DRIVE, DIRECTION OF ROTATION, AND MASSING OF PRACTICE AS DETERMINANTS OF THE DURATION OF THE AFTER-EFFECTS FROM THE ROTATING SPIRAL

By H. J. EYSENCK, R. A. WILLETT, and PATRICK SLATER,
University of London, England

Recent interest in the duration of after-effects following the inspection of a rotating spiral has been stimulated in part by the relationship this phenomenon appears to show to brain damage,[1] personality,[2] old age,[3] and drug effects.[4] A theoretical explanation of these relationships has been given by Eysenck.[5] Fundamental work on the determinants of the phenomenon itself has been rather neglected; according to Holland length of stimulation is the only major factor determining duration of after-effect of those examined.[6] This relationship is linear over much of its course.[7] More recently, investigations have been reported on the relevance to spiral after-effect (*SAE*) of drive or motivation,[8] the massing of trials,[9] and the direction of rotation of the spiral.[10] It is the purpose of this paper further to investigate these three variables and their effect on the *SAE*.

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[1] T. H. Blau and R. E. Schaffer, The spiral after-effect test (*SAET*) as a predictor of normal and abnormal electroencephalographic records in children, *J. clin. Psychol.,* 24, 1960, 35-42.

[2] H. J. Eysenck (ed.), *Experiments in Personality,* 1960, I, 205-215; II, 124.

[3] Stephen Griew and Richard Lynn, Construct "reactive inhibition" in the interpretation of age changes in performance, *Nature,* 186, 1960, 182.

[4] Eysenck, Objective psychological tests and the assessment of drug effects, *Internal. Rev. Neurobiol.,* 2, 1960, 333-384.

[5] Eysenck, *Dynamics of Anxiety and Hysteria,* 1957, 223-249.

[6] H. C. Holland, Some determinants of seen after movement in the Archimedes spiral, *Acta Psychol.*, 14, 1958, 215-222.

[7] H. C. Holland and H. J. Eysenck, Spiral after-effect as a function of length of stimulation, *Percept. Mot. Skills,* 11, 1960, 228.

[8] H. J. Eysenck and H. C. Holland, Length of spiral after-effect as a function of drive, *ibid.*, 11, 1960, 129-130.

[9] H. J. Eysenck and S. B. G. Eysenck, Reminiscence on the spiral after-effect as a function of length of rest-pause and of number of pre-test trials, *ibid.,* 10, 1960, 93 f.

[10] H. H. Spitz, Some parameters in the perception of the spiral after-effect, *ibid.,* 9, 1959, 81; C. G. Costello, Further observations on the spiral after-effect, *ibid.,* 11, 1960, 324; Effects of massed practice on the spiral after-effect and the homeostatic nature of excitation-inhibition, *ibid.*, 12, 1961, 11-14.

The following predictions were made, based partly on theory, and partly on results previously reported from this laboratory. (1) Increasing drive or motivation reduces the length of the *SAE.* (2) Massing of trials reduces the length of the *SAE.* (3) Rotation of the spiral so as to give a *contracting* effect and an *expanding* after-effect produces longer *SAE* than does rotation giving an *expanding* effect and a *contracting* after-effect. (For the sake of brevity, and as our interest is in the after-effect, we shall refer to these two forms of the phenomenon as 'expanding spiral' and 'contracting spiral,' respectively.)

Method. The spiral used has been described and illustrated elsewhere.[11] It was rotated at a speed of 100 r.p.m., at a distance of 9 ft. from *O.* Illumination was daylight, but never direct sunlight; this variable was not controlled very carefully as Holland has shown that quite large variations in illumination do not affect the *SAE* to any marked degree.[12] The *O*s were made acquainted with the phenomenon during a practice trial; they were instructed to signal the moment when the after-effect ceased to be apparent to them. Eight 30-sec. presentations of the spiral were made, each followed by a determination of the *SAE;* these presentations were *massed* in the sense that each presentation followed immediately upon the cessation of the *SAE* following the preceding presentation. After the eight massed presentations a 5-min. rest-period was introduced, followed by two further massed presentations. It was the purpose of the rest-period to allow reactive inhibition or satiation to dissipate, so that some form of reminiscence would be observable after the rest-period.[13] The assumption is made that reactive inhibition and satiation are fundamentally alike, and develop centrally and without any muscular involvement being necessary.[14]

Observers. Four groups of 36 *O*s each were used in the experiment, being tested respectively under high or low drive, and with an expanding or contracting spiral. Drive was manipulated in the manner described by Eysenck and Maxwell in their study of reminiscence on the pursuit rotor as a measure of motivation.[15] Both groups were made up of industrial apprentices 16–18 yr. of age. The *O*s, in the case of the low-drive group, had already been accepted for training by one of the biggest industrial firms in the country; while, in the case of the high-drive group, they were being subjected to a selection procedure of which the *SAE*-test was ostensibly a part. The effectiveness of this procedure has already been demonstrated in Eysenck and Maxwell's study mentioned above.

Results. The main results of the experiment are shown in Fig. 1; *SAE*s in terms of seconds are marked on the ordinate. It will be seen that all three predictions are verified. To assess the significance of these findings, a rather complex analysis of variance was performed. The main factors producing

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[11] Eysenck, *op. cit.*, 1957, 163-166.
[12] Holland, *op. cit.*, 219.
[13] Eysenck and Eysenck, *op. cit.*, 93.
[14] Eysenck, *op. cit.*, 1957, 150-154.
[15] H. J. Eysenck and A. E. Maxwell, Reminiscence as a function of drive. *Brit. J. Psychol.*, 52, 1961, 43-52.

variations are 'direction' (of rotation), 'drive' (high or low) and 'pause' (before or after). With four groups of 36 *O*s each, subjected to experimentation with a particular direction and drive, and eight trials made

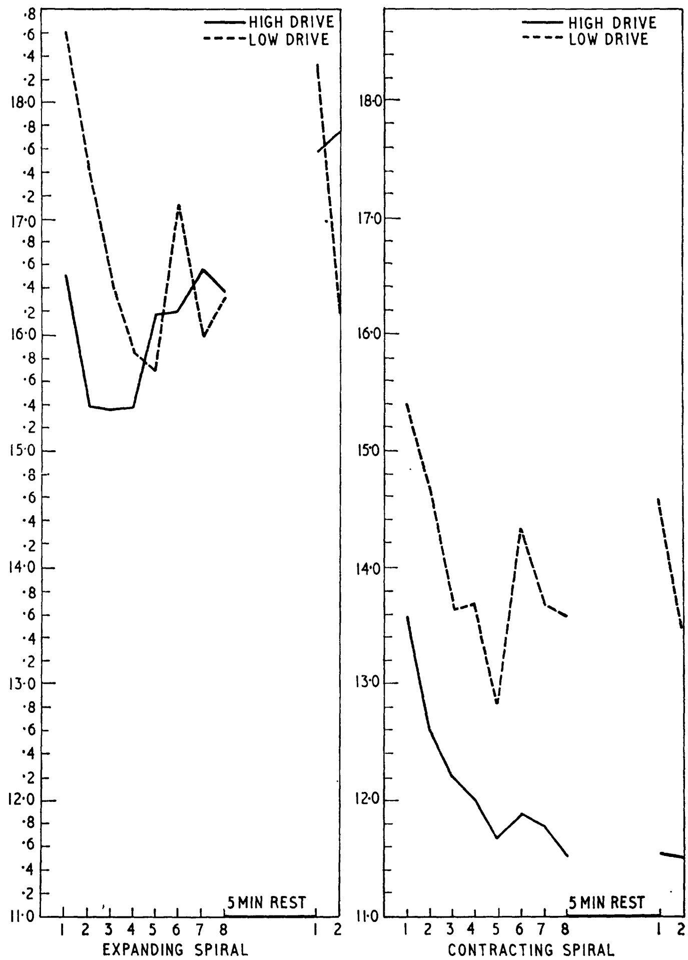

FIG. 1. SPIRAL AFTER-EFFECTS AS A FUNCTION OF DRIVE, DIRECTION OF ROTATION, AND MASSING OF PRACTICE
(Length of after-effects in seconds is shown on the ordinate; trials and rest periods are shown on the abscissa.)

before the rest-pause and two after, the total number of observations is $4 \times 36 \times 10 = 1440$. The total observed variation about the general mean is 77,880.16 with 1439 *df*. It is separable into two parts, variation among the *O*s and variation within the *O*s. The latter part consists of each *O*'s variation about his own mean for the 10 trials, so that it has $144 \times 9 = 1296$ *df*. It can be separated again into two parts: variation among trials, with 9 *df*; and a residual, due to interaction between person and trial.

The first part of the analysis, concerning variation among the *O*s, is

TABLE I

VARIATION AMONG THE *O*S

Source	Sum of squares	*df*	*MSV*
Total observed	63821.13	143	
Due to differences in direction	5384.34	1	5384.34 ($p<0.01$)
Due to differences in drive	830.38	1	830.38
Due to direction: drive-interaction	283.10	1	283.10
Residual error, *i.e.* variation between persons under the same experimental conditions	57323.31	140	409.45

TABLE II

VARIATION AMONG THE TRIALS

Source	Sum of squares	*df*	*MSV*
Total observed	448.97	9	49.89
Due to the pause	42.80	1	42.80
Residual variation between trials not separated by the pause	406.17	8	50.77

TABLE III

RESIDUAL VARIATION

Source	Sum of squares	*df*	*MSV*
Total observed	13610.06	1287	10.58
Attributable to interactions of direction, drive, pause, and trials	278.08	27	10.30
Not associated with any experimentally controlled effects	13331.98	1260	10.58

shown in Table I. The difference between drive-levels and their interaction with direction is not significant; differences due to differences in direction of rotation are highly significant.

The second part, concerning variation among trials, is shown in Table II. The effect of the pause does not appear to be statistically significant.

Finally the residual variation within *O*s can be analyzed as shown in

Table III. It does not seem that any of the experimentally controlled effects has produced significant interactions.

There is no reason why the variation among *O*s should be comparable with the variation within *O*s, but the two parts into which the variation within *O*s has been separated are comparable with one another. We may look for some explanation of the fact that the variation among trials is significantly greater than the residual variation within persons, viz. $F = 49.89/10.58 = 4.72$ (significant beyond the 1% level).

The mean *SAE*s per trial are given in Table IV. The mean for the

TABLE IV
MEAN *SAE*s PER TRIAL

	Trials before pause								Trials after pause	
	1	2	3	4	5	6	7	8	9	10
Mean	15.9	14.9	14.4	14.2	14.0	14.8	14.4	14.4	15.5	14.7

TABLE V
REANALYSIS OF THE VARIANCE BETWEEN SUCCESSIVE TRIALS

Source	Sum of squares	*df*	*MSV*
Total observed	448.97	9	
Between first and subsequent trials	337.37	1	337.37
Residual variance	111.60	8	13.95

first trial after the pause resembles the mean for the first trial of all; both are about a unit greater than the other means. Thus we may calculate that a first trial mean = 15.682 and that the mean of subsequent trials = 14.472 and reanalyze the variance between successive trials as follows (Table V).

This residual variance among trials is not significantly greater than the residual due to person × trial interactions, viz. $F = 13.95/10.58 = 1.32$. The variance, however, between first and subsequent trials is $F = 337.37/10.58 = 31.89$ (significant at 1% level). It appears that sequence-effects due to massing are present at a statistically significant level.

So far we have demonstrated a significant direction-effect ($p = 0.01$) and a significant decline-effect ($p = 0.01$); no interaction effects have reached satisfactory levels of significance, and the drive-effect has not been significant either. In view of the possible disturbing influence the massing of trials may have had on the drive-effect, it was decided to analyze just the first trial scores by themselves. The difference between the means of the high drive and the low drive groups (14.910 and 16.882 respectively) is 1.972, and the variance associated with it is 140.03. The variance among persons within groups on this trial is 43.51 (mean square with 142 *df*); hence $F = 3.218$, giving a *p*-level between 0.10 and 0.05.

While by itself clearly insufficient to prove the effect of drive, it may be said that in conjunction with the previous analogous demonstration of the depressing effect of high drive on *SAE*,[16] this finding renders it quite likely that some such effect is indeed a reality, and has to be explained by any convincing theory of the phenomenon. (On a one-tail test the effect would of course be 'significant.' Reasons for not using this test have been given elsewhere by one of us).[17]

As regards the reminiscence-phenomenon, which appears fairly clearly in Fig. 1, it also fails to receive support from the analysis. The means of the two drive-groups on Trial 8 may be substracted from those on Trial 9 to give the reminiscence-effect, *i.e.* 0.736 for the high drive group and 1.500 for the low drive group. Its significance can be considered by isolating it as a group × trial interaction with variance 10.51 and comparing it with the individual × trial interaction within groups (mean square 10.58 with 1260 *df*). *F* is approximately 1.0 and the null hypothesis is not disproved. This finding suggests that inhibition-satiation set up in the *SAE* dissipates very slowly; this may be regarded as support for Thompson's two-factor theory of inhibition that "stimulus-inhibition dissipates very slowly with the passage of time."[18]

While two of our three hypotheses have been verified at an acceptable level of significance, and the third one verified at a rather low level, it is apparent that the results are less striking than they might have been because of the very marked individual differences not associated with any of the experimentally controlled variables. This is not surprising, in view of the fact that the *SAE* has been found to be associated quite strongly not only with extraversion, but also with neuroticism.[19] It would be desirable in future experiments to include measures of these personality-variables in the experimental design in order to obtain more homogeneous groups. It is possible that such a procedure would give more impressive results.

Summary. Four groups of industrial apprentices, subdivided according to motivation and direction of rotation of spiral, were tested under conditions of massed practice for length of after-effect with a rotating spiral. It was predicted that increasing drive or motivation would reduce the

[16] Eysenck and Holland, *op. cit.*, 1960, 129 f.

[17] Eysenck, The concept of statistical significance and the controversy about "one-tailed" tests, *Psychol. Rep.* 67, 1960, 269-271.

[18] M. E. Thompson, A two-factor theory of inhibition. *Psychol. Rev.*, 67, 1960, 201.

[19] Eysenck, *op. cit.*, Experiments in Personality, II, 1960, 236.

length of the spiral after-effect (*SAE*), that massing of trials would reduce the length of the *SAE,* and that an expanding spiral would give longer *SAE*s than would a contracting one. All three predictions were verified, but that relating to drive failed to reach the 5% level of significance.