THE SPEED FACTOR IN PERFORMANCE TESTS

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I. Introduction

In a recent publication of the Scottish Council for Research in Education (2), in discussing the existence and nature of a speed factor among performance tests, I mentioned (on p. 41) certain further enquiries which I then hoped might be carried out by one of my students. The war has prevented this, and I am therefore writing this short note to report some calculations I have myself made,[1] and the tentative conclusions I have come to, regarding the speed factor.

The performance tests were those given to 443 boys and 430 girls by Dr A. M. Macmeeken (1), and were, in addition to a Binet test, the following: (1) Seguin Form Board, (2) Manikin, (3) Stutsman Picture, (4) Red Ridinghood Picture, (5) Healy Picture Completion II, (6) Knox Cube Imitation, (7) Cube Construction, and (8) Kohs Block Designs. The children were all, or practically all, of those born in Scotland on four days in 1926, and they were tested individually when their ages were round about 10½ (ranging from 8:11 to 11:9 in the extreme cases). Age has been eliminated from all the correlations quoted below, by partial correlation. The performance tests were given in the above numbered order, at one sitting (the Binet test later on the same day). For the Seguin Form Board times only were taken, and in this test the child was incited to speed and had three tries to see how quickly he or she could finish. The other tests were scored on the quality of the product, but times were also taken (except in the Knox test), and usually moves were also recorded. Since almost all the children produced perfect scores in Stutsman, and a very large majority did so in Manikin, I used times and not scores for these tests in my analysis. For the other tests (nos. 4–8) I used the scores.

[1] With considerable assistance from Miss Gullen, Mrs Youd, Miss Mellone, Miss Murray, Mr Nandi, and Mr Lawley.

Correlations between times and scores I called positive if the short time went with the high score, i.e. speed with good quality.

I extracted four factors, but felt doubtful of the statistical significance of the third and fourth. The first factor was general, and the second, with which I am here concerned, differentiated between the group of three tests where times were used, and the group of five other tests where scores were used. By rotation it could be given the form of positive loadings in the three times, and zero loadings in the five scores. To check this I then added Manikin *scores* to the analysis, expecting this new variate to cluster with the other five scores; but to my surprise it went (both in boys and girls) with the three times. At this point I said (op. cit. p. 40): "I am inclined at present to think that this speed factor, if it be a speed factor, is not so much due to using times as variates, as due to the actual incitement to speed which was employed in administering test 1, the Seguin Form Board.... In the other tests, although times were taken, there was no insistence on speed; but I fancy that in tests 2 and 3 (they were given always in this order) the memory of that demand for hurry might still persist, and show itself in the performance, while in the later tests it might have died away, so that possibly even their *times* may show no clustering with variates 1, 2 and 3." It is this which I have now tested.

II. Cube construction times

I chose first the last test but one to be given, Cube Construction (avoiding the last test of all, Kohs Block Designs, merely because its times were given on the record cards in ten parts which would have to be added together, whereas the Cube Construction times were only in three parts), and had grids made and correlations calculated for Cube Construction *times* with each of the other variates, including age which was then partialled out.[1] The resulting partial correlations are as follows:

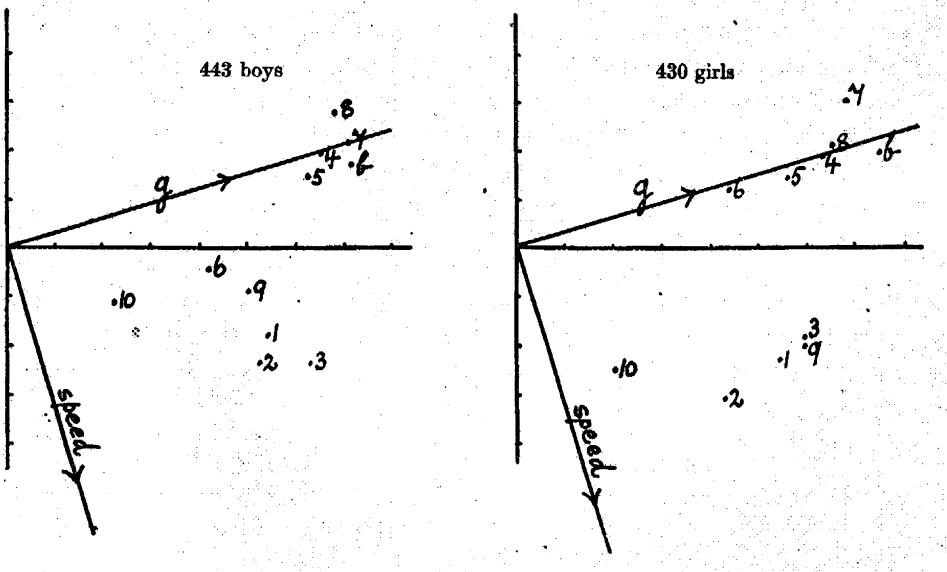
10. Cube Construction times with	443 boys	430 girls
b. Binet I.Q.	0·1266	0·0902
1. Seguin times	0·1552	0·1679
2. Manikin times	0·1245	0·1820
3. Stutsman times	0·1331	0·1799
4. Red Ridinghood scores	0·1404	0·0854
5. Healy P.C. II scores	0·1393	0·0155
6. Knox Cube Imitation scores	0·1327	0·1256
7. Cube Construction scores	0·0237	−0·0376
8. Kohs Designs scores	0·2902	0·2070
9. Manikin scores	0·1047	0·0731

[1] I now regret that I used the abbreviation C.C.T. for Cube Construction Test in my book, for the T. may be misread as 'times'. In that book the variate no. 7, C.C.T., is Cube Construction *scores*.

These may be added to Table V on p. 22 of *An Analysis of Performance Test Scores*. As is explained earlier, these correlations are reported as positive when short time, i.e. speed, goes with high score. None of the correlations is at all high (Kohs alone topping 0·2) and it is striking that there is no correlation between Cube Construction scores and Cube Construction times. (The correlations between Manikin scores and times are 0·3097 boys, 0·3565 girls; see (2), Table V.)

From the enlarged Table V two centroid factors were then extracted, with the following loadings:

		Boys		Girls	
		Factor I	Factor II	Factor I	Factor II
b.	Binet I.Q.	0·7183	0·1836	0·7503	0·2053
1.	Seguin times	0·5610	−0·1934	0·5605	−0·2452
2.	Manikin times	0·5352	−0·2507	0·4544	−0·3084
3.	Stutsman times	0·6369	−0·2541	0·6034	−0·1938
4.	Red Ridinghood scores	0·6551	0·2001	0·6315	0·1990
5.	Healy P.C. II scores	0·6302	0·1574	0·5723	0·1402
6.	Knox Cube Imitation scores	0·4346	−0·0493	0·4369	0·1326
7.	Cube Construction scores	0·7059	0·2246	0·6826	0·3029
8.	Kohs Designs scores	0·6803	0·2810	0·6545	0·2111
9.	Manikin scores	0·5185	−0·1002	0·5953	−0·2087
10.	Cube Construction times	0·2415	−0·1223	0·2105	−0·2563



It is at once seen, from the signs, that the variate Cube Construction times, in spite of the late position which this test had in the sequence of tests and its distance therefore from the incitement to speed given in test 1, nevertheless has some tendency to go with the other times rather than with the scores. In the diagrams a rotation to factors which may

be 'g' and 'speed' is indicated. The new variate 10 (Cube Construction times) shows a higher saturation with speed in the girls than in the boys, the difference being of doubtful significance.[1] The boys' diagram might perhaps be taken as in agreement with the hypothesis that an urge to speed given in test 1 had died away in the later tests, but hardly the girls' diagram. However, perhaps the most definite fact is that Cube Construction times (10) are only very slightly saturated with 'g', and that both the two first centroid factors together account for only a very small portion indeed of the variance of this variate, which is largely independent of both of them.

III. Kohs block designs times

To check all this I turned to the last test to be given, Kohs Block Designs, where up to ten different times had to be added to get the total time corresponding to the score, and I had caused this to be done and grids to be made before my attention was drawn to a peculiarity of the times in this case which made them quite unsuitable for my purpose. There were ten sub-tests of increasing difficulty, and it was Dr Macmeeken's custom to stop the test if two successive sub-tests produced no score. The total times therefore were for varying numbers of sub-tests from two to ten, and an artificial correlation is thus produced between a low score and a short time, which by our convention we call a negative correlation.

It may very well be that children who are clever at making the Kohs Block Designs in exact imitation of the pattern are also quicker at it; but this positive correlation between ability and speed, if it exist, is here entirely overwhelmed by the above artificial correlation. The measured correlations between times and scores were (for constant age):

Boys	−0·8124
Girls	−0·8524

The situation was further complicated by the fact that there were time limits, which were often reached, for each sub-test, and the complication was so great that any attempt to arrive at a 'true' time (by, say, adding the time limits for the sub-tests not attempted) had to be abandoned as quite out of the question.

[1] It is difficult, if not impossible, to test the significance of centroid loadings scientifically since guessed communalities are used. But a comparison of the present diagrams for boys and girls with one another, and with the figure given in (3), p. 39, gives some idea of the accuracy of placing of the dots.

IV. TWO SPEED FACTORS

I now returned to the Cube Construction test data, lest on investigation any difficulty of the same sort should be found there. This test was in three parts, separately timed, and these three times had been added together to give the times used as a variate. As, however, in practically all cases the child had tried all three parts of the test and had been given a score and a time for each, the above difficulty due to breaking off in the middle of the test did not occur. But it is a striking fact that the Cube Construction test data showed no correlation between times and scores, holding thus an intermediate position between the Manikin test on the one hand, where that correlation is positive (+0·3), and the Kohs test on the other, where it is negative (−0·8). It seemed possible therefore that the Cube Construction test was an example where the true positive correlation between ability and speed was exactly balanced by a false negative correlation, produced in some more insidious way than the obvious one observed in Kohs Block Designs, and it is my present opinion that this is indeed the case. There are, it would seem, two influences making for short time, even when the whole test is carried out by every child. The one influence makes one child soon get the correct, or at least a very good, result. The other influence makes another child soon satisfied with any result, even a bad one.

In tests (1) Seguin Form Board, (2) Manikin, and (3) Stutsman the task was easy and the great majority of the children accomplished it perfectly, though at different speeds. But in the Cube Construction test the task was difficult and the performances of the children produced scores spread over a wide range. In those first three 'easy' tests the former of the two influences or factors is at work almost alone. In the difficult test both factors are at work. Some children get short times because they are quick at putting the cubes correctly into position. Others get short times because they are easily and quickly satisfied with a poor shot at the task. If this surmise is correct, it seems to follow that times can only be useful data if they are all times for performing *correctly*, or at least nearly correctly, the task set. Times for performing a task with varying degrees of correctness spread over a wide range seem to be a complex variate of little use in practice.

REFERENCES

(1) MACMEEKEN, A. M. (1939). *The Intelligence of a Representative Group of Scottish Children.* University of London Press.

(2) THOMSON, GODFREY H. (1940). *An Analysis of Performance Test Scores of a Representative Group of Scottish Children.* University of London Press.

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