

rainfall on the part of engineers occupied with water supply is considerable and fully justifies a permanent organisation of that kind; whether the same will be found in the case of thunderstorms as a result of electrical developments, wireless transmission, and aviation, remains to be seen.

The response to this enterprise has been very good for it is stated in the foreword to this report that 966 voluntary observers and organisations have contributed to it. The only criticism that suggests itself is that the working up of the statistical material does not appear to promise any notable advance in our knowledge of the conditions favourable for the development of thunderstorms, or of their life history. Great accumulations of statistical information of this kind abound in meteorology, but it only too often happens that nobody comes forward to extract new knowledge from them.

Nothing in the way of a generalisation is suggested by this report except that the regions of maximum frequency of winter thunderstorms—the western coasts of Scotland and Ireland—are roughly those of minimum frequency of summer storms. This is not new knowledge; it has been recognised with the aid of a comparatively moderate number of regular official observing stations, and the explanation is furnished by ordinary synoptic meteorology, when due attention is paid to the possible ways in which atmospheric instability can arise at the two seasons. It seems reasonable to suppose that real advance will necessitate a study of selected portions of this detailed statistical information on correspondingly detailed synoptic lines in the endeavour to trace the physical processes that accompany the development and decay of individual storms or systems of storms.

### Mathematical and Experimental Evidence for the Existence of a Central Intellectual Factor\*

By DR. WILLIAM BROWN

IF a number of sufficiently dissimilar mental tests of intellectual ability be applied to a group of individuals and correlation coefficients calculated, it is found that these correlation coefficients are related to one another in such a way that for any four (or tetrad) of them the following relation holds good within the limits of random sampling:

$$r_{ap} r_{bq} - r_{aq} r_{bp} = 0;$$

and similarly with other arrangements of these four

The method of applying the tetrad criterion is to draw up a frequency distribution of all the possible tetrad differences derivable from the table of correlation coefficients ( $6 \times {}^nC_4$  in number, where  $n$  is the number of mental tests correlated with one another), and to compare its standard deviation with the theoretical standard deviation of a purely chance distribution of such tetrad differences. A formula for the latter has been calculated by Spearman and Holzinger.

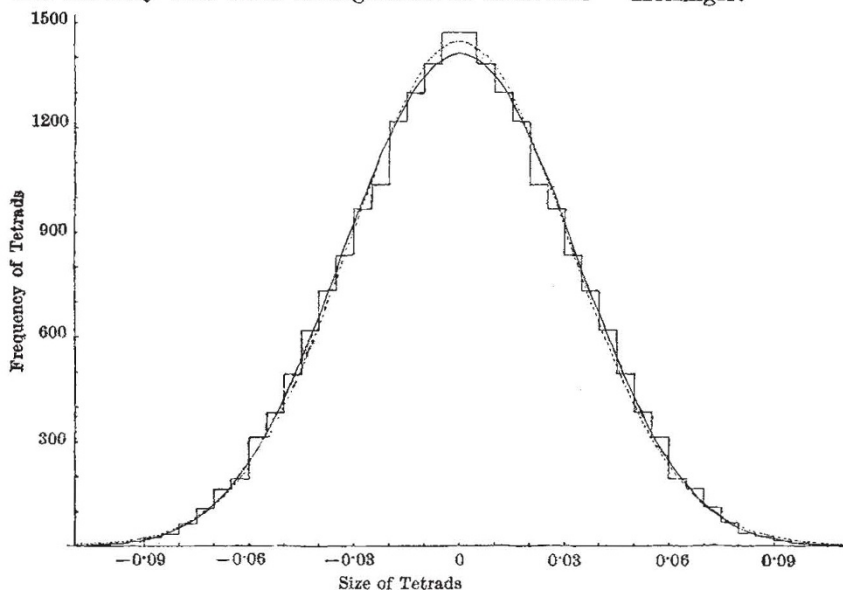


FIG. 1. Frequency distribution of tetrad differences. Best-fitting curve (Type IIA Pearson Curve) ———. Best-fitting Probability Curve - - - - -.

coefficients. We owe both the discovery of fact and the devising of the tetrad criterion to Prof. C. Spearman.

The inference drawn from this is that the abilities measured by the mental tests are divisible into two factors each, one being common to all (the general factor,  $g$ ), while the other is in each case specific and independent (the specific factor,  $s$ ).<sup>1</sup>

\* Summary of a paper read on Aug. 24 to the Tenth International Congress of Psychology at Copenhagen.

I have re-tested my earlier correlation results of twenty to twenty-three years back<sup>2</sup> by this criterion, and find that, so far as they go, they do support Spearman's two-factor theory. But a statistically adequate proof of the theory needs a large random sample of cases (several hundreds) and, especially, a large number of not too similar mental tests of intellectual ability—much larger than those applied in any research up to the present date.<sup>3</sup>

To fulfil these conditions, I have organised a research during the past year with the help of Prof. Spearman and Dr. W. Stephenson of University College, London. Dr.

Stephenson has devised a series of twenty tests of apparently non-overlapping intellectual ability, selected not *a priori* but after much preliminary trial, which received the approval of Prof. Spearman, and has applied them for me to 300 boys, aged 10½–11 years, drawn from twelve elementary schools of the L.C.C., forming a homogeneous random 'sample' of adequate size for statistical purposes. The total number of positive tetrad differences is 14,535 (and there is an equal number of negative tetrad differences, of course). It has since been found necessary to reject one of the tests and one of the correlation coefficients. There remain 11,356

positive tetrads (and an equal number of negative ones) which form a smooth frequency curve, the mathematical properties of which I am now working out.

I have found that the best-fitting frequency-curve is a Type IIa Pearson curve, with equation

$$y = 1412 \left(1 - \frac{x^2}{1188}\right)^{13.669} \text{ [unit of grouping} = 0.005]$$

The curve is platykurtic, with  $\beta_2 = 2.81446$ . (For a 'probability' curve,  $\beta_2 = 3$ ).  $\chi^2 = 20.69494$  (for 21 groups), and therefore  $P = 0.41537$ ,—a good fit. The standard deviation,  $\sigma_t = 0.031289$ .

If we compare this with the 'theoretical' Spearman-Holinger value<sup>1</sup>,  $\bar{\sigma}_t = 0.02827 \pm 0.002586$ , we find an excess of 0.003019, which is 1.167 times the probable error. This means that the odds are about 4 to 3 against such a deviation,—a good correspondence of observation with theory.

The best-fitting probability curve to the distribution is

$$y = 1448 e^{-x^2/78.32}$$

This is far less good a fit than the Type IIa Pearson curve above-mentioned, since for it  $\chi^2 = 39.21517$ , and therefore  $P = 0.0114809$ ,—a poor fit.

The small size of  $P$  is partly due to the large number (21) of groups in each half of the frequency-distribution. Actually both curves appear to fit the distribution closely, when superposed upon it, and the superiority of the Type IIa curve only becomes visually apparent in a large-scale drawing, such as would be too large to reproduce here.

<sup>1</sup> Spearman, C. "The Abilities of Man". London, 1927, pp. 74, 75.

<sup>2</sup> Brown, William. "The Essentials of Mental Measurement", First Edition 1911, Cambridge, pp. 114, 116.

<sup>3</sup> Pearson, K. and Moul, M. "The Mathematics of Intelligence, I. The Sampling Errors in the Theory of a Generalized Factor." *Biometrika*, vol. 19, p. 261, Dec., 1927.

<sup>4</sup> Spearman, C. and Holzinger, K. "The Average Value for the Probable Error of Tetrad Differences". *Brit. J. Psychol.*, vol. 20, part 4, p. 370, April, 1930.

## University and Educational Intelligence

**BIRMINGHAM.**—Prof. W. Stiles has been elected dean of the Faculty of Science to succeed Prof. S. W. J. Smith whose term of office has expired.

**OXFORD.**—Dr. F. Homes Dudden, Master of Pembroke College, delivered on Oct. 5 his valedictory address as retiring vice-chancellor. In it, after paying tribute to the memory of the late Dr. G. Claridge Druce, of whom he spoke as the greatest English field botanist of his generation, he extended the welcome of the University to Prof. Plaskett, the new Savilian professor of astronomy. He announced that the extension of the Radcliffe Science Library would be taken in hand at once, though the additional space thus secured would at first be used to relieve congestion in the main Bodleian building. Among benefactions he mentioned the gift of £1000 from Prof. J. M. Baldwin for the capital endowment of the Edward Bagnall Poulton Fund; and as recent interesting developments he enumerated the experimental establishment of a bureau for the prosecution of research on the ecology and population problems of wild animals, and the proposed establishment of an Institute of Ornithology to collect and co-ordinate information concerning the numbers, distribution, and habits of British birds.

ON November 4, at 8 P.M., Mr. H. Ramsbotham, Parliamentary Secretary to the Board of Education, will open the building extension of the Chelsea Polytechnic, Manresa Road, London, S.W.3, and distribute diplomas and certificates to students.

THE Trustees under the will of the late Viscount Leverhulme have instituted a number of post-graduate studentships in chemical engineering. These studentships, which are of the annual value of £250 each, are tenable at the Ramsay Memorial Laboratory of Chemical Engineering, University College, London. They are open to graduates in chemistry or engineering who also have an adequate acquaintance, gained by employment or otherwise, with factory or business conditions. The holders of the studentships may, at the discretion of the Ramsay professor of chemical engineering, either follow the ordinary course of study, leading to the College diploma in chemical engineering, or a special course of study in that subject, or carry out original research work. It is particularly appropriate that these studentships should be associated with the memory of Lord Leverhulme, since chemical engineering research and practice have always played a very large part in promoting the development and success of the great industrial organisation which he founded. Two studentships are to be awarded immediately. Applications for these should be addressed to the Secretary, University College, Gower Street, London, W.C.1.

THE London County Council's programme of lectures and classes for teachers includes under the headings of Science and Domestic and Health Subjects items which should enable teachers to make good some of the alleged deficiencies in present practice. A course of lectures and demonstrations by Mr. F. J. Pearson at the Institute of Education in "General Science for Senior Pupils", will direct attention to the advantage of framing science syllabuses on a wider basis than that traditionally employed. Courses of lecture-demonstrations by Prof. J. R. Partington at East London College, in "The Chemistry of Daily Life", and by Prof. Chas. R. Darling at the Borough Polytechnic, in "Physical Science in the Modern Home", will illustrate the application of the principles of science and scientific knowledge to vocational and other useful purposes, and link up work in the laboratory with work in the kitchen. Biology presents special difficulties as a practical school subject, especially in urban schools. Assistance in overcoming them will be the aim of a course of ten lectures by Miss von Wyss, beginning next January, at the Institute of Education. Food and dietetics will be dealt with in a course of lectures by Prof. Winifred Cullis, beginning in February.

RURAL schools in the United States of America have for many years presented peculiar problems of great difficulty and importance. Their importance is apparent in view of the fact that schools in rural districts (population under 2500) have an enrolment of nearly eleven million children and are staffed by four hundred thousand teachers. As schools have to a large extent been administered as a local district affair, and as wealth has been largely concentrated in urban districts, the schools in the rural districts have suffered from lack of financial support comparable with that enjoyed by city schools. The backward condition of large numbers of them has been known in a general way, but few research agencies have interested them-