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The Effects of Operant Heart Rate Conditioning on Cognitive Elaboration and Attitude Change

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ABSTRACT

A psychophysiological investigation was conducted to assess the relationships among heart rate, affect-laden thought processes, and attitudes. Twenty subjects were trained for five days to raise and lower heart rate by means of a discriminative operant conditioning procedure. On the fifth day, communications that advocated positions with which undergraduates disagreed were presented during a raised, lowered, and basal (unaltered) heart rate trial. Results revealed that the heart rate conditioning procedure produced specific changes in heart rate, and affected the counterarguing (critical processing) to and acceptance of the persuasive communications; counterarguing and resistance to persuasion were greater during raised heart rate trials than during lowered heart rate trials. These findings are consistent with and suggest an extension of the Laceys' hypothesis concerning cardiac activity and cognitive elaboration, and provide evidence of the influence of affect-laden thought processes on evaluative reactions.

DESCRIPTORS: Heart rate, Cognitive elaboration, Laceys' hypothesis, Attitudes.

The "emotional response" elicited by an attitude object or opinion issue is thought to produce consequent physiological patterning and/or arousal. This perspective of the relationship between attitudes and physiology evolved from early studies (e.g., Peterson & Jung, 1907; Smith, 1922; Rankin & Campbell, 1955), and continues to be a dominant theoretical approach (cf. Cacioppo & Sandman, in press; Summers, 1970). Thus, electrophysiological measurements of autonomic nervous system (ANS) activity are thought to tap involuntary responses resulting from the evaluative response to the attitude object. While this approach has proved to be heuristic, two problems have plagued empirical investigations: a) patterns of ANS activity that differentiate affective states have not been identified (cf. Summers, 1970; Levi, 1975); and b) separate ANS indices of arousal have not correlated highly, bringing into question the usefulness of the concept of "arousal" (Lacey, 1959, 1967).

Research *has* provided evidence of predictable relationships between cognitive processing and autonomic activity; tasks requiring cognitive elaboration of information are associated with heart rate acceleration while tasks requiring sensory intake are associated with heart rate deceleration (e.g., Lacey, 1959; Lacey, Kagan, Lacey, & Moss, 1963). Additionally, involvement in the intellectual tasks has been positively correlated with heart rate (Lacey et al., 1963). Subsequent research has confirmed that tasks requiring cognitive processing are accompanied by cardiac acceleration (Kaiser & Sandman, 1975; Lacey & Lacey, 1974; Tursky, Schwartz, & Crider, 1970).

Cognitive processing also is associated with (and a mediator of) attitude formation and change. For

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instance, Petty, Wells, and Brock (1976) found that persons encoded and elaborated upon the arguments contained in a persuasive communication; cognitive elaboration rather than simple attention to and memorization of the message arguments was related to the subsequent agreement with the advocacy. Petty (1977) found that cognitive elaboration, not message-argument memorization, led to *persisting* attitude change. Thus, cognitive activity may affect both heart rate and attitude change.

The purpose of the present investigation was to test an information-processing approach to the covariation of attitude change and heart rate. Consistent with the neurophysiological model of sensory intake-cognitive elaboration proposed by the Laceys (e.g., Lacey & Lacey, 1974; Lacey, 1967; Lacey et al., 1963), it was predicted that operantly conditioned changes in heart rate ceteris paribus would alter cognitive elaboration; when cognitive elaboration is altered concurrently with the presentation of attitudinal information, the profile of cognitive responses elicited by the persuasive appeal, and ultimately, the subsequent attitude should be affected.

Previous research has demonstrated that counterargumentation is elicited by the anticipation (Cacioppo, 1977; Cialdini, Levy, Herman, Kozlowski, & Petty, 1976; Petty & Cacioppo, 1977) and presentation (Petty et al., 1976; Petty, 1977) of involving communications advocating counterattitudinal positions. Therefore, a variety of counterattitudinal communications that concerned involving topics were presented to subjects during increased, decreased, and basal heart rate trials. It was hypothesized that when counterattitudinal communications were presented during accelerated heart rate trials, the generation of counterarguments and the resistance to persuasion would be greater than when the discrepant communications were presented during decelerated heart rate trials.

Method

Subjects

Twenty male undergraduates from Ohio State University volunteered for the study. All subjects had undergone operant heart rate conditioning for approximately 1½ hrs per day (15 acceleration and 15 deceleration trials) for the four previous days, and approximately ¾ hrs (8 acceleration and 8 deceleration trials) immediately prior to the test trials.

Design, Materials, and Pilot Testing

Employed in the experiment was a 3 (accelerated, basal, and decelerated heart rate conditioning trial) × 2 (high vs low message persuasiveness) mixed (within and between subjects) factorial design. Ten of the subjects received the high-persuasive communications and 10 of the subjects received the low-persuasive communications; counterattitudinal communications were presented to each subject during an accelerated, basal, and decelerated heart rate trial. The order of presentation of messages and of the cardiac conditioning trials was determined randomly for each subject; the colors of the discriminative stimuli (red, blue, and yellow) were also determined randomly for each subject.

Examples of the persuasive communications are presented in Table 1. Counterattitudinal communications at two levels of persuasiveness for each of three topics were developed in pilot testing; during the experimental trials, the communications were on 5.1×5.1 cm (2×2 in.) slides and were projected on a screen approximately one meter directly in front of the subject.

Procedure

During the first four days of conditioning, all subjects were told that the purpose of the experiment was to determine the degree to which individuals could learn to control their heart rate. Subjects were informed they would see a series of colored lights; they were to try to increase, decrease, or not control their heart rate when the (appropriate) light was illuminated; they were also told not to alter their breathing rate or depth, or engage in muscle tensing or movement during conditioning trials. Visual inspection of the polygraph record indicated sub-

TABLE 1

Sample experimental stimuli

Advocacy	Persuasiveness	Sample Message Argument
Lower drinking age to 13	Low	Increased drinking would increase tax revenue
	High	The recent reduction of the drinking age to 18 has reduced drinking problems in that age group
Not allowing undergraduates and graduates to be in the same class	Low	Undergraduates should wait until graduate school to take graduate courses
	High	Undergraduates pay more money, yet receive less attention in such classes
Toothbrushing three times a day can harm your teeth	Low	Never brushing your teeth leads to cleaner teeth and fresher breath
	High	Less but more careful toothbrushing provides whiter, healthier teeth and gums

jects complied generally with these instructions. Subjects were given sec-by-sec audio feedback by means of a clicking clock which was activated whenever they produced accelerated or decelerated heart rates of criterion magnitudes. During these sessions, an operant shaping procedure was employed to modify each subject's heart rate (McCanne & Sandman, 1975).

Instructions were followed by a 5-min adaptation period to allow subjects to adjust to the experimental chamber. A 1-min basal heart rate was taken for each subject immediately following the adaptation period.

Each conditioning and experimental trial lasted 64 heart-beat intervals (IBIs) and was separated from the next trial by a variable intertrial interval of 10 to 30 sec. The initial criterion for the first accelerated trial was 2 bpm above the base rate, while for the first decelerated trial the initial criterion was 2 bpm below the base rate. If a subject produced 48 or more IBIs (75%) which exceeded the criterion for any trial, the criterion for the next trial with the same discriminative stimulus was made more difficult by increasing or decreasing the heart rate level necessary to trigger reinforcement by 2 bpm. If a subject produced 24 or fewer correct IBIs during a trial (37.5%), the criterion for the next trial with the same stimulus was made easier by 2 bpm.

On the fifth day of the conditioning each subject was greeted and instructed as usual by the experimenter; he was seated in a reclining chair, and electrodes were attached to him. A 5-min adaptation period was provided, basal heart rate was determined, and 8 trials of accelerated and 8 trials of decelerated heart rate conditioning were administered. The criteria used for the eighth accelerated and decelerated heart rate conditioning trials were used as criteria during the experimental trials.

Afterwards, subjects were told that they were to see slides of written messages. "When the slide is presented, read the message to yourself. The slide will be presented for thirty seconds, but the messages are short. The next slide presented will ask your opinion on the topic about which you just read. That is, it will ask you how you feel about the topic. Answer aloud by telling us the number that is closest to your true feeling." (Subjects responded to a 15-point rating scale in which 1 was labeled "agree completely" and 15 was labeled "disagree completely.")

"Messages will be presented only when a light on the panel in front of you is illuminated. The (yellow) light means to increase your heart rate, the (blue) light means to decrease your heart rate, and the (red) light means not to control your heart rate. When no light appears, no slides will be presented. Even though slides are to be presented, you will still be paid for accelerating your heart rate when the (yellow) light appears and for decelerating your heart rate when the (blue) light appears; be certain, though, not to change your breathing rate or depth and do not engage in muscle tensing or movements when the lights are illuminated. Finally, keep your eyes on the screen in front of you during the trial. Are there any questions?" The light appeared at the beginning of the experimental trial; the message was presented when the subject's heart rate exceeded the criterion. (During basal heart rate trials, the message was presented 5 to 15 sec after trial onset.)

At the end of the experimental session, subjects were given a questionnaire in which they were asked to list the thoughts they had had during the presentation of each message. Their responses were rated independently by two judges who were unaware of the experimental conditions.[1] Subjects were also asked to list what they were thinking during the conditioning trials and what their thoughts and suspicions were concerning the experiment.

Physiological Measures

Heart Rate. Grass E5S cup electrodes filled with EKG Sol were placed near the lower left rib cage and the right collar bone. The signal was amplified by a Grass Wide Band AC Preamplifier and processed using a Grass cardiotachometer. Mean heart rate was calculated with the following formula: Heart Rate=(64 beats/trial $\times$ s mm/sec $\times$ 60 sec/min)/(l mm/trial) where 64 is the number of heart beats in the trial, s is the paper speed in mm/sec, and l is the length of the trial in mm.

Chin Muscle Activity. Two Grass E5S Ag-AgCl cup electrodes filled with Grass EKG electrode paste were placed on the midline of the chin; the first was placed 1.8 cm above the point of the chin and the second was placed 1.8 cm below the point of the chin (Venables & Martin, 1967). The signal was amplified by a Grass Wide Band AC Preamplifier using a time constant of .08 sec. Chin muscle activity was calculated with the following formula: Activity Index$=(l_i \times s_i)/l_t$ where s_i is the scale value of a particular amplitude of EMG activity (larger amplitude EMG activity was assigned larger scale values; scale values ranged from 0 to 5), and l_i is the total length of a particular scale value of EMG activity measured in mm. Chin muscle activity was selected to monitor general motor activity because it is a sensitive measure of muscle tensing and movement (cf. Obrist, Howard, Lawler, Galosy, Meyers, & Gaebelein, 1974).

Respiration. The respirometer[2] consisted of a thin-walled opaque neophrene tubing 5.1 mm in length and 3.5 mm in diameter with an optical sensor and emitter mounted at each end. The mounting was roughly spherical with a diameter such that the tubing, when stretched across the chest, was drawn taut in a straight line between mounts. Attached to each mount was a cloth band 1.95 cm in width and of sufficient length to encompass different chest sizes. Velcro fasteners on each end held the respirometer in place. Current output of the phototransistor was approximately linear with chest expansion. The varying voltage was amplified by an AC Grass Preamplifier. Average respiration amplitude and frequency were calculated for each trial with the following formulas: Respiration Frequency=(N cycles/trial $\times$ s mm/sec $\times$ 60 sec/

[1] Statements directed against the advocated position which mentioned specific unfavorable consequences, statements of alternative methods, challenges to the validity of arguments in the message, and statements of affect opposing the advocated position were counted as counterarguments. Statements in favor of the advocated position which mentioned specific favorable consequences, statements eliminating alternatives, statements that supported the validity of the message arguments, and statements of affect supporting the advocated position were scored as favorable thoughts.

[2] The respirometer and plethysmograph were developed by Robert Isenhart.

min)/(*l* mm/trial) where *N* is the number of respiration cycles, *s* mm/sec is the paper speed, and *l* mm/trial is the length of the trial; Amplitude Index=(total mV/cm × average wave amplitude in mm)/(100 mV/cm) where total mV/cm was the sensitivity for a given subject.

Digital Blood Flow. A reflective plethysmograph was placed over the first phalanx of the fourth finger of the right hand. The plethysmograph contained a light-emitting diode (LED) and a narrow band emitter of infra-red radiation with a wavelength of .74 micrometers. The emitter of the plethysmograph was placed in the same place as a photodarlington transistor of matched sensitivity. These two devices were mounted on a small glass epoxy printed circuit. The signal was amplified by a Grass Wide Band AC Preamplifier. Digital pulse amplitude was calculated using the Amplitude-Index formula.

Cephalic Blood Flow. A plethysmograph with a design similar to the one used for digital blood flow was placed over the supraorbital notch, just above the eyebrow. This provided a relative measure of blood flow in the supraorbital artery, a branch of the opthalamic artery (Wallace & Wallace, 1968). Cephalic pulse amplitude was calculated with the Amplitude-Index formula.

Data Reduction. Each subject received three messages (all three either high or low in persuasiveness), one each during an accelerated heart rate, a decelerated heart rate, and a basal heart rate trial. Persons scoring the physiological and cognitive-response data were unaware of the experimental hypotheses. The interjudge-reliability coefficient for ratings of the cognitive-response data was $r=.87$, and analyses of cognitive-response measures were performed on the average of the judges' ratings.

Results[3]

An analysis of variance was performed for heart rate during the conditioning trial and intertrial intervals preceding the experimental trials to assess the effects of the discriminative operant-conditioning procedures. It was found that conditioning affected heart rate, $F(1/19)=15.83$, $MS_e=42.34$. The Interval × Conditioning interaction was also significant, $F(1/19)=12.76$, $MS_e=70.92$, indicating that the discriminative conditioning procedure affected heart rate only during the trial intervals (see Table 2). Pair-wise comparisons using the Newman-Keuls procedure (Kirk, 1968) revealed heart rate was greater during accelerated heart rate trials than during decelerated heart rate trials; no other pair-wise comparison was statistically significant. Inspection of Table 2, however, indicates that subjects attained some degree of bidirectional control of heart rate; heart rate was raised 2.28 bpm during acceleration trials, and was lowered 2.48 bpm during deceleration trials.

An analysis of variance was conducted for heart rate during the experimental trial and intertrial intervals to determine if the voluntary control of

[3]All effects reported are statistically significant at the $p<.05$ level.

TABLE 2

Summary of mean heart rate during conditioning and experimental trial and intertrial intervals

Trials	Mean Heart Rates	
	Intertrial Interval	Trial Interval
Conditioning		
Acceleration	68.6^{ab}	70.9^{a}
Deceleration	68.9^{ab}	66.5^{b}
Experimental		
Acceleration	66.5^{cd}	68.0^{c}
Base	66.0^{cd}	64.8^{d}
Deceleration	64.5^{d}	64.6^{d}

Note.—Means with unlike superscripts differ significantly from each other.

heart rate was maintained during the presentation of the counterattitudinal communications. The analysis revealed that conditioning affected heart rate, $F(2/36)=8.53$, $MS_e=9.12$. The Interval × Conditioning interaction, however, was not significant, $F(2/36)=2.94$, $MS_e=6.94$. Pair-wise comparisons using the Newman-Keuls procedure indicated that only heart rate during accelerated heart rate trials differed from heart rate during basal and decelerated heart rate trials (see Table 2). Thus, only accelerated heart rate conditioning generalized to the experimental trials.

The following sections concern the analyses of the effects of the conditioning treatment (accelerated, decelerated, and basal heart rate) and message persuasiveness (high vs low) on cognitive and physiological responses during the experimental trial intervals.

Conditioning Treatment

Physiological Measures. A multivariate analysis of variance of the effect of conditioning on the set of six physiological measures yielded a significant effect, $F(12/62)=2.15$. Univariate analyses of variance were conducted for each physiological measure to assess the *specificity* of the effect of conditioning on heart rate during the experimental trial intervals. The ANOVAs indicated that, of the six physiological dependent variables, only mean heart rate during the accelerated, decelerated, and basal trials differed significantly, $F(2/36)=9.74$, $MS_e=7.59$. An *a priori* comparison of each physiological response during the accelerated and decelerated heart rate trials was planned as the manipulation check. Results yielded strong support for the manipulation; only heart rate was higher during accelerated than decelerated trials, $F(1/18)=12.12$, $MS_e=9.83$. An *a priori* comparison of each physiological response during the conditioning trials (accelerated and decelerated heart rate) and basal trials was planned to assess if conditioning *per se* altered physiological activity; no evidence for this hypothesis was found.

Physiological responses during the basal trials were also compared to response during *each* of the conditioning trials using the Dunnette procedure (Kirk, 1968). Mean heart rate was higher during accelerated than basal trials, $d(3/36)=2.81$; no other differences were significant (see Table 3). These results indicate that the differences in heart rate displayed during the presentation of the communications: a) were due to the maintenance of the voluntary control of heart rate during accelerated heart rate trials, and b) were not accompanied by major changes in the measured motor and respiratory activity.

Cognitive Response and Opinion Measures. It was hypothesized that during accelerated heart rate trials, cognitive responding (i.e., elaboration) to the communication would be reflected in increased counterargument production, and would result in increased resistance to persuasion. *A priori* comparisons of cognitive response and opinion measures supplied strong support for these predictions: the number of counterarguments generated, $F(1/18)=4.12$, $MS_e=0.49$, and the resistance to persuasion, $F(1/18)=4.31$, $MS_e=13.94$, were greater during the accelerated heart rate trials than during the decelerated heart rate trials.[4] Also as expected, no other effects for conditioning were significant (see Table 4). Using the Dunnette procedure, minor analyses of the cognitive response and opinion measures were conducted to compare the effects of a basal heart rate trial with each of the conditioning trials. A consistent relationship between heart rate, the number of counterarguments generated, and opinion ratings was observed though the comparisons were not significant; accelerated heart rate was related to increased counterarguing and greater resistance to persuasion, and decelerated heart rate was related to decreased counterarguing and relative susceptibility to persuasion (see Fig. 1).

[4]One-tailed comparisons.

TABLE 3

Summary of mean responses for physiological variables

Measures	Mean Physiological Responses		
	Heart Rate Trial		
	Acceleration	Base	Deceleration
Cephalic blood flow (mm)	16.4	16.5	16.2
Digital blood flow (mm)	7.4	9.0	8.0
EMG activity index (chin)	9.5	7.1	7.3
Respiration frequency (cycles/min)	15.7	15.8	15.1
Respiration amplitude (mm)	11.7	9.7	9.3

Analyses of the post-experimental protocols revealed that: a) no subject expressed awareness of the experimental hypotheses; and b) reports of what subjects were thinking during the conditioning trials were not affected by the experimental manipulations.

Message Persuasiveness Treatment

A between-subjects Message Persuasiveness factor was included as a replication factor to increase the generalizability of results. It was expected that this factor would affect the number of counterarguments generated and resistance to persuasion. No predictions concerning physiological differentiation were made.

TABLE 4

Summary of opinion and cognitive response measures for counterattitudinal messages

Response Measures	Means								
	Low Persuasive Messages			High Persuasive Messages			All Messages Combined		
	Acceleration	Base	Deceleration	Acceleration	Base	Deceleration	Acceleration	Base	Deceleration
Attitude	13.90	12.60	11.70	9.50	6.90	6.80	11.70	9.75	9.25
Counterarguments	2.80	2.70	2.10	2.10	0.90	0.80	2.45	1.80	1.45
Favorable thoughts	0.00	0.00	0.20	0.90	1.40	1.50	0.45	0.70	0.85
Neutral thoughts	0.40	0.30	0.10	2.00	2.40	1.90	1.20	1.35	1.00

Note. Higher means on the attitude measure indicate less agreement with the speaker's position. All other entries refer to the mean frequency of the response.

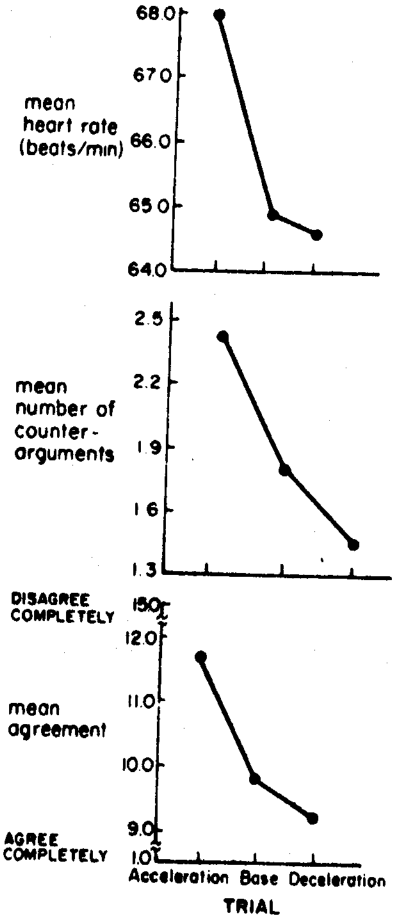

Fig. 1. The effects of cardiac conditioning on heart rate, counterargument production, and resistance to persuasion.

Physiological Responses. The multivariate analysis of variance for the effect of message persuasiveness on the set of six physiological measures failed to reach a statistically significant level. Univariate ANOVAs revealed message persuasiveness was differentiated by chin EMG activity, $F(1/18)=5.73$, $MS_e=0.24$; low-persuasive messages led to more chin EMG activity than high-persuasive messages. Due to the absence of a significant multivariate statistic, however, this result should be considered tentative. There were no conditioning × message persuasiveness interactions.

Cognitive Response and Opinion Measures. The analyses of message persuasiveness revealed that the low-persuasive messages elicited more counterarguments, $F(1/18)=5.69$, $MS_e=4.45$, were less persuasive, $F(1/18)=44.41$, $MS_e=6.64$, and elicited fewer total thoughts, $F(1/18)=8.43$, $MS_e=4.56$, than the high persuasive messages (see Table 4). Thus, the manipulation of message persuasiveness was effective and influenced the entire profile of cognitive responding. The expected inverse relationship between counterargument production and resistance to persuasion was also found (within-cell $r=.41$). There were no conditioning × message persuasiveness interactions.

Discussion

The operant conditioning of heart rate had an instrumental effect on thinking (cognitive responding) and attitudes. The results of this study indicated that greater counterargumentation and resistance to persuasion occurred during accelerated heart rate trials than during decelerated heart rate trials. Several possible interpretations of this relationship between affect-laden thought and physiological processes are reviewed in the context of the present results.

A neo-Jamesian psychophysiological model of cognitive responding and persuasion provides a parsimonious account of the relationship demonstrated in the present study. According to this interpretation, accelerated heart rate facilitated the critical processing of the counterattitudinal communication; the resultant increase in counterargumentation then altered the attitudinal reaction to the persuasive appeal (i.e., increased resistance to persuasion). It was also predicted that decelerated heart rate would inhibit the critical processing of the counterattitudinal communications, and that susceptibility to persuasion would thereby be enhanced; the failure to find decelerated heart rate during the experimental trials prevented an assessment of this hypothesis.

The Laceys (Lacey, 1967; Lacey et al., 1963) have suggested that heart rate may influence behavior by its effects on pressure-sensitive receptors (baroreceptors). Transient pressure changes associated with cardiac activity are detected by baroreceptors in the carotid sinus and aortic arch and influence electrocortical activity. There is considerable neurophysiological evidence for such effects (Bonvallet & Allen, 1963; Bonvallet, Dell, & Hiebel, 1954). The Laceys speculated that accelerated heart rate was related to cognitive elaboration and "rejection of the environment," while decelerated heart rate was related to sensory reception and "acceptance of the environment" (e.g., Lacey et al., 1963).

The findings of the present investigation are in accord with the Laceys' formulations; however, it was proposed that acceptance or rejection of the environment (e.g., susceptibility or resistance to persuasion) was mediated by the relationship between heart rate and *information processing*. The profile of cognitive responses supported this hypothesis. Furthermore, the work of Sirota, Schwartz, and Shapiro (1974, 1976) has provided evidence that is difficult to explain in terms of the Laceys' hypothesis of environmental acceptance or rejection and heart rate. Sirota et al. (1974, 1976) found that subjects who increased heart rate voluntarily reported the electric shocks were more painful than subjects who decreased heart rate voluntarily; in other words, accelerated heart rate was associated with acceptance rather than rejection of the environment. This effect was true only for subjects who reported that they were typically "highly aware of the occurrence of certain cardiovascular changes during anxiety or fear situations in daily life" (Sirota et al., 1976, p. 473). Since it is possible that a) cognitive responses pertaining to the intensity of the painful shocks were elicited predominantly or exclusively in these subjects, and b) accelerated heart rate facilitated the generation of these cognitive responses while decelerated heart rate inhibited their generation, the findings of Sirota et al. (1974, 1976) are consistent with the present analysis of heart rate, cognitive elaboration, and affect.

If decelerated heart rate conditioning were merely more distracting or stressful than accelerated heart rate conditioning during the message presentations, the cognitive response and agreement ratings may have resulted from one or both of these factors. Two lines of evidence from the present study, however, argue against this interpretation: a) Analyses of the digital and cephalic pulse amplitudes revealed no differences in either of these measures during the message presentations. Since these measures are sensitive to orienting and defensive reactions (Sokolov, 1963; Lynn, 1966) differences in stress or distraction during accelerated, decelerated, and basal heart rate trials should also have resulted in differences in one or both of these measures. b) The presentation of the communications when subjects were not exerting control over their heart rate (i.e., basal heart rate trials) should have been associated with less distraction, effort, and stress than when subjects were exerting control over their heart rate. Thus, both the comparison of the conditioning trials versus the basal heart rate trials, and the comparison of the accelerated (or decelerated) heart rate trials versus the basal heart rate trials should have revealed differences in cognitive responding and agreement. These comparisons, however, did not approach statistical significance.

The observed relationships between heart rate, counterargumentation, and attitude cannot be explained parsimoniously by either demand characteristics or by a cognitive strategy for conditioning interpretation. Inspection of the postexperimental protocols revealed that subjects were not aware of the experimental hypotheses. Moreover, Detweiler and Zanna (1976) found that false feedback about a subject's heart rate led to *increased* attitude change whether the feedback indicated heart rate was increasing or decreasing.

It could be reasoned that the accelerated and decelerated heart rate resulted in different cognitive labels. Schachter (Schachter & Singer, 1962; Schachter, 1964) argued that persons experiencing a general undifferentiated pattern of sympathetic discharge and who have no explanation for the physiological state, experience an "evaluative need"; they label the autonomic arousal in a manner consistent with situational cues in order to satisfy this need. The procedures and results of the present experiment, however, are not relevant to Schachter's theoretical analysis for the following reasons: a) The manipulations of autonomic arousal used by Schachter and Singer (1962) and Schachter (1964) resulted in widespread autonomic changes (e.g., the injection of epinephrine results in widespread alterations of physiological activity). The manipulation of heart rate in the current experiment resulted only in a variation in heart rate of the several responses studied. Consequently, the general undifferentiated pattern of sympathetic discharge assumed to be a crucial component in the development of a person's "evaluative need" was not present in the current experiment. b) Previous research has demonstrated that heart rate is not a reliable index of emotion (Baker, Sandman, & Pepinsky, 1975; Libby, Lacey, & Lacey, 1973; Sandman, 1975). Thus, the variation in autonomic activity present in the current experiment has not been related consistently to different emotional states in previous investigations. c) Schachter (Schachter, 1964; Schachter & Singer, 1962) indicated that the autonomic arousal must be unexplained if a need to label the aroused physiological state is to occur. However, persons in the present experiment evidenced discriminative control of their heart rate and had no question as to the reasons for their changing physiological state. An immediate feedback system gave subjects second by second information concerning their heart rate. In summary, both components necessary for the development of an "evaluative need" and subsequent cognitive labeling of physiological states were absent in the current experiment.

Similarly, the emotional response to an attitude object may lead to specific physiological responses (Lemon, 1973). The present results cannot be explained in these terms though, since opinion issues were assigned randomly to the heart rate trials for each subject. This procedure controls for the emotional reactions elicited by the opinion issue.

It is possible that the observed relationship between heart rate and resistance to persuasion was due to differential affective states produced by the instruction to raise heart rate *and* the accompanying feedback and reinforcement. This interpretation is based upon the experimental demonstrations that instructions to relax *plus*: a) EMG feedback to induce muscle relaxation (Wickramasekera, 1971, 1973), or b) EEG alpha feedback to increase alpha rhythm duration (Engstrom, 1976; Engstrom, London, & Hart, 1970; London, Cooper, & Engstrom, 1974) are accompanied by increased hypnotic susceptibility. Thus, instructional and conditioning procedures that alter the "arousal" or relaxation of the subjects may also affect the suggestibility of the subjects, thereby affecting cognitive responding and resistance to persuasion. Although subjects' reports of what they thought during the conditioning trials were not affected significantly by the type of conditioning (i.e., accelerated vs decelerated heart rate) trial, the measure, which was contained in a postexperimental questionnaire, may have been insensitive (cf. Bell & Schwartz, 1975). Future research might assess if instructions and feedback to *reduce* muscle relaxation (or alpha duration) are associated with decreased hypnotic susceptibility, increased critical processing, and increased resistance to persuasion. Research might also assess if relaxation instructions and EEG alpha (or EMG feedback) affect heart rate; it is possible that changes in heart rate accompanied these procedures, altered critical processing, and ultimately altered hypnotic susceptibility.

In summary, an approach to the study of cognitive responding and attitude change has been proposed and tested. In the proposed account, a relationship exists between attitude change and physiological responses because of the relationship of each to information processing. If the cognitive responses elicited by an attitude object or opinion issue are negative (e.g., counterarguments), facilitated processing confers greater resistance to persuasion. Further research must be conducted to determine whether the changes in heart rate or the *conditioning* of heart rate affected information processing. For instance, Cacioppo (1977) employed subjects with cardiac pacemakers to examine the effects of changes in heart rate produced peripherally on cognitive performance. This procedure could also be used to investigate the effects of changes in heart rate on cognitive elaboration and resistance to persuasion.

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