Cardiovascular change and mental task gradient¹

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Twenty-four Ss in two groups engaged in three intensity dimensions and two duration dimensions of problem-solving for a Lacey type "silent elaboration" task. One group performed under a white noise environment and the other under a silent environment. The results indicated that contrary to general expectation, difficult mental tasks are associated with less heart rate acceleration than easy mental tasks. These findings obtain under the white noise condition only. The results were considered in relation to the Lacey formulation and arousal theory.

Darrow (1929) observed a relation between ideational activity and heart rate. Lacey et al (1962), Obrist (1963), and Lewis et al (1966), have since noted that autonomic feedback to the central nervous system enhances or curtails stimulus reception dependent upon qualitative aspects of the mental task. Problems requiring silent elaboration for their solution are accompanied by cardiac acceleration which is thought to decrease sensitivity to extraneous environmental inputs. Cue screening kinds of mental tasks have been associated with cardiac deceleration which serves to increase sensitivity to stimulus inputs. The concept that direction of heart rate change is a concomitant of quality of mental task has not been further elaborated with regard to the quantitative or energy characteristics of mental work. The issue has recently been delineated by Graham & Clifton (1966).

Constructs derived from the work of Lacey and his associates permit some prediction about the relation of degree to task demand to magnitude and direction of cardiovascular alteration. One expectation would be that as task difficulty is intensified, the need for exclusion of extraneous stimulation would become more acute and might provoke increased cardiac shielding. The expectation is, however, tempered by a lack of evidence that type and degree of mental task is a sufficient condition for cardiac alteration. Cardiac alteration, during problem solving, might be (1) a consequence of the characteristics of the mental task, (2) a result of the potency of the competing background, or (3) due to some interaction of the properties of the task and the surrounding stimulus environment.

The present study examined two energy dimensions (task duration and intensity) of a Lacey type conceptual task against two auditory background conditions. Heart rate has been found to be the most singularly consistent index of arousal (Schnore, 1959), for purposes of this and previous studies.

Subjects

The Ss were 24 undergraduates at the University of Calgary.

Apparatus

The apparatus was a Grass Model 7 polygraph using the model PTT1-6 photoelectric cardiac transducer through a model 7P4A tachograph preamplifier. White noise was generated by a Grason-Stadler model 455-B noise generator through Sharpe HA 10 stereo earphones wired so that both channels received the same signal.

Procedure

Difficulty of mental task was arranged in two stages of task duration and three stages of task intensity. Ss were required to invent grammatically correct sentences of five words and eight words, each word in the sentence to begin with the letter P, then V, then E, from least to most difficult. Order of difficulty was determined on pretest trials. Task completion times ranged from 157 to 367 sec. under white noise (mean of 208 sec.) and 20 to 417 sec. under auditory muting (mean of 212 sec.). All tasks were successfully completed by all subjects.

Ss were randomly assigned to six experimental conditions under the silent environment, and to six experimental conditions under white noise. Bell stereophonic earphones were worn by all Ss in a noise controlled environment. Pretest Ss judged the white noise level (point 8 on a 10-point scale) to be palpable but short of noxious over a 4-min. test period. The polygraph cardiac rate indicator (photoelectric relay) was attached to the fourth or fifth digit of S's left hand. Ss were seated comfortably and relaxation encouraged for 10 min. during which a basal rate was established. Basal rates did not differ for the two groups. Differences were taken between the 12 highest beats during the resting period and the 12 highest beats during problem solving. Heart rate and performance time scores were treated by analysis of variance design and by Duncan's new multiple range test.

Results and Discussion

There was no tendency for Ss mean heart rate to differ between the white noise and the silent environment prior to introduction of a mental task. Heart rate decelerated (in five of six cells) below the resting rate when a mental task was introduced under the silent environment. The subnoxious level of white noise seemed to be intrusive only when in competition with another attention demanding stimulus source.

Figure 1 permits three observations about the data.

(1) Magnitude of heart rate difference (rest versus work) for two dimensions of mental task under two background conditions. Cardiac accelerations was significantly greater under white noise than under the silent auditory condition, irrespective of task gradient ($F = 8.09$, $df = 1/12$, $p < .025$).

Fig. 1. Cardiovascular change, task intensity and task duration under two background conditions.

(2) Magnitude of heart rate differences for task difficulty gradients, irrespective of background condition. Heart rate varied significantly with three levels of task intensity ($F=4.34$, $df=2/12$, $p<.05$). Heart rate differences did not vary significantly with two levels of task duration ($F=1.70$, $df=1/12$).

(3) Direction of heart rate change (rest versus work) for gradients of task difficulty (intensity and duration) under each auditory background. Degree of task intensity and direction of heart rate change was not significantly related under the silent environment. Under the white noise condition the least intense mental task was associated with a significantly greater cardiac rate difference than the most intense mental task (Duncan's new multiple range test, $p<.05$). Task duration did not so differ.

Analysis of variance tests of task completion times were made (1) for comparison of the two background conditions with respect to task time, and (2) for comparison of task intensity gradients with task completion time. Overall, task completion times did not vary significantly with background condition. Degrees of task intensity and task completion time, irrespective of background condition, varied significantly ($F=3.68$, $df=2/18$, $p<.05$). Mental tasks designated as most difficult on pretest trials took Ss longer to complete than tasks designated as less difficult.

There was no evidence that mental work alone is a sufficient condition for acceleration or deceleration of heart rate. Acceleration versus deceleration of heart rate is possibly not a meaningful adjunct to facilitation versus inhibition of sensory and ideational input. Attention, regardless of type of problem and in the absence of stimulus interference, would likely be accompanied by

cardiac quietening. Competing demands for attention, and the inhibiting cardiac acceleration which might ensue, would be more probable in a circumscribed problem solving situation requiring internal concentration. Tasks requiring external stimulus evaluation, wherein the entire stimulus field might have cognitive relevance, would be less apt to invoke cardiac shielding. There are no experiments which manipulate extraneous non-noxious stimulation (of internal or external origin) to observe cardiovascular events for the two Lacey type mental tasks graduated by difficulty.

Interpretation is tentative. Perhaps difficult mental tasks, having strong energy requirements, will invoke attention intense enough to also inhibit competing stimulus inputs. Comparatively easy mental tasks, requiring less concentration for optimum task management, might require cardiac supplementation for successful inhibition of irrelevant stimulation. The argument is that cardiac acceleration serves to augment the blocking of competing stimulation only when irrelevant stimulation is potentially intrusive or when the challenge of a mental problem is not sufficient to prevent distraction by a second stimulus source. This interpretation is not easily compatible with the observation (Elliot, 1964) of rising quality of performance with rising level of physiological activation.

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