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Field Dependency and the Accuracy of Heart Rate Control

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A possibly useful approach for the exploration of the accuracy of heart rate control (HRC) as related to cognitive functioning was supplied by the introduction of the field dependency concept by Witkin, Dyk, Fatterson, Goodenough, and Karp (1962) and by Witkin, Lewis, Hertsman, Machover, Meissner, and Wapner (1954). One index of an individuals level of field dependency is The Rod and Frame Test (RFT) (Witkin et al., 1962).

The RFT consists of an illuminated rod surrounded by an equally illuminated frame. Both the rod and the frame can be individually tilted, and are the only objects visible to the subject. With the frame tilted, the subject is required to adjust the rod until it appears vertical. At one end of the population distribution are the field dependent (FD) individuals whose perception of the upright is more influenced by the frame. They tilt the rod toward the angle of tilt of the frame in order to perceive the rod as vertical. At the other end of the distribution are the field independent (FI) individuals who are not as influenced by the frame and are better able to adjust the rod to a vertical position.

The Embedded Figures Test (EFT) is another measure of field dependency (Witkin et al., 1962). This test requires the subject to locate a single figure which is incorporated within the context of a larger more complex one. The FI subject more easily recognizes the hidden figure.

The performance between the EFT and the RFT is related in that an individual who is less accurate in adjusting the rod to true vertical tends to do less well indentifing the figure within the context of the larger one (Witkin et al., 1962).

Witkin et al. (1954) in an extensive series of studies concluded that:

> field dependent persons tend to be characterized by passivity in dealing with the environment, and by unfamiliarity with and fear of their own impulses, together with poor control over them; by lack of self-esteem; and by the possession of a relatively primitive, undifferentiated body image. Independent or analytical perceptual performers, in contrast, tend to be characterized by activity and independence in relation to the environment, by closer communication and better control over their own impulses; and by relatively high self-esteem and a more differentiated, mature body image. (p. 469)

Silverman, Cohen, Shmavonian, and Greenberg (1961) investigated field dependency and subjects' responses to a low sensory situation in relation to physiological variables. While there was a gradual decrease in the nonspecific galvanic skin response (NSGSR) for both the FI and FD groups across time, the NSGSR of the FD group remained at a higher level. Basal skin resistance findings displayed a similiar elevated level for the FD group. These increases, combined with the FD subjects' electroencephalograph (EEG) trend for greater cortical alerting, suggested that the FD subjects maintained greater arousal and exhibited a differential handling of the low sensory environment.

Experiments have further demonstrated that FI and FD individuals are also dichotomized with respect to their physiological responses to sedative and stimulant drugs (Cohen, Silverman, & Shmavonian, 1962), insulin (Silverman, McGough, & Bogdonoff, 1967), letter identification and two point discrimination (Cohen et al., 1962).

Since experiments had revealed a trend for physiological response differences between groups of FI and FD individuals, Hein, Cohen, and Shmavonian (1965) proposed that differential conditioning characteristics would also exist. An autonomic conditioning design employing one reinforced and four nonreinforced lights was used to investigate this premise. By using galvanic skin response (GSR) as an indicator, it was observed

that the FI subjects displayed a greater differentiation of reinforced to nonreinforced stimuli. The FI subjects also had greater and more prolonged GSR responsivity to the specific reinforced external stimuli.

A similiar finding was reported in a study which used tone as the conditioned stimulus (CS) and shock as the unconditioned stimulus (UCS) (Courter, Wattenmaker, & Ax, 1965). A significant decrease in the GSR amplitude as the tones separated demonstrated the FI subject was better able to discriminate between the CS and the three other unreinforced generalization tones. Such a gradient was not manifested by the FD subject.

A different method for empirically investigating the relationship between physiological reactivity and field dependency was used by Goldstein, Pardes, Small, and Steinberg (1970). Subjects were required to perform a visual attending task. Both FI and FD groups had increased nonspecific GSR (NGSR) activity and initial heart rate (HR) decreases during the attending period. This increase in NGSR and decrease in HR has been termed directional fractionation by Lacey (1959) who related the phenomea to attention being directed outward. While resting, the FD group had a higher NGSR level than the FI group, i.e., the FD subjects were more aroused. The FI group displayed a higher NGSR level and greater HR deceleration during the attending period. The FI subjects thus exhibited more consistent directional fractionation and physiologically responded more consistently to the experimenter defined task.

In a series of studies on HR control, subjects provided with externalized feedback of their own HRs and then required to respectively reduce cardiac rate variability (Hnatiow & Lang, 1965), speed HRs (Brener, 1966; Engel & Hansen, 1966), and to raise and also lower HRs Brener & Hothersall, 1966), have demonstrated instrumental conditioning.

Respiration data and post experimental interviews indicated that these particular modifications of an autonomic response were not cognitively mediated.

Dale and Anderson (1972) extended the above findings in an effort to determine personality differences, namely field dependency, as a predictive variable. Subjects were selected on the basis of their scores on an EFT modified by Jackson (1956) (JEFT) which was further modified by Dale and Anderson (1972) for their experiment. A subject was designated to be FI if he scored 11 correct of the 12 figures, FD if he received a score of seven or less. The subjects were presented with 15 randomly determined speed, slow, or same trials (five each). During these trials subjects were to respectively speed up, slow down, or maintain their HR during the one minute period without the use of external feedback. There was no evidence that the FI subjects were better able to raise their HR and a superiority of the FI subjects for lowering their HR only approached significance. However, results disclosed that the FI subjects exhibited a greater overall change in HR from the mean of the same trials than did the FD subjects.

In the above study subjects were required to alter their HR across each instructional condition, i.e., raise, lower, and same. In contrast, an experiment without field dependency measures obtained highly significant HR alteration results ($p < .001$) by requiring subjects to alter their HR unidirectionally (Bergman & Johnson, 1971). One group was to raise their HR each time a tone was heard and another group was instructed to lower their HR upon presentation of the tone. A control group did not receive any instructions as to HR alteration. No form of sensory feedback was provided the subjects. Subjects were highly capable of unidirectionally raising or lowering their HR without using external feedback.

Data further showed the cardiovascular changes were not a result of respiration modification or GSR fluctuation.

A question raised by the observations of Bergman and Johnson (1971) concerns the findings of Dale and Anderson (1972). If Dale and Anderson (1972) had used a unidirectional HR alteration design instead of requiring subjects to randomly speed up, slow down or maintain their HR, would they have obtained significant results for the FI subjects in altering their HR?

In addition to the question of HR alteration directions, Dale and Anderson (1972) used an EFT modified from the JEFT to determine the degree of field dependency of their subjects. Arbuthnot (1972) found that modifications of the JEFT did not bear resemblance to Witkin's (Witkin et al., 1962; Witkin et al., 1954) measures.

The present experimenter analyzed the results of Dale and Anderson (1972) in terms of the unidirectional HR alteration findings by Bergman and Johnson (1971) and the cautionary findings of Arbuthnot (1972) concerning field dependency measures.

Because of the above findings it was subsequently hypothesized that FI individuals would be found to be superior to FD individuals in raising and lowering their HR if (a) unidirectional HR changes were required of the subject in a manner similiar to that of Bergman and Johnson (1971) and (b) a measure of field dependency in the tradition of Witkin et al. (1954) and Witkin et al. (1962) was employed.

Method

Subjects

The subjects were 20 FI and 20 FD volunteer male college students who were selected from a total N of 66 as being extreme in their scores as determined by the PRFT described in detail by Oltman (1968). The subjects were randomly assigned to one of two subgroups: raise HR and lower HR instructions. Half of the subjects in each field dependency group were instructed to raise their HR and half to lower it. Means of the PRFT scores for the 10 subjects in each subgroup, i.e., raise and lower HR instructions, were 1.57° and 1.53° respectively, for the FI subgroups and 6.90° and 6.12° respectively, for the FD subgroups.

Apparatus

HR recordings were made on a Narco Bio-Systems Physiograph Model DMP-4A, using standard Narco Bio-Systems surface electrodes filled with Redux paste. The recording instrument was located in a room adjacent to the experimental room. The experimental room was sound treated and equipped with a two way mirror through which the experimenter could observe the subject.

Procedure

Subjects were seated in a comfortable reclining chair and told that their HR was going to be recorded with the electrodes. The recording sites were prepared with alcohol and abraded. HR was monitored from the left and right forearm. A third electrode was placed on the lower right forearm and connected to ground.

A tape recorder provided the subjects with the HR control directions via headphones. Prerecorded 700 Hz, 65 db tones of 6 second duration were delivered in a similiar manner. The duration of the tone was marked automatically by an event marker.

The experiment was comprised of a 5 minute rest period, an instruction period, and 15 six second trials. Intertrial intervals ranged from 30 to 59 seconds and averaged 44 seconds. After the rest period taped instructions, adapted from Bergman and Johnson (1971), were given to the subject. The instructions for the raise group were:

> This study deals with controlling your HR. The majority of people can increase their HR when they are given a signal to do so. Increasing your HR is possible if you concentrate on your heart and try very hard to make your HR go faster. In this experiment, you will hear tones lasting for 6 seconds. During the time interval that you hear the tone, I want you to try to make your HR go faster. There will be a number of tones presented and I would like to see if you can increase your HR during each of these tones.
>
> Abnormal breathing or making your muscles go tense or loose will have no effect on helping you increase your HR. In fact, abnormal breathing will foul up the measurements I am taking so please breath normally. During the time you hear the tone use only mental process to increase your HR. Also, please do not make any excess movements.

The instructions provided the lower group were identical except that the words "decrease", "decreasing", and "slower" were appropriately substituted for the words "increase", "increasing", and "faster". The tones followed the instructions after an intertrial time interval.

Results

The mean prestimulus HRs for the FI subjects in the raise and lower instructional groups were 72.81 and 72.81 bpm, respectively. The FD subjects displayed mean prestimulus HRs in the raise and lower groups of 71.70 and 74.45 bpm, respectively. The combined increase group raised their HR an average of 2.86 bpm while the combined decrease group lowered their HR an average of .22 bpm. The difference between the increase and decrease group was significant. (See Table 1).

HR difference scores were calculated by finding the mean HR for the six heart beats preceding the tone and subtracting this mean HR from each of the first six heart beats during the respective tone. Thus, six HR difference scores were obtained for each of the subjects' 15 tones. HR difference scores combined across field dependency groups and HR instructional groups proved significant with the first six heart beats during the tone being altered an average of -.21, 1.51, 1.95, 2.07, 1.51, and 1.12 bpm, respectively.

The instructions x HR difference scores interaction was significant as subjects in the raise instructional groups altered their HR for the first six beats during the tone an average of .41, 3.10, 3.68, 3.07, and 3.07 bpm, respectively. Subjects in the lower instructional groups had average HR difference scores of -.82, -.07, .22, .26, -.06, and -.83 bpm, respectively.

The interaction of trials x HR difference scores was significant as was the interaction of field dependency x trials x HR difference scores.

Table 1

Summary of 5-Factor Analysis of Variance

Source	df	MS	F
Field dependency (A)	1	694.68	2.03
Instructional group (B)	1	8562.38	25.02*
A x B	1	1149.36	3.36
Error	36	342.26	
Trials (C)	14	107.61	.92
A x C	14	47.81	.41
B x C	14	103.42	.89
A x B x C	14	107.95	.93
Error	504	116.40	
HR difference scores (D)	5	2049.98	11.95*
A x D	5	50.25	1.46
B x D	5	137.46	4.00**
A x B x D	5	23.08	.67
Error	180	34.32	
C x D	70	28.82	1.52*
A x C x D	70	21.43	1.13*
B x C x D	70	16.01	.84
A x B x C x D	70	24.73	1.30
Error	2520	18.99	

*$p < .001$

**$p < .005$

Discussion

The effects of the HR instructions were in accordance with the findings of Bergman and Johnson (1971) in that the raise groups significantly altered their HR more than the lower groups. However, when the present heart rate control data were further analyzed in terms of HR change relative to the mean prestimulus HR, only the raise groups significantly altered their HR with a mean change of 2.87 bpm, t (10) = 9.26, $p < .001$. See Figure 1. The lower groups slowed their HR a nonsignificant .22 bpm, t (10) = .40, $p < 1$. This finding is manifested by the significance of the six HR difference scores which showed an overall raise in HR even though both raise and lower groups were combined. This failure of the lower groups to significantly slow their HR was in agreement with the research of Headrick, Feather, and Wells (1971) and Leven, Engel, and Pearson (1968) which found that while subjects can easily raise their HR relative to the prestimulus mean HR, it is exceedingly difficult for them to lower it.

While Dale and Anderson (1972) did detect a superiority of the FI subject for greater overall change in HR from the mean HR, their subjects were randomly instructed to speed, slow, or maintain their HR. As the mean HR was defined as an average of the maintaining trials, the data did not utilize HR changes made relative to any specific prestimulus HR. Thus, Dale and Anderson (1972) could not readily distinguish baseline changes from those of raise and lower instructions.

Since the raise groups were the only ones to significantly alter their HR relative to a prestimulus HR, the present research can only partially substantiate the hypothesized superiority of the FI subject for controlling his HR in the absence of exteroceptive HR information. The

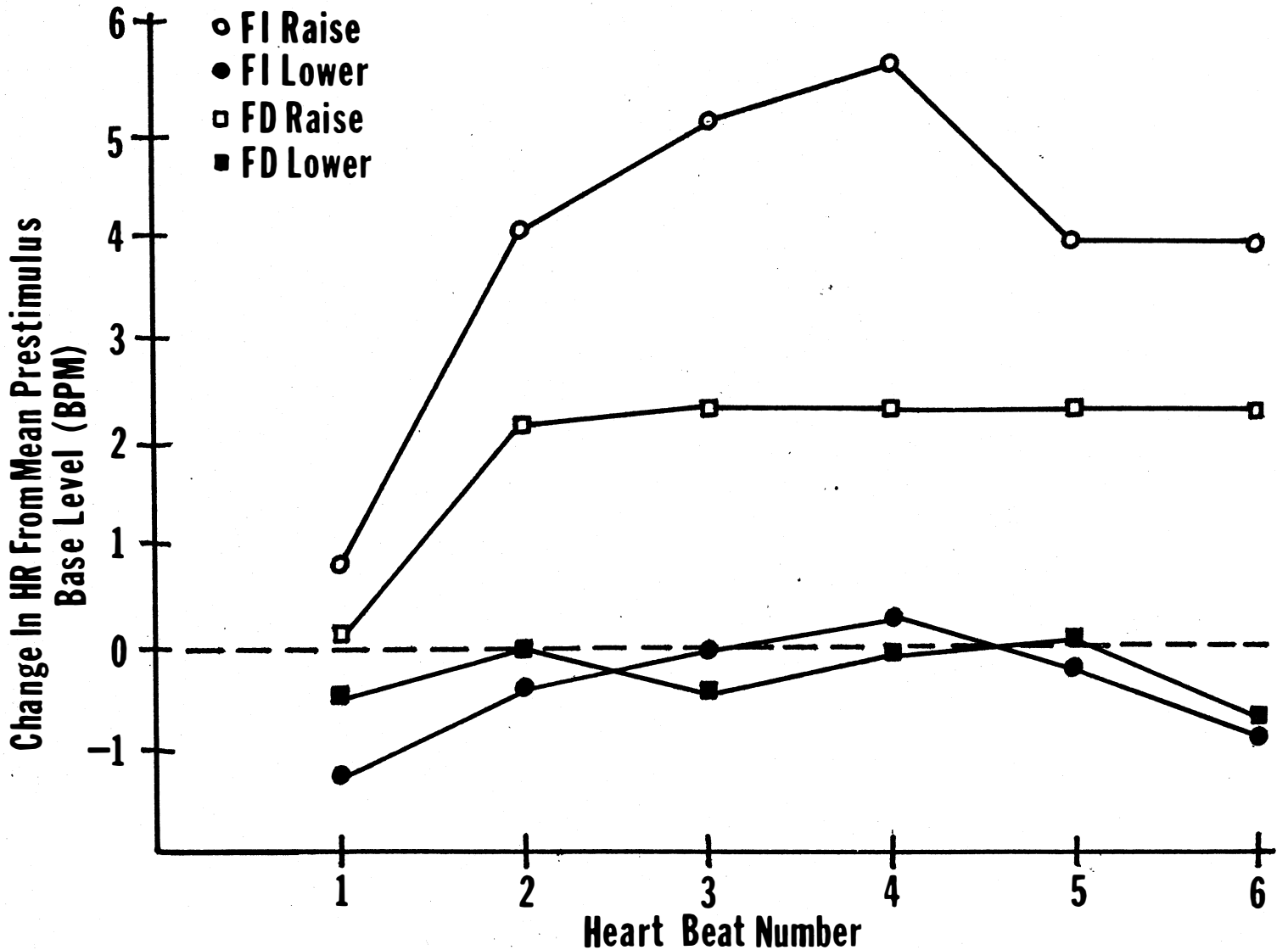

Figure 1. Change in HR across six beats during tone (FI = field independent; FD = field dependent).

FI subjects significantly raised their HR an average of 3.87 bpm as compared to the FD subjects' mean HR elevation of 1.87 bpm, $\underline{t}$ (18) = 2.41, $\underline{p} < .025$.

In view of the partially demonstrated instrumental HR response differences between perceptual mode groups, further cardiovascular experimentation should pursue the possibility that informing subjects of the physiological measure significantly decreases the margin field dependency has on cardiac control. Brener and Hothersall (1966) demonstrated HR conditioning was possible even though subjects were not aware of the correct response. Instrumental HR conditioning investigations which do not inform the subjects as to the specific required response should yield more pronounced information concerning the difference of heart rate control abilities between field dependency groups.

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