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A RECONSIDERATION OF THE COOPER/KLINE CRITIQUE OF THE FACTOR STRUCTURE OF THE MOTIVATION ANALYSIS TEST

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ABSTRACT

Criticism of Cattell's Motivation Analysis Test (MAT) partly on the basis of a quasi-higher-order factor analysis of the MAT subscales on a sample of 109 subjects is untenable, given the methodological weaknesses inherent in the procedural application of the method by Cooper and Kline (1982). Cattell's (1982) response to the Cooper/Kline critique did not address these methodological issues directly, but instead concentrated on the controversy pertaining to intra-scale item-homogeneity. The debate over the structure of the MAT requires consideration of the factor analytic issues *per se*. The present reconsideration of the Cooper/Kline critique attempts to do this, and to provide a fuller perspective on the issues raised by Cooper and Kline.

A series of articles recently published in the *British Journal of Educational Psychology* concerning the internal structure of the Motivation Analysis Test (MAT) has left the reader with a less than adequate account of the reliability and validity of the instrument. Cooper and Kline (1982) criticized both the low item-homogeneities and also the factor structure of the MAT. Cattell (1982) responded to the Cooper/Kline critique and addressed the issue of intra-scale item-homogeneity. However the question of the factor structure of the MAT remained unresolved, and subsequently, Kline and Cooper (1982) reiterated their belief that the factor structures of the MAT were not stable across different samples. As Cattell did not address this issue in his response, it is germane to reconsider the evidence provided in the paper by Cooper and Kline. In particular, the present discussion focuses on (1) the validity of the MAT, (2) the number of subjects required, (3) the number of factors extracted, and (4) the question of simple structure. Finally, conclusions regarding the adequacy of the Cooper/Kline critique of the MAT are presented.

VALIDITY OF THE MAT

Cooper and Kline (1982), and subsequently Kline and Cooper (1982) argued that the factor analytic evidence on the higher-order structure of the MAT (e.g., Cattell, 1957; Burdsal, 1973, 1975, 1976) was inconsistent, thereby supporting

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their own factor analytic findings which were also inconsistent with these previous findings. Both Cattell, and Burdsal had reported six higher-order MAT factors, although the nature of these secondaries differed across studies. However, Burdsal (1975) clearly underfactored as his final factor solution attained a $\pm .10$ hyperplane count of only 62.7%. Gillis and Lee (1978) reported a nine-factor second-order MAT solution, and therefore, discounted these earlier results as being invalid. As their $\pm .10$ hyperplane count was 79%, their conclusions were probably correct. Similarly, Boyle (1983b) reported nine MAT secondaries and a $\pm .10$ hyperplane count which was almost 10% higher than Burdsal's.

The validity of the MAT has been demonstrated in numerous studies (e.g., Kline & Grindley, 1974; Birkett & Cattell, 1978; Cattell & Child, 1975). More recently, Boyle (1983a, 1984), as well as Boyle and Cattell (1984) have provided considerable evidence of MAT validity.

The confusion in the Cooper and Kline (1982) study was demonstrated in their statement (p. 230) that,

If the test were valid we should expect a clear factor structure of ergs and sentiments as described in the manual to the test. The MAT and 16PF scales were thus subjected to a rotated (direct oblimin . . .) factor analysis.

Unfortunately it is not possible to derive factors describing isolated ergs and sentiments when starting from the MAT scales (ergs and sentiments) themselves. It is unrealistic to expect the separate U (unintegrated) and I (integrated) primaries to coalesce in any simple way at the higher-order level. From a structural viewpoint (starting from the factorial compositions of the scales), it would be expected that higher-order factors involving various bipolar combinations of scale loadings would emerge (Boyle, 1983b, indeed reported such a finding). In order to obtain factors defining the separate ergs and sentiments, it would be necessary to factor the MAT item intercorrelations, or at least to factor several item parcels. By conducting their analysis on the MAT scales, Cooper and Kline precluded the possibility of obtaining factors defining discrete ergs and sentiments. Seemingly they failed to recognize that the MAT scales are already at the first-order factor level.

NUMBER OF SUBJECTS

Cooper and Kline's sample of only 109 male students was inadequate for factor analysis. Magoon (1980), and Nunnally (1978) argued for a minimum of 10 subjects per variable for valid factor analytic work. Nunnally however recommended 20 subjects per variable, and Magoon (1978) suggested that 30 subjects per variable was more appropriate for multivariate statistical applications. Even on the minimum requirement, Cooper and Kline needed a sample of 360 subjects (36 scales for the MAT and 16PF). Cooper and Kline's sampling error was almost certainly very significant, thereby reducing the validity of their factor solution.

NUMBER OF FACTORS

Cooper and Kline failed to justify adequately their decision to extract eight second-order factors. Their statement that the scree test indicated either eight or

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13 factors suggests an indecisiveness over its correct interpretation. The Kaiser-Guttman criterion suggested 13 factors. However, Cooper and Kline accepted the lower extraction estimate, citing Cattell (1978) that the Kaiser-Guttman method overestimates the number of significant factors. To the contrary, perusal of Cattell (p. 91) reveals that this index has been shown in several empirical analyses on plasmodes to underestimate the number of factors when there are few variables in the analysis. As Child (1970) pointed out, the Kaiser-Guttman estimate suggests too many factors when the number of variables exceeds 50. This certainly was not the case in the Cooper and Kline study.

The number of factors problem is complex (cf. Barrett & Kline, 1981; Zwick & Velicer, 1982). The scree test generally emerges as well as any other methods (e.g., the Velicer, 1976, or Revelle & Rocklin's, 1979, method), as shown in the studies by Cattell and Vogelman (1977), Horn and Engstrom (1979), and also Hakstian, Rogers, and Cattell (1982). Barrett and Kline (1982a, b) have developed an automated scree test that overcomes any subjectivity in interpretation. Barrett's semi-objective computer algorithm compared favorably with Kline's subjective judgment of scree. Barrett (Note 1) suggested that Kline's judgment was possibly amiss however, Given that the Kaiser-Guttman and scree test both indicated 13 factors, it is incomprehensible why Cooper and Kline only extracted and rotated eight factors.

SIMPLE STRUCTURE

It is difficult to draw any conclusions about the achievement of appropriate simple structure, as Cooper and Kline did not provide enough evidence on this issue. It is not clear if an iterative procedure was employed. This is important, as use of principal components adds spurious common factor variance into the solution due to inflated communality estimates (Lee & Comrey, 1979, p. 301). While the justification for using iterative principal factor analysis versus image component analysis may not be that strong (see Velicer, Peacock, & Jackson, 1982), Cooper and Kline at least should have reported their methodology so that other investigators could replicate their study and check their results.

It appears that resolution of unique simple structure was probably not attained by Cooper and Kline. Reliance solely on 'push-button' analytic rotation as in the direct Oblimin method is usually inadequate. Boyle (1983b, 1984) has reported the efficacy of the topological Rotoplot method in attaining superior approximation to simple structure with (1) resultant clarification of the final factor solution, (2) increased hyperplane count, and (3) more meaningful psychological interpretation. Cooper and Kline failed to indicate the extent to which any of these three criteria were achieved. They did not employ topological rotation. Use of Rotoplot may often improve approximation to maximum simple structure. The factor analyst has nothing to lose by employing it, and may sometimes have much to gain. Since Cooper and Kline almost certainly extracted too few factors, there would be little point in subjecting their factor pattern to a Rotoplot finish, in the hope of 'cleaning-up' their mixed secondaries. The problem in their analysis was more basic than this.

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To be certain of their findings, Cooper and Kline should have checked the invariance of their factors across different samples, using congruence, and salient-variable similarity indices (cf. Cattell, 1978). Any effects which are large would be expected to emerge from factorings that differ in minor procedural detail. Clearly there was no point in calculating similarity indices with those factors found by Burdsal (1975), as simple inspection of the solutions indicated no similarity. However, if Cooper and Kline's findings really were robust, a cross-validation study (which would have enabled such statistical comparison) should have been performed. No cross-validation was attempted.

CONCLUSIONS

The criticism of the MAT by Cooper and Kline (1982), and by Kline and Cooper (1982) was not justified insofar as their argument depended on their own inadequate factoring of the instrument. Methodological weaknesses included insufficient sample size, apparent incomplete factor extraction, failure to obtain maximum simple structure, and failure to cross-validate their findings. The early studies of Cattell (1957), and of Burdsal (1973, 1975, 1976) cannot be cited as relevant to any contemporary consideration of the higher-order factor structure of the MAT. Indeed, Cattell and Kline (1977, p. 184), and Kline (1979, p. 170) had called for further research into the higher-order factor structure for this very reason. In consequence, the Cooper and Kline study was pertinent, albeit methodologically unsound.

Nevertheless, the proper procedure to determine whether the ergs and sentiments in the MAT were valid was confirmatory factor analysis (see Nunnally, 1978, p. 420), rather than the exploratory procedure used by Cooper and Kline. The question was not whether other structures could be found for the MAT (a common result from exploratory factor analysis), but whether the ergic and sentiment factors as defined were sustainable — a confirmatory rather than an exploratory question. Cooper and Kline completely missed this crucial point.

Before castigating Cattell's MAT, it was beholden on Cooper and Kline to ensure that what they claimed was correct, and that their findings were robust. Even if the MAT is eventually shown as inadequate psychometrically, Cooper and Kline were not justified on the basis of their dubious factoring of the instrument to draw this conclusion. Their statement that the MAT requires extensive revision was clearly premature, and not sustainable on present evidence.

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REFERENCE NOTE: 1. P.T. Barrett, *Personal communication*, October, 1983.

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