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Primaries or Second-order Factors: A Critical Consideration of Cattell's 16 PF Battery

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Intercorrelations between certain Cattell 16 PF scales contributing to the second-order factors exvia–invia and adjustment–anxiety were corrected for attenuation, in order to test Cattell's views about the relative importance of primary and second-order factors. It was found that when the contribution of second-order factors was extracted from the battery, very little was left over for primaries to measure, and it was concluded that in Cattell's own data there is no good evidence to suggest that primaries make any independent contribution to measurement apart from the higher-order factors.

There are considerable similarities between the personality descriptions given by the factor-analysis based systems of Cattell, Guilford and Eysenck; these similarities, however, appear only in the higher-order factors called extraversion–introversion and neuroticism–stability by Eysenck, and exvia–invia and adjustment–anxiety by Cattell (Eysenck & Eysenck, 1969). While the factors extracted at this level from sets of questions contributed by these three authors are virtually identical, there is little agreement on primary (first-order) factors; furthermore, Eysenck was unable to replicate Cattell's or Guilford's factors on his samples (Eysenck & Eysenck, 1969). As far as Cattell's primaries are concerned, this failure seems common; Peterson (1960) in the U.S.A. and Greif (1970) in Germany similarly failed to provide any kind of replication. It could be argued, in the case of the Eysenck & Eysenck studies, that the method of rotation used was dissimilar to that used by Cattell; however, Promax (Hendrickson & White, 1966) was devised in our laboratories by two former collaborators of Cattell's with intent to capture the principles underlying his own methods, and a study carried out in Cattell's own laboratory has shown Promax to be equivalent to Cattell's own methods (personal communication).

Even if Cattell's factors were replicable, there would still be disagreement on the relative importance and value of primary factors and of second-order factors. Cattell is quite specific in his claims: 'The primary factors give one most information, and we would advocate higher strata contributors only as supplementary concepts.... It is a mistake, generally, to work at the secondary level only, for one certainly loses a lot of valuable information present initially at the primary level' (Cattell *et al.*, 1970, pp. 111–12). Eysenck's position is equally clear; he would maintain that second-order factors are far more meaningful psychologically (Eysenck, 1967*a*), and that little if any information is lost by disregarding the primaries in such personality studies as those reported by Cattell. It is not suggested that this would always and inevitably be so; in the field of intelligence testing Eysenck would still regard *g* as the most important single factor, but would certainly agree that half a dozen or so

of primaries make a definite contribution to prediction in many cases (Eysenck, 1967*b*; Vernon, 1965; McNemar, 1964).

Such an argument should be amenable to factual settlement, and the present paper constitutes an attempt to provide some information which may be considered relevant. Cattell *et al.* (1970) have published a table (p. 113) of intercorrelations between the 16 PF scale scores of 423 male and 535 female college students, separately; they used the sum of scores on forms A and B for this purpose. Many of these are quite high, but for our purposes these raw correlations are not very useful as they are of course very much lower than the 'true' correlations between scales by virtue of the rather low reliabilities. Our argument will be that if the correlations between scales contributing to a particular factor (exvia, or anxiety) at the second-order level are at or near unity, then clearly the individual scales (primaries) make no contribution over and above that made by the second-order factor. To test this hypothesis we must correct the existing correlations for attenuation; without this correction the failure of the observed correlations to reach unity may be due entirely to random error rather than to factor-specific contributions. For this purpose, reliability coefficients are required for the scales used; fortunately correlations between scales A and B (which Cattell *et al.* consider 'parallel forms' on p. 32) are given in their Table 5.3 for 6476 subjects, and have been used for our calculations. It would have been more suitable if these reliabilities had been calculated on the actual sample studied, but the requisite data are not available; this may introduce some minor errors into the computations. On the other hand, the reliabilities of the figures may be considerably improved because they are based on much larger numbers; it is possible that advantages and disadvantages balance out in this case. This correlation between parallel forms, Cattell calls 'equivalence coefficient'; as he points out, there are many different 'reliability' coefficients in the literature, all having quite different properties, and it is necessary to be quite specific about one's use of the term.*

Table 1 gives the corrected correlations for men (upper half) and women (lower half) between the five scales which, according to Cattell, contribute to his anxiety second-order factor. Scale H, which is also included by him, has been omitted because it also contributes to exvia–invia, the other main second-order factor, and correlates more highly with this. Out of 20 coefficients, 12 are above unity, and another three are only just below unity; this leaves five coefficients in the 0·8's (three in all) and below (two). Coefficients above unity are, of course, evidence of

* It might be argued that 'equivalence coefficients' are not the proper reliabilities to use in correction for attenuation, and that some form of split-half reliability ought to have been used. Such would not be Cattell's own view, and to give his theory the optimum opportunity to prove itself we have followed his own reasoning in our procedure. It should also be noted that there are gross differences in the empirical literature about the split-half reliabilities to be expected in relation to Cattell's 16 scales; Greif (1970) gives an interesting comparison (Table 2 in his paper) of his own findings and Cattell's. For scale A, Cattell reports a correlation of 0·82, Greif of 0·28; for scale M, the values are 0·79 and 0·21; for scale N, 0·65 and −0·04. The average reliability in Greif's study is only 0·37. Had we used these reliabilities, conclusions about the intercorrelations between scales corrected for attenuation would have been much more adverse than those actually recorded.

Table 1. *Intercorrelations between Cattell's five 'anxiety' scales, corrected for attenuation*

		C(−)	L	O	Q_3(−)	Q_4
C(−)	(Low ego strength)	—	1·14	1·22	1·04	1·19
L	(Suspiciousness)	0·98	—	0·86	0·78	1·15
O	(Guilt proneness)	1·24	0·66	—	0·95	1·24
Q_3(−)	(Low self-sentiment)	1·02	0·80	0·87	—	0·97
Q_4	(High ergic tension)	1·23	1·04	1·11	1·14	—

overcorrection, and may be due to the fact that the reliabilities were calculated on groups other than the ones furnishing the actual correlations between scales; similarly, the lower coefficients may be evidence of undercorrection. However we look at these figures, they do not justify Cattell's claim that work with the second-order factors would cause one to 'lose a lot of valuable information present initially at the primary level'. As far as one can see, practically all the information contained unreliably in the primaries is contained reliably in the second-order factor; very little information indeed is left over for contribution by the primaries.

The position is not quite as clear in Table 2, which presents the intercorrelations

Table 2. *Intercorrelations between Cattell's five 'exvia' scales, corrected for attenuation*

		A	E	F	Q_2(−)	H
A	(Affecto-thymia)	—	0·44	0·66	0·91	0·69
E	(Dominance)	0·28	—	0·94	0·18	0·89
F	(Surgency)	0·61	0·85	—	1·07	1·00
Q_2(−)	(Group adherence)	0·93	0·04	0·78	—	0·86
H	(Venturesomeness)	0·50	0·72	0·87	0·76	—

between the five scales which according to Cattell contribute to the second-order factor exvia–invia. Only two out of 20 correlations exceed unity, and another six could be rounded up to 0·9; this leaves 12 correlations below this level. Of these, three belong to scale H (Venturesomeness) which, as already noted, also loads on the anxiety factor; as its contribution is spread over two second-order factors, its correlations for either must of course be considerably lower than unity. Of the remaining coefficients, two are very low, viz. those referring to the correlations between E (Dominance) and Q_2 (Group adherence) in the male and female samples respectively. This would appear to be a good example of what Frenkel-Brunswik (1942) has called the principle of alternative manifestation; 'different classes of behavioral expressions were often related to one drive as alternative manifestations of that drive .... One drive variable may circumscribe a family of alternative manifestations unrelated to each other: the meaning of the drive concept emerges in terms of families of divergent manifestations held together dynamically or genotypically, though often not phenotypically'.

Other correlations which are well below unity are those involving A and E, and A and F. A and E are both noted by Cattell as being involved in second-order factor 3 (Pathemia); E is also involved in factor 4 (Independence), and A in factor 5 (Naturalness). F is involved in factor 8 (Superego strength). We thus find that primaries whose intercorrelations do not come up to unity when second-order

factors 1 and 2 are concerned are also involved in other second-order factors; this would be impossible if all their variance were taken up by one second-order factor.

If it is permissible to draw any conclusions from these figures, it must be that they fail to support Cattell's statement quoted at the beginning of this paper; primary factors add little to the contribution made by second-order factors, with the possible exception of the 'alternative manifestations' factors contrasting extraverted attitudes leading to either leadership or group adherence. The figures given are not incompatible with a general view which would regard the primaries advocated by Cattell as random groupings of items either measuring extraversion or neuroticism, or occasionally both (i.e. the items making up his factor H). Such a view would also be compatible with the fact that several writers have found it impossible to replicate Cattell's factors in independent analyses, using both his items and his methods of analysis and rotation. The figures upon which this tentative conclusion is based are of course not very precise, for reasons already given, and the fact that several of the corrected correlations exceed unity bears witness to this. In this lack of accuracy, of course, psychology is an exact replica of physics; as Taylor *et al.* (1970) point out, 'contrary to popular opinion, physics is usually not a very exact science .... In some cases finding agreement to within an order of magnitude (a factor of 10) is a considerable achievement'. And the reason for this lack of exactitude is the same in both sciences: 'First, most experiments deal with a complex system in which a variety of interrelated and often poorly understood phenomena are involved. Second, the pertinent theory usually provides only an approximation based on a simplified conceptual model of the system' (p. 62). In spite of the obvious inaccuracies in our calculations, the data do seem to support reasonably well the writer's conception of the relation between primary and second-order factors, and to contradict that advocated by Cattell. At the very least, the data and analyses presented seem to require some form of proof from Cattell to substantiate his contention that 'one certainly loses a lot of valuable information present initially at the primary level' in working with second-order factors only. Even restricting ourselves to two only of the eight second-order factors Cattell claims to have isolated, this just does not seem to be so.

It is interesting to speculate on the reasons for this rather strange phenomenon. Eysenck & Eysenck (1969) have drawn attention to a continuum ranging from factors which are essentially tautological (T factors) to factors which are made up of many complex and divergent items (C factors); Guilford and Eysenck, in so far as they deal with primaries, are concerned more with the former, whereas Cattell is concerned with the latter. This difference emerges also in the stress laid by these different authors on high factor loadings, leading to simple structure defined by clusters of similar items (Guilford and Eysenck), or rather on high hyperplane counts (Cattell), which are compatible with much lower factor loadings, and particularly with much lower item correlations within a given primary factor. The resulting factors are called by Cattell 'surface' (T factors) and 'source' (C factors) traits, but these terms are question begging; there is no independent evidence to show that Cattell's factors come any closer to some truly fundamental 'source' of human behaviour, and there is some evidence that Eysenck's E and N factors do

(Eysenck, 1967*a*). As far as our analysis goes, it seems to suggest that far from being 'source' traits, Cattell's primaries are chance aggregations of items measuring E, or N, or both, as well as possibly some other second-order factors. This conclusion fits in well with the argument presented by Eysenck & Eysenck (1969) that replicable primaries are of the 'T' type, and that replicable 'C' type factors are always of the second-order kind, at least in the non-cognitive personality field.

There is now considerable international agreement regarding the vulnerability of Cattell's system to these criticisms (Becker, 1961; Borgatta, 1962; Greif, 1970; Levonian, 1961*a*, *b*; Peterson, 1960; Timm, 1968). Greif, for instance, points out that, in his detailed analysis, out of 170 items only 28 correlate more highly with the scale they are supposed to measure than with some other scale; out of 15 scales there are six without a single item which correlated more highly with the scale it is supposed to measure than with some other scale. He also concludes, as we have done, that 'the 16 scales cannot by any means be regarded as functionally independent, but are relatively highly correlated' (p. 211). Clearly, Cattell's hypothesis of 16 functionally independent factors being measured by his test requires considerable support if it is to continue being accepted by test users.

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