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Estimation of Measurement Redundancy across the Eight State Questionnaire and the Differential Emotions Scale

Gregory J. Boyle*
University of Melbourne

The present article addresses the important issue of the psychometric assessment of mood, and evaluates the measurement overlap (redundancy) between two multidimensional instruments, the Eight State Questionnaire (8SQ) and the Differential Emotions Scale (DES-IV). Both measures are purported to index some of the major emotions evident in human behaviour. While the subscale descriptions differ somewhat across the two measures, nevertheless, some apparent commonalities exist, although in general each instrument seems to be tapping significant discrete psychological variance within the mood-state sphere. In order to quantify the measurement redundancy across the two scales, and to elucidate the content similarities and differences of the 8SQ and DES-IV subscales, both multiple-regression and canonical-redundancy analyses were computed for all 450 subjects. Results confirmed that only a small number of DES-IV subscales predicted most of the 8SQ variance, and vice versa, thereby suggesting avenues for improved psychometric assessment of mood.

Human behaviour is a complex product of the interaction of numerous intrapersonal psychological variables, including characteristic personality traits, dynamic motivational factors, intellectual abilities, and situationally sensitive, transitory emotional/mood states. These intrapersonal influences on behaviour each can account for up to 25 per cent of the variance involved in, say, academic achievement, giving a combined prediction of up to 60-75 per cent of the performance variance (Gillis & Lee, 1978, p. 241). The importance of this psychometric model for understanding the complexities of psychological moods has been documented by Kline (1980, 1982, 1983). These intrapersonal psychological structures (and especially the constantly fluctuating emotional states) are significantly influenced by environmental stimulation, as Cattell (1979) has described in his complex econetic model. Cattell (1983a) as well as Cattell and Brennan (1986) have proposed an abstruse modulation theory model for the investigation of human emotional states. The present paper focuses on the multivariate assessment of such situationally sensitive mood states.

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The effort to quantify human emotions has resulted in the development of a number of multidimensional self-report instruments designed to measure some of the most fundamental mood states. Measurement of moods is important, given that an individual's behaviour not only depends on trait personality and motivational propensities, but often more critically on the particular emotional feeling state which happens to be dominat at the actual time of behavioural response (cf. Thorne, 1974, 1980). Moreover, as Curran and Cattell (1976, p. 3) have pointed out, the importance of reliable and valid state measures is clearly evident in areas such as pharmaceutical research on new drugs, wherein the emotional reactions of the drug are investigated in comparison with placebo drugs; psychiatric evaluation of the emotional effects of different dosages of medication; educational evaluation of different classroom conditions such as a comparison of different teaching methods on learning outcomes; studies of morale in industrial and other occupational settings in response to work conditions being altered; clinical evaluation and monitoring of therapeutic intervention in treatment programmes; psychological research into the effects of experimental manipulation of mood states, and so on.

The use of multidimensional mood-state

instruments, rather than simpler unitary scales designed only to measure a single emotional state, has the obvious advantage of providing more comprehensive assessment of the range of moods which might be altered significantly under various conditions. The prevalent use of unitary mood-state instruments in the past (cf. Boyle, 1983a) has clearly hindered advancement of psychological research and practice. As Boyle (1985b, p. 52) stated in regard to the clinical measurement of depression, "The use of instruments designed only to index depression is a risky procedure. The difficulty in using such scales is that elevations in other psychological states such as anxiety or stress may go undetected. While scores on a single depression measure may alter due to therapeutic intervention, the greatest effect might involve other unmeasured states. Change in the depression score might even result from its correlation with other states. One can never really be certain that alterations to scores on a single scale of depression are due to alterations in depression itself. Contemporary psychometry of depression phenomena requires a multivariate perspective."

In addition to the need for multivariate measurement of psychological moods, it is important that the psychometric instruments employed have moderate rather than maximum item-homogeneities. In the past, the practice has often been to maximise internal-consistency thereby unnecessarily inducing significant item-redundancy. With high internal-consistency estimates (0.80 or higher) it is clear that the particular mood state being measured could be assessed more efficiently with a reduced number of items in the subscales. High levels of item-homogeneity/internal-consistency produce narrow, redundant measurement of the construct under investigation. What is required is broad measurement of the construct, wherein each item adds something new to the measurement variance. To achieve this, it is desirable that each item correlate highly with the actual construct/factor (i.e., has good concept validity), but exhibit only moderate correlations with the remaining subscale items. This issue has been discussed comprehensively by Allen and Potkay (1983), Boyle (1983a, pp. 389-390, 1985b, pp. 48-49), Cattell (1973, pp. 357-379, 1978, pp. 289-293, 1982), Kline (1979, p. 3), and Lachar and Wirt (1981). Clearly, it is not possible to simply equate internal-consistency estimates with notions of reliability of a scale (McDonald, 1981). In the present study, two multi-dimensional instruments of moderate item-homogeneity, purported to measure *source* states and *fundamental* emotions respectively, namely the Eight State Questionnaire (8SQ; Curran & Cattell, 1976), and the Differential Emotions Scale (DES-IV; Izard, Dougherty, Bloxom, & Kotsch, 1974) are compared in terms of their measurement overlap.

The DES-IV was developed by Izard and his colleagues on the basis of his differential emotions theory (e.g., Izard, 1980, 1982; Izard & Blumberg, 1985; Izard Blumberg & Oyster, 1985). The instrument was designed to measure the subjective-experience component of fundamental emotions which were discernible in the facial expression of infants. The DES-IV focuses on 12 discrete moods labelled: Interest, Joy, Surprise, Sadness, Anger, Disgust, Contempt, Hostility (inner-directed), Fear, Shame, Shyness, and Guilt. According to Izard et al. (1974, p. 1), each of the fundamental emotions measured in the instrument were "defined theoretically as having neural, neuromuscular-expressive, and experiential components. The components are interactive, but in the fundamental emotion process the common order of occurrence is: (a) efferent neural activity in the facial nerve and consequent patterned facial expression, (b) sensory feedback from the expression via the trigiminal nerve, (c) cortical integration of the sensory data and consequent subjective experience." The reliability and validity of the instrument has been examined in several studies (e.g., Emde, 1980; Fuenzalida, Emde, Pannabecker & Stenberg, 1981; Boyle, 1984a, 1985c, 1986b; Kotsch, Gerbing & Schwartz, 1982). Boyle (1984b) demonstrated the construct validity of several of the fundamental emotions using both factor anaysis and a repeated-measures application of discriminant function analysis. In particular, the subscales of Contempt, Suprise, Fear, and Disgust received clearcut support, from the item factor analysis, while the subscales of Sadness/Anger, Guilt/Sadness/Shame/Shyness, and Joy/Surprise/Interest emerged as combined factors (cf. Boyle, 1986b).

Apart from the DES-IV subscales of Sadness, Hostility, and Shame (which are comprised of four, seven, and eleven items respectively), the remaining subscales consist of merely three items each, which necessarily reduces their reliability in accord with the Spearman-Brown prophecy formula (cf. Crocker & Algina, 1986, pp. 118-119). Despite this limitation, estimated dependabilities (for immediate retest) range from .48 to .98, with the average reliability estimate being .76 over all 12 subscales (Boyle, 1986d). The subscales of Contempt, Hostility, Fear, Shame, Shyness, and Guilt all exhibit dependability estimates higher than that for the scale overall. As expected from the Spearman-Brown formulation, the largest subscale (Shame) exhibits the highest dependability (.98 in Boyle's, 1986d study). Realistically, the DES-IV assumes *patterns of fundamental emotions* wherein say, depression involves a pattern of Sadness, Shame, Guilt, Fear, and Hostility (inner-directed; cf. Izard et al., 1985). However, this patterns of fundamental emotions which together comprises the surface syndrome, can also be understood as primary (source) factors which relate to secondary (higher-order) factors within the usual hierarchical factor analytic model (cf. Cattell, 1978, pp. 198-204).

The 8SQ, which is based on the hierarchical common factor model, is purported to measure eight of the most important clinical *source* states which have been discerned factor analytically (Curran & Cattell, 1976). The states of Anxiety, Stress, Depression, Regression, Fatigue, Guilt, Extraversion, and Arousal have a measurement basis in the 8SQ. Each subscale comprises 12 items which are cyclically placed so as to avoid spurious contiguity effects. Hence, most of the 8SQ subscales are necessarily more reliable than are the DES-IV subscales with 8SQ dependabilities ranging from .91 to .96 (Curran & Cattell, p. 14), and the average dependability estimate being .94, which is clearly considerably higher than that for the DES-IV. The reliability and validity of the 8SQ has been supported in several studies (e.g., Boyle, 1983b, 1984a, 1985a, b, 1986a, c; Boyle & Cattell, 1984; Boyle, Start & Stanley, 1985). Although the 8SQ subscales have moderate intercorrelations (.48 to .83 in the Boyle et al. study, with the average being .66), accounted for partially in terms of trait contamination (cf. Cattell, 1979, p. 320), there is substantial evidence that the subscales have distinct hyperplances (cf. Cattell, 1978; Gorsuch, 1983) which precludes reducing them to a single factor (e.g., Barton & Flocchini, 1985). After comprehensively reviewing the psychometric evidence pertaining to the multivariate measurement of mood, Kline (1979, p. 170) concluded that basically, "These are the moods and states discovered by the proper application of multivariate analysis to the state sphere . . . these are the fundamental dimensions of moods."

Comparison of the states measured in the 8SQ with those in other multivariate mood-state instruments has received relatively little attention in the research literature. However, it is interesting to note that at least four or five of the 8SQ subscales appear to correspond highly with DES-IV subscales. Even so, the 8SQ subscales, Stress, Regression, and Fatigue appear to have no DES-IV counterpart, while the DES-IV subscales, Anger, Disgust, Shame, and Hostility seem to have no measurement basis in the 8SQ. In this context, it is germane to investigate further the measurement redundancy of both instruments, with particular attention being focused on those subscales which overlap significantly.

In assessing inter-inventory redundancy, previous studies have employed canonical correlation analysis combined with Stewart and Love's (1968) redundancy index (cf. Boyle et al., 1985). Appliction of canonical-redundancy analysis has enabled precise quantification of the measurement variance in one psychometric instrument accounted for by the other one, and vice versa. As Krug (1978, p. 201) pointed out, the use of canonical-redundancy analysis, "avoids theoretical controversies regarding methods of extraction and rotational techniques if the joint matrix were to be fully factor analysed." The validity of the canonical-redundancy approach has been supported frequently in the methodological literature (e.g., Gleason, 1976; van den Wollenberg, 1977; DeSarbo, 1981; Johansson, 1981; Muller, 1981). When used by itself, canonical correlation analysis is effectively "double-barrelled principal components anaylsis" (Tatsuoka in Cattell, 1978, pp. 390-396), a procedure while mathematically elegant, nevertheless is psychologically and substantively meaningless. Even rotation of the canonical variates is not particularly useful, with the only available option at present being rotation to the orthogonal criterion (cf. Cliff & Krus, 1976; Norušis, 1985, pp. 243-244). The problem with orthogonal rotation is that it artificially imposes orthogonality onto the data, when in reality the variables are actually correlated (cf. Loo, 1979). Moreover, as Cattell (1978, pp. 136-137) has correctly pointed out, an oblique rotation will actually stop at the appropriate special orthogonal position in the event that the factors are independent. However, such a situation is the exception rather than the rule. Nevertheless, *quantitative* estimation of inter-inventory redundancy by the Stewart and Love method is entirely justified on methodological grounds (cf. Harris, 1985).

In a different approach to the estimation of inter-inventory redundancy, Goldberg (1977) demonstrated the efficacy of employing stepwise multiple-regression procedures. This method has the advantage not only of quantifying the overall measurement redundancy across each psychometric instrument, but also of estimating multiple-regression equations for predicting the subscale scores in one instrument from those on the other one, and vice versa. A review of the literature in this area was undertaken by Campbell and Chun (1977) in regard to the overlapping in measurement of multidimensional personality inventories. Calculation of cross-inventory prediction equations results in a set of subscale predictors from one instrument which significantly predict the subscale scores in the other. This information identifies significant inter-inventory subscale redundancies. While such an approach enables both quantitative and qualitative evaluation of the subscale interrelationships across instruments, it also has the advantage of enabling results from different studies using one or other of the instruments to be "translated", thereby enabling direct comparison of results across studies (cf. Goldberg, p. 339). In employing this technique with the 8SQ and DES-IV instruments, it should be possible to validate the results from the canonical-redundancy analysis, while at the same time delineating which aspects of the two psychometric mood-state instruments should be incorporated into a better, more refined instrument.

Method

Subjects and Procedure

The total sample comprised 450 teachers college students enrolled either at the Melbourne College of Advanced Education, or at the Institute of Catholic Education, Melbourne. The mean age of the sample (males and females) was 22.61 years (S.D. = 7.52 years). Each instrument was administered as part of the student's regularly scheduled classes, thereby facilitating their co-operation in the study. Very few students actually chose to withdraw from the study even though they were entirely free to participate or to withdraw at any time. Those students who finished the two questionnaires quickly were encouraged to leave class early, in order to provide some incentive for the students to complete their responses to the 8SQ and DES-IV as quickly as possible. Almost all students appeared to take the psychological testing seriously and to respond to the mood-state items willingly.

Results and Discussion

Descriptive statistics, including the means and standard deviations on the total 20 8SQ and DES-IV subscales, as well as the inter-correlations of the subscales for all 450 subjects are given in Boyle (1986a). In addition, it is interesting to note that the correlations of age and sex with the 8SQ and DES-IV subscales were all nonsignificant, except for the correlation of sex with the DES-IV subscale Contempt (-.21, $p<.05$). On this evidence, the female students were somewhat more contemptuous than were their male counterparts. Clearly though, females more readily admit to negative mood states than do males, in general (cf. Boyle, 1985b).

The results of the canonical analysis (using Veldman's, 1967, programme CANONA) alone suggested that the two mood-state inventories exhibited some comparability of measurement. Eight canonical roots were extracted in accord with the smaller number of subscales in the 8SQ as compared with the DES-IV. Of these canonical variate pairs, the first five exhibited significant roots, as shown in Table 1. As is evident, the canonical roots (the squared canonical correlations) varied from .72 down to .05, thereby indicating the relative strength of each variate pair. Clearly the first canonical root accounted for by far the greatest proportion of the variance. While extraction of the complete set of variates (eight) would be necessary for calculation of total redundancy, nevertheless, it was inappropriate to include more than five significant roots in calculating the redundancy across the 8SQ and DES-IV instruments. As Boyle et al. (1985, p. 116) stated, given the unreliability of measurement in the domain of psychological moods, "it is unclear what meaning can be drawn from the total redundancy values or from the later roots." The rationale for basing the redundancy calculations only on the significant roots is the same as that upon which stepwise forward multiple-regression analysis is based, wherein only those predictors which add significantly to the overall multiple R^2 are included in the prediction equation.

In view of this consideration, the redundancy calculations were based only on the five significant roots, as shown in Table 2. On the basis of these results (using single-occasion scores which undoubtedly include the overlap of significant trait contamination variance as well as that due solely to redundant state variance) it appears that the DES-IV scores account for some 48 per cent of the variance measured in the 8SQ single-occasion scores. Conversely, this finding implies that the 8SQ instrument measures at least 52 per cent unique variance which is not attributable to either DES-IV state, and trait-contaminated variance. In this regard, it is probable that the 8SQ is measuring a different segment of the total mood-state sphere, as compared with the DES-IV. Also it is evident that 32 per cent of the DES-IV variance is being accounted for by the 8SQ. Concomitantly, 68 per cent of the measurement variance in the DES-IV is not being predicted by the 8SQ. Part of the difference in estimates might be accounted for in terms of the different size of each mood-

Table 1: *Significant Roots for 8SQ/DES-IV Scales (N = 450)*

Roots	1	2	3	4	5
R^2	.7197	.1877	.1595	.0617	.0537
Chi-square	559.0069	91.3414	76.3722	28.0038	24.2707
D.F.	19	17	15	13	11
P less than	.00001	.00001	.00001	.01	.01

Note. The five significant canonical variates not only account for overlap in mood-state variance measured in the 8SQ and DES-IV, but also for 'trait contamination' variance measured in the single-occasion scores employed in the present study.

Table 2: *Calculation of Redundancy Indices for DES-IV and 8SQ*

	Root	Canonical R (Rc)	R Squared (λ)	Variance Extracted (VC)	Redundancy (λ.VC)
8SQ	1	.8484	.7197	.619	.445
	2	.4332	.1877	.099	.019
	3	.3994	.1595	.030	.005
	4	.2484	.0617	.037	.002
	5	.2317	.0537	.115	.006
DES-IV	1	.8484	.7197	.395	.284
	2	.4332	.1877	.073	.014
	3	.3994	.1595	.089	.014
	4	.2484	.0617	.114	.007
	5	.2317	.0537	.039	.002

Notes. Redundancy calculated for significant roots only.
Redundancy of 8SQ given DES-IV = .477
Redundancy of DES-IV given 8SQ = .321
The intercorrelation matrix for the combined DES-IV/8SQ data is reported in Boyle (1986a), for all 450 subjects.

state inventory. Thus the redundancy estimated for the 8SQ given the DES-IV is larger than is that for the DES-IV given the 8SQ, because the canonical analysis was based on subscale data rather than on items, and because the DES-IV has 12 subscales whereas the 8SQ has only eight. Had item responses been used as the basis for the canonical analysis, the percent of predicted variance in each instance would probably have been reversed, with the 8SQ predicting more of the DES-IV variance and vice versa. The reason for such a reversal is because of the greater number of items in each of the 8SQ subscales than in the DES-IV subscales. Given this difficulty, it is probably appropriate to consider the measurement overlap of the two instruments in terms of the average 40 per cent redundancy, across the 8SQ and DES-IV. In this context, 60 per cent on average of unexplained measurement variance exists across the two scales.

The results from the multiple-regression analyses confirmed the findings from the canonical-redundancy analysis with the estimated redundancy (average multiple R^2) for the 8SQ given the DES-IV being 47 per cent, while that for the DES-IV given 8SQ was 32 per cent. Moreover it is clear from Table 3 that most of the redundancy could be accounted for by the overlap in measurement variance for only a small number of subscales in each instrument. Thus most of the 8SQ subscales exhibited significant redundancy with the DES-IV subscales of Sadness and Joy, while most of the DES-IV subscales displayed significant commonality with the 8SQ subscales of Guilt, Depression, and Anxiety. Clearly, these findings provide qualitative and quantitative data on the actual overlap in subscale variance across the two instruments, which is important for future work on the psychometric measurement of moods. When compared with the results of the higher-order factor analysis of the 8SQ and DES-IV subscale intercorrelations (cf. Boyle, 1986a), the present multiple-regression equations for each subscale in the two instruments provide far more definitive information as to the exact nature of the across-inventory subscale redundancies. In that analysis, evidence for major typological (higher-order) mood-state factors of Neuroticism, Extraversion, Arousal vs. Fatigue, Hostility (inner-directed), and Depression was forthcoming. From the present regression

Table 3: *Cross-Inventory Prediction Equations for 8SQ and DES-IV*

8SQ	No. of Steps	Multiple R^2	Suggested Equations
Anxiety	6	.60	.40 *Sad* -, .24 *Joy* + .17 *Ang* + .17 *Fea* - .12 *Shy* - .10 *Int* + 12.62
Stress	6	.38	.54 *Sad* - .37 *Joy* + .18 *Ang* + .30 *Fea* - .46 *Shy* + .20 *Gui* + 16.26
Depression	4	.64	.92 *Sad* - .72 *Joy* - .33 *Int* + .21 *Ang* + 18.81
Regression	3	.41	.56 *Sad* - .45 *Joy* + .43 *Sha* + 14.22
Fatigue	4	.29	.66 *Sad* - .67 *Joy* + .42 *Sha* - .34 *Sur* + 19.49
Guilt	6	.61	.48 *Sad* - .50 *Joy* + .45 *Hos* + .43 *Gui* + .30 *Fea* - .23 *Int* + 8.19
Extraversion	5	.43	-.61 *Sad* + .47 *Joy* - .49 *Shy* + .32 *Sur* + .21 *Int* + 15.12
Arousal	5	.39	-.68 *Sad* + .32 *Joy* - .36 *Sha* + .34 *Sur* + .32 *Int* + 15.33
DES-IV			
Interest	2	.16	-.20 *De* + .06 *St* + 10.58
Joy	3	.47	-.09 *Gi* - .27 *De* + .06 *Rg* + 14.61
Surprise	3	.07	.06 *Gi* + .15 *Ar* + .11 *Rg* + 1.46
Sadness	4	.57	.14 *Gi* + .19 *De* + .09 *Ax* - .04 *Fa* + 1.47
Anger	4	.36	.12 *Gi* + .13 *Ax* + .08 *De* 2.42
Disgust	2	.32	.16 *Gi* + .08 *Ax* + 2.50
Contempt	4	.14	.09 *Gi* + .07 *De* + .09 *Ar* + .04 *Ax* + 1.74
Hostility (inner)	5	.43	.20 *Gi* + .10 *De* + .07 *Rg* - .06 *St* - .05 *Fa* + 2.48
Fear	3	.38	.15 *Gi* + .13 *Ax* - .04 *Fa* + 2.53
Shame	3	.32	.13 *Gi* + .07 *Rg* - .04 *Ex* + 4.07
Shyness	3	.27	.17 *Gi* - .10 *Ex* - .06 *St* + 6.30
Guilt	3	.32	.24 *Gi* - .06 *Fa* - .06 *Ar* + 5.06

Note. The average multiple R^2 for the 8SQ given the DES-IV is .47, while that for the DES-IV given the 8SQ is .32. These findings support the results of the canonical-redundancy analysis.

results it is evident that virtually all of the subscale redundancy can be attributed to the typological mood states Extraversion and Neuroticism, and considerably to Depression. Interestingly, the present findings tend to provide support for the Eysenckian view (e.g., Eysenck, 1982) that the two most important non-ability temperamental factors are Extraversion and Neuroticism. Previous higher-order factorings of mood-state data (Boyle, 1985a, 1986c) have also supported this interpretation, albeit within the emotional domain.

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