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SOME EXPERIMENTAL RESULTS IN CORRELATION

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The Use of the Theory of Correlation in Psychology, together with some experimental Results.

I propose in this short paper to give a condensed account of some correlation work in psychology carried out during the past few months, to state briefly some of the principal results, and, finally, to consider in what ways the method may be expected to be of help to the science in the immediate future. It has, unfortunately, been quite impossible for me hitherto to use more than a small fraction of the data already obtained, and in some cases repetitions of the tests will be necessary to complete the work, so that the descriptions and results that follow are to be taken as merely illustrative samples from a research still in progress.

The tests employed were the following :—

1. Striking out letters *e* and *r* in a page of print.
2. » » » *a, n, o,* and *s* » » »
3. » » every letter in a page of print.
4. Bisecting ten printed lines (80^{mm} long), and putting in one of the points of trisection in each of ten other lines (90^{mm} long).
5. Adding up sets of ten single digits.
6. Müller-Lyer Illusion. Dr W. H. R. Rivers' adjustable apparatus was used; with the adults 4 measurements were taken, with the children, 10.
7. Vertical-Horizontal Illusion : ten measurements in each test.
8. Combination Test (using Ebbinghaus' system of marking).
9. Mechanical memory (permanent). Subject learnt ten nonsense syllables for three minutes, and attempted to reproduce them 24 hrs later.

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10. Memory for poetry: three verses of Hood's « Queen Mab » learnt for 5 minutes and reproduced 24 hrs later.

The tests were in almost every case repeated twice, on different days, and were applied to the following groups of subjects:—

A. About 100 adults, men and women between the ages of 20 and 26, mainly college students.

B. 56 training-college students (women).

C. 39 elementary school children (girls: ages 11-12).

D. 66 » » » (boys: » »)

E. 40 higher grade schoolboys: ages 11-12.

Reliability coefficients were calculated between the two series of measurements in each test. As in some cases less than the full number took the tests, the number of cases (n) is appended to every coefficient in the following record, which is a selection from some of the values already worked out.

Crude values. Pearson coefficients.

$r_{\substack{\text{speed of addition}\\ \text{accuracy of addition}}}$	A **0.44** (P.E. = 0.077, $n = 46$);	B **0.40** (P.E. 0.075, $n = 56$);
	C **0.45** (P.E. 0.086, $n = 39$);	D **0.054** (P.E. 0.079, $n = 64$).
$r_{\substack{\text{bisection}\\ \text{trisection}}}$	A **0.66** (P.E. 0.054, $n = 43$);	B **0.43** (P.E. 0.072, $n = 56$).
$r_{\substack{\text{V.-H. illusion}\\ \text{M.-L. »}}}$	C **—0.16** (P.E. 0.13, $n = 24$);	E **0.13** (P.E. 0.132, $n = 26$).
$r_{\substack{\text{combination}\\ \text{V.-H. illusion}}}$	B **0.24** (P.E. 0.094, $n = 44$);	D + E **0.26** (P.E. 0.078, $n = 67$).
$r_{\substack{\text{combination}\\ \text{M.-L. illusion}}}$	A **—0.57** (P.E. = 0.11, $n = 17$);	C + E **—0.11** (P.E. 0.08, $n = 71$)
$r_{\substack{\text{combination}\\ \text{bisection}}}$	A **0.08** (P.E. 0.08, $n = 71$);	B **0.00** ($n = 56$).
	D **0.13** (P.E. 0.094, $n = 45$;	
$r_{\substack{\text{combination}\\ \text{trisection}}}$	A **0.18** (P.E. 0.09, $n = 43$).	
$r_{\substack{\text{combination}\\ \text{mechanical memory}}}$	C **0.31** (P.E. 0.099, $n = 34$);	D **0.57** (P.E. 0.064, $n = 52$).
	E **0.27** (P.E. = 0.102, $n = 34$.	
$r_{\substack{\text{mechanical memory}\\ \text{V.-H. illusion}}}$	D + E **0.16** (P.E. 0.08. $n = 63$).	

Reliability coefficients.

Speed of Addition.	A **0.96**, B **0.93**, C **0.69**, D + E **0.83**.
Accuracy of Addition.	A **0.36**, B **0.29**, C **0.46**, D **0.33**.
Bisection.	A **0.48**, C **0.28**, D **0.35**.
Trisection.	A **0.81**, C **0.18**.
Vertical-Horizontal Illusion.	C **0.69**, D + E **0.62**.
Müller-Lyer Illusion.	A **0.67**, C **0.65**, E **0.86**.
Combination Test.	A **0.38**, B **0.46**, C **0.56**, D + E **0.81**.
Mechanical Memory.	D **0.51**.

It will be observed that the degree of reliability varies not only from test to test, but also from group to group of subjects in the case of one and the same test.

Before attempting to use these reliability coefficient in raising our « crude » correlation-coefficients to their « correct » values by substituting in Spearman's « correction formula », viz.

$$\overline{r_{xy}} = \frac{\sqrt[4]{r_{x_1y_1}\, r_{x_1y_2}\, r_{x_2y_1}\, r_{x_2y_2}}}{\sqrt{r_{x_1x_2}\, r_{y_2y_2}}} ,$$

or the simplified form

$$\overline{r_{xy}} = \frac{r_{xy}}{\sqrt{r_{x_1x_2}\, r_{y_2y_2}}} ,$$

it is necessary for us to consider whether this formula is really applicable. The validity of thé formula is based on the assumption that the differences between the two series of values x_1, x_2 and likewise the differences between the two series y_1, y_2 are mere errors of measurement and as such are uncorrelated with each other or with x and y. This assumption is involved in the proof which Spearman gives of his formula in the American Journal of Psychology vol. XVII, but stands out more clearly in the following proof which I owe to the kindness of Mr. G. Udney Yule, and which I quote verbatim from his manuscript :

« x, y, ε, δ denoting deviations from means :—

x_1 and y_1 are measures of x and y at a certain series of measurements

x_2 » y_2 » » » another » »

The errors of measurement are uncorrelated with each other or with the correspnoding true values of x and y.

Let

$$x_1 = x + \delta_1 \qquad x_2 = x + \delta_2$$
$$y_1 = y + \varepsilon_1 \qquad y_2 = y + \varepsilon_2 .$$

Then δ, ε, the errors of measurement, are not correlated with each other or with x or y. Hence, as $\Sigma(x\delta)$ etc $= 0$,

$$\Sigma(x_1y_1) = \Sigma(xy) :$$

that is,

$$r_{x_1y_1}\sigma_{x_1}\sigma_{y_1} = r_{xy}\sigma_x\sigma_y$$

and similarly,

$$\left.\begin{aligned} r_{x_2y_2}\sigma_{x_2}\sigma_{y_2} &= \text{»} \\ r_{x_1y_2}\sigma_{x_1}\sigma_{y_2} &= \text{»} \\ r_{x_2y_1}\sigma_{x_2}\sigma_{y_1} &= \text{»} \end{aligned}\right\}$$

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