beat after the initiation of the first stimulus. The electrodermal data indicated that Externals were more likely to exhibit electrodermal activity and Internals were less likely to display electrodermal activity during the first stimulus trial. It is suggested that the differential autonomic responsivity noted for Internals and Externals during the task may indicate that Externals attend more to environmental stimuli than Internals.

Several investigators have noted that subjects scoring at the Internal end of the Internal-External Locus of Control Scale (I-E; Rotter, 1966) are better able to raise their heart rates than subjects scoring at the External end of the I-E during trials designed to produce voluntary control of heart rate (Blankstein & Egner, 1977; Gatchel, 1975; Ray, 1974; Ray & Lamb, 1974; Schneider, Sobol, Herrmann, & Cousins, 1978). Several of these studies have indicated that Externals are better at decreasing heart rate in such situations than are Internals.

Ray (1974) has utilized a hypothesis formulated by Lacey and Lacey (1970, 1974) to explain the difference in ability to control heart rate between Internals and Externals. The Laceys have noted that decreases in heart rate are associated with attentiveness to environmental events in a number of situations. Ray (1974) has suggested that the differential heart-rate changes detected for Internals and Externals may have occurred because Externals were more attentive to the environmental events around them than Internals during heart-rate control tasks.

If Ray's (1974) hypothesis is correct, then differential heart-rate changes should occur for Internals and Externals during other types of attention-demanding tasks. For example, Ray's hypothesis would predict

that Externals would manifest larger decreases in heart rate during a nonsignal orienting task than Internals. A recent study by Berggren, Ohman, and Fredrickson (1977) examined responses of Internals and Externals during nonsignal auditory orienting stimuli and concluded that Externals manifested larger orienting responses than Internals. Unfortunately, Berggren et al. (1977) examined changes in skin responding rather than heart rate. Thus, although their results generally support the hypothesis that Externals are more attentive to environmental information than Internals, the skin response data do not have any direct bearing on Ray's (1974) suggestion concerning differential ability to control heart rate.

The purpose of the present experiment was to examine changes in heart rate and skin responding in Internals and Externals during a visual orienting task. It was predicted that Externals would manifest larger heart-rate deceleration in response to the orienting stimulus than Internals.

METHOD

Subjects

Twenty-four females and 24 males enrolled in an introductory psychology course at Northern Illinois University served as subjects in the study. The subjects ranged in age from 18 to 24 years. All subjects received experimental credit for participation in the experiment.

Apparatus

All physiological recording took place in a sound-attenuated and electrically shielded chamber. Physiological recording was accomplished in an adjoining chamber with a Grass Model 7D polygraph equipped with appropriate bridges, preamplifiers, and driver ampli-

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fiers. Heart rate and electrodermal responding were recorded continuously throughout the experiment. Stimuli were projected by means of a Kodak Carousel slide projector located in the control chamber and controlled by means of electronic timers.

Procedure

Prior to the physiological portion of the experiment, each subject was given the I-E scale to complete (Rotter, 1966). Subjects' scores on the scale were utilized in classifying them as Internals or Externals.

Each subject was then taken to the experimental chamber and was asked to be seated in a reclining chair. (The subjects remained seated upright throughout the experiment). Electrodes for monitoring heart-rate and electrodermal responding were then attached (see below). The subjects were told that they would be viewing several brief visual stimuli during the next few minutes and that no voluntary responses were required of them. After these instructions, the experimenter left the experimental chamber and the subject was allowed a 10-min rest period in order to adapt to the laboratory.

At the end of the 10-min rest period, the experimenter informed the subject that the visual stimuli would begin within the next minute, asked the subject to focus his/her eyes on the projection screen, and reminded the subject that no voluntary responses to the stimuli were required. Approximately 1 minute later, the first slide was projected on a screen directly in front of the subject. The subjects were presented with either a blue slide or a red slide, with the color of the slide counterbalanced within each sex. The slide was presented eight times for 5 sec each time, with a variable intertrial interval of 10 to 20 sec. The onset and offset of slide presentation was automatically marked on the polygraph record.

Electrode Placement

Heart rate. Grass E5S cup electrodes filled with EKG Sol were placed on the lower left rib cage and the right collar bone. The signal as averaged by a Grass cardiometer which provided a beat-by-beat record of heart rate.

Electrodermal response. A Ag-AgCl Beckman cup electrode of 1 cm² placed on the volar surface of the second phalange of the nonpreferred hand served as one electrode, and an identical electrode placed on the volar surface of the fourth phalange of the nonpreferred hand served as a second electrode. A constant current of 10 μ A supplied by a Grass dc preamplifier was impressed at the second phalange, making that portion of the subject's epidermis lying between the two electrodes an arm of a resistance bridge. A .05 NaCl molar solution suspended in an inert plastic medium served as electrode paste. Surface body oils were removed by swabbing the electrode sites with alcohol.

Physiological Data Reduction

Heart rate. For each trial of stimulus presentation, the heart beat associated with stimulus onset (designated the 0 beat) was tabulated. In addition, the 1st through 5th beats following stimulus onset (designated beats +1 through +5) were tabulated. Thus, the unit of analysis for the heart rate variable was the raw, beat-by-beat change in heart rate.

Electrodermal response. Decreases in resistance of 100 Ω or more that were initiated 1-4 sec after stimulus onset were tabulated for each trial for each subject. The maximum amplitude of the response during each trial was scored in ohms and was transformed to conductance in μ mhos by means of the following formula: $\Delta C = (\Delta R/R^2) \times 10^3$, where ΔC = change in conductance (in μ mhos), ΔR = change in resistance (in kilohms), and R = resting resistance (in kilohms).

Data Analysis

The overall statistical design for the study was a 2 by 2 by 8 (Sex by Locus of Control by Trials) factorial model with repeated measures over the last factor. For the Locus of Control factor, the 24 female subjects were split into 12 Internals and 12 Externals based upon total scores on the I-E scale. In a similar fashion, the 24 males were split into 12 Internals and 12 Externals.

RESULTS

Scores on the I-E scale for male Internals ranged from 2 to 10, while those of male Externals ranged from 11 to 19. I-E scores for female Internals ranged from 5 to 13, while those of female Externals ranged from 15 to 20.

Preliminary analyses of variance including the color of the orienting stimulus as a factor in the design were computed for the heart-rate and electrodermal data. However, no significant main or interaction effects were found for the color of the stimulus. Accordingly, color of the stimulus was not included as a factor in the analyses reported below.

Heart Rate

A 2 by 2 by 8 by 6 (Sex by Locus of Control by Trials by Heart Beats) analysis of variance was computed using the heart-rate data from the heart beat associated with stimulus onset and the 5 following beats. The analysis yielded a highly significant Sex main effect [$F(1,44) = 13.28, p < .001$], indicating that male subjects exhibited lower heart rates ($M = 66.8$ beats/min) than female subjects ($M = 78.1$ beats/min). However, the Sex factor did not interact with any of the other factors, indicating that differences between the sexes in resting heart rate did not differentially affect heart-rate responses to the stimuli.

The heart-rate analysis also indicated a significant Heart Beats main effect [$F(5,220) = 3.69, p < .01$] and a significant Locus of Control by Heart Beats interaction [$F(5,220) = 2.40, p < .05$]. Both of these effects are illustrated in Table 1. Separate Neuman-Keuls tests were computed for Internals and Externals to compare heart-rate values for each of the heart beats presented in Table 1. No significant differences between heart beats were detected for Internals. However, for Externals, the +2 beat was significantly lower than all other beats ($p < .01$), and the +1 beat was significantly lower than the last 3 beats ($p < .01$). In addition, simple effects tests indicated that Internals displayed significantly higher heart rates than Externals ($p < .05$) during the +1 and +2 heart beats. Thus, Externals appeared to exhibit a decrease in heart rate in response to the stimulus which reached a nadir during the 2nd beat following the stimulus, whereas Internals did not exhibit any significant change in heart rate in response to the stimulus.

Table 1
Heart Rates of Internals and Externals During the Heart Beats Following Stimulus Presentation

	Heart Beats					
	0	+1	+2	+3	+4	+5
Internals	73.7	74.3	74.9	74.5	74.2	74.4
Externals	70.1	69.5	66.3	70.9	71.3	70.7
Overall	71.9	71.9	70.6	72.7	72.8	72.6

Figure 1. Heart rates for Internals and Externals for the heart beats associated with stimulus presentation during Trial 1.

In addition to the overall analysis of variance reported above for the heart-rate variable, the heart-rate responses of subjects during the first trial were also subjected to an analysis of variance. The first trial was of particular interest because the largest orienting responses have been reported during initial exposure to stimuli (Graham & Clifton, 1966). The statistical model for this analysis of variance was a 2 by 2 by 6 (Sex by Locus of Control by Heart Beats) factorial design with repeated measures over the last factor.

The analysis of variance of the heart rate values during Trial 1 also yielded a significant Locus of Control by Heart Beats interaction [$F(5,220) = 4.63$, $p < .001$], which is presented in Figure 1. Separate Neuman-Keuls tests were again computed for Internals

and Externals to examine differences between heart rates for each of the heart beats during and after stimulus presentation. For Internals, the +1 and +2 beats were significantly higher than all of the other heart-rate values ($p < .01$). For Externals, the +1 beat was significantly lower than all other beats ($p < .01$) and the +2 beat was significantly lower than the +4 and +5 beats ($p < .01$). In addition, simple effects tests between the heart-rate means of Internals and Externals for each of the heart beats indicated that Internals exhibited significantly higher heart rates than Externals during the +1 beat ($p < .01$) and during the +2 beat ($p < .05$).

Electrodermal Response

The maximum amplitude electrodermal data were analyzed by means of a 2 by 2 by 8 (Sex by Locus of Control by Trials) analysis of variance. This analysis yielded a significant Trials main effect [$F(7,308) = 12.57$, $p < .001$]. This effect indicated that the maximum amplitude of electrodermal activity decreased over the eight trials. No significant main or interaction effects were detected for this variable.

In addition, the number of subjects exhibiting an electrodermal response of 100 Ω or more was tabulated during each trial separately for Internals and Externals. Trials were then averaged into blocks of two, to yield four trial blocks, for Internals and Externals. Percentages of subjects exhibiting electrodermal activity during each of the four trial blocks are presented in Table 2.

Nonparametric statistics were utilized to examine changes in electrodermal activity over trial blocks for Internals and Externals as well as differences between Internals and Externals during each trial block. These nonparametric analyses indicated a significant decrease in the number of Externals exhibiting electrodermal activity over trials ($\chi^2 = 15.61$, $df = 3$, $p < .005$). However, no significant change was noted over trials in the number of Internals exhibiting electrodermal activity.

An additional nonparametric test was applied to the number of Internals and Externals exhibiting electrodermal activity during the first trial. The rationale for this analysis was that maximal orienting responses are

Table 2
Percentages of Subjects Exhibiting Electrodermal Activity During Trial 1 and During Trial Blocks 1-4 of Stimulus Presentation

Trial 1	Internals	63
	Externals	92
Trial Block 1	Internals	50
	Externals	67
Trial Block 2	Internals	31
	Externals	48
Trial Block 3	Internals	29
	Externals	42
Trial Block 4	Internals	33
	Externals	27

typically detected during the first exposure of a novel stimulus, with subsequent exposures of the stimulus resulting in habituation of the orienting response. The percentages of Internals and Externals exhibiting electrodermal activity during the first trial are also presented in Table 2. The nonparametric analysis indicated that Externals were more likely to exhibit electrodermal activity and Internals less likely to exhibit electrodermal activity during the first trial of stimulus presentation (χ^2 corrected for continuity = 4.25, $p < .05$).

DISCUSSION

The heart-rate results of the present experiment provide support for Ray's (1974) assertion that Externals are more able to lower their heart rates than Internals because they are more attentive to environmental information. In response to a repeated orienting stimulus, Externals exhibited a significant decrease in heart rate, whereas Internals did not display a significant change in heart rate. The decrease in heart rate noted for Externals suggests that they were more attentive to the stimulus than were Internals.

The heart-rate results detected during the first exposure of the stimulus indicated that Externals manifested a deceleration in heart rate in response to the stimulus, whereas Internals displayed an acceleration in heart rate. The decrease in heart rate for Externals was consistent with their cardiac responding during the other presentations of the stimulus, but the increase in heart rate for Internals was an unexpected finding. Previous experimenters have consistently noted that Internals are better able than Externals to increase heart rate when instructed to do so (Blankstein & Egner, 1977; Gatchel, 1975; Ray, 1974; Ray & Lamb, 1974; Schneider et al., 1978). The heart-rate results from the first trial suggest that Internals may be predisposed to respond to a visual stimulus with an initial increase in heart rate.

Graham and Clifton (1966) have argued that heart-rate acceleration in response to a novel stimulus is indicative of a defensive response. However, given the innocuousness of the visual stimuli employed in the present study, it seems unlikely that the cardiac change noted for Internals could be attributed solely to a defensive response. Lacey and Lacey (1970, 1974) have noted increases in heart rate associated with tasks requiring internal manipulation of symbolic material, and Ray (1974) reported that Internals reported more "thought about feelings" than Externals during instructed heart-rate control. It is possible that the heart-rate increase noted for Internals during the first trial of the present study may reflect a cognitive response to the stimulus, although it should be noted that the duration of the heart-rate change was relatively brief. In any event, the heart-rate increase detected for Internals during the first stimulus was consistent with the facility Internals have displayed at increasing heart rate in previous studies.

The electrodermal data indicated that Externals manifested more responding initially than Internals and that they exhibited habituation of responding over trials. These electrodermal results are similar to those reported previously by Berggren et al. (1977) for Internals and Externals, and suggest that Externals may have manifested more attentiveness to the initial stimulus presentation than Internals.

In general, it appears that Externals are more likely to display decreases in heart rate than Internals during attention-demanding tasks. The proclivity that Externals exhibit for decelerating heart rate may be due to an increased attentiveness to environmental cues. It should be remembered, however, that the heart-rate changes noted during orienting in the present study were of relatively brief duration (2 or 3 heart beats), whereas those detected during heart-rate control studies are typically of much longer duration (30- to 60-sec trials). Thus, although the present experiment provides independent support for a hypothesis developed from studies on voluntary heart-rate control, it is important to note that the short-term changes in heart rate during orienting could not, by themselves, account for the longer term changes in heart rate noted during studies examining voluntary control of heart rate.

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