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HIGHER-ORDER FACTOR STRUCTURE OF CATTELL'S MAT AND 8SQ

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ABSTRACT

Previous research has failed to delineate adequately the higher-order factor structure of the Eight State Questionnaire (8SQ), and of the Motivation Analysis Test (MAT). Kline (1979, p. 185) concluded that, "... there is considerable need for further investigation . . . utilizing factorial procedures in accord with the technical demands which are listed ... so that one can have confidence in the attainment of simple structure and the consequent psychological import of the results." In response to Kline's suggestion, the present study indicated *two* third-order 8SQ factors, and *nine* second-order MAT factors, on an Australian sample of 258 college students. Use of Cattell's Rotoplot program was shown to be a valid and useful factor analytic procedure. Findings are discussed and tentative labels are assigned to each higher-order factor.

The question as to the higher-order factor structure of Cattell's Motivation Analysis Test — MAT (Cattell, Horn, Sweney, & Radcliffe, 1964), and also the Eight State Questionnaire — 8SQ (Curran & Cattell, 1976) has remained unresolved (cf. Boyle, 1983b). Cattell and Kline (1977, p. 184) asserted that, "... much further research into the higher-order structure of ergs and sentiments combined with investigation of the factors in experimental studies needs to be done..." Kline (1979, p. 185) concluded that, "... the proper higher-order structure of dynamic traits is not known." While three third-order 8SQ factors have been reported (cf. Cattell & Kline, pp. 222-223), "Much further research is, however, demanded before these factors can be properly labelled" (Kline, 1979, p. 170).

It is pertinent to examine the higher-order factor structure of the MAT and 8SQ. The present investigation also should provide some evidence on the similarity and differences between the general emotional state, and the more specific motivational dynamic trait domains. This study additionally aims to investigate the merits of orthogonal versus oblique rotation, and as well, the efficacy of Cattell's Rotoplot program.

METHOD

SUBJECTS

The total sample comprised 258 male and female student teachers attending I.C.E., Melbourne. There were 219 females, and 39 males. The college was located in a predominantly middle-class socioeconomic area. The majority (about 80 percent) of the students was Australian born. The sample ranged in age from 18 to 47 years, with the mean age being about 22 years.

INSTRUMENTS

Two measures were used: (i) Eight State Questionnaire (8SQ); and (ii) Motivation Analysis Test (MAT). According to Curran and Cattell (1976, p. 3), the 8SQ "... was designed specifically for measuring eight important emotional states and moods ... The theoretical importance of measuring emotional states lies in the fact that any prediction of how a person will act or how he will perform depends as much on his present state as on his usual trait." Form A of the 8SQ was chosen since immediate test-retest (dependability) coefficients, and stability coefficients (retest after one week) were higher than for Form B (Curran & Cattell, p. 14). Hence significant changes on Form A subscales could be regarded with greater certainty as indicative of *real* psychological alterations. Form A of the MAT was the only one available. According to Cattell et al. (1964, p. 3), the MAT "... presents a unique advance in psychological measurement techniques in that it uses objective devices instead of the usual self-evaluative, verbal-preference opinionaire methods." There were moreover, no other comparable, factorially based, instruments available, designed to measure simultaneously several emotional states and specific motivational dynamics respectively.

As demonstrated by Kline (1979), these measures are as reliable and valid as most measures in the personality and motivation domains (cf. Buros, 1978). Each is prefaced by standard instructions, and responses are marked on separate answer sheets. The mean time for completing the 8SQ is about 20 minutes, and for the MAT about 50-55 minutes (cf. Cattell, 1982, p. 23). Each subscale, including the integrated (I) and unintegrated (U) MAT subscales, is scored separately.

DESIGN AND PROCEDURE

To avoid the unreliability and specificity of items (cf. Cable, 1972; Cattell, 1973; Boyle, 1979), the 8SQ and MAT subscale scores for all 258 students were intercorrelated, producing a 28 × 28 matrix. While the intercorrelations among the 8SQ scales ranged from .48 to .83, those among the 20 U and I MAT subscales ranged from .01 to .29. There were few significant correlations between 8SQ and MAT subscales. As per the factor analytic methodology enunciated by Cattell (1973, pp. 282-287; 1979, p. 351), and confirmed by Kline (1979, pp. 38-41), an iterative principal factoring analysis was performed. Initial communality estimates (SMC's) were iterated until convergence occurred at well beyond the fifth decimal place (550 iterations). Hence the communality estimates were accurate, and not inflated, as occurs in the principal components method, which adds spurious common factor variance into the solution (Lee & Comrey, 1979, p. 301). A plot of the eigenvalues indicated eight significant factors on the basis of the Kaiser — Guttman (K-G) criterion. The scree test (Cattell, 1966) indicated 11 significant factors (see Fig. 1.)

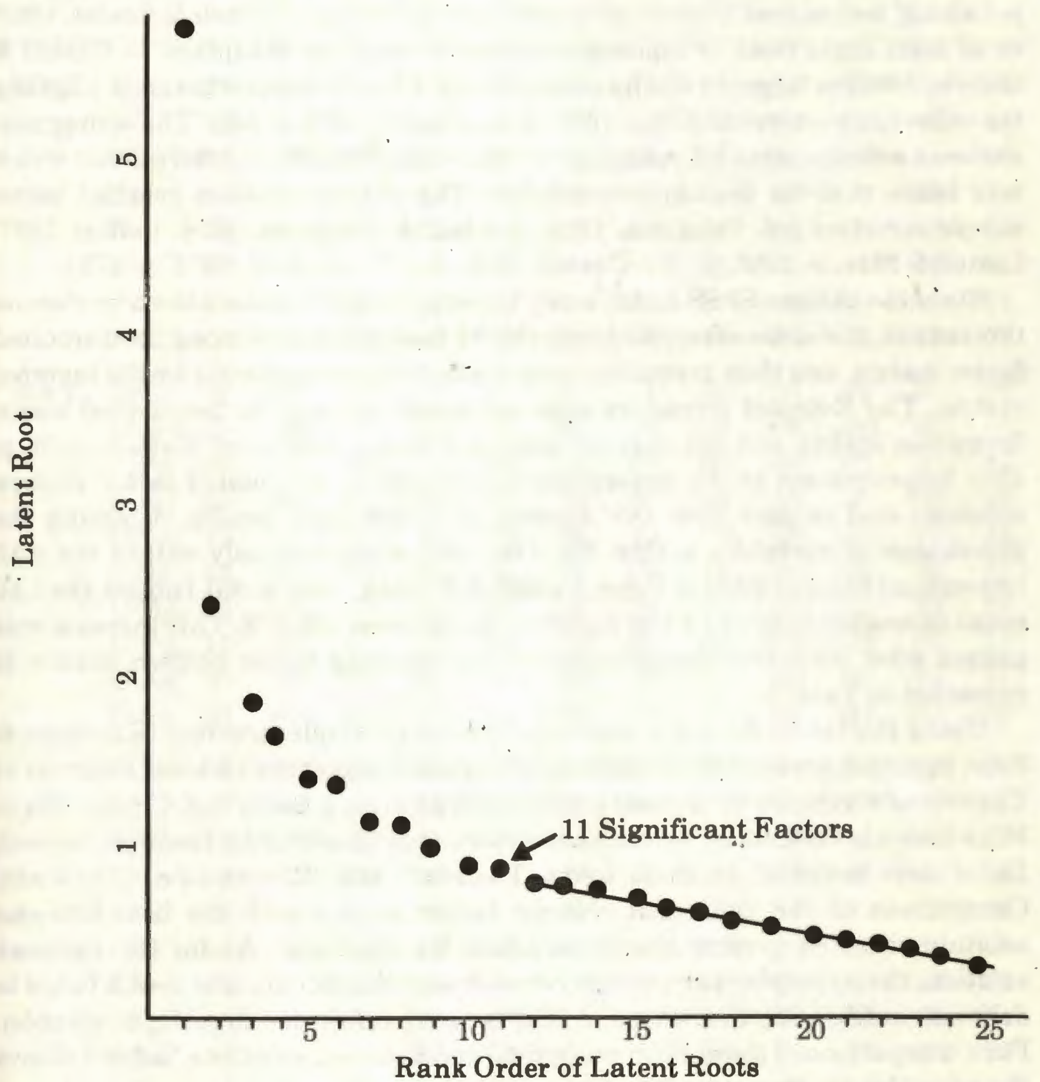

Figure 1. Scree plot of latent roots on 8SQ and MAT data ($N = 258$)

Using the SPSS package (Nie, Hadlai, Hull, Jenkins, Steinbrenner, & Bent, 1975), 11 factors were rotated to both the orthogonal varimax criterion, and to an oblique (direct oblimin) solution. Despite its limitations (cf. Cattell & Vogelmann, 1977; Hakstian, Rogers & Cattell, 1982), the scree test gave a more accurate indication of the correct factor number than did the K-G criterion (which seriously underestimated the number of significant factors). Eleven factors were rotated since underfactoring would have thrown useful information away (cf. Crawford, 1975).

RESULTS

The advantage of 550 iterations was that the hyperplane (±.10) count increased from 64.61% for the oblimin solution with only 28 iterations (convergence at third decimal place) to 65.91%. While this increase was small, it did allow a more accurate point of departure for the subsequent rotation and 'visual polishing' techniques. Cattell advocated use of Rotoplot (Cattell & Foster, 1963) or at least some form of topological rotation (such as Maxplane — Cattell & Muerle, 1960) to improve the hyperplane count by more appropriately aligning the reference vectors (cf. Kline, 1979, p. 41; Cattell, 1978, p. 142). The orthogonal varimax solution gave a hyperplane (±.10) count of 64.29% (550 iterations) which was below that for the oblimin solution. The oblique rotation reached better simple structure (cf. Vaughan, 1973; Burdsal & Vaughan, 1974; Bolton, 1977; Cattell & Muerle, 1960, p. 569; Cattell, 1978, p. 137; Nie et al., 1975, p. 473).

Since the oblique SPSS factor analytic output did not contain the transformation matrix, it was necessary to derive this by first pseudo-inverting the unrotated factor matrix, and then premultiplying the factor pattern matrix by the inverted matrix. The Rotoplot procedure was instigated using both the derived transformation matrix and the original unrotated factor matrix (cf. Cattell, 1978, p. 151). Improvement to the hyperplane count (and to the rotated factor pattern solution) was evident from the 'History of Hyperplane' profile, depicting the percentage of variables within the ±.05, and simultaneously within the ±.10 hyperplane bandwidths (cf. Price, Cattell, & Patrick, 1981, p. 85). Indeed, the ±.10 count increased from 65.91% to 72.08% — an increase of 6.17%. This increase was gained after only five Rotoplot runs. The resulting factor pattern matrix is presented in Table 1.

Using the tables for statistical significance of simple structure (Kameoka & Sine, in press), seven of the 11 factors were significant at the 1% level. In terms of Thurstone's criterion of "at least n zero loadings in each factor" (cf. Child, 1970, p. 56), where n is the number of common factors, only 11 zero order loadings for each factor were required. In these terms, Factors 7 and 10 were also significant. Comparison of the analytical oblimin factor pattern with the best Rotoplot solution revealed greater simple structure for the latter. As for the varimax solution, the hyperplane count was below that of the oblimin one, and it failed to delineate sufficiently the two major 8SQ factors exhibited in the oblique solution. For a comparison of the oblique analytical and Rotoplot solutions, Table 2 shows the variables loading significantly on each factor for each solution.

The Rotoplot solution was more readily interpretable with less overlap between the factors. Factors 1, 8, 9, and 11 were less complex in the Rotoplot solution. The factor pattern failed to demonstrate any overlap of the higher-order 8SQ and MAT factors, thereby providing support that the two measures tap discrete psychological variance. Factor pattern correlations ranged from -.52 to .24, however the vast majority did not reach significance at the 5% level. Interpretation of these higher-order factors is best made in terms of the variables loading significantly.

TABLE 1

Oblique Factor Solution on 8SQ and MAT Variables

	Variable	Factor Number 1	2	3	4	5	6	7	8	9	10	11	h^2
8SQ	Ax	**69**	03	01	-07	01	06	-16	05	01	03	-05	92
	St	**56**	07	09	-10	-09	04	-14	05	00	12	03	64
	De	**44**	-05	-07	-09	03	01	**-38**	03	12	-14	04	87
	Rg	**44**	-06	05	10	10	00	**-29**	03	10	-14	02	73
	Fa	18	04	01	08	00	-07	**-63**	-01	-06	04	-10	78
	Gi	**66**	-15	03	15	03	-09	-02	01	06	-15	-08	81
	Ex	-17	02	14	02	-04	-09	**54**	03	01	19	-15	73
	Ar	-08	-06	09	-09	01	-03	**64**	03	-10	05	00	75
MAT	U-Ca	-01	00	-03	**-35**	10	-11	11	-01	05	-02	01	23
	U-Ho	-09	**48**	06	05	12	07	10	05	-08	**-20**	00	43
	U-Fr	03	01	04	08	**-60**	-02	06	01	05	03	-01	40
	U-Na	-06	**-30**	12	-09	-07	00	-03	16	-18	06	-08	30
	U-Se	15	19	-01	02	03	06	13	**-22**	-10	-12	07	25
	U-Ss	02	02	-09	-05	02	08	08	-19	**-35**	06	00	25
	U-Ma	-06	-10	16	**41**	**25**	06	02	03	07	11	01	37
	U-Pg	10	03	01	07	-10	**24**	02	**39**	04	00	-01	31
	U-As	03	00	-06	-06	-07	-01	02	-10	**52**	03	04	34
	U-Sw	-05	-03	-01	02	-01	02	03	-01	00	**51**	-03	32
	I-Ca	-01	-03	03	04	-07	**-45**	02	01	08	-03	02	23
	I-Ho	-02	**69**	01	-14	-01	-07	-10	05	01	07	-17	61
	I-Fr	-11	-02	**33**	-11	-17	-01	-08	02	-05	-16	18	31
	I-Na	-03	03	**20**	**-53**	13	18	-01	-05	03	07	06	42
	I-Se	-01	-10	-01	00	-03	-05	-01	05	-04	-02	**56**	43
	I-Ss	-08	-10	**32**	-02	-10	**31**	-12	**-52**	08	-05	-10	66
	I-Ma	10	-05	12	05	05	**20**	06	17	05	10	-19	22
	I-Pg	-09	-07	**-61**	01	-05	08	-09	05	05	-05	08	44
	I-As	-02	-19	-02	-05	-04	-04	-04	06	08	-03	**-23**	23
	I-Sw	08	22	12	12	07	-03	-06	-02	-12	16	12	28
Hyper-plane Count	±.10	19	21	19	21	21	22	17	22	22	17	21	
	±.05	10	12	12	9	12	12	10	16	9	11	14	

Notes. (i) Factor loadings rounded to two decimal places.
(ii) Significant loadings bold.

TABLE 2

Significant Variables for Each Factor Solution

Factor	Oblimin	Rotoplot
1	Ax, St, De, Rg, Fa, Gi *vs.* Ex	Ax, St, De, Rg, Gi
2	(U + I) Ho, I-Sw *vs.* U-Na	(U + I) Ho, I-Sw *vs.* U-Na
3	I-Fr, I-Na, I-Ss *vs.* I-Pg	I-Fr, I-Na, I-Ss *vs.* I-Pg
4	U-Ma *vs.* U-Ca, I-Na	U-Ma *vs.* U-Ca, I-Na
5	U-Ma *vs.* U-Fr	U-Ma *vs.* U-Fr
6	U-Pg, I-Ss, I-Ma *vs.* I-Ca	U-Pg, I-Ss, I-Ma *vs.* I-Ca
7	Ex, Ar *vs.* De, Rg, Fa	Ex, Ar *vs.* De, Rg, Fa
8	U-Pg *vs.* U-Se, (U + I) Ss	U-Pg *vs.* U-Se, I-Ss
9	U-As *vs.* U-Ss, U-Na	U-As *vs.* U-Ss
10	U-Sw *vs.* U-Ho	U-Sw *vs.* U-Ho
11	I-Fr, I-Se, I-Sw *vs.* I-Ma, I-As	I-Se *vs.* I-As

DISCUSSION

That extraction and rotation of 11 factors was correct was checked empirically with factor patterns resulting from extraction of 8, 9, 10, 12, and 13 factors. Below 11 factors important information was lost and factor space was inadequate. Above 11 factors, primaries began to emerge (e.g., I-Ca, I-Fr, U-Sw) with only one significant factor loading (cf. Bolton, 1977, pp. 4-5). The general superiority of the scree test over the K-G criteria has been well documented in previous studies (cf. Cattell & Vogelmann, 1977, p. 318). The correct number of factors was extracted in the present study. As Cattell (1978, p. 189) demonstrated, "... rotation offers a second 'court of appeal'." There was noticeable decline in factor variance with 12 or more factors. Examination of factor solutions with less than 11 factors, revealed wide (at least ±.20) hyperplanes. With 11 factors, the ±.10 hyperplane count was 72.08% as stated above.

Whereas underfactoring produces pseudosecondaries (Eysenck & Eysenck, 1976, pp. 53-54), overfactoring produces pseudospecific factors (Crawford, 1975, p. 226). The use of the 'blind' Rotoplot finish to objectively attain greater simple structure (determined by increasing ±.10 hyperplane counts), dramatically altered the resulting factor pattern. Hence Cattell's contentions concerning topological rotation seem correct. Rotoplot provides an effective means of improving simple structure over and above that attained by oblique analytical rotation alone.

While three third-order factors had been reported previously (Kline, 1979, pp. 169-170) for the 8SQ (8SQ subscales are largely at the second-stratum level, with the exception of Stress, and Fatigue — Cattell, 1973, p. 228), only *two* third-order factors emerged in the present study. The first represented a cluster of stress related subscales (Anxiety, Stress, Depression, Regression, Guilt) rather indicative of neuroticism. The other characterized the extraversion — introversion dimension (cf. Eysenck & Eysenck's 1969, N and E factors). This bipolar factor contrasted Extraversion, and Arousal at one pole, with Depression, Regression, and Fatigue at the other. Hence the 8SQ appears too narrow in the range of states tapped. One dimension suggested in factor analytic research (Boyle, 1979; 1983a) is state curiosity. Another is state hostility (cf. Zuckerman, 1976; 1979). Variables related to these states should be included in any resampling of the state sphere.

Nine second-order MAT factors emerged. Previously Cattell (1957) reported six secondaries. However as Kline (1979) pointed out, "This preliminary research is not particularly helpful in classifying what is obviously a highly complex field. Certainly no substantive implications can be drawn from the results" (p. 185). Burdsal (1975) reported six secondaries, which according to Kline (p. 185), ". . . bore little relation to those discussed above or to the hypotheses implicit in the nature of these ergs and sentiments." That Burdsal underfactored is almost certain, since his hyperplane count (±.10) reached only 62.7%, even though he employed Rotoplot *and* Maxplane. The present findings attained greater simple structure since the ±.10 hyperplane count was almost 10% higher than that obtained by Burdsal.

Interpretation of the nine bipolar higher-order MAT factors was less than certain, given the factor complexities as defined by the loadings in Table 1. However, the first of these MAT factors contrasted home orientation and sweetheart attachment with narcistic tendencies, suggesting therefore, the incompatibility of family life and self-indulgent gratification. This factor might be labelled *Family vs. Self-Orientation.* The second contrasted the I components of fear, narcism, and self-sentiment with pugnacity. This secondary partially resembled the largest second-order MAT factor reported by Cattell (1957) which he interpreted as ergic inhibition versus ergic expression. While having some of this flavor, it also suggested caution and self-protection as opposed to outright aggression, and destructive, hostile impulses. This factor might be labelled *Caution vs. Hostility.* The third factor contrasted mating tendencies with attitudes toward self-satisfaction through a career, suggesting therein, the incompatibility of a successful career, with unrestrained sexual behavior. Seemingly the latter would need to be well controlled if it is not to distract one, and interfere with career attainment. This secondary might be labelled *Sexual Expression vs. Career Comfort.* The fourth factor contrasted mating and fear ergs, suggesting the incompatibility of strong sex drive and heightened levels of alertness to external dangers. Such unconscious inhibition of sexual behaviors is readily apparent in the psychoanalytic case histories of neurotic individuals, for example. This factor might be labelled *Uninhibited vs. Inhibited Libido.* The fifth MAT secondary contrasted pugnacity, self-sentiment, and mating tendencies with career orientation. This factor suggested an incompatibility betweeen excessive self-concern and career. It might be labelled *Selfishness vs. Occupational Success.* The sixth factor contrasted pugnacity with superego and self-sentiment. It suggested the incompatibility of aggressive, destructive, hostile impulses with self-integrity in terms of one's social repute and moral respect. This factor might be labelled *Hostility vs. Self-Integrity.* The seventh factor was an unintegrated one contrasting assertiveness with self-sentiment. According to this factor, the level of drive to self-assertion, mastery, and achievement is inversely related to level of self-concern. Presumably the more an individual is preoccupied with him/herself (perhaps even in the sense of neurotic self-concern), the less likely is that individual to achieve, and be self-assertive. This factor might be labelled *Assertiveness vs. Self-Sensitivity.* The eighth factor contrasted sweetheart-spouse sentiment with strength of attitudes attaching to the parental home. This factor might be labelled *Sweetheart vs. Parental Attachment.* Finally, the ninth MAT secondary contrasted superego with assertiveness, suggesting therefore, an incompatibility of the strength of the drive to achieve with the level of one's conscience development. This factor might be labelled *Conscience Development vs. Achievement Motivation.*

All the MAT secondaries make good psychological sense, although their specific interpretations remain tentative, pending cross-validational studies with differing and larger samples. The two previous investigations of higher-order structure of the MAT failed to provide substantive evidence on the MAT secondaries. Given the comments above concerning underfactoring, and the attainment of *maximum* simple structure, the present study has seemingly provided the first valid, albeit approximate evidence on this issue. These conclusions apply also to the higher-order factor structure of the 8SQ.

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