Repeated elicitation of the blood pressure response

R. L. RAY and H. H. EMURIAN

Programmed Environment Research Center

The Johns Hopkins University School of Medicine, Baltimore, Maryland

Task-elicited blood pressure (BP), heart rate (HR), and respiration rate (RR) responses were reliably and persistently elicited during the five 5-min trials for two consecutive daily sessions. BP response magnitude declined slightly over trials for both sessions. This diminution in magnitude was due, however, to a gradual rise in baseline levels. In general, examination of trial-by-trial data and of the between-session correlations for baseline and response magnitude values suggests that task-elicited BP and HR responses, and, to a lesser extent, RR responses, constitute a highly stable system that changes slowly, if at all, with practice.

It is well known that the performance of a variety of psychomotor and cognitive tasks is associated with elevations in blood pressure (BP). These tasks have ranged from performing a reaction-time task to filling out a questionnaire. Despite the ubiquity of such demonstrations, relatively little is known about the dynamics of task-elicited BP responding. Instead, studies involving the elicitation of BP responses have typically used the elicited response as a tool for the study of other variables, such as response patterning (Engel & Bickford, 1961) and vulnerability to cardiovascular disease (Krantz, Schaeffer, Davia, Dembroski, MacDougall, & Shaffer, 1981), and the study of sophisticated theories of cardiovascular-somatic integration (Obrist, 1976). Because of such research emphases, only a few studies have directly addressed the short-term and long-term persistence of such responses. For example, in an early study, Malmo, Shagass, and Heslam (1951) found that task-elicited increases in systolic BP declined sharply in magnitude after several trials. One problem with this finding is that a different task was used on each trial and the tasks were presented in a fixed sequence. This procedure inextricably confounds the effects of type of task with order, thus allowing the alternative explanation that the tasks presented late in the series were less "potent" than the tasks presented early in the series. More recently, Ray and Emurian (1982) found that task-elicited BP elevations showed no diminution in magnitude during a 60-min experimental session in which the task was continuously present. This could be demonstrated with both naive subjects and highly practiced subjects. In another series of experiments, Manuck and Garland (1980)

and Manuck and Schaefer (1978) found that BP responses elicited by an anagram task showed a high test-retest reliability, even over an interval of 13 months. An examination of the figures presented in the Manuck and Garland and Manuck and Schaefer studies suggests that the magnitude of the elicited BP response diminished slightly over sessions. This trend, however, was not discussed by the authors.

The purposes of the present study were to investigate the effect of repeated elicitation of the BP response, both within sessions and between sessions, and to examine, in a preliminary way, the reliability of BP responding across sessions and the intercorrelation of BP response magnitude with other psychophysiological measures and with task performance.

METHOD

Subjects

Ten paid volunteers (four females and six males) were used as subjects.

Apparatus

The Multiple Task Performance Battery (MTPB) is a minicomputer-controlled battery of tasks that can be presented individually or in any combination on a single peripheral device, a VT 100 cathode-ray tube (CRT), and that uses the accompanying keyboard as a response manipulandum. A DEC PDP-8e serves as the system's central processing unit. The five subtasks constituting the MTPB are a probability monitoring task, an arithmetic-operations task, a target-identification task, a warning-light task, and a blinking-light monitoring task. Further description of the MTPB can be found in Emurian (1978). BP was automatically measured with a Vitastat BP monitor every 2.5 min and displayed on a VT05 CRT. The EKG and respiration data were preamplified and displayed on a Harvard chart writer.

Procedure

Upon entering the laboratory, each subject was informed that the purpose of the experiment was to investigate physiological responding during task performance. The subject was then seated in a comfortable chair in a sound-attenuated room and trained to perform the MTPB in the following fashion. The entire battery of five subtasks was presented, but instruction and famil-

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iarization were given for each subtask separately. When the subject had indicated that he or she understood the nature of a given subtask and had made several correct responses, familiarization on the next subtask began. After familiarization with all subtasks, the subjects were given a short rest. After the rest period, each subject was resealed in the sound-attenuated room, a BP cuff was placed on the left arm, and the left arm was propped up at approximately heart level on a cushioned platform. A nose-clip thermister for respiration monitoring was placed on the subject's nose, and EKG electrodes were placed on the subject's right calf, on the sternum, and on the right lateral chest wall. Each subject was then informed that the experiment would consist of approximately 10 min of rest followed by 5 min of task performance, 5 min of rest, 5 min of task performance, etc., until five task and five rest segments were completed. The subjects were also informed that each point earned on the task was worth \$.04 and that changes in posture and movement of the left arm should be avoided. Each subject participated for two consecutive daily sessions at the same time of day. The second session was identical to the first session, with the exception that training on the MTPB was given at the beginning of the first session only.

The BP data were averaged into successive 5-min means for each subject. The EKG and respiration data were measured during 30-sec epochs prior to each BP cuff inflation. The average interbeat and interinspiration interval was obtained for each epoch, transformed to its reciprocal, and then averaged into successive 5-min means. Although the Vitastat measured systolic, diastolic, and mean BP, only mean BP data are presented, in the interest of simplicity. Also, the reciprocal transformed average interbeat and interinspiration interval data are called heart rate (HR) and respiration rate (RR), respectively, although they correspond only approximately to true rate measures. Unless otherwise noted, response magnitude is defined as the difference between each task level and the immediately preceding baseline level.

RESULTS

Figure 1 shows the mean BP response for Days 1 and 2 for all 10 subjects. This figure shows that the mean BP response declined in magnitude over trials for both days and that the overall response magnitude was higher on the 1st day. An analysis of variance revealed that the average mean BP response magnitude was significantly greater than zero [$F(1,9) = 27.10$, $p < .01$] and that the difference in average mean BP response magnitude for Days 1 and 2 failed to reach significance [$F(1,9) = 2.89$]. The analysis

Figure 1. The average BP response magnitude for five consecutive 5-min trials for each of two consecutive daily sessions. The decline in response magnitude is produced by an increase in baseline magnitude.

Figure 2. The average baseline BP levels for five consecutive 5-min baseline periods for each of two consecutive daily sessions.

also revealed that the overall linear trend in mean BP response magnitude was significant [$F(1,9) = 5.23$, $p < .05$] and that the difference in linear trend between Days 1 and 2 was not significant ($F < 1$).

Figure 2 shows the baseline mean BP values for Days 1 and 2 for all 10 subjects. This figure shows that the baseline mean BP increased in level over trials and that the overall baseline mean BP level was greater for Day 1 than for Day 2. An analysis of variance revealed that the difference in baseline mean BP level between Days 1 and 2 was not significant ($F < 1$) but that the linear trend in baseline BP over trials was significant [$F(1,9) = 9.75$, $p < .01$]. The difference in linear trend between Days 1 and 2 was also not significant ($F < 1$). Inspection of Figures 1 and 2 suggests that the apparent decline in mean BP response magnitude over trials is produced by a gradual increase in baseline levels. Accordingly, mean BP response magnitude was redefined as the difference between the first baseline value and each of the five successive task levels. An analysis of variance of the (redefined) mean BP responses revealed that the average mean BP response magnitude was significantly different from zero [$F(1,9) = 26.02$, $p < .01$] and that the difference between Days 1 and 2 in mean BP response magnitude was not significant [$F(1,9) = 2.16$]. In addition, neither the linear trend in mean BP response magnitude over trials [$F(1,9) = 1.25$] nor the difference in linear trend between days ($F < 1$) was significant.

Figures 3a and 3b show the average baseline and task levels for HR and for RR. An analysis of variance of HR response magnitude showed that the average HR response was significantly different from zero [$F(1,9) = 17.62$, $p < .01$] and that the difference in response magnitude between Days 1 and 2 barely failed to reach significance [$F(1,9) = 4.15$, $p < .1$]. The linear trend in HR response magnitude [$F(1,9) = 1.04$] and the difference in linear trend between Days 1 and 2 ($F < 1$) also failed to reach significance. Similarly, an analysis of variance of respiration response magnitude revealed that the average respira-

Figure 3. The average baseline level and average task level for HR (a) and for RR (b).

tion response was significantly different from zero [$F(1,7) = 23.09$, $p < .05$]. No significant effects were found for the difference in respiration response magnitude between Days 1 and 2 ($F < 1$), linear trend in response magnitude ($F < 1$), and the difference in linear trend in response magnitude between Days 1 and 2 [$F(1,7) = 2.09$].

Table 1 shows the intercorrelation between several mean BP, HR, and respiration measures for Days 1 and 2. The baseline measures are those obtained during the first baseline period of the day, and the response measures are those obtained by subtracting each baseline level from the respective task level. Inspection of this table shows that the correlations between the baseline values for BP, HR, and RR are near zero for both days. Substantial positive correlation exists between BP response magnitude and HR response magnitude for both days, and substantial negative correlation exists between baseline levels and response magnitude for BP and for RR for both days. In addition, the negative correlation between baseline BP and HR response magnitude becomes greater in magnitude and reaches significance on the 2nd day. Other evidence of dynamic changes in the pattern of interrelationships over days can be found in the table, but the sample size precludes the use of more sophisticated techniques for the investigation of such changes.

Intercorrelations or test-retest correlations were also computed between Days 1 and 2 for baseline levels and for the response magnitude values. The

correlations between Day 1 and Day 2 values for BP baseline levels, HR baseline levels, and RR baseline levels were .683, .897, and $-.382$, respectively. The correlations between Day 1 and Day 2 values for BP response magnitude, HR response magnitude, and RR response magnitude were .677, .761, and $-.387$. As might be expected, performance on the MTPB improved with practice. The mean number of performance points earned was 140.2 and 169.2 for Days 1 and 2. This difference was significant [$F(1,9) = 39.28$, $p < .01$]. A significant effect was also found for the overall positive linear trend in performance [$F(1,9) = 20.07$, $p < .05$]. However, the difference between Days 1 and 2 in linear trend [$F(1,9) = 1.21$] was not significant. In addition, no correlation between performance and the several cardiovascular and respiration measures was significant.

DISCUSSION

Repeated performance on an MTPB was associated with persistent and reliable increases in mean BP as well as increases in HR and RR. BP response magnitude tended to decline over trials, but this trend was due to a gradual increase in baseline levels over trials. When BP response magnitude was redefined as the change in BP level from an initial baseline, no trial-by-trial diminution in BP response magnitude occurred. The correlations between the baseline values for Days 1 and 2 and for response magnitude values for Days 1 and 2 were positive in sign and statistically significant for both mean BP and HR, which indicated that task-elicited cardiovascular responding exhibits between-session stability as well as within-session stability. These findings, together with the Manuck and Garland (1980), Manuck and Schaefer (1978), and Ray and Emurian (1982) findings, suggest that the task-elicited BP response is characterized by stability and persistence with respect to time, which makes it an ideal tool for the study of individual differences in cardiovascular function as well as for the study of the effects of long-acting experimental variables on cardiovascular change.

It should be noted that it is not being maintained that task-elicited BP elevations never habituate or

Table 1
Product-Moment Correlations Between Blood Pressure (BP), Heart Rate (HR), and Respiration Rate (RR) Values for Average Baseline Levels (b) and Average Response Magnitude (r) for Each Daily Session

	Day 1					Day 2				
	BPr	HRb	HRr	RRb	RRr	BPr	HRb	HRr	RRb	RRr
BPb	-.694	.056	-.442	.117	-.198	-.634	.289	-.725	-.056	-.163
BPr		-.017	.794	-.581	.370		-.590	.777	.508	-.617
HRb			-.122	.342	.157			-.527	-.551	.566
HRr				-.136	-.141				.490	-.275
RRb					-.767					-.702

decline with practice. It seems clear, however, that, at least under certain conditions, reliable elevations in BP can continue to be elicited by task performance even after extensive experience with the task. The fact that the task-elicited BP response declines slowly, if at all, in magnitude with experience assumes special significance when it is considered that the task used in the present study, the MTPB, was designed as a synthetic work task and is capable of being performed for as much as 8 h a day for many consecutive days. The task was not designed to be stressful, and subjects rarely describe the operation of the task in language reflecting the presence of subjective feelings of discomfort. Instead, subjects often typically describe the task as "challenging" or "interesting" or as "the TV game." It may be that the dimension of the task responsible for persistent BP elevations is due to an effect such as active coping, as described by Obrist (1981), and not due to a stressful or aversive component.

Despite the fact that an earlier study (Ray & Emurian, 1982) reported a significant, positive correlation with BP response magnitude and performance on the MTPB, in the present study no significant correlations between response magnitude and performance were obtained. It is interesting to note that in the Ray and Emurian (1982) study, money earned was not contingent on performance, whereas in the present study, each performance was associated with an increment of \$.04. It may be that money reinforcement narrows the range of a motivational or individual difference variable responsible for the correlation between BP response magnitude and performance, obscuring the relationship. A similar finding has been reported with respect to the relationship between the Type A-Type B dimension and BP response magnitude. Manuck and Garland (1979) found that the correlation between scores on the Jenkins Activity Survey for Health Prediction (a self-report inventory for measurement of the Type A-Type B dimension) and systolic BP response was

significant only when no incentive was awarded for task performance.

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NOTE

1. Due to technical problems, respiration data for two subjects were not usable. All analyses involving respiration were performed with an N of 8.

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