THACKRAY, R. I., ***Personality and physiological correlates of performance decrement on a monotonous task requiring sustained attention*** , British Journal of Psychology, 65:3 (1974:Aug.) p.351

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PERSONALITY AND PHYSIOLOGICAL CORRELATES OF PERFORMANCE DECREMENT ON A MONOTONOUS TASK REQUIRING SUSTAINED ATTENTION

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A serial-reaction task was used to study personality, as well as physiological, correlates of individual differences in performance decrement under low task-load conditions. Sixty subjects performed the task continuously for 40 min. Extraverted subjects showed increasing lapses of attention, while introverted subjects failed to show any evidence of a decline in attention. Of the two extraversion components (impulsivity and sociability), impulsivity was the component responsible for the obtained decrement. Heart-rate variability showed significant relationships with personality and with performance decrement, while mean heart rate did not.

In a previous study by Thackray *et al.* (1973), it was found that individuals who rated themselves as highly distractable in their daily lives were unable to sustain attention when required to perform a monotonous serial-reaction task demanding continuous attention. In contrast, low distractability subjects were able to perform the task in a superior manner with no evidence of a decline in attention. The obtained decrement took the form of increasingly variable response times with frequent gaps or pauses which various investigators have hypothesized to be a reflexion of declining task attention (Broadbent, 1971; Faulkner, 1962). The high and low distractability groups did not show differing patterns of decrement in either mean response time or frequency of errors.

Although it is fairly well established that extraversion also is related to performance decrement on monotonous, repetitious tasks (Bakan, 1959; Claridge, 1967; Corcoran, 1965; Davies & Hockey, 1966), a satisfactory explanation of why extraverts do more poorly than introverts on these tasks has not been developed. Using a factor-analytic approach, Eysenck & Eysenck (1963) have determined that extraversion is not a unitary dimension but rather consists of two main components, sociability and impulsivity. Since there is evidence that impulsivity is related to distractability (Kagan & Rosman, 1964), the findings of a relationship between distractability and performance decrement in the previous study by Thackray *et al.* (1973) might suggest impulsivity rather than sociability to be the component of extraversion most directly related to vigilance decrement. The findings of a vigilance study by Krupski *et al.* (1971) also suggest this possibility. Impulsivity and sociability subscores of the Eysenck Personality Inventory (Eysenck & Eysenck, 1968) were obtained and both found to be positively correlated with commission errors. While neither correlation was statistically significant, the higher value was obtained for impulsivity.

On the basis of this previous research, it was hypothesized that extraversion would be positively related to performance decrement on a serial-reaction task and that the obtained decrement would be primarily manifested in increased response varia-

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p.351

bility. It was further hypothesized that, of the two extraversion components (impulsivity and sociability), impulsivity would show the greater relationship with the obtained decrement.

A second aspect of the present study was to evaluate the use of heart-rate variability as a monitor of declining attention during monotonous performance. Evidence from a variety of studies suggests that this measure may be a sensitive physiological index of attention. Relative to resting conditions, heart-rate variability has been shown to decrease markedly when attention is initially directed to task stimuli (Kagan & Rosman, 1964; Thackray, 1969; Welford, 1968) or when changes in the direction of increased task load occur (Kalsbeek, 1968). To the extent that attention declines during performance on a monotonous task, this decline should be reflected in increased heart-rate variability.

While the previous study by Thackray *et al.* (1973) failed to establish a relationship between heart-rate variability and performance decrement, it was felt that the measurement intervals were too few to adequately assess whether or not a relationship existed. In the present study, heart-rate data were continuously recorded and computer-processed to provide a more adequate determination of possible relationships. It was hypothesized that heart-rate variability would show a progressive increase during the task session and that this increase would be positively correlated with performance decrement (increased response variability) on the serial-reaction task. Since Thackray *et al.* (1973) failed to obtain any evidence of a change in mean heart rate during performance on this task, no relationship between mean heart rate and performance decrement was expected.

METHOD

Subjects

Sixty paid college men served as subjects. None had any prior experience with the task used.

Apparatus

The same serial-reaction task employed in the previous study (Thackray *et al.*, 1973) was used in this study. This type of task appears ideal for studying the decrement function, since it provides repetitive and monotonous stimulation, demands continuous discrimination, involves only minor physical fatigue, yields essentially continuous measures of response time, provides immediate feedback to the subject, and gives a measure of errors as well as correct responses.

The subject's panel contained four lever-actuated microswitches arranged in a row 3 cm apart with a 1·9 cm diameter visual display centrally located over the keys. The visual display presented the numbers 1–4 corresponding to keys 1–4 as numbered from left to right. A tape reader was used to present the numerical stimuli to the subject. Stimuli consisted of a quasi-random series of numbers with the restrictions that no number occur twice in succession and that each number occur an equal number of times in the series. The series was 300 stimuli in length and repeated itself automatically.

Each time a given number appeared, the subject attempted to press the corresponding key. If a correct response was made, the tape reader advanced, a new number was presented, and the cycle continued. If an incorrect response was made, the visual stimulus did not change until the correct key was pressed. Elapsed time between responses was measured by means of a Welford Mark V SETAR (Welford Bioelectronics Enterprises) and the data punched on paper tape. Response times were identified as to whether they corresponded to correct or incorrect responses.

Heart rate was obtained from chest electrodes with the leads connected to a Beckman Type R Dynograph. Pulses from a cardiotachometer coupler were used as inputs to the SETAR for recording successive heart beats.

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Table 1. *Product-moment correlations between extraversion, neuroticism, impulsivity and sociability*

	1 Extraversion	2 Neuroticism	3 Impulsivity	4 Sociability
1		−0·33**	0·52**	0·75**
2			0·00	−0·40**
3				0·03

** $P < 0{\cdot}01$.

Procedure

Upon arriving for the experiment, the subject was administered Form A of the Eysenck Personality Inventory (EPI). To minimize association between the inventory and the experiment, the subject was not told that the personality scale was relevant to the present experiment, and one experimenter administered the inventory while a different experimenter conducted the rest of the experiment.

Following completion of the inventory, the subject was taken to the experimental room, instrumented for physiological recording, and the task instructions were presented. Besides explaining the basic procedure, the instructions emphasized that the task should be performed as rapidly as possible but not at the expense of accuracy.

After the task instructions, the subject was given a 1-min. practice trial and then told that he was to work continuously for approximately 50 min. To prevent the subject's knowing that the task was almost over, the experiment was stopped after 40 rather than 50 min.

Measurement of the performance and physiological data

The performance data were computer-processed and the following data obtained for each subject for each successive 4-min. period of the session: (*a*) mean response time, (*b*) standard deviation of the response times (response variability), (*c*) number of incorrect responses.

For heart rate, a computer program was developed to yield two measures for each successive 4-min. period during the performance session. These measures were the mean rate and the standard deviation. Because of occasional muscle potential artifacts and premature contractions, the computer program was designed to reject any apparent heart-beat interval which, when converted to a beat per minute (bpm) basis, exceeded 160 bpm or fell below 30 bpm. In addition, any two successive heart beats which increased by more than 25 bpm or decreased by more than 46 bpm were also rejected. These limits were empirically determined from preliminary hand-scored analyses and were felt to represent values for this set of experimental conditions which would maximize rejection of artifacts and minimize rejection of 'valid' heart-rate data.

Results

Personality variables

Mean scores on the EPI were 12·3, 9·4, 4·0 and 5·4 for the extraversion, neuroticism, impulsivity and sociability scales, respectively. Table 1 shows the intercorrelations of these measures. As expected, extraversion showed a significant positive correlation with both impulsivity and sociability. The significant negative correlation between extraversion and neuroticism, however, was not expected.

Although negative correlations between extraversion and neuroticism are frequently found, these are generally non-significant (Eysenck & Eysenck, 1968). Because a significant relationship was obtained between these two variables in the sample employed, neuroticism was separately examined even though it was not originally intended to do so. (Neuroticism has been frequently examined in vigilance-type studies and has typically shown no relationship to performance decrement

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p.351

Table 2. *Mean response time, response variability (standard deviation) and frequency of errors for each 4-min. period of the task session*

(Data are for the total group of 60 subjects.)

Variable	4-min. periods									
	1	2	3	4	5	6	7	8	9	10
Mean response time (sec.)	0·78	0·80	0·80	0·80	0·80	0·80	0·80	0·80	0·82	0·82
Response variability (sec.)	0·16	0·19	0·21	0·21	0·23	0·24	0·25	0·27	0·28	0·29
Frequency of errors	4·8	6·8	7·2	7·2	8·4	8·4	9·6	9·6	10·0	9·6

(Davies & Tune, 1969).) For each of the four scales, the 15 subjects with the highest and lowest scores were identified. The high and low cut-off scores for each distribution were as follows: extraversion (15 and 10), neuroticism (12 and 6), impulsivity (5 and 3), and sociability (7 and 4).

Since the neuroticism, extraversion, impulsivity and sociability subgroups were each drawn from the same sample of 60 subjects, the total group data for each performance measure were analysed in order to provide reference data for the comparison of differential response patterns of the various subgroups. The data for mean response time, response variability and frequency of errors for the 60 subjects are given in Table 2. Analyses of variance conducted on each set of data yielded significant F values for the effect of 4-min. periods for mean response time ($F = 4{\cdot}16; P < 0{\cdot}01$), response variability ($F = 21{\cdot}19$; $P < 0{\cdot}01$) and frequency of errors ($F = 12{\cdot}79$; $P < 0{\cdot}01$). The only variable which did not reveal a progressive increase with time was mean response time, and the significant F value was apparently the result of slight increases at the beginning and end of the session.

Analyses of variance were then conducted on the performance data of each subgroup. Since the between-periods effects were significant in the analyses of variance conducted on the data for all 60 subjects, it is not surprising that the differences between periods were significant ($P < 0{\cdot}05$) for all variables in each subgroup with the exception of mean response time for extraversion. This F value approached, but did not reach, significance at the 5 per cent level ($P < 0{\cdot}10$). None of the group differences was significant, but significant interactions were obtained between groups and periods for mean response time on the extraversion factor ($F = 3{\cdot}03; P < 0{\cdot}01$) and for response variability on both the extraversion ($F = 2{\cdot}77$; $P < 0{\cdot}01$) and impulsivity ($F = 2{\cdot}03; P < 0{\cdot}05$) factors. Fig. 1, which displays mean response time for the high and low extraversion groups, shows generally increasing response times for the high group, but a mixed pattern for the low group. However, although the interaction was significant and differences between the high and low groups appear pronounced at some of the time periods, tests of simple effects of groups revealed none of the differences between the groups at any of the periods to be significant ($P > 0{\cdot}05$). Fig. 2 shows the response variability patterns for the high and low extraversion and impulsivity groups. There is a continuous rise in variability among the high extraversion and impulsivity subjects during the experimental session with a relatively stable level of response variability among the low subjects. Tests of simple effects of periods revealed the differences between periods to be significant

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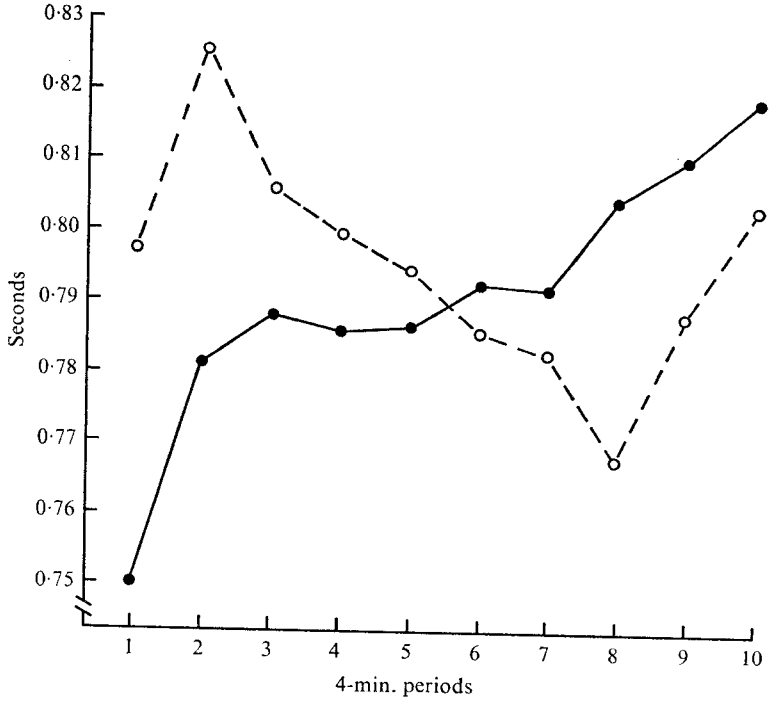

Fig. 1. Mean response times for the high (●) and low (○) extraversion groups across periods.

for the high extraversion ($F = 11{\cdot}03$; $P < 0{\cdot}001$) and high impulsivity ($F = 9{\cdot}59$; $P < 0{\cdot}001$) groups. There were no differences between periods for either the low extraversion ($F = 1{\cdot}42$; $P > 0{\cdot}05$) or low impulsivity ($F = 1{\cdot}74$; $P > 0{\cdot}05$ groups).

Heart-rate measures

As expected, heart-rate variability for the entire sample of 60 subjects showed a progressive, significant increase ($F = 20{\cdot}64$; $P < 0{\cdot}001$) during the session. Mean heart-rate showed a slight, but significant, decrease ($F = 2{\cdot}54$; $P < 0{\cdot}01$). These data are given in Table 3. Since the previous study by Thackray *et al.* (1973) failed to find any change in mean heart rate, further tests were conducted on mean heart rate. Scheffé tests (Edwards, 1960) revealed no difference between periods 1 and 8 ($F = 1{\cdot}53$; $P > 0{\cdot}05$) or between periods 1 and 10 ($F = 8{\cdot}57$; $P > 0{\cdot}05$). The only significant difference was obtained when the periods with the highest (period 2) and lowest (period 10) heart rates were compared ($F = 16{\cdot}84$; $P = 0{\cdot}05$).

Mean heart rate and heart-rate variability were separately correlated with performance variability for each of the 4-min. periods. None of the correlations of mean heart rate with performance variability was significant ($P > 0{\cdot}05$). Heart-rate variability was not significantly correlated with performance during the first three periods, but showed significant ($P < 0{\cdot}05$), increasing correlations during the remaining seven periods. The correlations for periods 4–10 were 0·26, 0·35, 0·34, 0·37, 0·36, 0·43 and 0·42, respectively.

Since both extraversion and heart-rate variability were found to be related to per-

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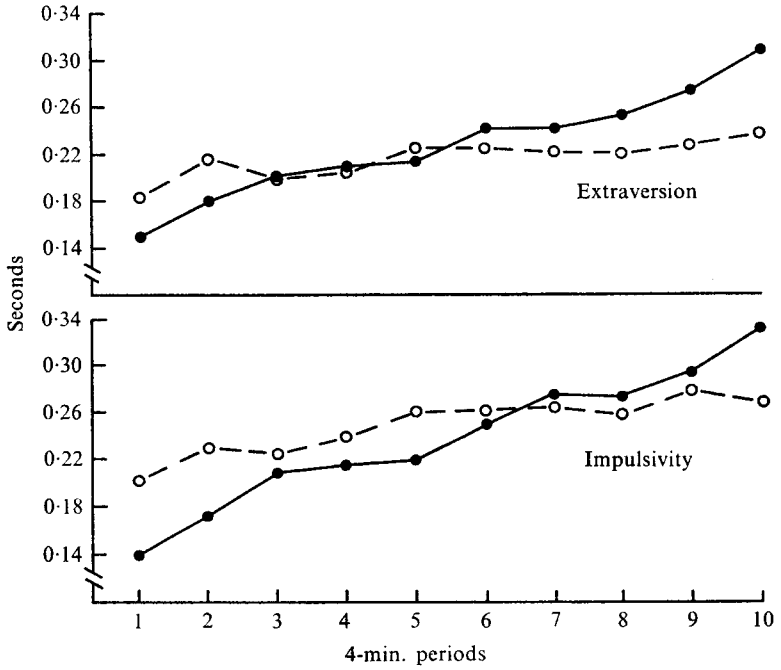

Fig. 2. Response variability for the high (●) and low (○) extraversion and impulsivity groups across periods.

Table 3. *Mean heart rate and heart-rate variability (standard deviation) for each of the 4-min. periods*

(Data shown are for all 60 subjects.)

	4-min. periods									
Variable	1	2	3	4	5	6	7	8	9	10
Mean heart rate (bpm)	73	74	73	73	73	73	73	73	72	72
Heart-rate variability (bpm)	4·4	4·6	4·6	4·8	5·2	5·5	5·5	5·7	5·9	5·9

formance variability, it would seem reasonable that extraversion might show some degree of relationship with heart-rate variability. In order to evaluate this, the difference between period 1 and period 10 was obtained for each subject's heart-rate variability scores and these values separately correlated with each of the personality variables. The resulting correlations were 0·30 ($P < 0·05$), 0·12 ($P > 0·05$), 0·30 ($P < 0·05$) and 0·06 ($P > 0·05$) for extraversion, impulsivity, sociability, and neuroticism respectively.

DISCUSSION

Extraverts are known to exhibit more frequent pauses or blocks during performance on serial-reaction (Corcoran, 1965) and simple tapping (Spielmann, 1963) tasks than do introverts, and the present results support these previous findings. Of greater interest, however, was the predicted finding that impulsivity rather than sociability was the extraversion factor primarily responsible for the obtained decrement.

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Although both impulsivity and sociability were significantly correlated with extraversion, only the high and low impulsivity groups showed response variability patterns which were similar to those of the high and low extraverts. This cannot be attributed simply to a sampling bias in which a greater proportion of impulsivity than sociability subjects were drawn from the extraversion groups. The proportions were approximately equal, with 57 per cent of the high and low impulsivity subjects and 63 per cent of the high and low sociability subjects common to the two extraversion groups.

Neither errors nor mean response time showed any appreciable relationship with any of the personality variables. The lack of relationship between frequency of errors and any of the personality variables agrees with the lack of relationship between this measure and susceptibility to distraction obtained in the previous study (Thackray *et al.*, 1973). It would appear that an increase in error frequency during serial-reaction performance is either a poor index of declining attention or it reflects attentional processes unrelated to those manifested by increased response variability.

While the negative correlation between extraversion and neuroticism was not anticipated, this small, though significant, correlation does not alter interpretation of the results obtained. First, no relationships were found between neuroticism and any of the performance measures. And, second, although impulsivity showed no correlation with neuroticism, the decrement pattern obtained for impulsivity was essentially the same as that obtained for extraversion. Thus the negative correlation is interpreted to reflect a common factor not related to performance decrement on this type of task.

The finding of a generally increasing correlation between heart-rate variability and performance variability would appear to support previous findings of Ettema & Zielhuis (1971) that heart-rate variability increases with a reduction in the mental or attentional requirements of a task. Apparently this increase in heart-rate variability during monotonous task performance is more pronounced among extraverts than among introverts. Why heart-rate variability was found to be related to the sociability, but not to the impulsivity, dimension of extraversion is somewhat puzzling. On the basis of the performance data, one might have expected impulsivity to show the higher relationship. Further research is clearly needed to clarify the possibly quite different behavioural and physiological correlates of these two dimensions of extraversion.

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