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A SIMPLIFIED METHOD OF CONDUCTING McDOUGALL'S SPOT-PATTERN TEST.

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SUMMARY.

The problem was to determine whether the rather complicated method developed by McDougall and used by other English investigators for conducting the spot-pattern test (series of five very short exposures, delivered by interrupting transmitted light at stated intervals) could be replaced with no loss in diagnostic value by a simpler method (single exposures with an ordinary tachistoscope and reflected light).

The quantitative results demonstrate that these two methods are interchangeable so far as rank-order of the subjects is concerned. The qualitative results reveal no marked or constant differences between the mental processes operative under the two sets of conditions.

The conclusion is reached that this test, which appears to have fairly high correlations with general intelligence, may be conducted by a much simpler method than that employed by its originator, and with no loss to its diagnostic value. No claim is made, however, that these results for adults will necessarily hold true in work with children.

THE PROBLEM.

The "spot-pattern test," first proposed by McDougall (3), and subsequently employed by Burt (1), Burt and Moore (2), and Schuster (4), warrants special attention because of the high correlations found between performance in it and estimated general intelligence. But the technique and apparatus which these English investigators have developed for the test renders it unduly difficult of administration, and tends to re-

duce the reliability of the results obtained by it. The following description by Burt (pp. 150ff.) will serve to describe the test and to explain this technique.¹

"A card 10 cm. square is pierced with eight or ten holes, each 1 mm. in diam. These perforations form an irregular pattern within an area 1.5 in. square, but always coincide with the intersections of any imaginary system of vertical and horizontal lines $\frac{1}{4}$ in. apart. One face of the card is now covered with clear, dead-white paper and the whole card is placed in an aperture of a screen in the path of a beam of light to *S*'s eye. By means of a photographic shutter the light is flashed upon the card in groups of 5 flashes, each lasting 20 σ , and at the rate of one every 2 sec. After each series of 5 flashes, *S* is asked to make a map of the spots of light upon a bit of squared paper 1.5 in. in size, ruled to correspond to the system of lines above mentioned, *i. e.*, in $\frac{1}{4}$ in. squares. He is told the number of spots and that each spot must fall at the intersection of two lines. He attempts a new map after each 5 flashes, until he makes an accurate reproduction."

The spot-pattern test is evidently a variation of the ordinary tachistoscopic tests for range or scope of attention, but with a much more complex method. The problem that we undertook to solve by experimentation was: would equally reliable diagnostic values be secured if the spot-patterns were displayed in an ordinary tachistoscope, *i. e.*, with a single exposure instead of a series of exposures, with relatively long instead of relatively short exposures, and illumined by reflected instead of transmitted light? To answer these questions it was planned to compare the quantitative results secured under both methods and to secure introspective accounts of the mental processes involved in them.

SUBJECTS.

The experiments were performed in the Educational Laboratory at Cornell University during the second semesters of the academic years 1911-12 and 1912-13. The subjects were Dr. Day (*D*), Messrs. Dallenbach (*Da*) and Johnstone (*J*), graduate students in psychology, Mr. Foster (*F*), research assistant in psychology, and Mr. Ruckmich (*R*), instructor in psychology. They were highly-trained observers, especially *D* and *F*. Besides these, two undergraduates, Messrs. Goldstone (*G*) and Machatt (*M*), who were doing work in education, were subjects in the experiments for the quantitative results.

¹For further description see Whipple (5).

APPARATUS.

We needed two pieces of apparatus for the experiment, the one to reproduce McDougall's conditions, the other to fulfill the requirements of the longer exposure time.

The one apparatus, then, was so devised as to reproduce in all essentials the experimental conditions of the portable tachistoscope used by McDougall. In a vertical screen of white cardboard an opening 4.7 cm. square was cut at a height such that it would be on the level with the subject's eyes when seated in front of the apparatus. Around three sides of this opening were pasted strips of cardboard, to form a frame for holding the exposure-cards. The illumination of the cards was given by a 16 candle-power frosted incandescent lamp, fitted with a semi-circular cardboard reflector, and mounted about 12 cm. directly back of the opening. A simple telegraph key, introduced into the lamp-circuit, enabled *E* to close or open the circuit at will. Instead of the photographic shutter used by Burt and McDougall, we used a revolving cardboard disc to make the series of exposures. With the aid of a kymograph this disc, 45 cm. in diameter, was rotated vertically just behind the screen. A notch of 10 deg. was cut at one point of the disc, and the speed of the kymograph was so regulated as to give exposures of 0.04 sec., at intervals of 1.5 sec., when this open notch passed between the lamp and the exposure-card.

The other apparatus was a laboratory-made model of Whipple's disc tachistoscope (5, 264ff.). The two pieces of apparatus were then both disc tachistoscopes. They were as alike as could be, except for the conditions under comparison, viz., transmitted versus reflected light and short serial versus long single exposures.

For convenience, the McDougall apparatus will be referred to as Apparatus T (transmitted light), and the other as Apparatus R (reflected light).

The exposure-cards for Apparatus R were virtually identical in pattern with those of Apparatus T, only here the dots were ink-dots, because the cards were to be illumined by reflected light. Daylight illumination was reduced to a negligible amount by black window curtains, and the room was artificially lighted by electricity.

PROCEDURE.

Experimental Series I. In this series there were three sets of patterns, one of 8-spot, one of 9-spot and one of 10-spot cards for each apparatus. Each set contained 20 patterns. The patterns for Apparatus R were the same as those for Apparatus T. And, further, the second half of the 8-, 9- and 10-spot patterns were the same as the first half, only turned around at an angle of 180 deg.²

Now, obviously, a subject could not have the same patterns for Apparatus R as for Apparatus T and, yet, different patterns could not be used with the two pieces of apparatus, because it would then be impossible to get a reliable basis for the quantitative and qualitative comparisons. To fulfill this condition, therefore, we divided our subjects into groups.

Group I (comprising *D*, *Da* and *G*) were given the first half of the three sets of patterns devised for Apparatus T, and also these same patterns, turned at an angle of 180 deg., devised for Apparatus R.

Group II (*J*, *M* and *R*) were given the remaining patterns. Each group thus worked through three sets, which contained half the number of patterns contained in the three full sets. In this way the patterns which were presented to Group I in Apparatus T were given to Group II in Apparatus R; and those presented to Group I in Apparatus R were given to Group II in Apparatus T.

Practice effects were distributed by changing the subjects from one apparatus to the other after each step in the experiment, *i. e.*, as soon as the pattern had been correctly reproduced. Group I began the series of experiments with Apparatus T and Group II with Apparatus R.

S sat at such a distance from the apparatus that his eyes were 45 cm. from the exposure-card, and in such a position that his

²It was necessary to make use of some plan of this kind, because the area of the pattern was so limited that it would have been impossible to make 20 different patterns with each given number of spots and have them all of sufficient difficulty. It may be mentioned that no subject noticed that any given pattern had been presented before at a different angle. Once or twice only a subject thought that he had had the pattern before, but in these cases it happened that he was mistaken.

eyes were fairly on a level with it. He was given a "ready" signal 1.5 sec. before the exposure. Prepared sectional paper on which to reproduce the design was placed before him. These squares of sectional paper were laid off at one side as fast as they were used, but they were not concealed from *S*'s view.³

The general purpose of the problem was known to the subject, and specific instructions were also given to him. For Apparatus T: "There will be a 'ready' signal, and shortly afterwards you will see a pattern of 8 spots [or 9 or 10 spots] lighted up by transmitted light for a fraction of a second, five times in succession. You are then to reproduce the pattern on this prepared sectional paper. The pattern is such that the whole design will fall within a large single square of the paper. The large square contains 36 small ones, and each spot will fall at the corner of a small square. If you fail to reproduce the pattern correctly the first time, the exposure will be repeated until you are successful."

The same instructions were given for Apparatus R, with the substitution of "reflected light for a brief period" for "transmitted light for a fraction of a second, five times in succession." Those subjects who also reported upon the qualitative aspects of the work were given appropriate directions for that.

Experimental Series II. Another set of experiments consisting of two sets of patterns—9-spot and 10-spot patterns—was carried out with Apparatus T for some subjects (*Da*, *F*, *J*, *R*). This series was very short.

McDougall at first allowed his subjects to try to reproduce the pattern after each exposure, but this was found confusing

³It is not clear whether McDougall, Burt and Schuster permitted their subjects to keep their several attempts at reproduction in view. The instructions set for the test in my *Manual of Mental and Physical Tests* and ordinarily followed in the Cornell Laboratory are to conceal these attempts as soon as they are made. It was intended that this procedure should also be followed in the present experiment, but Miss Goudge, who did most of her experimental work during my absence in Europe, interpreted Burt's instructions to indicate that the attempts need not be concealed. It is impossible to say just what effect this change in method may have had other than to have reduced the number of exposures necessary for a perfect reproduction. In any event, whatever effect was present was a constant factor in both the methods under comparison.—G. M. W.

to them, and he concluded that a short series of exposures was better. As finally developed, then, his method called for an attempt at reproduction after every group of five flashes. The intervals between the exposures in the groups were equal, and in this way a better control of the mental processes was thought to be attained. Each of the short exposures represent for McDougall a quantitative unit, and it is in the terms of them that the subject is scored. Now, it seemed to us that if the flashes were such units, their full value as units would be diminished by giving the subject a chance to draw the pattern correctly from five flashes only. For example, suppose the subject reproduced the given design correctly after three trials of five flashes each, his score would be recorded as 15 units. Now, it is really quite conceivable that his score was somewhere between 10 and 15 units. With this in mind, we carried out three experiments after each set, wherein the subject was asked for a reproduction after each flash. These patterns were obtained by turning some of our earlier patterns at an angle of 90 deg. No subject recognized a previous pattern. Introspections were required after each trial.

QUANTITATIVE RESULTS.

Experimental Series I. A glance at Table I shows that all the subjects reproduced the 8-spot patterns correctly with fewer repetitions in the case of Apparatus R than in the case of Apparatus T. Tables II and III show the same for the 9- and 10-spot patterns.

TABLE I.

*Mean Number of Exposures Necessary for a Correct Reproduction.**

(8-Spot Patterns.)

Subjects.	Apparatus T.	Apparatus R.
Da.	8.5	2.0
D.	12.5	4.7
G.	21.0	8.5
J.	19.5	5.4
M.	22.5	4.4
R.	13.5	3.3

*Scores for Apparatus T in all three tables are based on the single flash as a unit, e. g., a score of 10 means two exposures of 5 flashes each.

TABLE II.

*Mean Number of Exposures Necessary for a Correct Reproduction.**(9-Spot Patterns.)*

Subjects.	Apparatus T.	Apparatus R.
Da.	5.5	1.3
D.	9.5	2.6
G.	23.0	6.5
J.	20.0	5.4
M.	16.5	3.7
R.	9.5	2.6

TABLE III.

*Mean Number of Exposures Necessary for a Correct Reproduction.**(10-Spot Patterns.)*

Da.	9.0	1.9
D.	9.0	2.4
G.	20.5	5.1
J.	16.0	2.9
M.	13.5	3.2
R.	15.0	2.7

Obviously, these results as they stand show nothing either for or against using Apparatus R as a substitute for Apparatus T in the spot-pattern test. They simply show that under the conditions used a single exposure of 1.5 sec. is not as effective as a *group of five* exposures of .04 sec. each. But, if we now arrange the subjects in order of rank for Apparatus T and again for Apparatus R, and if we find that the rank-order of R corresponds with that of T, then we shall have strong evidence that the one apparatus can be as satisfactorily used for the test as the other. The result of such treatment is shown in Table IV, where we see that, with five

TABLE IV.

Subjects Arranged According to Rank.^a

Subjects.	8-Spot Patterns.		9-Spot Patterns.		10-Spot Patterns.	
	App. T.	App. R.	App. T.	App. R.	App. T.	App. R.
G.	210	85	230	65	205	51
M.	225*	74	165*	37*	135*	32
J.	195	54	200	54	160	29
R.	135	33*	95	26	150	27
D.	125	47	95	26	90	24
Da.	85	20	55	13	90	19

^aThe asterisks show the exceptions to the order. The means in the previous tables are here multiplied by 10.

exceptions, the same rank-order holds for all the conditions. This alone would seem a sufficiently close approximation to warrant the use of either apparatus for the test. At the same time, in order to obtain further evidence of our conclusion, the coefficients of the correlation between the mean-values obtained with Apparatus T and those with Apparatus R for the three sets of patterns were next worked out by means of the Pearson formula. From the results shown in Table V we see that all three sets of patterns give a high positive coefficient—especially the 9-spot patterns, which give a coefficient of .99. These coefficients have also a high degree of reliability, as the values for the probable error show. We are, then,

TABLE V.

Correlations Between Performances with Apparatus T and Apparatus R.*

Pattern-Sets.	Correlation.	P. E.
8-Spot Patterns	.92	.042
9-Spot Patterns.....	.99	.008
10-Spot Patterns.....	.87	.069

fully justified in assigning equal diagnostic value to both methods of conducting the test, at least for adult *S*'s.

Experimental Series II. Our results from these experiments show that in over 70 per cent. of the experiments the subjects reproduced the presented pattern correctly in less than five actual exposures, while in the remaining experiments the reproduction was made in less than 10 trials—only once in exactly five trials (see Table VI).⁷

TABLE VI.

Results for Experimental Series II.

Pattern.	9-Spot Patterns.				10-Spot Patterns.		
	D.	J.	R.	D.	J.	F.	R.
I.....	3	6	8	1	2	4	4
II.....	2	6	2	3	6	2	4
III.....	2	5	2	1	7	3	2
Mean.....	2.5	5.7	4	1.6	5	3	3.3

*See Tables I-III.

⁷One subject (*Da*), near the beginning of the experiments with the 8-spot patterns, said that he was sure that he could get a correct copy more easily by one flash than by a group of five. Accordingly, we made our one deviation in our procedure, giving him an 8-spot pattern, which did not form a part of the regular set, and he did really reproduce this correctly in one flash as he had predicted.

QUALITATIVE RESULTS.

In order to gain all the information possible concerning the two methods the quantitative results have been supplemented by quite detailed and systematic introspective reports from our most competent *S*'s concerning the mental processes operative under both methods during the period from the "ready" signal to the exposure, during the period of the exposure and during the period after the exposure while the pattern was being reproduced.

Despite certain individual differences, such as would be quite natural, the introspective accounts exhibit so much similarity that a general summary for all *S*'s will suffice for the purposes of this report. The important point is that there is not only a general similarity between the introspections of the several *S*'s, but also between the introspections for the two different methods. The qualitative records, then, reveal no reason why the simpler method of single exposures by reflected light may not be substituted for the original and more awkward method used by McDougall, Burt and others in England.

The following are the main points of similarity in regard to the mental processes concerned in the learning and the reproduction:

(1) During the exposures the subjects invariably arranged the dots subjectively into groups. Attention was now on one group, or figure, and now on another. In experiments with Apparatus T it is usually remained on one group during the flash-like exposure, and the shift of attention, accompanied by eye-kinaesthesia, occurred in the intervals between the exposures. Notwithstanding the difference in conditions, a very similar method was followed with Apparatus R. There, too, attention would shift from group (or figure) to group. The five momentary exposures with the intervals between them used with Apparatus T, therefore, form practically one long exposure, and may be likened to the exposure with Apparatus R.

(2) There was frequently verbal kinaesthesia relevant to the grouping in the mid-period also.

(3) Three subjects (*D*, *Da*, *F*) mentioned an after-image

of the preceding figure (or figures) during the intervals between the momentary exposures of Apparatus T.

(4) The following factors were usually present in the reproduction: (a) visual imagery, (b) verbal kinaesthesia (*J* excepted), (c) eye-kinaesthesia (*D* and *R* excepted).

When our *S*'s were asked to make direct comparisons of the mental processes set up by the two methods, their testimony showed again that the method of learning and reproduction is, in the main, the same for both kinds of apparatus. The following include the essential, though minor, differences reported:

(1) The "dots were more intensive" in the case of Apparatus T (*Da*).

(2) They make greater claim on the attention (*F*, *J*).

(3) The successive acts of attention are objectively separated in Apparatus T, "whereas, in the other experiments, one has to do one's own separating of these during the exposure itself" (*F*).⁸

(4) *F* experiences exceptionally strong strain sensations throughout the experiment with Apparatus T, while the reverse is true for *J*.

(5) *R* usually finds work with Apparatus T unpleasant, due to three factors: (a) noise of the motor, (b) "cutting off of initiation of eye-movement," (c) translating the bright dots on the darkish background (during the learning) to black dots on a white ground (in their reproduction). *F*'s statement, twice made, that "the interval" (referring to the momentary exposures) "is for consciousness practically a

⁸We understand that McDougall favored a brief exposure, partly to stimulate attention, and partly to render the attitude of various *S*'s toward the task more nearly alike, and that five brief exposures were used instead of one in order to shorten the time of the whole experiment and not to let attempts at reproduction interfere with the development of the perception before it was fairly well begun. *F*'s introspection is the only bit of evidence revealed during our experiments that might be construed as partially justifying McDougall's experimental technique, since it suggests that a series of objectively distinct brief exposures tends to regulate and distribute the several acts of attention given to the pattern by *S*. Not enough tests were made with *F* to determine whether the introspective distinction which he made would be paralleled by a discrepancy between his quantitative performances with the two methods.

part of the whole period," substantiates our inference given above.

The essential introspective features brought out by Experimental Series II are:

(1) During the exposure attention was usually focused on one group only; but, sometimes, on two, just as in the momentary exposure with Apparatus T.

(2) *Da* and *F*, who were accustomed to have after-images in the interims between flashes in Apparatus T, Series I, got after-images here also, directly after the exposure, and used this time, during which these images were present, as if it were part of the real exposure time, *i. e.*, they used it for learning the pattern.

(3) All *S*'s used visual imagery in the reproduction. *Da* and *F* often had kinaesthetic cues as well, and *G* sometimes drew the figure quite automatically.

SUMMARY OF MAIN RESULTS.

(1) In Experimental Series I the ranking of the subjects for the experiments with Apparatus T is, with a few exceptions, the same as that in the experiments with Apparatus R, so that there is a high positive correlation between the values obtained with Apparatus T and Apparatus R.

(2) In Experimental Series II, with one exception, the subjects always produced the pattern correctly in a number of trials other than 5 or any multiple of 5.

(3) The subjects learned the patterns by grouping the dots.

(4) Usually a visual perception of one group only was attended to at once. In experiments with Apparatus T attention remained on a group during a momentary exposure and shifted between exposures. With Apparatus R there was a similar shift of attention during the mid-period, though this shift was not objectively regulated as with Apparatus T.

(5) Other mental processes, chiefly kinaesthesia (naming groups or figures), accompanied the perception of the groups and formed part of the learning processes.

(6) The following factors played an important rôle in the

reproduction—visual imagery, eye-kinaesthesia (and hand-kinaesthesia for *F'*), verbal kinaesthesia.

(7) In Experimental Series II the mental processes concerned in learning a pattern were quite the same as in Series I, except that the mid-period here gave no chance for a change of attention during the total exposure-time. Two of the subjects continued the learning after the momentary exposures by shifting attention to the memory after-image of the group just fixated. This additional period of learning would correspond fairly well with the intervals between exposures in Series I with Apparatus T, which were used in a similar way.

CONCLUSION.

All of our results seem to justify us in the use of Whipple's tachistoscope* for McDougall's "spot-pattern" test. And, further, we are inclined to think that where the McDougall's portable tachistoscope is used for the test, a somewhat more accurate rating of the subject—at least with adults—can be obtained by giving him a chance to reproduce the pattern after each momentary exposure.

REFERENCES.

- (1) C. BURT. *Experimental Tests of General Intelligence*. Brit. Jour. of Psych., 3: 1909, 94-177, especially 150 ff.
- (2) C. BURT AND R. C. MOORE. *The Mental Differences Between the Sexes*. Jour. of Exp. Ped., 1: 1912, 273-284, 355-388.
- (3) W. McDOUGALL. *Physiological Psychology*. London, 2d. ed., 1908, especially 129 ff.
- (4) E. SCHUSTER. *First Results from the Oxford Anthropometric Laboratory*. Biometrika, 8: 1911, 40-51.
- (5) G. M. WHIPPLE. *Manual of Mental and Physical Tests*. Baltimore, Part I, 2d ed., 1914, 290-296.

*Since the completion of these experiments Professor Whipple has devised a portable tachistoscope, which gives satisfactory results for the McDougall 'spot-pattern' test (5, 293 f.).