Life Sciences Vol. 4, pp. 889-897, 1965. Pergamon Press Ltd. Printed in Great Britain.

PURSUIT ROTOR PERFORMANCE AS A FUNCTION OF DIFFERENT DEGREES OF DISTRACTION

Kerstin Sterky and H.J. Eysenck [1]

Institute of Psychiatry, University of London

(Received 25 February 1965)

Introduction

Distraction experiments, i.e. the investigation of the effects of a distracting task (P_d) on performance of another task (P_a), flourished around the turn of the century (1), but in recent years interest seems to have waned, in spite of the important theoretical problems raised by this type of work (2). Lehman (1) used mental arithmetic (P_d) in order to study its influence on ergograph work (P_a); his results supported the formula: $M = \frac{S - V}{S}$, where M is a constant, V the ergographic work performed during the mental task, and S the amount of such work that would have been performed had not the mental task distracted the subject's attention. The value of M, constant for each level of difficulty, was found to be larger the more difficult the arithmetical task. In recent years there has been some revival of interest in simultaneous performance experiments, partly stimulated by the theory that from some points of view the human organism can be regarded as a communication channel with limited capacity; according to such a conception, "distribution of attention" must lead to reduction of output.

Much of the early work was technically faulty, and few of the conclusions drawn seem to be properly supported. The number of subjects used was usually quite small, the writer himself often being the only subject; conditions tended to be varied from subject to subject, and no statistical significance

1. We are indebted to the Maudsley and Bethlem Royal Research Fund for the support of this investigation. Dr. J.W.H. Kalsbeek suggested the choice of distracting task to us, and furnished us with much unpublished information regarding its effect on other activities.

tests were usually reported. Instructions do not always specify, as they should, that subjects must concentrate on P_d; if this is not done it is impossible to know which task is P_a and which P_d ! P_a has often been a task in which double scoring (time and errors) was necessary, thus making the derivation of a single distraction score impossible. Results of all this work must, therefore, be regarded as suggestive rather than as definitive; it is the purpose of this experiment to check some of the conclusions reported by earlier workers.

The experiment

Twenty subjects, all male, were chosen at random from a pool of paid subjects attending the Institute; their ages were from 20 to 50. P_a was performance on the pursuit rotor, scored as time on target for successive 10 sec. periods; a description of the apparatus used has been given elsewhere (3). (Glucksberg (4) has previously used the pursuit rotor in a similar capacity.) P_d consisted in pressing a pedal with the right or left foot according to whether a high or low tone was presented in random order through earphones; correct responses, incorrect responses, and omissions were automatically summated on counters. Rate of presentation could be varied within wide limits.

Subjects were exposed to a pre-experimental period of practice in order to make them acquainted with the apparatus and procedure. They were given nine 20-second periods of practice on the pursuit rotor, interspersed with 20-second rest periods, and they carried out the P_d task for 2 minutes without interruption. A five minute rest followed before the experimental part of the investigation began. In this part subjects practised on the pursuit rotor for 39 successive 10-second periods; most of the time work was done under conditions of no distraction (ND), but during six 20-second periods P_d had to be carried out simultaneously with P_a. There were 3 levels of difficulty of

P_d, corresponding to 17, 43 and 74 signals per minute respectively. These three levels of distraction will be called, respectively, easy (ED), medium (MD) and difficult (DD); each level was represented twice, the order being: ED, MD, DD, DD, MD, ED. Between periods involving P_d there were always 30-second periods of ND. The precise arrangement of the experiment can be seen from Fig. 1, which also demonstrates the main experimental findings.

Results

Fig. 1 shows clearly that under ND conditions there is a continued decrement in performance. This is not due to the interpolated P_d conditions but is the usual type of performance found on the pursuit rotor after a rest pause preceded by either massed or spaced practice (5). In drawing a best-fitting least squares line through the ND performances we have omitted from the calculations trials 1 and 2 because they are affected by the so-called "warm-up" or post-rest upswing phenomenon (5), and we have also omitted the first 10-second period succeeding each of the 6 P_d periods, on the grounds that these scores are probably still affected by the preceding P_d, the subject having to settle down again to ND performance. Analysis of variance tests showed (1) that this general downward slope was significant at the 5% level, and (2) that any departures from linearity were non-significant. It follows that the effects of P_d have to be calculated from the hypothetical score the subject would have obtained had he not been subjected to P_d (Lehman's S compared with his V), and for this purpose the hypothetical score was read off from the regression line drawn in on Fig. 1.

It is clear that all three levels of P_d have some effect in lowering performance, and that the amount of decrement is proportional to the number of signals presented - least for ED, greatest for DD, and intermediate for MD. These three conditions are designated "C" in the analysis of variance presented in Table 1. It will be seen that the order of P_d trials shows some differences; for ED conditions the second 10-second trial gives a higher score than the

first, while for MD and DD conditions the second 10-second trial in each case gives a lower score. These order effects will be designated "O" in the analysis of variance. "P" designates people. It will be seen that conditions give rise to differences significant beyond the .001 level, and that people give rise to differences also beyond the .001 level, while order effects are

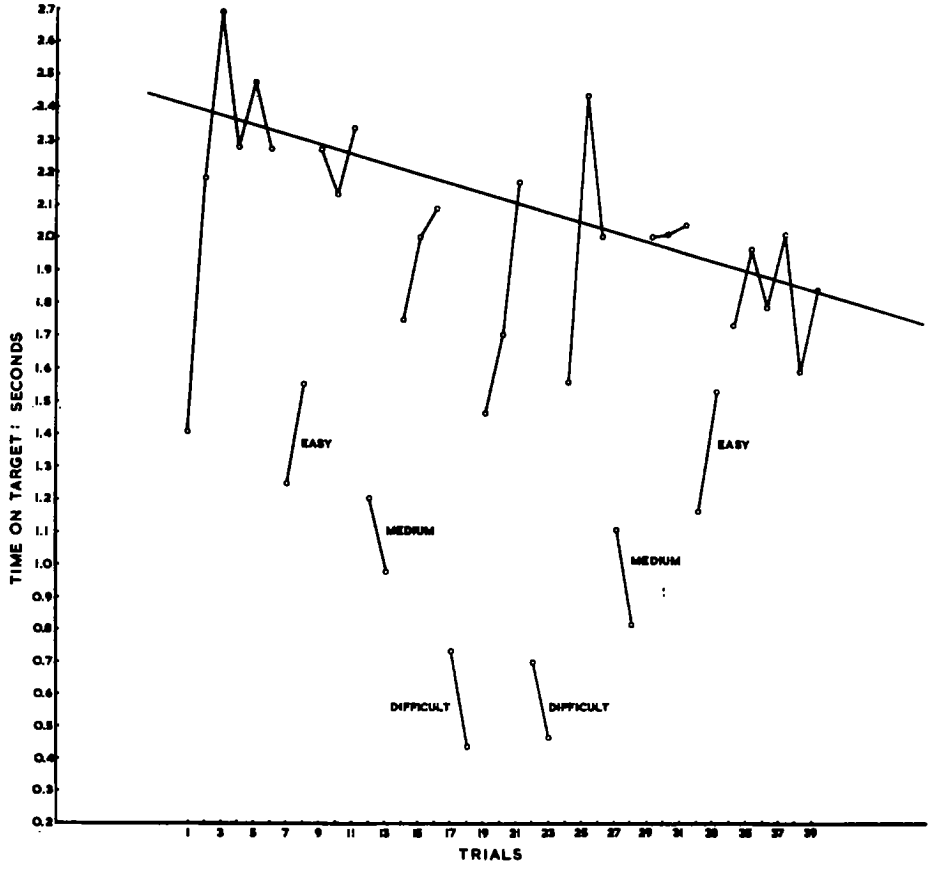

FIG. 1

Pursuit rotor performance during 39 10-second periods. Six 20-second distraction periods (Easy, Medium, Difficult) are interspersed among periods of no distraction.

not significant. That this failure is due to the inversion of effects mentioned above is indicated, however, by the fact that the interaction term C x O is significant beyond the .001 level. C x P is also significant, but only at a relatively low level; inspection of the records shows that this is almost entirely due to one subject who changed his grip on the stylus during the experiment. It might be safest to disregard this interaction effect. Using Tukey's studentized range test, the six P_d conditions were compared with each other; there is no significance attaching to comparisons of similar difficulty levels (i.e. ED vs. ED, MD vs.MD, or DD vs. DD). Of all the between-level comparisons, only two fail to be significant at beyond the .01 level; these involve the first MD and the second ED conditions, and the first MD and the first ED conditions. Neither comparison fails by more than a small amount to reach the 5% level.

TABLE 1

Analysis of Variance

Source	d.f.	S.Squares	V.R.	P <
C	5	22.90	21.6651	.001
O	1	.05	-	
P	19	71.14	17.7114	.001
C x O	5	6.27	5.9319	.001
C x P	95	29.16	1.4518	.05
O x P	19	3.78	-	
Residual	95	20.08		
Total	239	153.38		

Using Lehman's formula we can compare the three conditions of P_d; the results are shown in Table 2. For similar conditions results are quite similar, and there is the expected regular progression from ED through MD to DD. The actual regression of decrement in performance on signal rate is linear, as

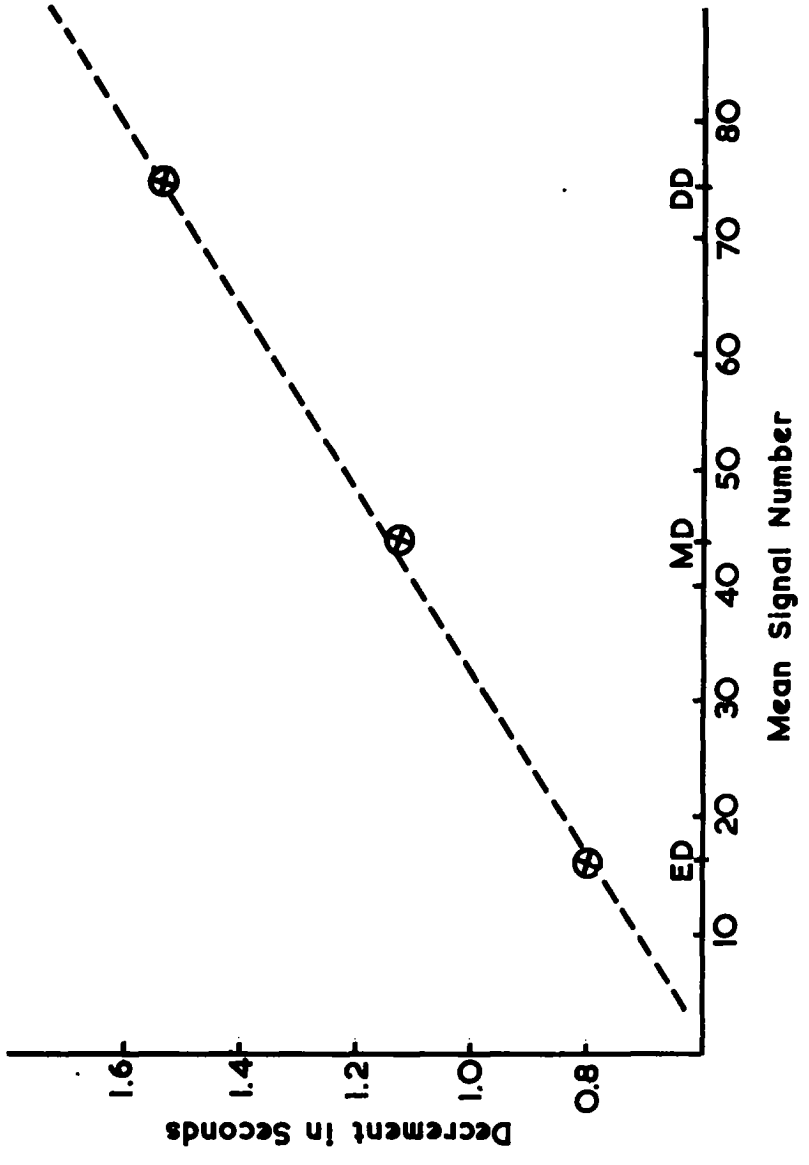

FIG. 2

Performance decrement in seconds on pursuit rotor as a function of the mean signal number of distracting task.

is best shown in Fig. 2. It is, of course, difficult to know to what extent this regression line can be extrapolated beyond the values incorporated in the experiment itself, i.e. from a 30% decrement to a 70% decrement. Extrapolation along the upper range suggests that with a signal frequency of 110 or thereabouts, attention would be centred completely on P_d, so that all work on P_a would cease; casual experimentation with a few subjects suggests that this is a reasonable assumption. Extrapolation downward is clearly impossible beyond a very narrow range; decreasing the signal rate to zero would result in a decrement of almost 30% ! Clearly this region should be investigated in some detail to show just when the straight-line function breaks down and turns into a curvilinear one.

TABLE 2

Condition of P_d:	$\frac{S - V}{S}$ = 1	2	Average
Easy	.39	.29	.34
Medium	.50	.52	.51
Difficult	.72	.72	.72

Lehman's formula applied to experimental conditions.
V = work under distraction; S = work expected without distraction.

It is of interest to consider the problem of individual differences in "distractibility". If success at P_a under conditions of simultaneous performance of P_d constitutes an ability, separate from the ability involved in carrying out P_a without distraction, then we would expect different subjects to possess this "ability" to differing degree; it would seem to follow that Lehman's value M, while constant for a given person for a given level of P_d, would vary not only with changes in P_d, but also from person to person. To test this hypothesis, M values were calculated separately for each person for

each of the six conditions, and intercorrelated; they were also correlated with the absolute level of performance (sum of pursuit rotor scores during periods 3, 4, 5, 6, 10, 11, 15, 16, 20, 21, 25, 26, 30, 31, 35, 36, 37, 38, 39; referred to as P), and the amount of decline from periods 3, 4, 5 and 6 to periods 35, 36, 37, 38 and 39, i.e. the slope of the regression line in Fig.1; this score is referred to as D. The results are shown in Table 3. It will be seen that the correlations between the six M scores are all positive, with an average of $\bar{r} = 0.42$; thus there is considerable evidence for the existence of consistent individual difference in "distractibility". The sum of the six scores involved has a predicted reliability of 0.81, suggesting that"distractibility" on this particular combination of P_a and P_d tasks can be measured with considerable accuracy. It would be of some interest to know whether such a score would correlate with similar scores derived from other combinations of tasks, and whether it would correlate with personality variables, such as Extraversion or Neuroticism (3). It is apparent that the scores involved in "distractibility" are independent of P and D, i.e. are not related to absolute performance or decline of performance on P_a; none of the correlations in question are statistically significant.

TABLE 3

	E_1	M_1	P_1	P_2	M_2	E_2	P	D
1) E_1	-	.41	.04	.15	.43	.49	.33	-.17
2) M_1	.41	-	.57	.54	.25	.56	-.19	-.11
3) P_1	.04	.57	-	.68	.23	.44	.07	.23
4) P_2	.15	.54	.68	-	.37	.67	-.28	-.06
5) M_2	.43	.25	.23	.37	-	.51	.15	-.02
6) E_2	.49	.56	.44	.67	.51	-	-.11	-.07
7) P	.33	-.19	.07	-.28	.15	-.11	-	.22
8) D	-.17	-.11	.23	-.06	-.02	-.07	.22	-

Intercorrelations among distractibility scores (1 - 6); performance level (7) and decline in performance (8).

Summary.

An experimental study has been undertaken of the distracting effects of one task (selective pedal pressing in response to two tones of different pitch) on another (pursuit rotor performance.) The following conclusions were reached. (1) Distraction always lowers performance, even when the signal rate is very slow. (2) Performance decrement is proportional to the amount of distraction, there being a linear relation between performance decrement and signal rate. (3) Amount of performance decrement is in part determined by individual differences, some subjects being more "distractible" than others. (4) Distractibility is independent of level of performance. (5) Distractibility can be measured with a reliability of 0.81.

References.

1. A. LEHMAN. Die physischen Äquivalente der Bewusstseinserscheinungen. O.R. Reisland, Leipzig. (1901).
2. C. SPEARMAN. The abilities of Man. Macmillan, London. (1927).
3. H.J. EYSENCK. The dynamics of anxiety and hysteria. Routledge & Kegan Paul, London. (1957).
4. S. GLUCKSBERG. Rotary pursuit tracking, with divided attention to cutaneous, visual and auditory signals. J. Exp. Psychol. 2, 119-125. (1963).
5. H.J. EYSENCK. A three-factor theory of reminiscence. Brit. J. Psychol. (1965). To appear.