Brit. J. Psychol. (1961), **52**, 1, *pp.* 43–52
Printed in Great Britain

REMINISCENCE AS A FUNCTION OF DRIVE

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Groups of engineering apprentices were tested on the pursuit rotor under conditions of high and low drive, respectively, and with a 6 min. rest pause occurring after 3 and 8 min. massed practice, respectively; a post-rest practice period of 4 min. was given to all the groups. Reminiscence scores were obtained by subtracting scores on the last 10 sec. pre-rest trial from scores on the first 10 sec. post-rest trial. It was predicted that reminiscence scores would be higher for the high drive group than for the low drive group, and it was also predicted that this difference would be greater after 8 min. practice than after 3 min. practice. Differences were also predicted in level of performance, both pre-rest and post-rest. Predictions relating to reminiscence were verified at a high level of statistical significance; those relating to performance were in the predicted direction, but did not support the theory quite as clearly. A model of pursuit rotor performance was constructed on the basis of the data obtained in this experiment, as well as on previously obtained information, which permits quantitative predictions to be made.

INTRODUCTION

It is widely recognized that the measurement of drive or motivation in human beings is one of the most important as well as one of the most neglected parts of modern psychology. Such measurement is only likely to be practicable in terms of some wider and more general formulation, in which drive appears as the unknown in an equation otherwise containing only measurable quantities. Hull's (1943) system appears to be capable of mediating such measurement, particularly in the form given to some of its postulates by Kimble (1949). The experiment reported here was designed to test some predictions made from the Hull–Kimble theory, and to furnish data from which a rough-and-ready preliminary quantification of drive could be obtained.

The theory, together with certain additions by the first-named author (Eysenck, 1956, 1957), may be stated briefly and dogmatically thus. (1) Massed practice produces reactive inhibition (I_R). (2) I_R grows as a linear function of duration of practice. (3) I_R is a negative drive which cancels out part or all of the positive drive (D) active in the testing situation. (4) When $I_R = D$, performance stops and an involuntary rest pause (I.R.P.) ensues. (5) During this I.R.P. inhibition, being a fatigue-like product dissipates. (6) When I_R falls sufficiently below D, performance begins again. (7) I_R is accumulated again until another I.R.P. is enforced. (8) Once the *critical level* where I.R.P.'s interrupt performance has been reached, these rest pauses will occur regularly until a programmed rest pause allows all or nearly all of I_R to dissipate. (9) I.R.P.'s act as reinforcements for the state of *not working* on the experimental task, and thus produce conditioned inhibition ($_SI_R$). (10) $_SI_R$ is a habit and does not dissipate during rest. (11) When $_SI_R = {_SH_R}$, performance stops for good (Kendrick, in Eysenck, 1960*a*).

(12) Introduction of a lengthy, programmed rest pause allows I_R to dissipate. (13) This dissipation is shown in performance as *reminiscence*, i.e. an improvement

* We are indebted to the Ford Foundation for making this study possible, and to Miss N. Hemsley who did the calculations.

in performance after the rest pause, as compared with the level of performance just preceding the rest pause. (14) Due to the absence of I_R after the rest pause, I.R.P.'s do not occur, $_SI_R$ is not reinforced and extinguishes. (15) This extinction is shown by a marked up-swing in performance. (16) This up-swing lasts until enough I_R is accumulated again to reach the critical level.

It will be seen from this brief statement that when the programmed rest pause is sufficiently extended to allow all, or nearly all of I_R to dissipate reminiscence is a good measure of I_R. But I_R is a direct measure of D *at and after* the moment when the critical level has been reached. It follows that reminiscence, under these circumstances, may be regarded as a direct measure of motivation or D, and it can be predicted that *high drive levels should give rise to greater reminiscence scores* than low drive levels. The work of Kimble (1950), Wasserman (1951), and Claridge in Eysenck (1960*b*) bears this out, as well as certain further predictions, such as that $_SI_R$ should occur later in learning under high than under low motivation.

In pursuit rotor learning, some of these interconnected hypotheses relevant to the measurement of D may be shown in diagrammatic form (Fig. 1). The abscissa shows successive minutes of massed practice, while the ordinate shows degree of I_R (and consequently also of reminiscence, and, at the critical level, of drive). The actual quantification is in terms of reminiscence scores, i.e. time on target during the first 10 sec. post-rest performance minus time on target during the last 10 sec. pre-rest performance. (This method of scoring is independent of level of performance; this is reasonable as long as performance is well short of its asymptote. Where this is not true, some adaptation of Hull's formula

$$^{N}_{S}H_R = M - Me^{-iN} \quad \text{(Hull, 1943, p. 119)}$$

might have to be used. No such complication seems justified with the pursuit rotor, where performance remains at quite a low level during the time periods usually involved in psychological experiments.)*

The line slanting upwards from the lower left to the upper right corner represents the growth of I_R for both a *high drive* and a *low drive* group. (The experimental manipulation of the groups in question which was in fact used to produce different drive states will be discussed below.) The low drive group is assumed to reach its critical level ($I_R = D$) after 2 min., while the high drive group does not reach it until 6 min. have elapsed. The value for the low drive group was chosen because earlier work with groups similarly motivated had shown that no extinction of $_SI_R$ occurred after 60 sec. (Eysenck, 1960*e*) or 90 sec. (Star, 1957) of practice; it did, however, occur after 2 min. of practice (Eysenck, 1956). The value for the high drive group was chosen because groups of this type, given variable rests after practising for 8 min., and then set to work again, produce an amount of post-rest up-swing indicative of

* Kimble (1949) and Wasserman (1951) have argued that late in learning I_R tends to decrease in magnitude. Their hypothesis is 'that the decrease in I_R occurs because of a decrease in motivation late in learning' (Kimble, p. 21). It may be argued that the effect is a scoring artefact; late in learning scores are higher, and in accordance with the Hull formula just quoted, equal differences in performance would be indexed by smaller differences in scores. Thus for certain purposes, transformation of scores to more rational values might be desirable. It should also be borne in mind that Bahrig, Fitts & Briggs (1957) have shown that the relationship between learning and score on the pursuit rotor is monotonic but not linear; this makes such small effects as those reported by Kimble and Wasserman doubly suspect.

the presence of sufficient ${}_SI_R$ to make the period of from 5 to 7 min. of practice the most likely for the occurrence of the critical level. Also, Kimble (1950) found no evidence of ${}_SI_R$ after 5 min. practice on the pursuit rotor. (His figure 1 may be overcorrected for warm-up decrement, but his motivating conditions were almost certainly lower than those used here.) Both time values constitute guesses rather than measurements, but for the purpose of the diagram this is not too important; both values can be ascertained with any desired amount of precision.

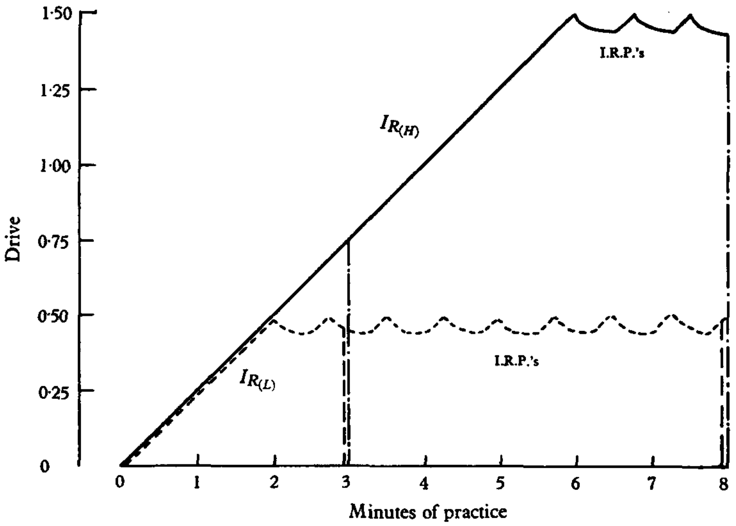

Fig. 1. Diagram showing growth of reactive inhibition in high drive [$I_{R(H)}$] and low drive [$I_{R(L)}$] groups.

If we now divide our high and low drive groups into two each, and allow these groups to take a 6 min. rest pause after 3 and 8 min., respectively, then it can be seen that the following predictions can be made: (1) Reminiscence for the low drive group should be the same after 3 as after 8 min. practice. (2) Reminiscence for the high drive group should be much higher after 8 than after 3 min. practice. (3) Reminiscence for the high drive group should be slightly higher than for the low drive group after 3 min. practice. (4) Reminiscence for the high drive group should be much higher than for the low drive group after 8 min. practice. These deductions were in fact tested. Other testable deductions are: (5) Up to 2 min. of practice, there should be no, or very small, differences in reminiscence between the high drive and low drive groups. (6) After 6 min. of practice, differences in reminiscence between the high drive and the low drive groups should stabilize. (7) Between 2 and 6 min. of practice, differences in reminiscence between the high and the low drive groups should increase monotonically and linearly. Further testable deductions, which were in fact tested, are these: (8) Extinction of ${}_SI_R$ should be more marked after 8 min. practice in the low drive group than in the high drive group (because of the larger number of I.R.P.'s received by the former). No such difference would be expected after 3 min. of practice (because both groups have had no or very few I.R.P.'s). (9) Performance before the rest pause should be superior for the high drive group, but with the growth of I_R this superiority should become less marked. (10) Performance of the high drive group after the rest pause should be at a much higher level, but should gradually approach, but never reach, the level of the low drive group. The grounds for the last two deductions are given in the discussion.

EXPERIMENTAL DESIGN AND PROCEDURE

The apparatus used was a modified Lafayette pursuit rotor which has been described in its essential details elsewhere (Eysenck, 1960*d*). Time on target was integrated over 10 sec. periods and registered on one of two chronotrons; at the end of the 10 sec. periods an automatic switching device brought into action the other chronotron, and after 8 sec. zeroed the first chronotron ready for being brought into play again; *E* recorded the setting during these 8 sec.

A total of 120 subjects was used in the experiment, half of whom were tested under low drive conditions, the other half under high drive conditions. All the subjects were young industrial apprentices, 16–18 years of age; all were male. The high drive group took the test as part of an entrance examination for engineering apprentices at one of the biggest car-making firms in this country;* they did not know that the score on this test would not in fact play any part in determining their success or failure in the examination. For most of the subjects success in this examination represented their only chance to become skilled workmen, rather than taking up some unskilled or semi-skilled job, and consequently their motivation was extremely high. The subjects in the low drive group had already been accepted as apprentices, and were working with the firm in question; under trade union agreement they were guaranteed advancement regardless of how well or poorly they worked, so that they had no particular motivation to do well on the pursuit rotor test, which they were told was of experimental interest to psychologists only.

Each group was in turn subdivided into two, differing with respect to the amount of pre-rest practice. The long practice group received 8 min. of practice (forty-eight 10 sec. trials), while the short practice group received 3 min. of practice (eighteen 10 sec. trials); this was followed by a 6 min. rest period, and this in turn by a 4 min. post-rest practice (twenty-four 10 sec. trials). The first post-rest trial was preceded by 2 sec. of practice, in order to make this trial properly comparable with the last pre-rest trial (Eysenck, 1956). The reminiscence score used was: first post-rest trial—last pre-rest trial.

Subjects were tested individually. They were also given the short version of the Maudsley Personality Inventory (Eysenck, 1959) in order to be sure that the group was comparable with respect to Extraversion and Neuroticism; scores on these questionnaires were in no case significantly different even at the 0·1 level.

RESULTS

Results are shown in Fig. 2 for the short-practice groups, and Fig. 3 for the long-practice groups. The reminiscence scores for the short-practice groups are: High drive = 0·80, low drive = 0·54; for the long-practice groups they are: High drive = 1·51, low drive = 0·51. (Scores for the long-practice and short-practice groups are 1·08 and 0·66, respectively.) The statistical significance of these results was tested by

* We are indebted to Mr C. Attwood of the Ford Motor Co., Dagenham, for his kind permission to test these boys.

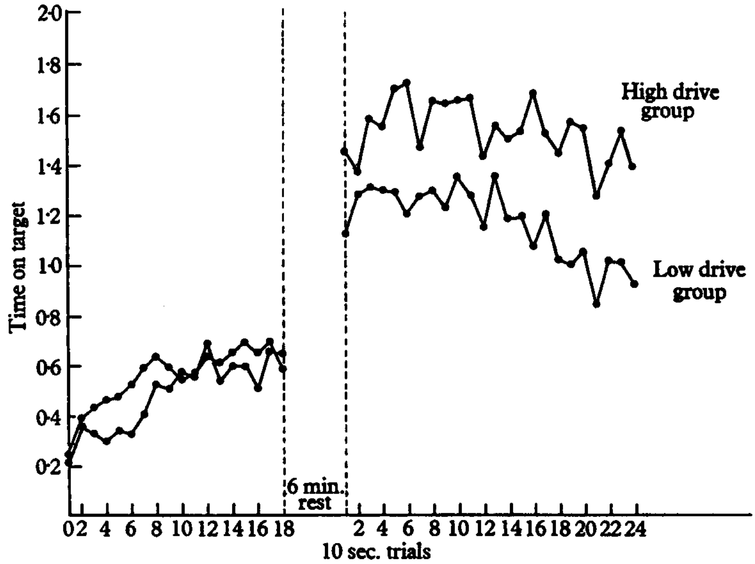

Fig. 2. Performance of high drive and low drive groups on pursuit rotor during 3 min. pre-rest and 4 min. post-rest practice.

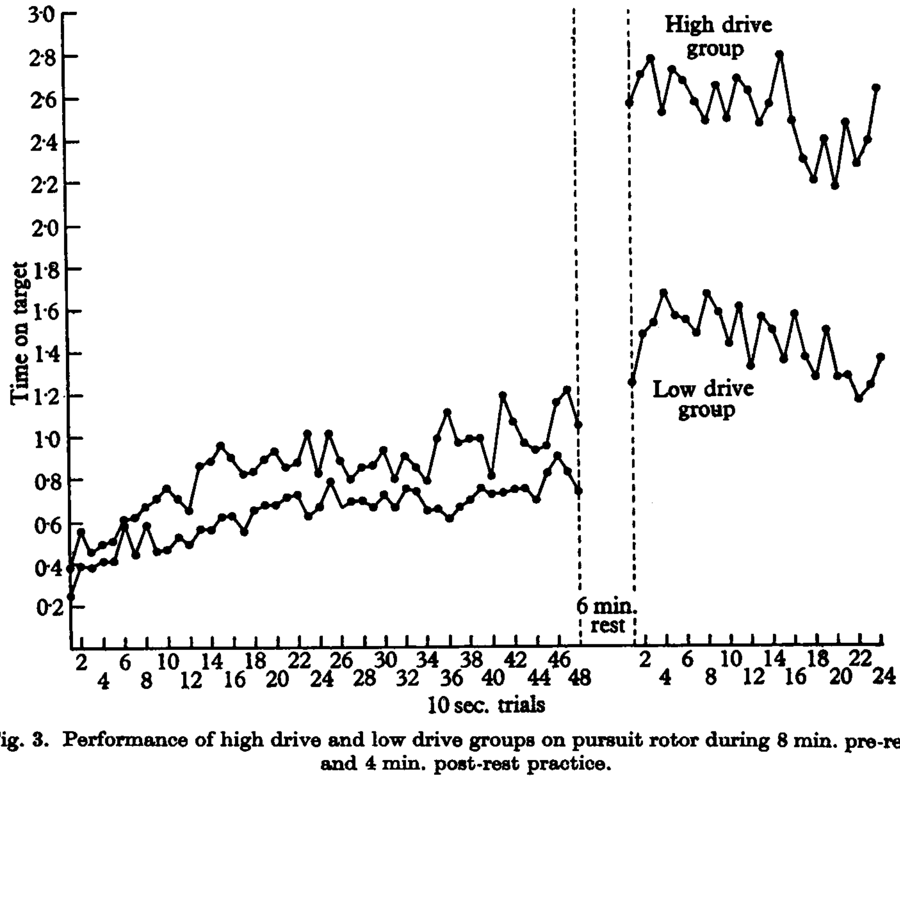

Fig. 3. Performance of high drive and low drive groups on pursuit rotor during 8 min. pre-rest and 4 min. post-rest practice.

analysis of variance, as shown in Table 1; it will be seen that differences in length of practice give a significant difference at the 5 % level, differences in drive strength give a significant difference at the 1 % level, and the interaction is significant at the 2 % level. These results are in excellent agreement with predictions, 1, 2, 3, and 4.

We must next turn to performance as such. It may be deduced from Hull's general formula: ${}_SE_R = {}_SH_R \times D$, that the high drive group should perform throughout at a higher level than the low drive group, and that this difference should increase with practice.* Wasserman (1951) made such a prediction and found indeed that 'high motivation resulted in performance which was significantly superior to that with low motivation, the difference becoming progressively greater as practice continued'. The data for our 3 min. groups do not seem to bear out this finding, and those for the 8 min. group do so at rather a poor level of differentiation. A statistical test is clearly necessary.

Table 1. *Analysis of variance for differences in length of pre-rest practice and in drive level*

	D.F.	S.S.	F	Sig. level (%)
Between practice groups	1	3·5192	5·7635	5
Between drive levels	1	11·9385	19·5521	1
Levels × Groups	1	4·1627	6·8174	2
Residual	116	70·8271	—	—
Total	119	90·4475	—	—

In the analysis of data such as these care must be taken since successive trials for the same subject are not independent. The correct procedure to follow was given first by Wishart (1939*a*, 1939*b*), and has since been elaborated by Leech & Healy (1959), and by others. In particular it has to be noted that the sequential difference between the groups is tested by comparing the 'group × trial' interaction with the 'subject × trial' interaction, while the test of the 'between groups' main effect is a test of the difference between the groups averaged over all trials.

The analysis of the data on which the pre-rest means in Fig. 2 are based is given in Table 2. No interpretation of the 'between trials' component in the analysis is attempted as this source of variation may consist largely of covariation between the trials since these are not independent. The 'between groups' mean square was tested against the 'within groups' mean square but a significant difference was not found. Next the $T \times G$ interaction term was tested against the $S \times P$ interaction term. To

* It is of course essential in this connexion to bear in mind the Yerkes-Dodson Law (cf. Eysenck, 1957, for a discussion). According to this law, which can be deduced from Hull's principles, performance is a *curvilinear* function of drive, too high drive being as disadvantageous as too low drive, and the optimal drive level is a function of the complexity or difficulty of the task, being low for complex and high for simple tasks. The prediction made in the text would hold only for certain portions of the curve, i.e. those preceding the optimal drive level. It is likely that the ordinary pursuit rotor is a 'simple' task within the meaning of the law, i.e. one in which the habit practised is not low in the habit family hierarchy; consequently the degree of drive produced in the present experiment is probably not excessive. The situation would be different if the experiment were to be complicated, say, by having the subject perform the rotary pursuit movement while observing the target in a mirror; under those conditions the task would probably be 'complex', and the higher of the two drive states involved in the present experiment might easily lead to a poorer performance than the lower drive state.

increase the sensitivity of this test the interaction sums of squares were partitioned into linears, quadratic, and 'higher degree' components, the linear component of $T \times G$ being tested against the linear component of $S \times P$, the quadratic component against the quadratic and so on. As no significant differences were obtained it was concluded that the two groups did not differ on their 3 min. pre-rest performance.

An analysis of variance similar to that just described was performed on the data on which the post-rest means in Fig. 2 are based. In this case, however, as there was little indication of a significant $T \times G$ interaction the separate linear and quadratic components were not obtained. The details of the analysis appear in Table 3; no significant effects were found.

Table 2. *Analysis of the* 3 *sec. pre-rest data*

	D.F.	S.S.	M.S.	V.R.	Sig. level
1. Between trials	17	15·94	—	Omit	—
2. Between groups	1	1·56	1·56	0·645	N.S.
3. $T \times G$ linear	1	0·19	0·19	0·625	N.S.
4. $T \times G$ quadratic	1	0·10	0·10	0·515	N.S.
5. $T \times G$ higher powers	15	1·29	0·086	1·036	N.S.
6. Subjects within groups	58	140·16	2·417	—	—
7. $S \times P$ linear	58	17·62	0·304	—	—
8. $S \times P$ quadratic	58	11·27	0·194	—	—
9. $S \times P$ higher powers	870	72·36	0·083	—	—
Total	1079	260·49	—	—	—

Table 3. *Analysis of post-rest data*

	D.F.	S.S.	M.S.	V.R.	Sig. level
Between trials	23	17·95	0·78	Omit	—
Between groups	1	48·62	48·62	3·3176	N.S. ($0·05 < P < 0·1$)
Trials × groups	23	5·24	0·2278	0·8516	N.S.
People within groups	58	850·01	14·6553	—	—
Trials × people	1334	356·8750	0·2675	—	—
Total	1439	1278·6950	—	—	—

Similar analyses were carried out on the data on which the means in Fig. 3 are based. Here the forty-eight pre-rest trials were divided in order into three sets of sixteen trials and a separate analysis performed on each. For the first two sets no significant differences were found, but for the third the 'between groups' difference was significant just at the 5 % level. This is the difference between the averages of the means plotted in Fig. 3, and the significant result indicates that for the sixteen trials immediately previous to the rest period the average difference between the curves for the high and low drive groups is greater than could reasonably be attributed to chance causes. However, since the $T \times G$-interaction effect is not significant there is no evidence for claiming that the gap between the groups is progressively widening.

For the twenty-four post-rest trials (Fig. 3) the difference between the group means was found to be highly significant ($P < 0·001$, Table 4). This shows that the average difference, for the twenty-four trials, between the groups is now quite pronounced. Moreover, since the $T \times G$-interaction effect is not significant there is no evidence for claiming that this difference increases sequentially; in other words, the difference between the groups can safely be attributed to the effect of the 'rest' itself, and not to any sequential effect in the post-rest performance.

In order to test the differences between the groups in the post-rest period after their pre-rest performances have been equated, analyses of covariance were carried out. In these analyses the two scores used for each subject were the means in his scores on his pre- and post-rest trials, respectively. The analysis of the adjusted post-rest scores for the data represented in Fig. 2 is given in Table 5*a*, and for those in Fig. 3 in Table 5*b*.

Table 4. *Analysis of twenty-four post-rest trials*

	D.F.	S.S.	M.S.V.	V.R.	Sig. level
Between trials	23	26·2551	1·1415	Omit	—
Between groups	1	422·8250	422·8250	20·7961	$P < 0{\cdot}001$
Trials × groups	23	9·5722	0·4162	1·1600	N.S.
People within groups	58	1179·2528	20·3319	—	—
Trials × people	1334	478·6349	0·3588	—	—
Total	1439	2116·5400	—	—	—

Table 5. *Outcome of analysis of covariance of post-rest scores*

Source of variation	D.F.	M.S.	V.R.	Sig. level
(*a*) Figure 2 data				
Between groups	1	3·9443	15·12	$P < 0{\cdot}001$
Within groups	57	0·2609	—	—
Total	58	—	—	—
(*b*) Figure 3 data				
Between groups	1	8·6780	30·45	$P < 0{\cdot}001$
Within groups	57	0·2850	—	—
Total	58	—	—	—

In each analysis the adjusted 'between group' means are very significantly different, though in the earlier analyses (Table 3) a significant difference for the unadjusted post-rest means for the data represented in Fig. 2 was not found. The differences indicated by the results in Table 5 are attributed to the differential effect of the 'rest' period on the groups.

Discussion

It will be seen that the evidence for differential effects of drive on performance is rather poor. While such differences as are observed are in the expected direction, and achieve significance at one point, yet the total differentiation is not very impressive. This may appear odd, but is not in fact contrary to theoretical analysis. As I_R grows, it requires to be subtracted from D (according to Gwynne Jones's (1958) formula), or from ${}_SE_R$ (according to Hull's original formula). In the former case, the effective size of D is getting progressively less, until the moment when both groups have reached the respective critical levels where I.R.P.'s are being produced; at that point D may be regarded as equal for the two groups, being in effect zero at the point where $I_R = D$. (This is so assuming the Jones formula; the position is slightly more complicated under Hull's formula, where I_R is summed with ${}_SI_R$ to produce $\dot{I}_R$ before being subtracted from ${}_{S}E_{R}$. The argument would not, however, be changed in its essentials even under these conditions.) It would seem to follow that differentiation should be best at the beginning, where differences in D are greatest, and least when both groups had reached the critical level where $D = I_R$, and where consequently there were no differences in drive between them. The *absolute* mean scores of the two groups might seem to contradict this prediction, but of course these are irrelevant; we are concerned with the *relative* sizes of the mean scores of the two groups, i.e. the size of their ratio. (Assume that D is twice as large in the high drive group as in the low drive group, and that habit strength grows from 0·1 to 0·5 during 8 min. practice. Performance of the two groups at the beginning of practice would be 0·1 and 0·2, a ratio of 2 but an absolute difference of only 0·1; after 8 min. the difference might be 0·4 and 0·6, a ratio of 1·5, but an absolute difference of 0·2.) These ratios show some tendency to decline, at least in the 8 min. group; their failure to do so more sharply is presumably due to the more prolonged growth of ${}_{S}I_{R}$ in the low drive group. It had been predicted that this would show itself in a more pronounced up-swing in performance following the rest pause, and inspection of Fig. 2 shows that the up-swing is both longer-continued (40 sec. as against 30 sec.) and more marked (0·38 as against 0·22 sec.). The difference is not significant when we compare maximum rise, which occurs at different points of the curve; when we compare rise after 40 sec. in both groups the respective figures are 0·38 and −0·04; this difference, however, would seem to capitalize on a chance depression in the high drive group. While the data are in general agreement with prediction 8, no conclusive verdict can be arrived at on the evidence available.

Post-rest differentiation is more clear-cut than pre-rest differentiation, and is obviously a function of the interspersed rest pause; indeed, the only differences between the groups to achieve substantial size are those analyzed in Table 5, relating to the corrected effects of the rest pause. Once differentiation is achieved, it continues at the same level; this may seem counter to theoretical prediction. Only differences in habit strength should give prolonged and non-vanishing differentiation, and there are no reasons for postulating such differences in ${}_{S}H_{R}$. Differences in ${}_{S}I_{R}$ are postulated, and may in part account for the phenomenon, but cannot completely explain it. It must be presumed that 4 min. post-rest practice is not sufficient to bring scores closer together, due to the failure of I_R to reach the critical level in the high drive group; even after 4 min. this group would still be working under higher D. Clearly it was a mistake not to continue the post-rest practice beyond the period chosen; it may be predicted that if this has been done a gradual closing of the gap would have been observed, although due to differences in ${}_{S}I_{R}$ this rapprochement would not be expected to become complete.

One other prediction seems to follow from these considerations. The effects of increased drive on performance under conditions of massed practice appear to be minimal because of the progressive neutralization of D by I_R; no such neutralization would occur under spaced conditions of practice, and it would follow that marked differences in performance should result from differences in drive under spaced conditions as compared with massed conditions of practice. Broadhurst & Broadhurst (1959) found much greater differentiation between schizophrenics and normals on the pursuit rotor when working under spaced than when working under massed conditions, and it is not impossible that this may be due to the often suspected lesser drive of schizophrenics. Alternative hypotheses are of course not ruled out; thus this difference may be due rather to the slower dissipation of I_R by the schizophrenics, an hypothesis favoured by their lower reminiscence scores (cf. also Claridge, in Eysenck, 1960*b*).

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(*Manuscript received* 4 *January* 1960)