LETTERS TO THE EDITORS

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Factorial Analysis of Physical Growth

THE 'Harvard growth study'¹, based on measurements of the same children year after year, is a type of co-operative research which urgently needs repeating in Great Britain. There are, however, one or two conclusions to be drawn from the American data which the investigators themselves seem to have overlooked. Until recently, it has been commonly supposed that there is no general factor entering into physical growth analogous to the general factor entering into mental growth², and no convincing evidence for the existence of group-factors, distinguishing human body-types, analogous to the well-established group-factors found in work on temperament, mental imagery, and the like (ref. 1, p. 291 and refs.). That physical development should proceed so differently from mental development would be somewhat surprising; but a glance at the literature shows that statistical methods adopted by Kretschmer, Spearman, and others in studying relations between physical measurements were scarcely as adequate as those now employed to establish mental types and mental factors in the field of individual psychology.

On applying the newer technique of 'multiple factor-analysis' to physical measurements, obtained from groups of English school children and students, I found strong *prima facie* evidence both for a general factor and for type-factors³. Similar results have since been obtained with groups of a different racial composition: Dr. J. I. Cohen, at my suggestion, analysed measurements for a Jewish sample, and reported the results in these columns⁴; more recently, Mr. W. H. Hammond has reached the same conclusions with measurements collected from Welsh adults by Prof. H. J. Fleure and from Irish adults by Mr. Moge⁵. But perhaps the most interesting confirmation of all is to be found in the Harvard data, where correlations are available for a far larger group, comprising more than five hundred 16-year-old American youths (ref. 1, p. 301). On applying the same technique as before, I find, first a general factor accounting for more than 60 per cent of the total variance, and secondly a bipolar factor distinguishing persons showing relatively excessive growth in 'vertical' directions (height, length of leg, arm, or trunk) and those showing relatively excessive 'transverse' or circumferential growth (iliac width, chest width, chest depth, weight). The second factor points to much the same distinction as that drawn by earlier French and Italian physiologists, and popularized by Kretschmer's work on psychotic patients, namely, the distinction between asthenic, leptosomic, or microsplanchnic types and pyknic, eurysonic, and megalosplanchnic types respectively.

The confirmation is the more remarkable because the American investigators themselves regard their measurements as "illustrating the futility of trying to describe any but extreme cases as types". Like so many, however, they interpret 'types' as implying sharply discriminable classes rather than relative or partial tendencies; and they make no attempt to eliminate the obscuring influence of the more powerful 'general factor'. How far the so-called types may be due to racial, genetic, or endocrinological 'factors'

is a question which statistical analysis alone is not competent to determine. It may be added, however, that the discovery of factors of two kinds, one influencing size, the other proportion or shape, is fully consistent with the distinction between isogonic and heterogonic growth in lowlier animals⁶ and with the theory of two fundamental forms of growth recently put forward by Smalhausen at the Institute of Experimental Biology at Kiev.

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¹ Dearborn, W. F., Rothney, J. W. M., and others, "Predicting the Child's Development" (1942).

² Spearman, C., "Abilities of Man", p. 141 (1926). Thomson, G., "Factorial Analysis of Human Ability", p. 280 (1939).

³ Burt, C., *Brit. J. Med. Psych.*, **17**, 184-187 (1938).

⁴ Cohen, J. I., *NATURE*, **144**, 914 (1939).

⁵ Hammond, W. H., *Man*, **42**, 4-11 (1942).

⁶ Huxley, J. S., "Problems of Relative Growth" (1932).

Semi-conducting Properties of Stannous Sulphide

SEMI-CONDUCTING properties of metallic oxides have received considerable study in recent years and have contributed largely to the theory of defect structures. By comparison, little attention has been paid to the heavy-metal chalcogenides, although their pronounced semi-metallic properties (for example, lustre, very high conductivity) suggest that among them, if anywhere, might be found the intrinsic Wilson semi-conductors¹. In this connexion, a special interest is attached to such compounds as lead sulphide and stannous sulphide, in which the cations possess unutilized valency electrons, which might well contribute to the metallic conduction. With this in mind we have studied the conducting properties of stannous sulphide, and present here our main conclusions. A fuller account and discussion of the experimental data will be published elsewhere.

In agreement with an isolated measurement by Tubandt², stannous sulphide is an electronic conductor at all temperatures. Even at the highest temperature investigated (750°C.), the ionic component of the conductivity certainly does not exceed 1 per cent of the total conductivity. Preliminary observations show that no pronounced increase in conductivity accompanies fusion (melting point of stannous sulphide, 870°C.), so that the liquid is probably a semi-conductor also.

Variation of conductivity with temperature can be represented by a two-term formula

$$\kappa_{I_0} = Ae^{-E_1/RT} + Be^{-E_2/RT}.$$

The high-temperature conductivity is reproducible from one specimen to another, and independent of past history; $E_1 = 12,600$ cal. This presumably corresponds to intrinsic semi-conduction. At lower temperatures (for example, below 300°C.), impurity conduction supervenes, and the manner in which the number of conducting centres and the activation energy E_2 depend on the previous treatment of each specimen indicates that under these conditions positive hole conduction takes place, in a non-stoichiometric crystal.

This may be exemplified by the accompanying data. Treatment of one particular specimen with pure hydrogen increased R_{18° almost 2,000-fold. Exposure at the ordinary temperature to air, or to hydrogen