A reanalysis of the higher-order factor structure of the Motivation Analysis Test and the Eight State Questionnaire

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A Reanalysis of the Higher-Order Factor Structure of the Motivation Analysis Test (MAT) and the Eight State Questionnaire (8SQ)

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Abstract

In an exploratory study of the higher-order factor structure of the Motivation Analysis Test (MAT) and the Eight State Questionnaire (8SQ), Boyle (1983c) obtained an 11-factor solution comprising 9 second-order MAT factors and 2 higher-order 8SQ factors. However, application of more conservative criteria regarding the size of significant factor pattern loadings, significance of derived factors, together with reinterpretation of the appropriate Scree 'break', suggest that in Boyle's earlier analysis two factors too many were extracted. Recalculation of the factor pattern for the MAT (using 8SQ data as 'hyperplane stuff') supports the view that 7 rather than 9 second-order MAT factors were appropriate. A separate dR-factoring of the intercorrelations of the subscale difference scores indicated 3 higher-order 8SQ factors, indicative of change dimensions, and not 2 factors as found in the static single-occasion combined factoring of both the MAT and 8SQ data.
Introduction

The higher-order factor structure of the Motivation Analysis Test (MAT; Cattell, Horn, Sweney and Radcliffe, 1964) and the Eight State Questionnaire (8SQ; Curran and Cattell, 1976) has not yet been resolved adequately (Cattell and Kline, 1977; Kline, 1979, 1980, 1982) despite a number of studies in this area (e.g. Cattell, 1957; Burdsal, 1973, 1975, 1976; Gillis and Lee, 1978; Stewart and Stewart, 1976; Cooper and Kline, 1982). Each of these prefatory studies has been defective on various counts as indicated by Boyle (1983c, 1984a).

In the most recent scale factoring of the MAT and 8SQ, Boyle (1983c) provided a detailed R-factoring of the two instruments, both of which have been shown to have important operational characteristics in applied research (e.g. Boyle, 1983b). Following the factor-analytic guidelines proposed by Cattell (1973, 1978, 1983) and Kline (1979, 1980, 1982), which were discussed by Boyle (1983a-c), an iterative principal-factoring procedure with SMCs as initial communality estimates was performed for an Australian sample of 258 teacher college students. This procedure has been recognized as an appropriate method of factor analysis by Gorsuch (1983). Likewise, Cureton and D'Agostino (1983, p. 137) asserted that the principal-factoring approach is the method of choice for initial factoring of a domain. The Scree test (e.g. Hakstian, Rogers and Cattell, 1982) suggested either 9 or 11 factors. However, the larger number was extracted and rotated to oblique simple structure via direct Oblimin plus topological Rotoplot (see Cattell, 1978) in order to avoid the possibility of under-extraction. This paper presents a reanalysis of the higher-order factor structure of both the MAT and 8SQ, in the light of the stringent methodological procedures advocated
by Barrett (1983). In addition, the 8SQ data for a second measurement occasion which was not utilized in Boyle's (1983c) study is incorporated here, enabling the presentation of results of a dR-factoring of the multivariate mood-state instrument (a method more appropriate for the elucidation of states/change dimensions).

**Combined Single Occasion Re-factoring of MAT and 8SQ Scale Data**

Apart from the iterative principal-factoring methodology suggested by Cattell (1973, 1978, 1979, 1983), Kline (1979, 1980, 1982), Gorsuch (1983), Cureton and D'Agostino (1983) among others (although Velicer, Peacock, and Jackson (1982) queried its superiority over image principal components), a number of specific decision points remain somewhat arbitrary. Specifically, the size of factor loadings which have conceptual and practical importance (and not just statistical significance by the Burt-Banks formula-see Child (1970)-which occurs all too frequently with large samples), the conceptual and statistical significance of extracted factors by the Sine and Kameoka (1978) tables of significance of simple structure, and the 0.10 hyperplane count index of attainment of maximum simple structure, need to be considered very carefully in determining the appropriate number of factors to extract and rotate. As Cattell (1979. p. 351) pointed out.

“... a factor analysis without a thorough test of number of factors is going to be wrong in all subsequent steps and to generate false perturbation factors or false patterns in real factors.”
Strict consideration of the above criteria as suggested by Barrett (1983) revealed that Boyle (1983c) had over-extracted by 2 factors, thereby reducing the validity of his final rotated factor pattern solution.

Boyle accepted factor pattern loadings of 0.20 as meeting the criterion for practical significance in order not to miss any important loadings. While it is true that such loadings were statistically significant, they were probably of little practical consequence since the variance accounted for was only 4%. Evidently, application of the Burt-Banks formula is irrelevant to the problem, and at the very least, needs modification so that only factor pattern loadings which account for sufficient variance are accepted as being statistically significant. Modifying the interpretation of a factor defined by variables that have only 4% of their variance accounted for by that factor seems unjustified. According to Barrett (1983), "given the likely amount of measurement error per variable, and the reliability of each test variable, attempting to use such variables in any explanatory exercise is very risky." In the light of Barrett and Kline (1982a,b), Nunnally (1978), Lee and Comrey (1979) and Gorsuch (1983) it seems preferable, as a rule-of-thumb, only to consider loadings of at least 0.30 as being conceptually relevant in iterative principal-factoring solutions. On this criterion, Boyle extracted too many factors. Boyle (1983c) extracted 11 factors, even though 2 were only significant at the 10% level, using Sine and Kameoka's (1978) tables. It was inferred that these tables were not sufficiently sensitive. However, despite limitations (Barrett, 1983; Gorsuch, 1983), the test may remain a satisfactory procedure in some instances (Cureton and D'Agostino, 1983). The finding that only 9 of the 11 extracted factors were significant at or beyond the 5% level supports the view that over-extraction occurred, however.
While it is true that Boyle obtained a high ± 0.10 hyperplane count of 72.08% for his final rotated (and ‘visually polished’) factor pattern solution, consideration of the total solution hyperplane count is not the sole, nor even the most important, criterion of attainment of maximum simple structure (cf. Gorsuch, 1983). Clearly, as the number of factors extracted is increased, the hyperplane count also increases. According to Barrett (1983), “…there can be no deterministic method for assessing ‘adequate' hyperplane values. This is as much a function of the particular factor variable relationships in question as well as the number of factors to be rotated. Simple structure is a concept that requires empirical maximisation...” The necessary slight reduction in hyperplane count with extraction of fewer than the 11 MAT/8SQ factors in Boyle's study therefore seems unavoidable.

As already indicated, the subjective Scree test indicated either 9 or 11 higher-order MAT and SSQ factors. Extraction of 9 factors would still have been more than the 8 conservatively indicated by the outmoded Kaiser-Guttman (K-G) criterion (cf. Barrett and Kline, 1981 1982b: Zwick and Velicer, 1982). Evidently, subjective interpretation of the Scree test is not particularly reliable. Barrett (1983) and Barrett and Kline (1982b) have developed an automated Scree test that overcomes this subjectivity in interpretation, as well as providing a semi-objective computer algorithm for practical use. Barrett (1983) reported that the automated Scree test was more accurate than Kline's judgements of the appropriate Scree "break'. Similarly, Gorsuch and Nelson (1981) have devised the objective CNG Scree test (cf. Gorsuch, 1983). According to Gorsuch, the CNG Scree test was more accurate than was subjective use of the Scree test when applied to the data of Cattell and Vogelmann (1977). The objective CNG Scree test emerges as well as,
if not better than, most alternative methods such as Revelle and Rocklin's (1979) VSS method or Velicer's (1976) MAP test (Gorsuch, 1983, Chapter 8).

With large correlation matrices as in Boyle's study, the need for very accurate communality estimates is not essential (Harman, 1976; Nunnally, 1978; Gorsuch, 1983). Accurate communality estimates are however, very important with small intercorrelation matrices, if the derived factors are to be valid. As for the Rotoplot topological finish, some 6% improvement in the ± 0.10 hyperplane count occurred over that for the direct Oblimin solution. However, only five Rotoplot cycles were completed by an investigator untrained in the procedure, whereas Cattell (1978, Chapter 7) had recommended that up to 20 or more cycles should be run in the search for maximum simple structure approximation of the final factor pattern solution. The main disadvantage of Rotoplot is that it is time-consuming, although the method has proved beneficial in a number of instances (e.g., Cattell and Nesselroade, 1976; Cattell, McGill, Lawlis and McGraw, 1979; Gillis and Cattell, 1979; Burdsal and Bolton, 1979; Price, Cattell, and Patrick, 1981).

**Procedure**

As in Boyle's (1983c) study, an iterative principal-factoring procedure was employed starting from the MAT and 8SQ scale correlations. Convergence at the fourth decimal place required 169 iterations, ensuring accurate communality estimates. More importantly, only 9 higher-order MAT and 8SQ factors were extracted on the basis of the reinterpretation of the Scree test, as discussed above. Only factor pattern loadings 0.30 were considered as significant. Rotation was to
the analytical direct Oblimin criterion alone. Finally, all 9 factors were tested for statistical significance using the tables of Sine and Kameoka (1978).

Results and Discussion

The ± 0.10 hyperplane count for the 9-factor direct Oblimin solution was 60.71% as compared with the 65.91% count obtained with the direct Oblimin solution prior to application of the Rotoplot finish in Boyle's earlier study. Hence the decrease in hyperplane count was fairly slight despite the extraction and rotation of 2 fewer factors. Application of Sine and Kameoka's (1978) tables for significance of simple structure unexpectedly revealed that again not all extracted and rotated factors were significant by this criterion. In particular, the two higher (third)-order 8SQ factors [8SQ scales are at the second-stratum level except for Stress and Fatigue—Cattell, 1979, p. 284] were statistically nonsignificant by the Sine and Kameoka tables. Evidently, the results of this test are spurious (cf. Barrett and Kline, 1980). Indeed, Barrett (1983) stated that.

"Given the tables are generated from Monte-Carlo studies using randomly generated data, under the assumption of an expected number of values being located within a ±0.10 region, the test is simply not sensitive to the specific data relationships in every sample of real data. What generally happens is that the observed factor hyperplanes are assigned low significance levels ... where it is obvious from external validity information that the concepts/scales are valuable measurement devices ... It is obvious that the Bargmann test can generally be considered to be irrelevant to the psychometric and psychological validity of a solution."
The present author can only agree with these comments of Barrett, on the basis of the findings presented here. The factor pattern for the obliquely rotated solution (cf. Loo. 1979) is shown in Table I.

Detailed psychological interpretations of the 11 higher-order MAT and 8SQ factors (9 MAT and 2 8SQ factors) obtained by Boyle (1983c) were reported in that paper. For the present purpose, it is not necessary to repeat these details here, as 7 of the present 9 extracted factors are essentially identical with 7 of the 11 factors reported by Boyle (1983c). Only two of the present 9 factors differ significantly from those extracted earlier. Thus, Factor 6 (see Table 1) represents both the integrated and unintegrated components of the Fear erg, and is clear evidence of the validity of this erg as measured in the MAT. The integrated and unintegrated components of the Fear erg were split-up in the earlier 11-factor solution which suggests that factor fission occurred irrespective of the conclusions reached earlier. Accordingly, the present Factor 6 was not represented adequately in the earlier analysis. Also, Factor 9 is an expansion of the eleventh factor in Boyle (1983c) and is now recognized as indicating Assertiveness.

Table 1
Direct Oblimin Factor Pattern for MAT and 8SQ

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vs. Passivity. In the present analysis, two ergs (Fear and Assertiveness) and one sentiment/sem (Home-Parental) received strong support as both the unintegrated and integrated components coalesced in a single factor for each. The present
findings, along with the review of Boyle (1984a) strongly suggest the inadequacy of Cooper and Kline's (1982) higher-order R-factoring of the MAT.

The intercorrelations of the total 9 factors are presented in Table 2. While it is evident that the 2 8SQ factors (Factors 1 and 8) were moderately intercorrelated, most of the remaining intercorrelations were quite small. This suggests the efficacy of the general oblique rotational strategy to approximate the 'special orthogonal position' when so required (cf. Cattell, 1978; Loo, 1979). Both positive and negative variation in level of intercorrelations using the $\delta$-shift parameter in the SPSSX package (SPSSX, 1983) resulted in lower hyperplane counts and reduced approximation to simple structure.

Comparison of the present findings with those of Boyle (1983c) demonstrate that in most instances the factor loading pattern was simplified in the reanalysis, thereby supporting the appropriateness of the more stringent criteria employed here.

<table>
<thead>
<tr>
<th>Table 2 Factor Pattern Intercorrelations ($N = 258$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summary of Combined R-factoring of MAT and 8SQ</td>
</tr>
</tbody>
</table>

The present reanalysis of the higher-order factor structure of the MAT and 8SQ demonstrated the necessity for appropriate decisions in conducting an exploratory factor-analytic study. The subjectivity of the Scree test was demonstrated when Boyle (1983c) extracted 2 factors too many. It is suggested that future exploratory factor-analytic investigations employ an objective Scree test such as that devised by Gorsuch and Nelson (1981), or Barrett and Kline
The importance, as a rule-of-thumb, of accepting factor pattern loadings no less than 0.30 was demonstrated. The present findings represent a simplification of those in Boyle (1983c) and probably are the most accurate statement on the higher-order structure of the MAT to-date.

**Higher-Order dR-Factor Analysis of the 8SQ**

The R-factoring of the combined MAT/8SQ data utilized only the information obtained from a single occasion of measurement. Accordingly, the derived factors were like a static photograph of the particular state and motivational dynamic dimensions, portraying their respective levels at that moment in time. In order to elucidate change dimensions per se, a dR-factoring of the 8SQ across two separate measurement occasions was required. This procedure has received support in the literature (e.g. Cattell, 1979, 1982; Lam, 1981). According to Nesselroade and Cable (1974, p. 281),

“...from a structural point of view, difference scores offer one way of getting at the multidimensional nature of change ... for some types of change, difference score factor analysis is not misleading but actually rather precise in not only revealing change dimensions but in suppressing dimensions of stable interindividual differences."

The use of dR-factoring of the 8SQ intercorrelations of the scale difference scores across two occasions potentially offered greater insight into the actual higher-order change dimensions measured in the mood-state instrument. Some 123 teacher college students took the 8SQ before and after exposure to disturbing stimuli which were known to induce significant alterations in mood states (Boyle and Cattell, 1984). A further 135 students took the 8SQ 3 weeks apart under
neutral mood conditions on each measurement occasion, as indicated in Boyle (1983b). Visual inspection of the 8SQ scale data prior to computing the difference scores indicated that there was a wide range of scores, and that they were relatively free of floor and ceiling effects (cf. Cattell, 1978). Means and standard deviations for the change scores are presented in Table 3.

As with the R-factoring of the combined MAT/8SQ data, an iterative principal-factoring procedure (with 277 iterations) was employed. In this instance it was more important to derive accurate communality estimates as the 8 x 8 correlation matrix was not large. Whereas the K-G criterion suggested only 2 higher-order dR-factors for the 8SQ, the Scree test clearly indicated 3 factors. As shown by Cattell and Vogelmann (1977), as well as Hakstian, Rogers, and Cattell (1982), the K-G criterion underestimates the appropriate number of factors when the number of variables is less than about 20. On the other hand, it overestimates the number of factors when the number of variables exceeds 50 or so (cf. Child. 1970).

Table 3 Means and standard deviations for 8SQ change scores (N = 258)

<table>
<thead>
<tr>
<th>Variable</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anxiety</td>
<td>5.59</td>
<td>5.24</td>
</tr>
<tr>
<td>Stress</td>
<td>5.43</td>
<td>2.90</td>
</tr>
<tr>
<td>Depression</td>
<td>4.83</td>
<td>4.66</td>
</tr>
<tr>
<td>Regression</td>
<td>4.00</td>
<td>3.63</td>
</tr>
<tr>
<td>Fatigue</td>
<td>5.04</td>
<td>4.88</td>
</tr>
<tr>
<td>Guilt</td>
<td>4.33</td>
<td>4.18</td>
</tr>
<tr>
<td>Extraversion</td>
<td>-3.97</td>
<td>3.77</td>
</tr>
<tr>
<td>Arousal</td>
<td>-4.02</td>
<td>3.56</td>
</tr>
</tbody>
</table>
The 3-factor direct Oblimin rotated solution is shown in Table 4.

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Evidently, the first dR-factor involved a combination of Anxiety, Stress, Depression, Regression and Guilt (as found in the single-occasion R-factoring of the MAT8SQ data), reminiscent of Eysenck’s (e.g. 1983) Neuroticism dimension, but at the state level. The second 8SQ factor clearly represented Eysenck’s Extraversion factor within the state realm, while the third dR-factor contrasted Fatigue with Arousal, indicative of a physiological dimension pertaining to CNS activation levels (cf. Meites, Lovallo, and Pishkin. 1980). Thus the dR-analysis supported the static picture of the 8SQ higher-order factors already found in the R-factoring of the MAT and 8SQ together. In addition, it demonstrated that at the state level. Extraversion is a separate entity (as defined within the limits of the 8SQ measure) from the Fatigue-Arousal one.

Conclusions

It is concluded therefore, that the 8SQ comprises 3 higher-order (tertiary) factors, and that the dR-technique is a useful procedure when factoring instruments purported to measure dimensions of change. Given the rather speculative nature of the previous investigations of the higher-order 8SQ structure (Stewart and Stewart, 1976; Cattell and Kline, 1977), it appears that the present
dR-findings (which were obtained on a large sample of 258 Ss and verified in terms of the separate data of the single-occasion R-factoring of the MAT and 8SQ) are probably the most accurate to date. Correlations of the 3 higher-order dR-factors were moderate (Factor 1 correlated 0.44 with Factor 2. and 0.52 with Factor 3. while Factor 2 correlated 0.47 with Factor 3). Variations in the level of obliquity using the SPSS δ-parameter reduced the approximation to simple structure of the factor pattern, as evidenced by lower hyperplane counts. If the 8SQ at the higher-order level is measuring state fluctuations in Extraversion, Neuroticism and Arousal, the instrument seemingly needs to be extended with items sensitive to psychotic mood changes as suggested by Kline (1979), and following directly from Eysenck’s factors (e.g., Barrett and Kline, 1980a,b). Concomitantly, the Eysenck Personality Questionnaire (EPQ; see S.B.G. Eysenck, 1983), although a trait measure, might be extended to include a dimension pertaining to characteristic physiological arousal. The development of a state EPQ might also prove useful.

Acknowledgements

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