Raman Spectra of Organic Sulphides.

It is more or less generally accepted that the various Raman frequencies of a molecule correspond to the oscillations of its component parts with respect to one another, each frequency being associated with one particular mode of oscillation. This conception of the origin of the frequencies is very fruitful in correlating the Raman spectra of molecules with their structure. One particular aspect of the application of this idea has attracted considerable attention during recent years, namely, the assigning of certain frequencies to each type of chemical bond and tracing their variation from compound to compound. We have made a detailed study of the Raman spectra of a number of organic sulphides and we give below the results obtained in two typical cases, ethyl sulphide and allyl sulphide, one representing the saturated and the other the unsaturated compound.

The Raman spectrum of ethyl sulphide is very simple, while that of allyl sulphide is rich in lines and also presents a continuous background. A comparison of the scattered spectrum of ethyl sulphide with that of ethyl ether shows a general agreement so far as the long shifts are concerned. The effect of the substitution of the heavier sulphur atom in the place of oxygen is to diminish the frequency shift, the changes in the shift getting smaller as the value of the shift increases.

	Wave numbers per cm.
Ethyl Sulphide $(C_2H_5)_2S$	652, 1061, 1282, 1439, and 2923
Allyl Sulphide $(C_3H_5)_2S$	410, 588, 741, 917, 1011, 1101, 1210, 1291, 1312, 1420, 1534, 1636, 3007, and 3088

Thus, corresponding to the sulphide shifts 1061, 1439, and 2923, we have the ether shifts 1082, 1457, and 2936.

The Raman spectrum of the sulphide resembles that of the corresponding alcohol in the region of the longer frequency shifts, while conspicuous changes are observable in the region of the shorter shifts. The frequency 652 in ethyl sulphide, which is presumably due to the C–S bond, is also the prominent frequency in carbon disulphide, the nature of the bond apparently having no effect on the oscillation frequency. This frequency is absent in allyl sulphide. Similarly, the prominent frequency 741 in allyl sulphide (which is also present in allyl thiocyanide) is absent in ethyl sulphide. It seems that the frequency 741 is characteristic of the unsaturated sulphides, and the frequency 652 of the saturated sulphides.

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The General Factor in Spearman's Theory of Intelligence.

I have recently undertaken an investigation of the theory of 'factors' from a mathematical point of view. This work is now complete and I hope to publish it shortly in full. The conclusions in brief are that, with certain reservations, the theorems relied on by psychologists are correct. They are, further, independent of the theory of probability: that is to say, no questions of distribution arise until we come to applications.

It is surprising that this comparatively simple work has not been done before. The reason seems to be that it has always been approached from the probability point of view, whereby difficult but irrelevant considerations have been introduced. It may, however, be noted that Yule in his classical paper on partial correlation (*Proc. Roy. Soc.*, 1907) proved his results independently of distribution, and that Spearman (*Proc. Roy. Soc.*, 1922) stated that the theorem proved by Garnett for error distributions (*Proc. Roy. Soc.*, 1919) had a similar generality. This is the subject of Prof. Piaggio's letter in Nature of Jan. 10. Another reason why mathematicians have as a rule failed to interest themselves in the theory lies in the special meanings assigned to common mathematical terms by statisticians and psychologists: independent for orthogonal, factor for component, array for section, etc., and the extension of the term 'error' to cover all components not under consideration.

The subject matter of statistical science is sets of measures of variates, that is, sequences of numbers, which for theoretical purposes may be reduced to standard deviation measure. These sequences can, like real functions of which they are a reduced case, be subjected to orthogonal partition and can be developed in series of sequences. N being the number of elements in each sequence, all sub-sets of N-1 independent sequences, orthogonal or not, are 'complete', and all sequences of the whole set can be developed linearly in terms of any complete sub-set. The possibilities for the expression of a sequence in terms of 'factors' are therefore unlimited, a fact upon which Godfrey Thomson has insisted from a rather different point of view. The theory can at this point be linked with that of linear substitutions or with that of unit vectors in multispace, but for the object in view there does not appear to be any advantage in doing so.

I have obtained the conditions for the existence of a sequence having given correlation coefficients with a given sub-set, and for the existence of a sub-set having a given array (mathematical sense) of correlation coefficients, together with the method of obtaining such a sequence and such a sub-set. In view of its great interest, I have also made a study of Spearman's two-factor form following the above methods. This form may be said to have the general validity claimed for it; it may be remarked, however, that there is another class of cases, besides those with negative correlations mentioned by Garnett, in which 'equi-proportionality' (Dodd) does not imply the form. I do not entirely agree with Prof. Piaggio's statement that the arbitrary sequence i can be made as small as we please; this depends on the divergence of a certain series, which is not bound to diverge.

When we come to application, distribution is all-important. An orthogonal partition of a sequence is of course not invariant for monotonic transformations, so that a partition such as Spearman's two-factor form is entirely dependent on the distributions adopted. In statistical measurements as a rule, and in psychological measurements always, there is no measuring rod, so that distributions are at our mercy, and it is usual to make them fit some standard such as the curve of errors and to insist on the linearity of the regressions. It is therefore on this standard distribution that the two-factor theory must rest, and not on the general method of partition. Karl Pearson has criticised Spearman's 'hierarchy' of correlation coefficients from the point of view of closeness of fit. A mathematician with a less severe statistical morality will, however, have no objection to Prof. Spearman making his fit perfect by small monotonic transformations or linear substitutions.

Orthogonal partition often connotes physical reality, as, for example, with harmonics in sound; but it must be remembered that in such cases the partition is completely specified by physical laws and conditions,