A RE-EXAMINATION AND ATTEMPTED REPLICATION OF THE STRUCTURE OF CATTELL'S SIXTEEN PERSONALITY FACTOR QUESTIONNAIRE

STEPHEN FREDERICK BLINKHORN

Ph. D.

Institute of Education
University of London

ABSTRACT

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Cattell's Sixteen Personality Factor Questionnaire is amongst the most widely used of psychometric measures of personality, yet little support for its structure is to be found in the critical literature. Consideration of what might constitute a decisive analysis leads to the view that previous studies have been deficient in concentrating unduly on technical criteria in the conduct of factor analysis to the exclusion of an analysis of psychometric and statistical features which could give rise to observed results.

Using a large sample of undergraduate subjects, both within-scale and between scale analyses were performed. The claim that the scales of the questionnaire are heterogeneous, accepted by Cattell, is shown to be invalid in statistical terms, with a few exceptions. Evidence for a limited but substantial degree of support for the structure proposed by Cattell is adduced from both traditional forms of factor analysis and the newer technique of structural analysis of covariance matrices. In the process doubt is cast on the relevance of certain technical disputes regarding the conduct of factor analysis, and the value of Cronbach's coefficient alpha as an index of psychometric adequacy is supported. The importance of reliability of variables in factor analysis is emphasised, and attention is drawn to the problems associated with the use of heterogeneous samples and ad libitum selection of variables.

Consideration of the results of the analyses suggests a reinterpretation of Cattell's scales in terms of homogeneity of content and possibly a facet analysis of the questionnaire synthesising a variety of viewpoints often presented as conflicting.

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> "She openeth her mouth with wisdom;
> And in her tongue is the law of kindness."
>
> (Ecclesiastes 31, xxvi)

INTRODUCTION

Cattell's Sixteen Personality Factor Questionnaire is amongst the most widely used of all psychometric techniques for the assessment of personality, yet its structure has consistently failed to find support in the results of independent research. This thesis is an attempt to test that structure directly, and results from the author's view that the crucial analyses have not elsewhere been carried out, nor has sufficient consideration been given to the problems of sample homogeneity and the reliability of variables in the use of factor analysis on personality test data.

The primary emphasis of the thesis is psychometric and confined to the questionnaire and its interpretation, and the order of discussion has been arrived at in an effort to minimise repetition and the discussion of methodological issues and empirical results simultaneously. As this order is not entirely conventional a brief guide to it may help the reader follow the line of argument.

Chapters 1 and 2 deal respectively with the historical context of the development of the questionnaire and some of the issues involved in the use of trait terms in the description of personality and the explanation of behaviour. Chapter 3 outlines the commonest criticisms that have been made of the questionnaire and its construction. Chapter 4 is largely concerned with methodological issues in factor analysis, pointing out the problems which may arise from sample heterogeneity and unreliability of variables, and developing the approach to analysis adopted for this study. Chapter 5 contains an account of the fieldwork. In Chapter 6 the question of scale homogeneity is discussed in the light of the general claim that Cattell's scales are notably heterogeneous: with some exceptions this claim is shown to be ill-founded. Chapters 7 and 8 contain accounts of a number of factor analyses, both unrestricted and restricted, which tended to produce mutually consistent results confirming those of Chapter 6. Chapter 9 begins with a discussion of certain features of the factor correlation matrices from the analyses of Chapter 8, shows that similar results arise from a multivariate correction for attenuation of the scale intercorrelaions, and then proceeds to an inspection of the item content of certain scales, followed by a sketch of a possible account of the structure of the 16PF in terms of content analysis of items. Chapter 10 then summarises and reviews the empirical results.

What is presented is not therefore an account which claims to be definitive confirmation or disconfirmation of the notional structure of the questionnaire. Rather it is shown that with a fairly homogeneous sample a moderately good approximation to that structure can be found, but that the departures from the notional structure may in themselves be informative and lead to a positive reappraisal of personality questionnaires.

CHAPTER 1

In many respects attempts to construct questionnaire measures of personality have been strongly influenced by developments in the measurement of mental ability. By the mid-1930's, intelligence tests had taken a form substantially similar to that of those currently in use. Development in this area had been aided by the emergence of correlational techniques, and perhaps most notably of factor analysis, which had been applied to the study of differential aptitudes with some success.

Attempts to pursue mental testing into the area of personality were perhaps inevitable, and indeed sufficient development had taken place for Cattell (1933) to publish a review article, and Guilford and Guilford (1934) to undertake one of the first factor-analytic studies of extraversion. However, one difference between ability and personality tests has particular implications for the application of psychometric methods, in that in general the former, being tests of maximum performance, may be expected to correlate with measures of external criterion performances where there is general agreement as to what constitutes a better or more correct level of performance. Thus the construction of the original Binet test could proceed without any guiding theory as to the fine structure of abilities, and later work could build from the notion of undifferentiated ability to finer-grained structures.

In the case of personality tests, however, the question of the dimensionality of personality is more pressing. It is by no means clear that a single scale, say ranging from inadequate to adequate personality, has the same kind of utility, even as a starting point, for the development of measures of personality. Indeed, articulated accounts of the structure of personality existed before the development of psychometric measures, most notably perhaps Galen's typology, adopted also by Kant, and the theories of psychoanalytically and psychiatrically oriented authors. Given the lack of clear criterion performances, the development of personality questionnaires was therefore more dependent on the theoretical orientation of test authors, and indeed between the two world wars they proliferated.

Cattell's (1946) initial attempts to formulate a factor-based theory of personality may be seen as an attempt to bring order into a confused field in which the fact that two scales shared a name was no guarantee that they measured related traits. Furthermore, in taking as his starting-point the list of trait words extracted from the dictionary by Allport and Odbert (1936), he implicitly rejected all theoretical approaches other than those embedded in the language. His stand was to assume that the

English language contained terms for all the distinctions that had been found valuable in the description of personality, and that appropriate methods of analysis applied to scores on rating scales, questionnaires and objective performance measures would yield a widely, or even universally, applicable framework for the development of a definitive theory of human personality. It is more than clear that he continues to hold this view, and also the opinion that his methods of analysis have at any given time been the most appropriate then available for this purpose (Cattell 1973).

Essentially, then, the only important theoretical assumption made by Cattell at the outset was that personality is properly conceived of in terms of traits, although, to anticipate the discussion in the next chapter, the precise meaning he attaches to the term is not altogether clear. Such an assumption was at the very least quite in keeping with the historical context in which it was made, especially given the apparent success of Thurstone and the London school, in their different ways, in giving a dimensional, trait-like account of the structure of mental abilities. Amongst those who accept this assumption as reasonable, then as now criticism of Cattell's work has centred on detailed matters of techniques of analysis and indices of psychometric adequacy, and it is with these matters that this thesis is principally concerned.

Before passing on to an outline account of the development and present state of Cattell's theory, there are two points which give rise to occasional misunderstanding, and are best settled in advance. First, although Cattell is perhaps best known to psychologists in general for his work on the development of personality questionnaires, originally he did not regard them as having a long-term future as first-rank measures. Recognising the imperfections of the questionnaire method, such as its susceptibility to faking, he expected the technique to fall out of use as more objective measuring devices were developed. Secondly, there is a matter of terminology: Cattell uses the terms 'primary factor' and 'source trait' interchangeably. Source traits are seen as the fundamental variables of personality, discovered by factor analysis of 'surface traits', which are clusters of observed behaviour, somewhat analogous to pathological syndromes in medicine. According to Cattell, source traits cause surface traits, and bear the burden of explanation insofar as individual differences in personality are responsible for differences in behaviour. Thus the term 'primary factor' has ontological rather than merely operational significance. What is a first-order factor from the point of view of the conduct of a factor-analytic investigation is not necessarily a primary factor in this sense. Cattell has attempted to popularise a distinction between factor orders (operational significance) and factor strata (ontological significance), but with little success to date.

The systematic account of the 'primary factors of personality' appearing in Cattell (1946) is based on behaviour rating scales. Working with a reduced list of trait words drawn from Allport and Odbert (1936), 100 subjects were rated on 171 bipolar scales, and clusters were identified. On the basis of this analysis, a smaller set of scales was factor analysed to yield 12 'primary factors' or 'source traits'. Cattell then proceeded to match these factors with those found in the analysis of questionnaire responses, and made tentative identifications in the domain of physiological and performance measures.

Howarth (1976) has presented a critical reanalysis of the original behaviour rating study, and raises the possibility that inaccuracies and inadequacies in this study had a detrimental effect on the eventual published questionnaires Cattell produced. However the link between this first exposition and the current versions of the questionnaires is not as rigid as might be supposed. In particular certain factors, e.g. D, J and K, are not represented in the standard adult versions, and as successive revisions of the scales have appeared there has been a certain amount of reinterpretation of the meanings of factors as well as claimed psychometric improvements of the scales which represent them.

The original 12 factors proposed by Cattell were labelled by letters, A to L, in descending order of the proportion of variance accounted for by each. From the first, Cattell has preferred oblique factor solutions on the grounds that the real causal influences he sought to identify by factor analysis were unlikely to be uncorrelated, even though 'functionally independent'. Subsequently, (Cattell 1950), he extended his investigation of the factors to be found in questionnaire response data, to yield the structure now represented in his Sixteen Personality Factor Questionnaire (16PF). As has been mentioned, three of the original factors are missing, but three others have been added which are claimed to have matches in rating data, and four additional factors are included which have only been found reliably in questionnaire data, and hence are labelled Q_1 to Q_4.

Since the factors are correlated, factor analysis of their intercorrelations is possible, and hence second-order factors may be derived. Four of these Cattell claims to be well-established, and four or five others tentatively identified (Cattell, Eber and Tatsuoka 1970). Of these, the first two have received particular attention, since they appear to align well with Eysenck's (1947) dimensions of Extraversion and Neuroticism (Cattell's labels being Exvia and Anxiety). Again, correlated second-order factors may themselves be factored to yield third-order factors: an example of such an analysis being presented by Cattell, Eber and Tatsuoka (1970).

For convenience of reference, and to avoid repetitive descriptions of the interpretation of Cattell's factors, a list of factor labels, 'technical names' and descriptive adjectives is bound as a fold-out at the back of this thesis.

Revised verions of the 16 PF appeared successively up to the definitive 1967/68 editions, since when a seven-factor supplement has appeared, and downward extensions to high-school age and below have also been produced. A long series of publications by Cattell and his collaborators from 1940 to the present day has detailed the elaboration of his theory: apart from the improvement of the questionnaires, this research has extended the scope of Cattell's theory to include an account of motivation and moods, has pursued factor matching between different measurement media, has contributed technical advances in factor-analytic methods, and has attempted to establish a central role for personality, and for factor analysis, in many areas of psychology.

Despite the ambitious scope of Cattell's work and the wide-ranging claims he has made for his theory, critical treatment of his approach has tended to concentrate on the validity of his original claim to have discovered the fundamental variables of personality and produced a questionnaire which measures them. Two areas of controversy are particularly relevant to this attempt to replicate Cattell's structure: the status of Cattell's concept of trait, and the psychometric criticisms which have been levelled at the 16 PF, to which questions we now turn.

CHAPTER 2

Only rarely has Cattell offered definitions of the word 'trait'. Two are, however, forthcoming in Cattell (1965):

> "Trait: a unitary configuration in behaviour such that when one part is present in a certain degree, we can infer that a person will show the other parts in a certain degree." (p. 375)

> "By a trait, therefore, we obviously mean some relatively permanent and broad reaction tendency." (p. 28)

These scarcely capture the distinctive characteristics of his use of the term, but more can be gleaned from a careful reading of his more recent writings, in particular Cattell (1973).

One distinction recurs constantly, that between 'surface traits', observable consistencies in behaviour, which are or may be determined by more than one 'source trait', and source traits themselves, which are not directly observable, but are revealed by factor analysis of surface traits. Source traits are seen as the fundamental variables of personality, substantially invariant across social and cultural groups (Cattell 1973, p. 330ff), although not necessarily invariant either in terms of their expression in behaviour or in terms of which items or tests are most appropriate for their measurement.

The overriding importance which Cattell attaches to source traits is exemplified by his account of the origins of the second-order Exvia factor, which, as has been mentioned, seems to be closely comparable with Eysenck's dimension of Extraversion. Whereas Eysenck (e.g. Eysenck and Eysenck 1969) treats this factor as the source of lower-order factors, which in his view are far from reliably identified, and as related to the functioning of the ascending reticular activating system in the brain stem, for Cattell it is the result of a complex positive-feedback interaction amongst source traits mediated by social mechanisms (Cattell 1957), and not a fundamental variable in its own right.

Next, there is the unusually strong emphasis placed by Cattell on the use of factor analysis in the discovery of source traits. Source traits are 'factor-dimensions', variations along which are determined by single unitary influences (Cattell 1965, p. 374). That is to say, he appears to view factor analysis not merely as a convenient technical device but as the sine qua non of research in this area, and he has devoted some effort to the demonstration of the efficiency of factor analysis in revealing known structures, e.g. the dimensions and contents of coffee cups (Cattell and Sullivan 1962). Along with this emphasis has gone an interest in the development and refinement of factor-analytic techniques.

Likewise, despite hints (Cattell 1952, 1973 p. 22) of possible nonlinearities in the regression of source traits on overt behaviour, and of interactions between traits, states and situations, multiple linear regression is the method of choice for prediction purposes. Thus a comprehensive attempt to predict overt behaviour would involve a specification of weights to be applied to source trait scores, to state variables and to situational variables, all of which may be classified by factor-analytic means.

Finally, the traits proposed are identified and named a posteriori. Cattell's initial work was an attempt to define the universe of discourse by reference to the dictionary, rather than to build on previous work. Perhaps in consequence, the list of traits measured by the 16PF reads as a rather eclectic collection with no guiding theoretical orientation. Some traits, e.g. factor C, Ego-strength, and factor G, Super-ego strength, have at least a nominal link with psychodynamic theory; a group of five (A, E, F, H, Q_2) reflect different aspects of extraversion, a notion with a long and complex history; one, factor I, seems not unlike William James' notion of tender-mindedness, and others, e.g. L and N, seem to be more or less peculiar to Cattell. From the point of view of ontogenetic development the source traits are equally heterogeneous. Factors A and H, he claims, have a strong hereditary, physiological basis, whilst at the other extreme factors I and M are more or less exclusively the result of learning in childhood.

These considerations make an overall assessment of the conceptual status of the source traits impossible, since all they have in common is their purported causal status and their discovery by a particular statistical/mathematical technique. The emphasis, to borrow the title of Cattell's early book, is on the description and measurement of personality rather than on a unified account of the sources and causes of personality differences.

This point has a bearing on one common criticism of trait-oriented personality theory, succinctly stated by Mischel (1968, p. 42):

> "Nothing is explained, however, if the state that _we_ have attributed to the person from his behavior ('he has a trait or state of anxiety') is now invoked as the _cause_ of the behavior from which it was inferred. We quickly emerge with the tautology: 'He behaves anxiously because he has a trait of anxiety'."

Thus Mischel claims that the use of trait names as explanatory devices is based on a confusion between the construction (or interpretation) of behaviour and the causes of behaviour. Insofar as trait names are merely summary terms for observed and interpreted behaviour, and so long as the only basis for the adoption of traits is descriptive in this sense, the criticism holds. However, in the longer term the enterprise on which Cattell embarked is not merely one of efficient description, although it is at least that. Rather there is an eventual aim of linking some traits to neural and endocrine events and structures in such a way as to bring elements of social behaviour into the same general nomological net as physical events. Given success in this enterprise the methods yielding traits which do map onto such physical variables have presumptive utility for the discovery of traits whose sources are in, for example, child-rearing practices.

In this respect, Cattell's work is closely modelled on the natural sciences in which he received his early academic training. For at various stages in the development of physics, Mischel's criticism might well have been levelled at concepts such as mass, valence or magnetic flux, concepts whose value derived at least for a time from their place in a systematic account of empirical phenomena, before their basis in the atomic and subatomic structure of matter had been elaborated.

The extent to which links between Cattell's source traits and neural and endocrine phenomena have actually been forged is debatable. Royce (1973) and Fahrenberg (1977) review some of the common ground occupied by various trait-oriented theorists, and Cattell and Warburton (1967) present a compendium of physiological and performance tests which, it is claimed, relate to certain of Cattell's second-order factors. However, for the moment such developments are at best promising rather than conclusive.

On the other hand, the converse argument is powerful: if it can be shown that traits, or some set of traits, cannot be consistently discovered or derived, then there is little chance of finding physical phenomena to which they relate, whereas if they can be replicated then some explanation is called for. Such an explanation might simply be in terms of response sets, or it might involve either the original theory or some reworking of it, such as Gray's (1973) reinterpretation of Eysenck's three personality dimensions.

In recent years there have been developments in thinking concerning the sources of a given behaviour in a given situation converging from several authors which have a bearing on the interpretation of Cattell's traits. For instance Mischel (1973) in a modification of his earlier view has argued that what is needed for adequate prediction of behaviour is information on a wide range of variables, some of which relate to the behaviour in question only through the conscious anticipation of the subject as being possible consequences of his actions. Bem and Allen (1974) in a similar vein argue for idiographic assumptions about the sources of individual behaviour, even when that behaviour shows consistency across situations and subjects. Argyle (1976) has moved away from a notion of personality dominated by the situation to a structuralist position in which behaviour is generated from a 'deep structure' of rules, which may at once be idiosyncratic and yet have elements of commonality across individuals.

Perhaps this move is best summed up by Harré and Secord (1972) and in Harré's (1976) collection of articles suggesting a cognitive approach to the understanding of social behaviour. Essentially it involves a rejection of the 'classical' model of physical science as applied to the explanation of social behaviour, in particular insofar as this permits only of inert entities and efficient causality. Harré and Secord state quite explicitly (op. cit. p. 256) that "A man's nature is a psycho-physiological mix", the psychological part of the mix involving such functions as anticipating the consequences of actions, giving accounts of the sources of past actions and the like. In other words they propose a formal reintroduction of the Aristotelian notion of final causality, at least insofar as a person may represent to himself future states of affairs and attempt to bring them about, into the explanation of behaviour.

As it happens, they cite Cattell's factors C and A as instances of the kind of powers and complementary liabilities which satisfy, at least in outline, their criteria for explanatory notions, and remark especially with regard to factor A that it is a notable instance of the kind of psychophysiological mix they regard as desirable in a full account of the sources of social behaviour.

However, Cattell's own position on this point is either unclear or simply so eclectic as to permit a variety of interpretations. The definitions of 'trait' quoted at the beginning of this chapter fall under Alston's (1976) notion of 'T-concept': "we think of different persons having different degrees of the disposition, where the degree is a function of the frequency of response in a representative set of situations along with the average magnitude of the responses" (p. 67, abbreviations expanded). Alston contrasts the 'T-concept' quite sharply with purposive-cognitive concepts. T-concepts, like co-operativeness, sociability, persistence, refer to overt, observable reaction tendencies, such that a given level of each is associated with a characteristic frequency and strength of response in a given situation. Purposive-cognitive concepts, on the other hand, such as <u>need</u> for social contact, or <u>desire</u> for control over others, may not give rise to overt behaviour in the form of actual social contact or actual exercise of control over others, yet there is no contradiction in ascribing these characteristics to individuals who do not involve themselves in social contact and who do not exercise control over others.

It is at least possible that Cattell sees some of his source traits as purposive-cognitive concepts, related causally to T-concepts, for which read surface traits. Alternatively, one might class some of his source traits as purposive-cognitive and others as T-concepts. The distinction is not made explicitly by Cattell himself, and inspection of his questionnaire items is of little help. Some items, e.g. "As a teenager, I joined in school sports: a. occasionally, b. fairly often, c. a great deal", seem to demand a factual report of the respondent's past or present behaviour, whilst others, e.g. "I would rather mix with polite people than with rough, rebellious individuals", seem designed to elicit a statement of preference between two hypothetical states of affairs.

The status of questionnaire responses is far from clear: they may be read as factual statements, including as facts needs, preferences, values, interests and the like, as attempts to express a self-concept in terms of item content, or as responses, in the full-blown behaviourist sense, to stimuli, viz. the items, whose content will not stand common-sense analysis. None of these approaches is wholly satisfactory, the first because one is potentially overrating the individual's self-knowledge and access to accurate information about his own behaviour, the second because there is as yet little research to show that this in fact is what subjects think they are doing, and the third because respondents do seem to believe that they are indeed conveying information about themselves, and often take pains to be as accurate as possible in their responses - a phenomenon which is difficult to quantify but which is very apparent in the course of supervising a test session.

The question of what actually takes place between the reading of an item andthe recording of a response is amongst the least researched aspects of psychometrics; however, for present purposes we may note the problem and leave it to one side. For there is a distinction to be made between two stages in the development of a scientific theory: in the first phase, one collects as accurately as possible measurements and observations appropriate to the phenomena under study, in an attempt to discover and formalise regularities; in the second, theories are constructed to account for the observed regularities and tested against them. (Of course, theories may suggest as yet unnoticed regularities whose presence or absence may result in modifications to or rejection of a theory, in the Popperian hypothetico-deductive pattern, but here we are concerned with the elements of theory-building, rather than the logic of scientific progress).

The classic example of this procedure is the development of the kinetic theory of gases as an account of the regularities formalised in Boyle's and Charles' gas laws, these gas laws being characterised by Harré and Secord (1972) as a matter of 'critical description' or 'proto-science' rather than of developed science.

Since a great deal of controversy has been fuelled by the question of what regularities are to be found in Cattell's personality scales, however, it seems that there is a need for some careful critical description to discover just what regularities are present to require a theoretical account. That is to say, the question of whether there is a good approximation to Cattell's structure to be found is prior to the question of why it should be present.

CHAPTER 3

The 16PF has received a good deal of attention in terms of its adequacy as a psychometric device, and in terms of the fit between questionnaire factors and factors found in rating studies. We are here concerned exclusively with the first of these.

Three lines of attack have been adopted by Cattell's critics. Firstly, the value of traits in predicting behaviour has been questioned. Mischel (1968) reviews a large number of studies relating trait measures, not specifically Cattell's, to external criteria, and concludes that their utility has been much exaggerated. This is a line of argument which will not be pursued here, since the problem of how best to incorporate trait measures into the prediction of behaviour would need a thesis to itself, and since past failures need not imply that the exercise is futile.

Secondly, the 16PF has been specifically criticised on account of the apparently low homogeneity of the scales it contains. Levonian (1961), Timm (1968), Eysenck and Eysenck (1969), Greif (1970) and Howarth, Browne and Marceau (1971) have taken this line. With attainment and ability tests, one is accustomed to find that the items in reliable and valid scales correlate moderately highly, and indices of reliability based on these correlations have a long history. Cattell has never challenged the empirical results of these authors; instead he has argued consistently that homogeneity is a red herring in the construction of personality tests with high transfer reliability (Cattell and Tsujioka 1964, Cattell 1973). Howarth and Browne (1971a) attempt a rebuttal of this argument in terms of the requirements of simple structure as a criterion for rotation in factor analysis. However, as will become clear when the results of homogeneity analyses in the present study are presented, this controversy is itself something of a red herring. It will be argued that, with a small number of exceptions, Cattell's scales meet accepted standards of internal consistency, length for length being about as homogeneous as Eysenck's own scales in terms of Cronbach's coefficient alpha (Cronbach 1951).

Thirdly and most controversially of all, the claim has been made repeatedly that when items and/or scales from the 16PF are factor analysed, Cattell's structure either cannot be identified, or is not the most parsimonious solution. Becker (1961), Borgatta (1962), Timm (1968), Eysenck and Eysenck (1969), Sells, Demaree and Will (1970, 1971), Howarth and Browne (1971a) and Vagg and Hammond (1976) all associate themselves with this point of view. In other words, there is almost total agreement in published studies arising outside Cattell's circle of collaborators that he is simply mistaken (Guilford 1975).

Two specific procedural points recur: his critics claim that Cattell consistently rotates more factors than are indicated by various criteria for the number of common factors present, and that his use of 'parcels' of items as the basic variables in his analyses, rather than single items, distorts the solution by imposing his structure a priori. A third consideration is that Cattell typically identifies items as being significantly loaded by a given factor on the basis of unconventionally low factor pattern coefficients.

The focus of attention throughout this long-standing controversy is on the replicability of Cattell's primary factors. There is little dispute about at least two and possibly four or more second-order factors. Indeed Eysenck (1972) makes the straightforward claim that the primary-factor scales of the 16PF yield no more reliable information than the second order, thus calling into question one of Cattell's fundamental arguments for the use of primary factor scales.

In response, Cattell (1972) has depended largely on technical arguments as to the adequacy of the procedures and criteria actually used by his critics in conducting their factor analyses. Cattell (1972), Cattell, Eber and Delhees (1973), and Burdsal and Vaughn (1974) have also presented factor pattern matrices purporting to show that the nominal structure of the 16PF is indeed to be found as the outcome of an item-factor analysis. However, in these studies many items have near-zero loadings on the factors to which they supposedly contribute, and large factor-pattern coefficients are few. This Cattell explains as being due to 'suppressor action' - inclusion of items with low or even negative loadings on a given factor but relatively high loadings elsewhere purifies the questionnaire scale by cancelling out the effects of unwanted variance associated with higher-loading items. Put otherwise this may simply mean that factor-score coefficients do not necessarily match factor-pattern coefficients, i. e. the best set of items for achieving a good estimate of a factor score is not always that set having the highest loadings. Certainly, as Guilford (1975) points out, Cattell has never explicitly stated which items are suppressing what.

On the question of the use of item parcels, Cattell is not alone. Nunnally (1967) and Comrey (1970) both advocate parcelling on the grounds that single items are too unreliable a basis for factor analysis. More detailed consideration of this point follows in a later chapter, as it is particularly relevant to the methods adopted in this study.

Overall, the present status of Cattell's scales is rather confused. There is controversy concerning both the appropriateness of various technical procedure in assessing the adequacy of the scales and factor-analytic studies of them, and the interpretation of published analyses. Little progress has been made over a period of nearly twenty years towards a rapprochement between Cattell and his critics, and no agreement has been reached as to what would count as an experimentum crucis. Meanwhile in commercial terms the 16PF has thrived alongside the products of other laboratories, and currently vies with Eysenck's questionnaires as the most widely used personality questionnaire in the United Kingdom, ranking about fifth in the USA. Whatever the psychometric arguments that have appeared so far, there is clearly a body of users who actually find the scales useful or are woefully blind to their inadequacies.

This thesis is therefore aimed at reconciling three points of view, Cattell's, his critics' and his customers'. It takes a fresh look at the controversy surrounding the 16PF from the point of view of the prospective user of the test, asking to what extent Cattell's structure can be replicated, and what steps are necessary to yield such a replication, in the hope that in the process light will be shed on the sources of dispute. The procedures adopted take as their fundamental variables the scales of the published test, since if the purported structure cannot be found at this level, there is little chance of it being found at the level of items (and even if it were, there would be little point in using the 16PF in its present form).

The next chapter therefore considers at length the problems involved in attempts to replicate an hypothesised factor model with a view to establishing the utility of the methods to be adopted.

CHAPTER 4

The use of factor analysis in personality research has not, in general, been directed simply at a reduction in the number of variables to be considered in a given data set. Rather it has been used as a strategic tool, with the aim of identifying replicable factors which will serve as fundamental elements in a rounded theory of personality. A great part of the controversy concerning rival accounts of the structure of personality has been attributed to differences in the technical procedures adopted by various theorists. In particular, three issues can be identified as important in the eyes of Cattell:

1. Method of decomposing the matrix to be analysed (principal components, principal factors, image factors, alpha factors, maximum likelihood etc.) along with corresponding methods of estimating communalities.
2. Basis of choice for number of factors to retain and rotate.
3. Method of rotation and criteria for acceptance of a solution as representing 'simple structure'.

In point of fact, none of these issues is capable of resolution by strict proof in the context in which it arises, since the fundamental question being asked is not "which solution gives the best reproduction of the original data?" but rather "which solution is

most useful in the elaboration of a theory of personality?"
Nonetheless, they are debated at length in a highly proprietary brand of disputation which is generally inaccessible to the non-specialist.

Rather less thought appears to have been given to certain other issues, notably:

4. Whether items, subscales ('parcels') or scales should be the unit of analysis?

5. What kind of prior scaling of variables is most appropriate for a given analysis?

6. How variables should be chosen, in terms both of their number and of what is already known of their interrelations.

And finally almost no discussion at all is to be found as to:

7. What the desirable characteristics of the sample providing the data base might be.

8. Whether influences other than the personality variables nominally under investigation may be reflected in the data base.

It is the contention of the present author that these issues should be tackled in reverse order, that is to say in the order, more or less, in which they arise in the practical business of choosing a sample, testing participants and analysing their scores.

From the point of view of the present work, factor analysis is seen as a means of confirming or disconfirming a proposed solution or model, itself derived by factor analysis. Thus we are not concerned with the question of whether the common-factor model is an appropriate aid in developing a personality theory, rather we shall be investigating the fit of a particular structure within the scope of that model.

The primary problem with factor analysis as a research technique is its indeterminacy. When it is used as an exploratory tool in the development of an hypothesis, this indeterminacy need not be a great handicap. In attempts to test the adequacy or replicability of a factor theory, however, it is a major problem (Pawlik 1973). To make matters worse, in factoring personality tests we are dealing with highly imperfect variables. Even with perfectly reliable variables, there would still be indeterminacy arising from the lack of definition of relevant common-factor variance, the lack of a guaranteed foolproof method of rotation, and sampling error in the matrix to be analysed. With unreliable variables a further source of variation enters.

Thus we now turn to a discussion of the problem of error, then to questions of sampling of both subjects and variables, and finally to the matter of the choice of matrix to analyse and the choice of items or scales as the units of analysis.

THE TREATMENT OF ERROR

The common-factor model involves assumptions concerning the structure of error variance in a correlation or covariance matrix which are of particular importance in the present context. Briefly stated, common-factor analysis decomposes an m x m matrix into k common factors, where k is less than m, and m 'unique', 'specific' or 'error' factors ('error' in the sense of making no contribution to the common-factor structure, rather than implying unreliability). On the assumption that the unique factors are orthogonal to each other and to the common factors, the analysis then yields common factors which are formally uncontaminated by measurement error.

In vector notation, the common-factor model may be expressed thus:

$$X = \mu + \Lambda\vartheta + \upsilon$$

where X is the vector of observed scores for a given individual

μ is the constant vector

Λ is the m x k matrix of factor pattern coefficients

ϑ is the vector, of length k, of common-factor scores for that individual

υ is the vector, of length m, of specific factor scores

This formulation is general, in that no modification is required to take account of correlations amongst the common factors, i.e. the factor-pattern coefficients are partial regression coefficients in the above equations. On the assumption that all specific factors are mutually uncorrelated, and uncorrelated with all the common factors, the correlations amongst the observed variables are accounted for entirely in terms of ϑ .

In matrix notation, the variance-covariance matrix of the observed variables, denoted here by Σ , may be expressed as:

$$\Sigma = \Lambda \Phi \Lambda' + \Psi^2$$

where Λ is again the matrix of factor-pattern coefficients or loadings

Φ is the variance-covariance matrix of ϑ

ψ^2 is the diagonal matrix of specific factor variances, or error variances (Lord and Novick 1968 p. 533)

Thus in terms of the formalisation of the common-factor model, the only term which may be called error relates to the uncorrelated parts of observed variables. There are two components of the specific factor variances. The first is errors of measurement, i. e. the unreliability of observed scores. The second is the extent to which the reliable parts of observed variables are only partly to be accounted for by the common factors in a given factor model. For instance, when a real influence on a given variable is represented only in scores on that variable it will not of course appear in the common-factor structure, even though the contribution it makes to the variance of that variable is consistent, and may be identified in a different analysis involving more or different variables.

Thus, when it comes to the interpretation of an obtained factor solution, even supposing (which is unlikely) there to be no non-zero off-diagonal residuals, one cannot without further information unpack the specific factor variances into measurement error and reliable variances associated with single variables. A further problem arises from certain inadequacies in the kinds of measures psychologists typically use. Interest usually centres on factors representing influences in some domain of theoretical interest, in the present case personality. However, what are nominally personality tests may well reflect variations in intelligence, or social class, or test response sets. Thus a factor analysis of personality tests may result in a structure which accurately describes the relationships among the tests, but not among the variables with which the investigator is primarily concerned, i.e. the personality traits, only imperfectly represented in test scores.

This kind of error, error with respect to some substantive theoretical model, may arise from any of three sources. In the first place, a trait relevant to the domain under investigation may be reflected in scores on tests intended to measure other traits.

Thus anxiety might influence scores on measures of sociability - in other words the sociability tests are to this extent inadequate - with the result that the factor pattern matrix shows a loading of the anxiety factor on the sociability tests. In the second place, unwanted influences may affect scores on two or more measures, in which case they may be identified, and rotated into separate factors, eliminated by careful test construction, or deliberately measured and thus accounted for. Attempts to deal with acquiescence and social desirability response sets and the like (Edwards 1957) illustrate this problem. Finally, variables which are not formally represented in the tests to be factored, but which can be measured by other means, may affect the obtained factor structure, in particular through their influence on the mean vectors of test variables.

To a great extent personality tests are composed of items which may be expected to vary in significance across social and cultural groups. That is to say, the same response to the same item may signify different levels of the same trait, or even a different trait altogether, in different groups. If the aim of personality testing were merely to outline dimensions of (reported) social behaviour, rather than such sources of differing behaviour as may be ascribed to consistencies in the individual, this point would be irrelevant, but we have it from Cattell (1973) that his scales are intended to measure traits with characteristically different expressions in different social, cultural and national groups.

Thus one must ask to what extent, for instance, differences in mean scale scores between identifiable social groups represent real differences in personality rather than a tendency for one group to respond more in the higher-scoring direction on account of the cultural loading of specific items. The consequences of spurious differences generated in this way will be to reduce correlations between variables when single scales are affected, and inflate them when both scales are involved. Thus within-group correlations may vary considerably from correlations computed over a total sample, and the more pervasive the influence of the moderator variable, the greater the distortion resulting.

Note that this problem is not identifiable with elements of either of the formulations of the common-factor model presented earlier. The formal model is concerned with accounting for the observed variates, not the underlying theoretically important variables. What is being suggested here is that parallel to the effects of unreliability in increasing the size of the specific-factor loadings is an effect of low validity on the common-factor loadings. Specificially, when there are pervasive moderator effects, one would expect increased values for correlations computed over the total sample when the algebraic product of the signs of the moderator-induced shift in mean scores is the same as the sign of the within-group correlation. Depending on the extent of the moderator effect, this may well result in either a reduction in the number of factors retained for rotation, when the criterion for retention is based on the size of the eigenvalues, or a spurious increase in correlations between common factors in an oblique solution, or the appearance of factors which are not readily interpretable in terms of the variables nominally entered into the analysis.

Since traditional methods of factor analysis do not recognise these effects as error (and nor are they from the point of view of the formal model), from the point of view of the personality theorist distorted solutions are likely to result.

Given the heuristic nature of exploratory factor analysis as typically used, there is little that can be done about error arising from contamination of one test by factors hypothetically relevant only to others, apart from attempts to purify measures by what Cattell has called 'progressive rectification', i. e. improving the tests in the light of successive studies - which can be something of a circular activity. Where the result has been that structure remains in the residual matrix, one should doubt one's criterion for the retention of factors for rotation, but this is only likely to be acceptable when nominally equivalent measures have appreciable residual covariance. (Inspection of residuals has, of course, been automated in the maximum likelihood and minres methods of analysis).

The correction of moderator-induced error is rather more feasible: likely moderators may be partialled out in advance of factor analysis, or analysis may be performed on homogeneous groups selected on appropriate measures of the hypothesised moderator. Simply entering likely moderators into the analysis will not do in general, however, since any criterion for the number of factors to extract which is based on eigenvalues may be too severe in consequence, the more so the greater the effect of the moderator.

To sum up, the problem of error when using factor analysis as an aid in theory building and testing is not exhausted by considerations of reliability. Factor analysis deals not in variables which have a place in some theoretical scheme of things, but in correlations or covariances between observed scores in a sample of variates which purport to reflect theoretically important variables, hence one must consider whether there may be influences affecting the validity of tests used for the sample involved.

Thus far we have considered errors in factor analysis arising from the imperfect reliability and validity of measures, a topic which has received relatively little consideration in published studies, although occasionally (e.g. Pawlik 1973, Cattell 1966 p. 112) theoretical writers have devoted some space to them. Such error has usually been lumped together with sampling error, and no distinction has been made for purposes of reporting the 'proportion of variance accounted for' by the factors retained for rotation. In general, however, factor analysts envisage the possibility of inference from the analysis of covariance matrices derived from sample data to some larger and usually ill-defined population. Thus limitations on the method may be imposed by the size and representativeness of the sample, both of which will affect the adequacy of the sample matrix as an estimate of the population matrix, the first by way of the standard error of the elements, the second in cases of unintentional selection on the variables included.

Note that the second of these is not identical with the question of moderator effects discussed earlier: moderator effects reduce to the intrusion of unwanted variables which should be eliminated; unintentional selection may result in a poor estimate of the population matrix, but by way of deficient sampling of subjects, possibly leading to restriction of range, rather than from different scaling properties of the measures within the sample.

Questions of sample adequacy can only be settled outside the computational devices of factor analysis; the matter of the effects of sample size on the procedure is internal to it, and attention has been focussed on this aspect with the emergence of maximum-likelihood methods. The smaller the sample size, the fewer common factors are needed for a statistically acceptable solution. That is to say, the goodness-of-fit test used may not, with small samples, be powerful enough to reject the hypothesis of a number of factors which, from the personality theorist's point of view, is smaller than optimum. Conversely, with a large sample many more factors may be indicated by the significance test associated with maximum likelihood procedures than are interpretable, or than would have been retained using other methods and criteria (see esp. Kaiser 1976), particularly when large numbers of variables are involved. Prior to the introduction of maximum likelihood methods, the adequacy of the size of a sample was judged by reference to rule of thumb, 'five times as many subjects as variables' being one common criterion. However, the apparent rigour of the chi-squared test for number of factors does not really bear on the matter of the number of relevant factors from the point of view of the investigator, since when error due to poor test validity is present in the matrix a sufficiently large sample size will ensure that the test will suggest a poor fit even when all factors of theoretical interest have been extracted.

A factor analysis of personality scales may reasonably be undertaken for either of two purposes: a) to assess the adequacy of or aid in the development of a factor theory of personality; or b) to investigate the adequacy of the scales representing such a theory, given that it is accepted. One must distinguish between a good theory poorly represented psychometrically and a bad theory pure and simple. Bad tests may support a theoretical model, even though they are quite unsuited for application to real-world problems.

SAMPLING OF SUBJECTS

There seems to be no general agreement as to what constitutes an appropriate sample for the purposes of conducting a factor-analytic investigation - indeed there appears to be very little discussion of the topic at all. Most textbooks of factor analysis simply ignore the matter, although Fruchter (1954) devotes a brief paragraph to the intrusion of unwanted variance due to deficient sampling.

Cattell (1966a) states that " ... preliminary taxonomic work is necessary to make clear when one is sampling within species and when across them," but continues by suggesting that this presents no problem, since we "know what we are doing and do not put men and monkeys in the same sample" (p. 113).

Eysenck (1966) takes a firmer line: "Ultimately what is being asserted here is that correlations between variables a and b may differ significantly in size and direction when total groups are subdivided according to typological principles, and correlations run over these subgroups." In the absence of such typological analyses "correlational analysis ... is liable to gross errors ... " Yet when it comes to one of the most often cited of his own factor analytic studies (Eysenck and Eysenck 1969), not only is the sample not divided, except by sex, on typological grounds; not only is no typological analysis presented to justify the procedures adopted; but (p. 182) apologetic remarks are made as to the inadequacy of the subject pool as representative of the population of the country as a whole.

Nonetheless, in principle at least, both seem to agree that homogeneity of subjects with regard to taxonomic considerations outside the personality domain is desirable. But at this point the problematic nature of the concept of personality intrudes. For the interaction between taxonomic groupings and test scores is in a sense what personality measurement is about. Trivially, supposing there to be extraverts and introverts as exlusively defined categories, one seeks an interaction between test scores and group membership as the basis of measurement.

Less trivially, females typically show higher average scores than males on measures of anxiety and neuroticism. This may of course be attributable to a real difference between the sexes in levels of anxiety, but on the other hand may result from a greater willingness on the part of females to admit to minor symptoms which in fact they suffer no more than males. In the first case the factor analyst would be justified in not analysing results separately for the two sexes, in the second he should split by sex. In general, given adequate sample size, there is nothing to be lost and possibly something to be gained by splitting a sample on taxonomic grounds or by seeking homogeneity on external criteria, in terms of achieving a better fit to the assumptions of the common-factor model.

SAMPLING OF VARIABLES

On the matter of sampling of variables, one could hardly do better than to quote Guilford (1975):

> "There must be a favorable pattern or combination of experimental variables. Each factor must be equally well represented in terms of the number of variables per factor, and each set must be equally strong with respect to the amount of variance. These requirements for selection are important because in connection with rotation of axes, there is a general principle that strong (better represented) factors tend to rob weak ones of their variances."

Such requirements assume a good deal of a priori information about the variables relevant to a given domain, and since factor analysis has been used mainly to generate hypotheses rather than test them, Guilford's argument appears to suggest that in the absence of a fortunate combination of circumstances most factor analyses will be inconclusive.

Guilford's point may be taken even further, for not only may weak factors be robbed of their variances in rotation, they may not be included amongst the factors retained for rotation if better-represented factors account for the greater part of the variance in the matrix, a problem which will be particularly relevant when the criterion for retention of factors is based on the absolute sizes of eigenvalues.

This question is of importance for a critical examination of studies which include sets of scales from different authors in the same analysis, e.g. Eysenck and Eysenck (1969) and Sells, Demaree and Wills (1970). Both studies are concerned, not to establish regression weights for one set of scales onto the others, but to determine which author's scales give the 'best' picture, if any. Both studies used principal components analysis, and had they rotated all components there would have been little of interest in these analyses. (This follows from the fact that all positive definite matrices of a given order form a group under non-singular transformation, which is itself simply a reflection of the fact that such matrices have an inverse. Thus the full set of components may always be rotated to a specified pattern, with consequences only for the matrix of correlations between rotated components.)

However, since in each case only the largest components were retained, one must ask what characteristics would lead to the representation of variables in the components rotated. Eysenck and Eysenck in their joint factorial study of the Guilford, Cattell and Eysenck scales extracted the first twenty principal components of correlation matrices for each sex, made up as follows:

From Eysenck's laboratory:

10 subscales representing Extraversion and Neuroticism	96 items
2 lie scales	18 items

From Cattell's laboratory:

15 short scales, each representing one source trait	99 items

From Guilford's laboratory:

13 short scales, each representing one primary factor	109 items

In addition three acquiescence scales were scored, one from the items contributed by each of the three authors. On the not unreasonable assumption that the various scales best represent, length for length, their authors' thinking, we thus have for the hypothesised personality factors:

48 each for the two Eysenck factors, in two groups of five scales.

6-7 each for the Cattell factors in fifteen scales

8-9 each for the Guilford factors in thirteen scales

Now consider three points: 1. the reliability of a test tends to increase with length; 2. correlations are attenuated as a function of decreasing reliability of the variables; 3. there is general agreement that Cattell's and Guilford's scales relate to Eysenck's as lower-order to higher order factors, hence Eysenck's factors represent common ground. It is hardly surprising that of the ten components extracted, after rotation the first two carried the largest portion of variance and were "unambiguously identified as neuroticism and extraversion". Simply on the grounds that Eysenck's factors are very overrepresented it is clear that the conclusion drawn, that Cattell's factors are not well replicated, is more a comment on the procedures adopted than on the adequacy of Cattell's model. One would need a great deal of faith in the capacity of factor analysis to reveal the true structure of personality traits regardless of the configuration of input variables to accept this analysis as a reasonable test of the adequacy of Cattell's primary factor scales.

This study is perhaps the clearest example of how sampling of variables can predetermine the outcome of an analysis, and illustrate how factor analysis favours areas of overlap between different systems at the expense of factors which may be represented in only one set of scales. It is likely, though more difficult to show clearly, that the same effect is present in other studies relating different sets of scales and items, such as Sells, Demaree and Wills (1970) and Howarth and Browne (1971b).

CHOICE OF MATRIX

Traditionally, factor analysis has been conducted on correlation matrix. Rarely are grounds for the choice specifically of correlations forthcoming from authors who use the technique, but in principle there is at least one other appropriate index, namely covariance. Perhaps the strongest reason for using correlations rather than covariances is that in general the units of measurement of psychometric tests are arbitrary, so that for a single sample study neither raw score means nor raw score variances have any absolute significance. Hence the removal of mean and variance effects which is implicit in the calculation of product-moment correlations seems to be a logical choice in the absence of strong indications to the contrary. That is to say, whilst there are no particular grounds for setting all variables to the same scale, psychometricians rarely have enough confidence to choose scaling factors for each variable separately, hence the use of correlations is a straightforward admission of ignorance. Statements as to the proportion of variance extracted in an analysis have therefore to be read as referring to weighted raw score variance and covariance, rather than variance in personality or whatever.

However, from time to time studies, e.g. Eysenck and Eysenck (1969), appear in which attempts are made to relate results from the factor analysis of two separate groups, often sex groups, and factor-pattern comparisons are made across samples and studies. Leaving aside the question of different rotational principles and methods which may lead to apparent lack of factorial invariance, the exclusion of mean and variance effects results in different metrics for the variables in different analyses. In confirmatory factor analysis one is concerned to discover whether a given factor solution, in terms of high and low loadings in the factor pattern matrix, is replicable on a different sample of variables and/or subjects. In neither case may one safely assume that factor variances will be identical across studies, or between groups within a study. Consequently in the process of selecting the strongest factors on the basis of the size of their associated eigenvalues and then rotating them blindly there is a risk that underextraction of factors may lead to quite different solutions for different samples, or that particular criteria for rotation may result in different positions for the axes where a common pattern, at least in terms of which factors have high and low loadings on which variables, could be established.

As a first step away from the totally arbitrary allocation of unit variance to each variable, the use of a common scale for the same variables in each sample followed by the factoring of variance-coveriance matrices seems prudent. This does not solve the overall problem of the relative size of variances between variables in the sample yielding the common scale, but is at least some improvement over the blind use of correlations. The common scale for each variable might be obtained by standardisation of variances in the pooled sample, and then proceeding to analyse within-group coveriance matrices. There are doubtless other possible approaches to this problem, and as with so many other aspects of psychometric methods a strict resolution of the problem will only come, if at all, with the establishment of non-arbitrary scaling factors for particular tests.

Cattell (1944) tackles the problem of comparing factor solutions across groups and samples, suggesting "parallel proportional profiles" as the criterion for an acceptable solution when more than one sample is involved. In effect, the results of adopting his approach are similar to the method just outlined, so long as an appropriate number of factors is retained for rotation. Eysenck and Eysenck (1969) adopted Cattell's suggestion as to the criterion for acceptability, and claimed poor matches between factors in their samples of males and females. However, they did not transform their factors to be as similar as possible before attempting to match. Otherwise the critics of Cattell's model have been notable for their omission of any consideration of the problem.

VARIABLE TYPE

Among Cattell's practices in his use of factor analysis one of the most criticised is his tactic of analysing correlations between parcels, that is to say subscales of small groups of homogeneous items, rather than between single items. Howarth (1976) among others has claimed that in effect this rigs a factor analysis to achieve the investigator's desired results. Eysenck (personal communication) has suggested that a definitive resolution of the debate between himself and Cattell must stem from the factor analysis of items. Comrey (1970) and Nunnally (1967) express themselves strongly against the use of factor analysis of items, largely on the grounds that items are highly unreliable, whilst Cattell (1972) and Burdsal and Vaughn (1974) imply that parcel factoring is both equivalent in terms of results and simply more convenient from a practical point of view. A further consideration, rarely if ever mentioned in the psychometric literature, is that items such as Cattell's, which have only three score categories, do not satisfy the linear model and hence without rescaling are not appropriate variables for factor analysis.

Serious arguments against item factoring tend to concentrate on the intrinsic unreliability of single items. The effect of test length on reliability is too well known to need extensive discussion; quite simply a single-item test will be very considerably less reliable than a test composed of a dozen or more similar items. Unreliability of variables in a factor analysis will tend (a) to reduce the absolute size of off-diagonal elements in a covariance matrix (the attenuation effect); (b) to increase the amount of correlated error through the intrusion of unwanted, specific covariance common to only two or three items; and consequently (c) to make rotation of the resultant factor-pattern both more difficult and less clear in outcome, since common-factor loadings on items will tend to be small, making the identification of salients problematic.

A further complication arises when factoring large numbers of items, in particular when their unreliability is taken into account. As a rule of thumb, a sample size of from five to ten times the number of variables is recommended so as to counteract the accumulation of sampling error in the off-diagonal elements of the matrix. Given the 368 scored items in forms A and B of the 16PF, a sample size for a single analysis of well over 1500 is indicated. Attempts to circumvent this particular problem, and the associated problem of arranging computer facilities to handle a matrix of the required size, have included the analysis of 'marker' items, that is to say items which are thought on the basis of previous analyses to be particularly efficient at delineating the structure of the factor space. Such a strategy, however, involves a trade-off: smaller samples are needed, but the consequent reduction in the number of hypothesised salients for each factor may make rotation difficult. A priori, there are only slight grounds for assuming that the best marker items for an American general population sample will also be best for a British undergraduate sample.

For the purposes of confirmatory analysis, it is hard to see why Cattell's critics have not attempted to analyse scale scores on two or more forms of the 16PF. There is after all a clear hypothesis implicit in the publication of the test, viz. that named scales in each form will be loaded by corresponding factors, and not by others. Since the rotational indeterminacy of factor analysis, exacerbated by the low loadings characteristic of item factoring, seems to preclude any agreement between Cattell and his critics at the item level, analysing scales offers certain distinct advantages:

1. The rank of a reduced (by insertion of communalities in the diagonal) covariance matrix based on scales will be a lower bound to the rank of a matrix based on the items combined in the scales. That is, since scale scores are the simple sums of mutually exclusive sets of item scores, at least as many factors should be found in an item factor analysis as in a scale factor analysis.

2. Given the higher reliability of scale scores, minor covariances between small numbers of items resulting from specific cultural or social influence local to the sample will be reduced in their influence (e.g. "I can always enjoy myself at a gay party" and "I am always straight in my dealings with my friends" are hypothetical items with local double meanings).

3. If the hypothesised model holds, factor salients will be larger, and hence rotation facilitated.

4. The argument that items which do not have large loadings on factors corresponding to the scales on which they are scored are nonetheless contributing to the purity of measurement by suppression of unwanted covariance between other items in the scale and other factors becomes irrelevant.

In other words, by analysing at the level of scale scores, the question as to whether Cattell's model is reasonably represented in his scales can be settled. If it does hold, then it may be worth investigating why, against evidence from other researchers, it does so. If it does not hold, then the way is open to develop notions of what the structure may be at the item level.

Thus the analysis of scale scores is convenient in several respects, requiring smaller samples, improving the chances of clear rotation, reducing demands on computing facilities (and hence allowing the use of more sophisticated techniques), and yielding the general advantage of dealing with more reliable variables.

Finally, against the use of item factoring, there is the possibility that scales consisting of items with different difficulty levels will suggest more or different factors in an item factor analysis as a consequence of their difficulties. Guttman's (1954) simplex model is but one example of how a matrix of correlations between measures of a single attribute, each measure differing from the others in terms of its difficulty or complexity, may have factors which fail to reflect the underlying unidimensionality. Lord and Novick (1968), Pawlik (1973) and Levy (1973) all point out this difficulty in equating the dimensionality of the factor space with the dimensionality of the latent space. Whilst in practice they may be uncommon, it is possible to envisage scales whose items differ in terms only of their difficulty. The item intercorrelation matrix for a perfect scale of this type would have values decreasing progressively with distance from the diagonal. Such a matrix will normally be of full rank, and will yield principal components following an oscillatory pattern, and whilst the scale may be unidimensional in the sense that all items are validly measuring the same attribute, the least and most difficult items may have near-zero correlation, be loaded by different factors in a factor analysis and give the impression of a heterogeneous scale. The compensatory model of scale construction is thus not the only possible model implicit in personality tests: conjunctive, disjunctive and mixed models may equally claim consideration.

Cattell is not explicit on this point, nor, given the unreliability of items, is it a straightforward matter to decide which model is implicit in his scales, or the extent to which they are mixed if that be the case. However the possibility of a progressive ordering of difficulty among the items of a scale is yet another counterindication for the use of factor analysis of items as a basis for evaluating the goodness of fit of Cattell's model.

CONCLUDING COMMENTS

The considerations outlined in this chapter were not developed in isolation from the practical problems involved in the design and conduct of the research project to which we shall turn shortly. Given the almost unanimously critical research literature, the author's expectations at the outset were that Cattell was likely to come out of a large-scale study rather badly. To avoid the possibility of predetermined negative results, especially given the acknowledged indeterminacy of factor analysis, it seemed prudent to allow Cattell's hypothesised model the benefit of the doubt and seek sources of contradictory findings other than in the technicalities of the arbitrary decisions which have to be made. In the event these were not hard to find. The author has no favourite criteria or techniques, rather his aim was to discover which techniques if any supported Cattell's model. A further gesture in the same direction is the use of an undergraduate subject pool. Cattell, Eber and Delhees (1973) state that most of the development work on the 16PF was done on samples of around 200, with a strong undergraduate or young adult representation. This study involves a sample five times as large, and the factor analyses reported were conducted with the specific aim of attempting to identify Cattell's model, rather than attempting to reject it.

CHAPTER 5

THE DATA BASE:

1. Sampling and Administration

The collection of the data on which this study is based has been described in Saville and Blinkhorn (1976). Since perhaps the most intensive use of Cattell's scales in this country is in higher education, in research, careers and personal counselling and by employers of graduates in recruitment procedures, there was, at the time the project was begun, a need for representative undergraduate norms in Britain. A literature search revealed that no systematic sampling of undergraduates for this purpose had been attempted even in the USA. Saville (1973) had used random location sampling techniques with repeated follow-up to collect general population standardisation data for the 16PF, but despite the undoubted success of this method it had proved expensive, involving commercial sponsorship and a large grant from a charitable trust to cover the services of the British Market Research Bureau.

In addition to the cost involved, ues of the same method for sampling of undergraduates was impractical, largely due to the difficulty of determining the place of residence of individuals in the target population. Some compromise between random and volunteer sampling had to be found, and eventually the cooperation of the careers advisory services of almost all the universities in the UK was enlisted, polytechnics and other colleges being excluded for lack of detailed statistics of undergraduate enrolment.

Based on the latest statistics then available (1969-70 entry) each university was asked early in 1973 to provide a sample proportionate to its annual undergraduate intake. At the time, students' sensitivity concerning the disclosure of personal information led to the universities being unwilling to release lists of names for random selection, hence selection of participants was delegated to the careers services and could not be supervised. Where possible the careers services arranged for random lists of names to be generated by computer; elsewhere every n'th name was taken from the list of registered students in their second year of undergraduate study. Each participant was written to individually and invited to take part.

In practice, the sample size obtained from each university was determined by a number of factors. In some cases the careers service was prepared to write repeatedly to the same individuals; in others a larger sample than requested was invited to participate and no follow-up was attempted. In the circumstances, such matters had to be left to the discretion of the collaborators. One university (Manchester) had no difficulty in recruiting most of its original sample without follow-up, and had to turn away uninvited volunteers, whilst at the other extreme Sussex had a very poor response. In an attempt to offset these differences in response rate, the universities had been stratified by location, using arbitrarily defined regions of the UK, and by a hybrid size/type classification (London, Oxbridge, provincial large, provincial medium and provincial small). Shortfall in one university was partially remedied by persuading fieldworkers in universities in the same stratum to increase their sample.

The sample consists entirely of undergraduates in their second (i. e. not necessarily penultimate) year of study, tested between March and June 1973. Second year students were chosen as being less under examination pressure than finalists, more accultured to university life than freshmen, and likely in any case to be about to make contact with the careers service. The sample was randomly divided in two within each university, half the students completing forms A and B of the 16PF, half forms C and D. All students also completed the APU Occupational Interest Guide (Advanced Version), and those taking the shorter forms C and D of the 16PF also took two short Cattell scales (IPAT Anxiety Scale and the Neuroticism Scale Questionnaire), plus form A of the Eysenck Personality Inventory. A further balancing was introduced by varying the administration order of forms of the 16PF, so that half of each subsample completed them in the order B-A (D-C) rather than A-B (C-D). This was achieved by manipulation of the page order in the specially printed booklets before stitching. The original print of the 1968 Anglicised versions of the 16PF was reproduced lithographically in the booklets used: answer sheets were dispensed with by instructing participants to ring their answers in the booklet - a procedure which speeds completion and eliminates transcription errors. Reports from the fieldworkers suggested that about 90 minutes had been adequate time for the majority of the participants, a figure suggested on the basis of a small pilot study conducted at Glamorgan Polytechnic.

2. Size and match of sample

The sample quotas negotiated with each university were aimed at providing a minimum total sample of 2,000, split equally by sex and across pairs of forms of the 16PF; the print run allowed for a maximum total sample of 3,000. Table 1 gives the actual numbers of returned protocols in each subgroup. The total of 2584 represents approximately 3% of the total undergraduate intake in British universities for the year in question, although clearly and designedly females are overrepresented. For the purposes of the analyses reported later, only complete protocols, including all biographical information, were included, to ensure

	Forms A and B		Forms C and D	
Order	A-B	B-A	C-D	D-C
Male	309	304	305	300
Female	339	339	344	344
Total	648	643	649	644
Total A+B	1291		Total C+D 1293	

Grand total 2584

Table 1: Numbers of protocols returned

	Males		Females		Total	
	% Pop.	% Sample	% Pop.	% Sample	% Pop	% Sample
Region						
Wales	6	8	7	9	6	8
W.England	5	5	6	6	5	6
S.E. England	14	10	12	9	13	10
London	12	9	12	11	13	10
E.Anglia	7	9	4	5	6	7
Midlands	11	11	12	11	11	11
N.England	26	25	26	28	26	26
Scotland	15	17	17	15	16	16
N.Ireland	4	6	4	6	4	6
Size and type						
Large Prov	32	33	37	34	33	33
Med. Prov.	29	31	29	31	29	31
Small Prov	18	21	18	22	18	21
London University	8	11	8	12	8	12
Oxbridge	10	9	4	6	8	8

Table 2: Percentages of university population of second-year undergraduates and of sample by region and size/type classification

that all analyses were based on identical samples. This reduced the sample for forms A and B of the 16PF to 545 males, 599 females and hence a total of 1144, a move which had no appreciable effect either on raw score distributions or on the match of the sample to published statistics of university entrants for the intake from which the same was drawn (University Grants Committee 1975). Table 2 gives percentage figures for population and sample classified according to the sampling frame mentioned above for the forms A and B sample.

Counting Oxford, Cambridge and London universities as one each and the colleges of the University of Wales as separate institutions, forty-three universities participated. Of the remainder, three refused, one did not reply and three were prevented from taking part as a result of their materials being strikebound at Heathrow airport. Table 3 gives the results of chi-squared goodness of fit tests between the sample and population figures of Table 2; these show no evidence of a significant mismatch in distribution of respondents across these (admittedly arbitrary) sampling categories.

3. Internal evidence of quality

All protocols were inspected individually to identify those with missing data and to ensure that incorrectly completed documents were not processed. In addition each script was checked for signs of

	by region (8 degrees of freedom)		by size/type (4 degrees of freedom)	
	χ^2	p	χ^2	p
Males	4.53	>0.80	1.85	>0.70
Females	3.12	>0.90	3.60	>0.30
Total	3.41	>0.90	2.00	>0.70
Critical value for significance at 0.05 level	15.51		9.49	

Table 3: Chi-squared tests for fit of sample to population

blatant frivolity. In the event, only a dozen or so scripts were rejected, all but one because certain identifying detail, e.g. sex, had not been recorded - the exception being one respondent who had systematically added extra response categories to certain test items. As mentioned above, other scripts were later rejected for present purposes due to incompleteness in other respects.

Since participation in the fieldwork was voluntary, there was a possibility that the project would attract respondents of a particular personality type, e.g. more anxious, more dependent or whatever. This might be expected to result in restriction of range of scores on one or more of the personality scales. Since population statistics are not available the crucial comparison is of course not possible. However, comparison of scale variances from this sample with those from Saville's general population sample and from the American college student standardisation sample suggests that if such an effect is present it is shared with other studies, in the case of Saville's with a study employing superior sampling techniques. Table 4 gives the standard deviations of scale scores for forms A and B combined for the three studies, divided by sex. With the notable exception of factor B (intelligence), there is an overall tendency for the standard deviations of scores for the present sample to be at least as large as for the other samples. Thus it does not seem that the problems

Factor	Males: This study	Males: British General Population	Males: American College Students	Females: This study	Females: British General Population	Females: American College Students
A	6·92	5·85	6·92	6·58	5·02	6·04
B	2·94	3·47	2·94	2·75	3·44	2·94
C	7·60	6·99	7·19	7·11	6·67	7·10
E	7·58	7·30	7·11	7·72	6·69	7·30
F	9·39	9·23	8·28	8·56	8·61	7·96
G	6·69	5·90	6·25	6·51	5·46	5·99
H	11·95	10·30	10·96	11·39	10·36	11·07
I	6·87	5·76	6·46	5·89	4·58	5·18
L	5·40	4·95	5·19	5·30	4·94	5·22
M	6·54	5·63	6·79	6·09	5·92	6·49
N	4·52	4·80	4·26	4·65	4·71	4·32
O	8·69	7·79	7·91	7·94	7·58	7·67
Q_1	5·58	4·97	5·26	5·91	4·71	5·11
Q_2	6·22	5·76	6·26	6·08	5·59	5·98
Q_3	6·69	6·00	5·60	6·58	5·73	5·96
Q_4	9·59	9·20	8·63	9·32	8·16	8·65

Table 4: Standard deviations of raw scale scores by sex in three standardisation samples, for forms A and B of the 16PF combined.

involved in recruiting the sample in this case had any consequences for the range of scores on individual scales that might lead one to suppose that self-selection had been a more serious problem than elsewhere.

In the circumstances, willing cooperation of participants was perhaps more important than obtaining a perfectly random sample by obliging selected individuals to take part in the project, which might have led to poor quality data simply because responses are entirely within the control of the individual. Had random responding taken place on a large scale in protest against enforced participation, the value of the exercise would have been considerably reduced.

The only explicit internal checks on the quality of the data were in the lie scale of the Eysenck Personality Inventory, and the Motivational Distortion Scales of forms C and D of the 16PF (i. e in tests which were not administered to the half of the sample with which this thesis is principally concerned). These scales were designed to detect deliberate distortion of responses. The mean scale scores for this study were almost exactly identical with those from Eysenck's standardisation in the case of the EPI, and about half a standard deviation lower than those from Cattell's college student standardisation of the 16PF. It is debatable to what extent these scales should be taken seriously as indicating level of faking, since the items in question can often be identified by the suspicious student. However, where the present author actually administered the questionnaires, the only suspicions voiced about the detection of faking and the like were when some participants suspected that items were repeated verbatim as a check on consistency (which is not the case).

The author's own observations of participants, in sessions at Brunel University and several of the London colleges, left him with the impression that there was considerable enthusiasm for the project amongst those who actually took part. Each of these sessions was, at the request of participants, followed by an extended discussion of the aims of the project in relation to the problems of assessing non-cognitive individual differences. Reports from fieldworkers in other universities corroborated the impression that motivation and interest was high.

No doubt the enthusiasm was in part due to the promise of feedback of scores through the careers services, demand for which continued throughout the following year. In practice, all participants' scores on the occupational interest guide were made available to those who requested them, and scores on the personality tests were sent where an appropriately qualified psychologist was available to interpret them. Anonymity was maintained by keeping records of participants names against index numbers only in the offices of the careers services.

4. Initial analyses

Saville and Blinkhorn (1976) report a large number of univariate and bivariate statistical analyses, with the aim of clarifying the degree and nature of variation within the samples. Relevant to this thesis in particular are the following findings.

(1) Sex differences in mean scale scores on the 16PF for several factors are both statistically significant and in some cases large in absolute terms. Furthermore there is overall consistency, with only minor exceptions, both across forms and in comparison with corresponding findings in the general population. (Saville and Blinkhorn 1976, tables 3.1 to 3.6).

(2) Mean scale score differences are statistically significant also in several cases across discipline categories, as coded in terms of the nine groupings used by the University Grants Committee. In particular there are large differences on Factor I, which also shows large sex differences. These differences remain when discipline groups are divided by sex. The size of these differences had not been anticipated - indeed one researcher with considerable experience in dealing with large undergraduate samples advised that there was little point in even collecting discipline information, since in his experience no groupings had ever been found to yield significant differences. In the event,

discipline differences appeared to be about as large as sex differences overall, although mostly they were concentrated in the division between Arts and Social Science students on the one hand and Science and Engineering students on the other, rather than between groups within these categories. In comparison with the approximately comparable age group in Saville's general population sample (mean age 20, range 16-24 years, of whom about 10% were university students) the undergraduates (mean age 20, 96% being in the range 17-24 years) show a complex pattern of differences. Table 5 gives means and standard deviations for the first-order scales of forms A and B combined of the 16PF for the undergraduate sample divided by sex and discipline, and the general population young adult group divided by sex. On some of the scales undergraduates as a whole tend to differ in the same direction from their general population coevals, whereas on others the young adult mean scores are in between undergraduate discipline groups.

(3) Reliability, as estimated by alternate form correlations, was generally higher than reported by Cattell, Eber and Tatsuoka (1970), but in general not impressive. For forms A and B coefficients ranged from .23 to .81, with median approximately .58. Fuller details and a comparison with other estimates of reliability are given in the next Chapter.

		Male Arts	Male Science	Female Arts	Female Science	Male Young Adult	Female Young Adult
A	mean	21·12	15·57	21·39	18·19	18·04	21·88
	s.d.	6·57	6·20	6·23	6·74	5·70	5·16
B	mean	18·00	18·40	18·62	18·56	15·02	14·68
	s.d.	3·04	2·84	2·70	2·84	3·02	3·27
C	mean	30·19	31·83	28·95	31·17	30·48	27·82
	s.d.	8·04	7·14	7·13	6·85	7·13	6·65
E	mean	28·28	26·44	22·23	21·30	26·77	20·87
	s.d.	7·28	7·70	7·87	7·39	7·35	6·50
F	mean	31·06	28·56	30·24	29·93	32·67	31·07
	s.d.	9·83	8·93	8·39	8·90	8·43	8·18
G	mean	21·51	21·71	21·63	22·94	21·07	21·98
	s.d.	6·72	6·68	6·44	6·59	6·14	5·47
H	mean	26·58	22·82	22·81	22·66	28·56	23·14
	s.d.	12·26	11·45	11·46	11·29	10·21	10·49
I	mean	23·35	18·10	28·64	23·22	17·02	24·14
	s.d.	6·37	6·39	5·01	5·86	6·11	4·49
L	mean	18·72	16·96	15·96	15·02	18·89	17·29
	s.d.	5·28	5·39	5·41	5·04	5·32	5·11
M	mean	28·36	26·90	28·10	25·93	23·32	21·34
	s.d.	6·63	6·41	6·09	5·86	5·83	6·04
N	mean	17·34	17·82	18·86	18·54	18·78	20·69
	s.d.	4·85	4·24	4·69	4·59	4·63	4·66
O	mean	21·34	20·91	26·17	25·04	20·47	26·34
	s.d.	8·92	8·49	8·03	7·73	8·32	7·09
Q_1	mean	22·32	20·99	20·27	19·29	21·57	18·13
	s.d.	5·61	5·49	6·03	5·60	5·03	4·81
Q_2	mean	20·18	20·92	20·09	19·33	18·85	18·97
	s.d.	6·61	5·89	6·14	5·92	5·84	5·40
Q_3	mean	21·37	22·82	19·98	21·50	21·57	20·02
	s.d.	6·97	6·42	6·77	6·09	6·09	5·67
Q_4	mean	25.11	23.67	29.25	27.85	25.54	30.71
	s.d.	9·98	9·28	9·41	9·10	9·24	7·38

Table 5: Means and standard deviations of forms A+B scale scores

(4) Factors C, O, and Q_4 on all forms and for all groups had intercorrelations approximately equal to their reliabilities, and factors L and N for some groups and forms had correlations with other scales equal to or greater than their reliabilities, suggesting that their factorial independence was seriously in doubt.

(5) Eysenck's Extraversion and Neuroticism scales, followed by Cattell's scales representing factors B, I and Q_1 were successively partialled out of a correlation matrix including the two Eysenck scales and the scales of forms C and D of the 16PF, calculated both for the total sample and for the sexes separately. Results indicated that Eysenck's (1972) claim that the reliable variance in Cattell's first order scales is almost totally accounted for by Neuroticism and Extraversion is exaggerated, and suggested a minimum of seven factors to account for these scales.

The results summarised above form the background and source of the present study. As far as can be ascertained, the discovery of large discipline differences in personality scale scores has been made elsewhere only by Barton and Cattell (1972) in a smaller study conducted in a single college. Certainly there appears to be a tacit assumption underlying both the conduct of psychological research on undergraduates and criticism of such research that undergraduates form a relatively homogeneous group selected from a heterogeneous population. In the case of the personality scales under discussion, this does not appear to be the case. It may well be that in the course of development of the 16PF, the use of preponderately undergraduate subjects resulted in its being peculiarly applicable to undergraduates, but on the present evidence it seems only prudent, in the light of the discussion in the last chapter, to be prepared to treat sex x discipline groups separately for the purposes of factor analysis.

The monograph containing the various initial analyses (Saville and Blinkhorn 1976) deliberately did not set out to tackle in detail the points of difference between Cattell and his critics, however certain of the results suggested that the problems of the reliability, homogeneity and factor structure of Cattell's scales had been to some extent exaggerated in the critical literature. The treatment of the question of homogeneity in particular seemed inadequate and yet there are simple widely used procedures for arriving at some kind of an agreed conclusion, which topic provides the material for the next Chapter.

CHAPTER 6

Several authors have criticised the 16PF on account of the apparently low homogeneity of the scales it contains. The use of homogeneity indices as a measure of the reliability of a test has, of course, become well established in the development of measures of attainment and ability. Commonly split-half coefficients, estimates from the Kuder-Richardson formulae and Cronbach's coefficient alpha (Cronbach 1951) are the indices adopted.

Perhaps the two most influential papers tackling this question are by Levonian (1961) and Howarth, Browne and Marceau (1971). Neither reports any overall homogeneity index for the scales of the 16PF, rather inter-item correlations are presented in summary form, the criterion used in each case being the statistical significance of correlations between items within and across scales. Howarth et al. report that of 3,267 significant correlations, only 348 were intra-factor correlations. Furthermore, on average an item correlated significantly with 1.89 items within its own (10-13 item) scale, and with 15.86 items of the remaining 171-174. Levonian's results were similar, although as his sample was considerably smaller, absolute numbers of significant correlations were correspondingly reduced.

Presentation of results in this form is highly misleading: let us consider the same data in another form. A single form of the 16PF has 184 scored items, implying a total of 16, 836 unique off-diagonal entries in a correlation matrix, of which 984 are intra-factor and 15, 852 extra-factor. Thus we may rewrite the Howarth et al. results as follows: rather more than one in three of all intra-factor correlations are significant whilst only about one in five of all extra-factor correlations meet the criterion, and on average an item correlates significantly with one in five of the items in its own scale, but with one in eleven of the items outside its scale. Given that the scales are designed to be correlated, it is of course hardly surprising that items in different scales should themselves be correlated.

It is in any case not at all clear that the approach adopted by Levonian and Howarth et al. is particularly appropriate to the problem. In Chapter 4 it was pointed out that items validly measuring the same attribute might have low intercorrelations on account of differences in their 'difficulty' levels leading to different univariate and bivariate score distributions. Since the product moment correlation coefficient essentially measures the linear component of the relationship, it is to be expected that items in a scale will show varying intercorrelations partly on account of their difficulty levels.

For instance, items 76 and 176 in form A of the 16PF correlate, in the total group for this study, 0.043. Univariate score distributions for these items, expressed as percentages, are as follows:

	Score 0	1	2
Item 76	73.01	6.67	20.32
Item 176	17.67	19.44	62.89

Despite the apparently low intercorrelation of the items, correlations between them and a composite formed of the remaining 19 items in factor A for forms A and B combined, equally weighted, are 0.394 for item 76 and 0.230 for item 176, very much the order of item-partial scale correlation one expects in a fairly homogeneous scale.

Since the instructions for the test suggest use of the middle 'uncertain' response category for no more than one item in five, one would expect item score distributions to tend to be bimodal. In fact, although overall this instruction appears to have been followed, 'uncertain' responses vary widely from item to item, from as few as 2% to over 50%, with the result that item score distributions vary enormously. The effects of this are not handled with any great sophistication by Levonian, who simply combines middle response categories with the less frequently chosen extreme response, or by Howarth, Browne and Marceau, who report only the distribution of frequency of use of the middle response without drawing attention to possible implications for item intercorrelations.

Cattell, in response to critics on the matter of homogeneity, has consistently agreed with them that his scales are heterogeneous, but equally consistently has argued that this is a desirable property (e.g. Tsujioka and Cattell 1964, Cattell 1972, Cattell 1973). Items which have low intercorrelations but which correlate well with the factor to be measured will, he claims, yield scales which are factor-true, in that their error variances will be a combination of unique variances and small components of many unwanted factors, rather than large components of a few.

However, actual indices of scale homogeneity are almost impossible to find in the literature where Cattell's scales are concerned. Cattell confines himself to presenting samples of interitem correlations, together with multiple correlations between items and factors in a factor analysis (e.g. Cattell 1972). In the case of the multiple correlations it is not clear whether these are based on equal item weighting, or on the usual maximisation procedure for multiple correlation (in which case the inference from items and their validities to scales and their relationship to factors is not necessarily reasonable). It seems likely that the latter is the method adopted, since such multiple correlations are easily obtainable from the matrices used in computing factor scores, and the presetting of weights to be equal is sufficiently unusual to warrant specific mention. If so, then these multiple correlations probably represent an overestimate of the validity of the questionnaire scales, which are scored by applying equal integer weights to items.

Cattell adopts (Cattell, Eber and Tatsuoka 1970) the notion of 'structured homogeneity', by which is meant that scales should be internally heterogeneous, but correlate highly with alternate forms and with the factor to be measured. Such scales are, he suggests, the most useful and generalisable given likely variations in item characteristics across social and cultural groups. Thus one might expect to find homogeneity coefficients for each of the scales of the 16PF rather lower than the corresponding alternate form reliabilities.

Coefficient alpha was therefore computed for each of forms A and B, and for forms A and B combined, for each sex and for the total group. Since variations across sex groups were very small, Table 6 presents these results for the whole group, together with the corresponding alternate form correlations and values for coefficient alpha taken from Burdsal and Vaughn (1974). These last are, to the best of the present author's knowledge, the only published values for the homogeneity of the 16PF scales.

	Cronbach's Alpha			Alternate Form coefficients	Cronbach's Alpha
	This Study		Burdsal and Vaughn (1974)	This Study	This Study
FACTOR	Form A	Form B	Form A	Form A with Form B	Forms A+B
A	0.52	0.60	0.59	0.64	0.74
B	0.40	0.24	0.36	0.36	0.51
C	0.57	0.59	0.58	0.54	0.73
E	0.62	0.56	0.53	0.59	0.74
F	0.69	0.66	0.66	0.70	0.81
G	0.59	0.48	0.56	0.56	0.71
H	0.82	0.83	0.85	0.80	0.90
I	0.62	0.54	0.67	0.60	0.74
L	0.44	0.44	0.47	0.36	0.59
M	0.20	0.47	0.42	0.23	0.52
N	0.22	0.23	0.08	0.26	0.39
O	0.58	0.71	0.54	0.65	0.79
Q_1	0.46	0.42	0.33	0.47	0.62
Q_2	0.40	0.50	0.47	0.48	0.63
Q_3	0.50	0.56	0.35	0.58	0.71
Q_4	0.74	0.72	0.71	0.70	0.84

Table 6: Indices of Internal Consistency and Reliability for the Primary Factor Scales

Clearly, these results lend no support to Cattell's claim for 'structured homogeneity'. On the contrary, the close correspondence between alternate form and homogeneity coefficients suggests that items have not been combined into scales on any principle of balanced heterogeneity, but rather that the scales are collections of items from moderately homogeneous domains. Since coefficient alpha may be interpreted as the average of all possible split-half correlations, corrected for test length, there is really nothing to choose between alpha and alternate form correlations as a measure of scale reliability.

Lest it be thought that the close correspondence of these two sets of indices results from cultural homogeneity in the sample of undergraduates on which they are based, Saville (personal communication) has found equally close correspondence between them for his general population sample using the same scales.

Variations in the value of alpha for different forms, as, e.g. in the cases of factors B, M and O, are traceable to specific items having negative or very low positive correlations with the rest of the items formed into a composite, i.e. item-partial scale correlations.

Whilst these results fail to support Cattell's specific claim for structured homogeneity, however, nor do they show the disastrous lack of homogeneity that Levonian and Howarth, Browne and Marceau seem to suggest. Coefficients alpha for the Extraversion and Neuroticism scales of the Eysenck Personality Inventory form A, based on the half of the sample which completed forms C and D of the 16PF, which is in all respects comparable with the forms A and B sample, are respectively 0.77 and 0.84. Since the EPI has 24 items per scale, these figures are comparable with the 20-26 item scales of forms A and B combined in the 16PF, that is to say with the last column in Table 6. On this basis, Cattell's scales for factors A, C, E, F, G, H, I, O, Q_3 and Q_4 are of approximately the same order of homogeneity as Eysenck's scales, with Q_1 and Q_2 not far adrift.

In the context of ability and attainment tests, Nunnally (1967) states that about 20 items are typically needed to reach a value for coefficient alpha of about 0.8. Although several of Cattell's scales fall below this level, even for two-form length, it would appear that the discrepancy is not nearly as great as both Cattell and his critics would have us believe. Domain-sampling theory (Nunnally 1967) suggests that the 'domain validity' for a scale should approach the square-root of coefficient alpha. In terms of factor analysis, this may be translated into an expected value of the factor-structure coefficient for any scale and the factor it represents, i.e. its factor validity. Comparison of the square-roots of the coefficients in Table 6 with factor validities quoted in

Tables 5.4 and 5.5 of Cattell, Eber and Tatsuoka (1970) supports this interpretation: domain validities approach, but are in general somewhat lower than, Cattell's claimed factor validities.

Of course within-scale statistics reveal nothing of the dimensionality of the 16PF as a whole. It is quite conceivable that several of the scales are drawn from the same domain of items. However as a check on the adequacy of a factor analysis, coefficient alpha provides an independent source of information. As will become clear, the results of the factor analyses which follow bear out the value of internal consistency as a measure of scale adequacy in the case of Cattell's scales.

CHAPTER 7

INTRODUCTION TO FACTOR ANALYSES

The remaining Chapters are concerned with a description and interpretation of factor analyses conducted on forms A and B of the 16PF. Most of these analyses are summarised rather than described in detail, for two reasons: first, many of the analyses gave interpretatively similar or identical results, and second presentation of the tables associated with all the analyses would add greatly to the bulk, but not the substance, of the thesis.

A number of strategic decisions were made in advance, in the light of the considerations discussed in Chapter 4. Firstly, it was decided to work with scale scores rather than items; apart from the technical advantages of this decision already discussed, the problems of factoring a square matrix of order 368 by any but the crudest methods were insuperable from a data-processing point of view. Secondly, the sex and discipline differences mentioned in Chaper 5 seemed large enough to demand at least some analyses based on within-group or pooled within-group matrices. The question of variable and factor variances was settled by standardising all scores on a common metric, viz. n-sten normed scores, with a mean of 5.5 and a nominal standard deviation of 2, which had been calculated on the present sample, imposing not only a common metric but also as close an approximation to a normal distribution as is possible. For convenience in interpretation the scale was further changed to a mean of 0 and standard deviation of 1, again on the total group.

Thirdly, the choice of computational methods used was deliberately eclectic. A variety of factoring methods, involving different definitions of and means of estimating communalities, and different rotational procedures, some automatic, some under human control, were adopted by way of exploratory analysis, in an order partly determined by availability of computer software and time at any given moment. The utility of such an exploratory sequence was seen as in either the partial or total replication of Cattell's model by means of traditional factoring methods as a prelude to the use of more expensive confirmatory methods, or alternatively in the absence of such replication, the identification of a likely alternative model for testing.

Certain desirable features of analysis proved not to be possible for lack of appropriate software. Most notably, off the shelf programs for unrestricted analysis of covariance matrices and Harris-Kaiser orthoblique rotation could not be implemented successfully within available resources, but in the event their lack did not detract from the emergence of a relatively stable and highly interpretable solution, linking Cattell's model to previous psychometric studies, the homogeneity analysis reported in Chapter 6 and even psychobiological notions concerning the roots of individual differences in personality.

UNRESTRICTED FACTOR ANALYSES

Perhaps the most obvious and most widely used first step in factor analysis is quite simply to correlate all variables in the total sample, iterate for communalities and rotate principal axes corresponding to principal components associated with eigenvalues greater than 1. This was accordingly done for the 32 scales in forms A and B of the 16PF. Seven factors were rotated using direct oblimin with the delta parameter set at zero. The resultant factor pattern matrix is presented in Table 7, and a plot of eigenvalues in Figure 1. This solution is rather close to Cattell's second-order factor model:

Factor 1 is clearly very close to the second-order Anxiety factor, with major loadings on scales C, L, O, Q_3, Q_4.

Factors 2 and 3 together involve most of the scales contributing to the second-order Exvia factor, A, E, F, H and Q_2, with an additional loading on N.

Factor 4 bears a strong resemblance to the second order 'prodigal subjectivity' factor, with loadings on I, M and possibly L.

Factor 5 loads G and Q_3, i. e. the second order superego factor.

	Factor						
Form A	1	2	3	4	5	6	7
A	-0.001	0.056	0.775	-0.042	-0.070	0.033	-0.058
B	0.016	-0.007	-0.016	-0.011	-0.007	-0.635	-0.072
C	-0.728	0.128	0.001	0.024	0.059	0.034	0.095
E	0.026	0.578	-0.102	-0.004	0.002	0.066	-0.426
F	0.019	0.681	0.207	0.040	0.188	0.086	0.061
G	0.047	0.028	0.026	0.061	-0.796	-0.001	0.032
H	-0.189	0.721	0.174	-0.077	-0.178	0.076	-0.134
I	0.208	-0.074	0.204	-0.674	-0.004	-0.003	0.092
L	0.421	0.214	0.021	0.068	-0.014	0.104	-0.370
M	-0.203	-0.035	0.087	-0.383	0.127	-0.036	-0.232
N	0.088	-0.411	0.171	0.005	-0.096	0.039	0.113
O	0.716	-0.126	-0.006	-0.013	0.060	0.032	0.141
Q1	-0.091	0.017	0.066	0.088	0.205	-0.033	-0.580
Q2	-0.014	-0.356	-0.303	-0.088	0.015	0.060	-0.158
Q3	-0.335	-0.063	-0.034	0.086	-0.578	-0.021	0.006
Q4	0.829	-0.022	0.030	0.019	0.057	-0.014	0.013
Form B							
A	-0.021	0.060	0.759	-0.135	0.006	-0.003	-0.209
B	0.038	0.034	-0.009	0.045	-0.019	-0.549	-0.006
C	-0.692	0.038	0.081	0.077	-0.061	-0.053	0.038
E	-0.091	0.283	-0.111	0.003	-0.019	0.079	-0.587
F	0.003	0.645	0.192	0.070	0.214	0.106	0.003
G	0.067	-0.038	0.085	-0.144	-0.649	-0.037	0.095
H	-0.337	0.611	0.155	-0.058	-0.120	0.028	-0.084
I	0.171	-0.035	0.062	-0.671	-0.115	-0.034	0.246
L	0.389	0.003	-0.039	0.201	-0.155	0.054	-0.464
M	-0.073	0.229	-0.299	-0.560	0.070	-0.016	-0.202
N	-0.216	-0.348	0.172	0.086	-0.150	-0.023	0.122
O	0.745	-0.146	-0.032	-0.105	0.049	-0.057	0.147
Q1	-0.008	0.026	0.069	-0.168	0.133	-0.116	-0.528
Q2	0.080	-0.465	-0.346	-0.048	0.022	0.050	-0.313
Q3	-0.371	-0.010	-0.040	0.063	-0.592	-0.022	-0.127
Q4	0.780	0.135	0.041	-0.055	0.140	-0.025	-0.003

Table 7: Factor-pattern elements for the seven factor solution

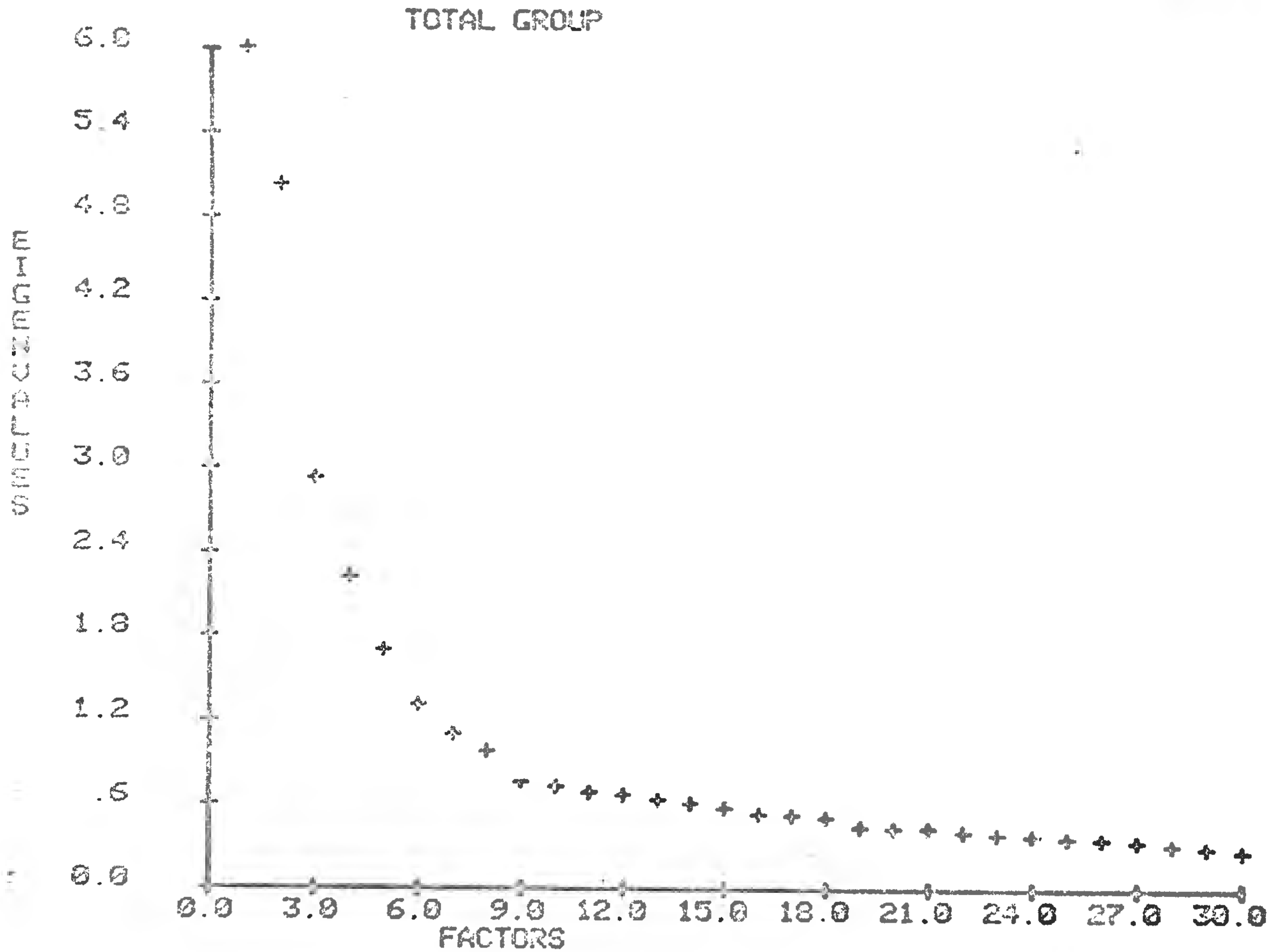

Figure 1: **Eigenvalue plot** for the total group

Factor 6 loads B, i.e. the first and second order intelligence factor.

Factor 7 is not unlike the second order Independence factor, with major loadings on E and Q_1.

However, there is relatively little dispute about second-order factors, our main interest is in reproducing the first-order structure, i.e. with single factors loading more or less exclusively pairs of scales. The eigenvalue plot of Figure 1 was therefore inspected, as suggested by Cattell (1966b) for his 'scree' test for number of factors. The two most likely choices are for 8 and 18 factors, implying extraction of 9 and 19 respectively to allow for one 'junk' factor into which odd scraps of correlated error may be rotated to allow for a cleaner solution. However, eight factors would give little scope for a closer approximation to Cattell's model, and the choice of 18 looks on the face of it fairly tenuous. It seemed more sensible to try other factoring methods involving different definitions of communalities, namely alpha factoring and image factoring. The first of these resulted in a solution virtually indistinguishable from principal axes, but image factoring gave a quite different result.

Thirteen factors were indicated, and again rotated by direct oblimin. . From this procedure a much clearer pattern emerged. Single factors loaded A, B, F, H, I, Q_1 and Q_2 in both forms, another

G and Q_3, but loadings on C, E, L, M, N, O and Q_4 were complex and uninterpretable. With hindsight, it is possible to say that the scales in this last group were the source of all difficulties in subsequent analyses. At this stage, given the quite different results suggested by different methods, it seemed that the wisest course was to experiment with different factoring and rotational methods, and to look at matrices computed within sex and discipline groups.

Initially, attempts were made to factor within-group covariance matrices, but the proprietary software used turned out to have traps for values over unity in the matrix, and since source code was unavilable could not be rewritten. By way of experiment, therefore, within group correlation matrices were factored both by principal axes and the image method. Eigenvalue plots for the iterated principal axes solutions are presented in Figures 2-5, but here the scree test is of very little help: there are no obvious choices for the number of factors. Image factoring of the same matrices gives 18 factors for Male Arts, 18 for Male Science, 16 for Female Arts and 17 for Female Science.

Rotation of the image factors by direct oblimin yields similar results overall. Clear factors corresponding to A, B, I, Q_1 and Q_2 appear in every analysis, F and H separate sometimes, E only in the Female Science group, G and Q_3 are loaded by the same

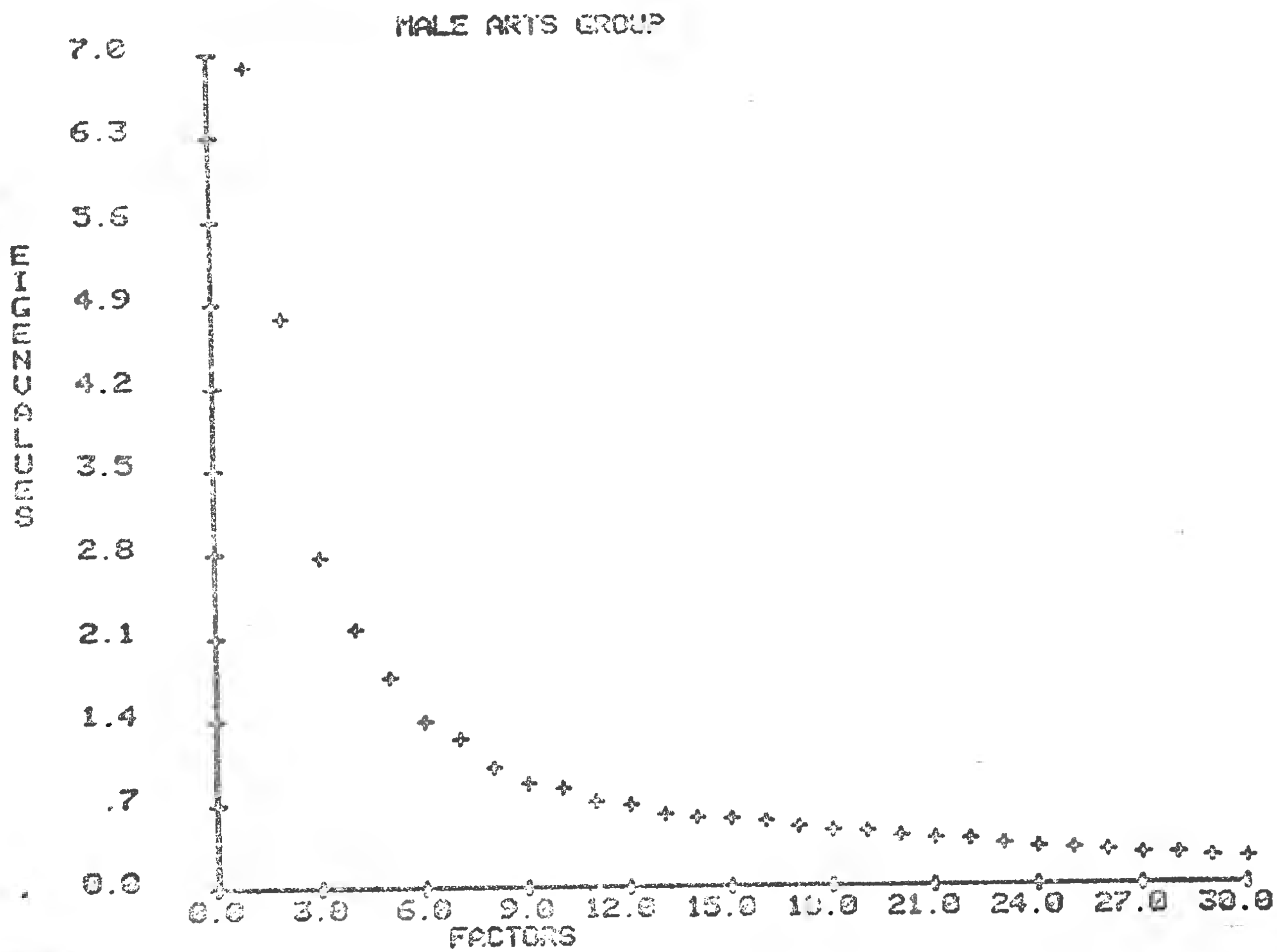

Figure 2: Eigenvalue plot for the male arts group

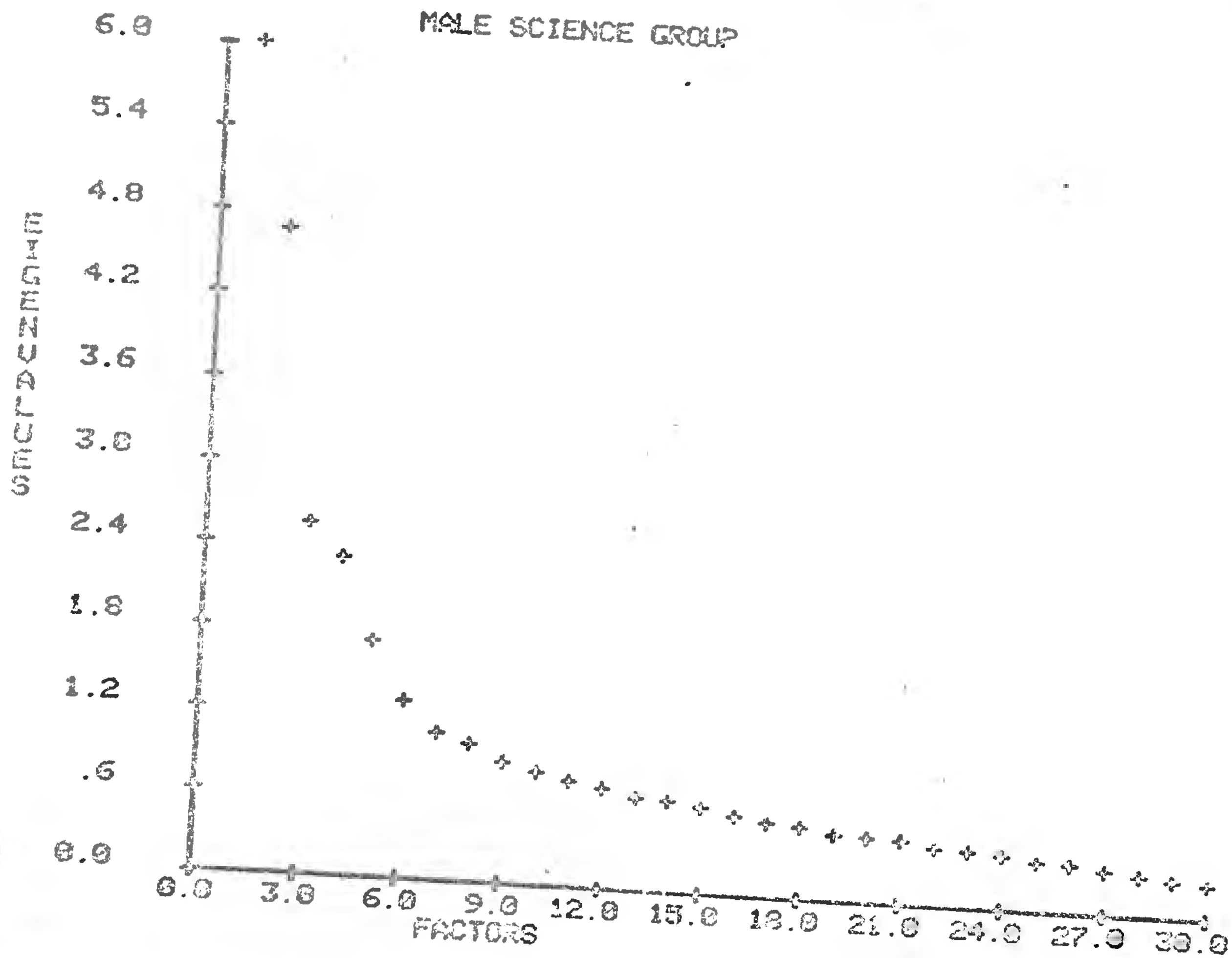

Figure 3: Eigenvalue plot for the male science group

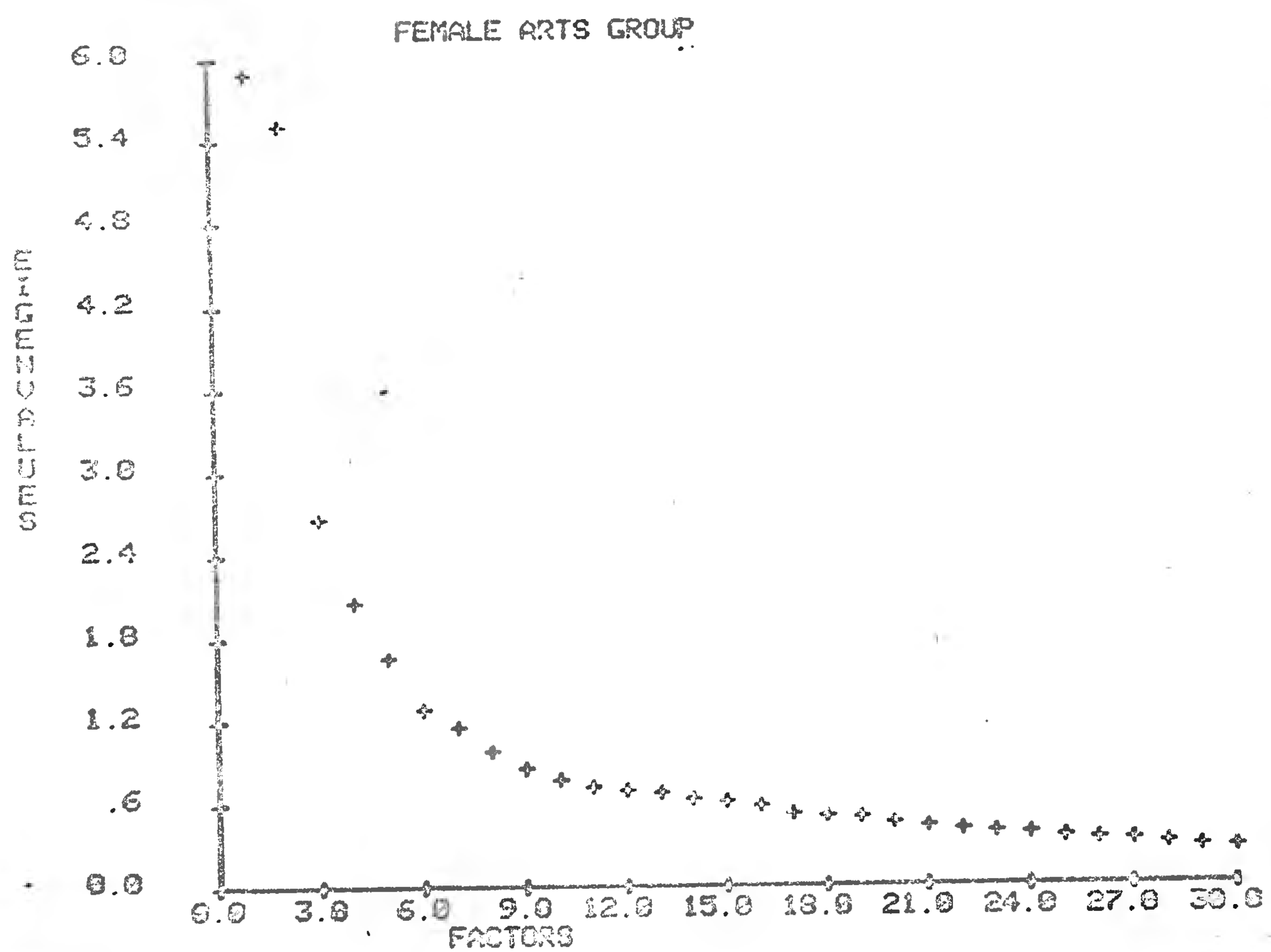

Figure 4: Eigenvalue plot for the female arts group

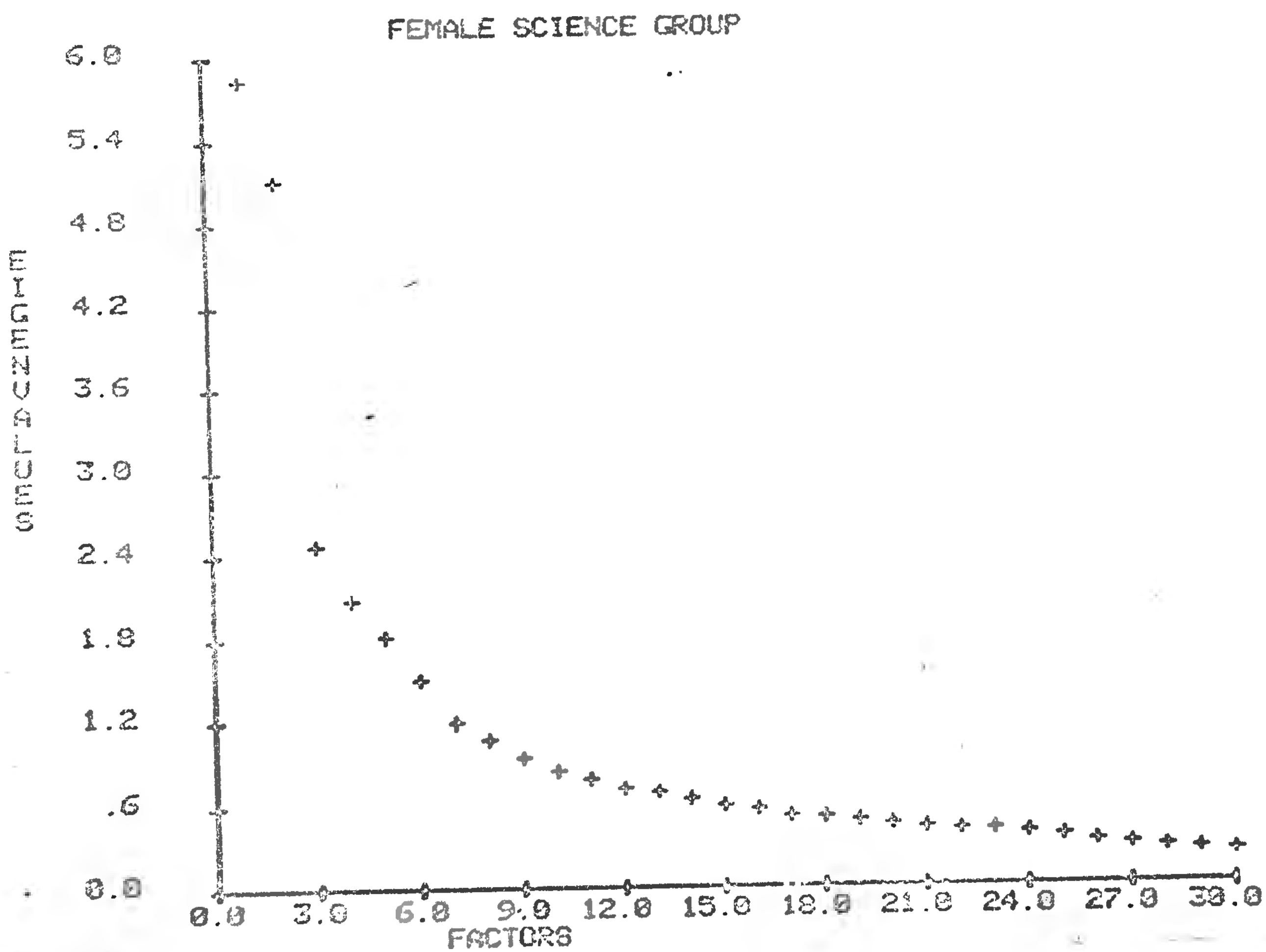

Figure 5: Eigenvalue plot for the female science group

factor in every analysis, C, O and Q_4 are invariably loaded by the same factor or factors, and the remainder show no clear pattern. Interpretatively similar results emerge from Varimax rotation of 16-factor principal axes analyses of the same matrices.

Thus a pattern begins to emerge. Factor B, as might be expected since it is not a personality factor in the same sense as the others, is invariably located; factors I and Q_1, which Saville and Blinkhorn (1976) showed to be clearly independent of extraversion and neuroticism in forms C and D, also appear clearly. Of the extraversion factors, A and Q_2 are most easily located, followed by F and H, whilst E is difficult to place. G and Q_3 are consistent but virtually inseparable, and when C, O and Q_4 split it is not along the lines suggested by their pairing across forms.

This emerging consistency suggested that perhaps with different rotational procedures, allowing for deliberate targeting of factors, Cattell's solution might be obtained. Analytic rotation programs, after all, are known to have idiosyncracies. Varimax for instance tends not to rotate much variance into the last few factors when relatively many are extracted. Furthermore, based as they are on particular operational definitions of simple structure, they are not well-equipped to cope with the situation where one or more variables may be complex, and not amenable to treatment in terms of simple structure.

Attention was thus directed to the search for a procedure which could rotate to a specified target. Graphical rotation was one obvious candidate, and work was set in hand to produce an on-line interactive graphical rotation program. Procrustean rotations of one kind or another had undergone development to the point where only a partly specified target was needed (Browne 1972 a and b), but nonetheless required specification of fixed numerical values of at least some elements in the factor pattern.

Hakstian's (1972) Optimal Resolution method seemed to offer a better prospect. This involves specification of which factors have high loadings on which variables, which low loadings, and which are to remain unspecified. The difference between high and low loadings as specified is then maximised, in the oblique case via a reference-factor solution, thus avoiding the need for a numerically defined target matrix.

The sixteen-factor principal axes factor patterns were analysed by this means, with target matrices set up in three ways:

1. With the pair of scales hypothesised to be loaded by a single factor specified as high, all others specified as low.
2. With only high loadings specified.
3. With only low loadings specified.

For all conditions, values of 1, 50, 100 and 1000 were tried for Hakstian's weighting constant 'r'. In every case the reference-factor correlation matrix proved to be singular, i.e. uninvertable, and the reference-factor structure matrix could not be interpreted with confidence.

However, a general interpretation of the failure of this procedure is possible. For one or more pairs of Cattell's scales, either one or both of a pair is loaded by another factor to the extent that two factors collapse into each other in the analysis, or one or more factors can be expressed as a linear composite of the others.

Factors C, O and Q_4 were the most likely culprits, as noted earlier, their intercorrelations being more or less identical with their reliabilities, and since analytic rotation had failed to separate them. Fourteen-factor matrices were therefore entered into optimal resolution rotation with these scales all targeted on one factor, but again the result was the collapse of the factor inter-correlation matrix.

At this stage, through the courtesy of Professor R. MacDonald at the University of Alberta, a program for unrestricted maximum likelihood factor analysis (COFA) was obtained, and at the same time work on the author's own graphical rotation program (ROTOG) was completed. COFA proved to have two major disadvantages: firstly it aborted consistently when covariance rather than correlation matrices were entered, and hence was not ideal for providing comparable results across groups; secondly it consumed large amounts of machine time, requiring a separate run for each hypothesised number of factors rather than successively estimating factors until an acceptable solution was obtained. For these reasons, only two runs were performed separately for each of the four sub-groups, one for seven or eight factors as suggested by the Kaiser-Guttman criterion, one for sixteen as suggested by Cattell's model. Analyses for 13-18 factors were run on the pooled within-group correlation matrix.

The Kaiser-Guttman model proved unacceptable for all except the Female Science group, whilst the 16-factor model was acceptable for all groups. For the pooled within-group matrix, the 13-factor model was just acceptable. The number of factors was then increased until the difference between chi-squared values for successive numbers of factors was no longer significant at the .05 level, which occurred after 17 factors had been extracted. Test statistics are presented in Tables 8 and 9.

Graphical rotation of the 17-factor solution was attempted with a view to targeting factors on to pairs of scales as before. For some factors this was very straightforward. Factors B, F, H, I, Q_1 and Q_2 were rapidly isolated. Factors G and Q_3

Group	No. of factors	Chi-squared	Degrees of freedom	p
Male Arts	7	395.14	293	0.00
Male Science	7	377.01	293	0.00
Female Arts	7	450.05	293	0.00
Female Science	8	280.24	268	0.29
Male Arts	16	75.34	104	0.98
Male Science	16	72.45	104	0.99
Female Arts	16	86.05	104	0.91
Female Science	16	59.80	104	1.00

Table 8: Test statistics for maximum likelihood factor analyses of data for four sex x discipline groups

No. of factors	Chi-squared	Degrees of freedom	p
13	193.26	158	0.04
14	159.61	139	0.11
15	135.31	121	0.18
16	102.82	104	0.53
17	72.66	88	0.88
18	60.22	73	0.86

Table 9: Test statistics for maximum likelihood factoring of the pooled within-groups correlation matrix

	Factor 1	2	3	4	5	6	7	8	9
Form A									
A	0.375	-0.054	0.068	0.094	-0.007	0.121	-0.035	0.082	-0.293
B	-0.075	0.038	-0.042	-0.089	-0.028	-0.011	0.001	0.037	-0.075
C	0.043	-0.017	-0.541	0.065	-0.135	0.107	-0.027	0.175	0.080
E	0.066	0.077	0.187	0.053	-0.012	0.454	0.020	0.029	0.021
F	0.047	0.025	0.010	-0.066	0.017	0.160	0.019	-0.005	-0.258
G	-0.026	-0.029	0.112	0.797	0.067	-0.061	-0.035	0.069	-0.124
H	0.017	-0.034	-0.016	0.100	0.044	0.873	0.019	0.002	-0.131
I	0.028	0.050	0.081	0.001	-0.001	-0.034	0.042	-0.101	0.126
L	0.052	0.061	0.649	0.070	-0.113	-0.068	0.073	-0.048	0.050
M	0.043	0.245	-0.192	-0.274	-0.031	0.060	0.356	0.117	0.036
N	-0.040	-0.249	-0.019	0.111	0.054	-0.115	-0.016	-0.137	0.174
O	-0.060	-0.036	0.273	-0.346	0.283	-0.093	0.044	-0.135	0.318
Q1	0.034	0.009	0.011	-0.121	-0.0[illegible]1	0.014	0.494	-0.004	-0.039
Q2	-0.075	-0.062	0.053	-0.013	0.011	0.025	0.005	0.099	0.978
Q3	0.033	0.027	-0.141	0.877	-0.060	-0.015	0.019	-0.046	0.043
Q4	-0.043	0.011	0.891	0.148	0.091	0.011	-0.032	-0.051	0.001
Form B									
A	1.045	-0.017	-0.010	-0.038	0.006	-0.041	-0.007	-0.000	0.013
B	0.075	-0.040	0.056	0.092	0.028	0.020	0.003	-0.031	0.059
C	0.005	-0.004	0.027	0.007	0.027	-0.035	0.003	1.061	0.058
E	0.121	0.198	-0.028	0.052	0.036	0.518	0.088	-0.070	0.249
F	0.031	0.006	-0.082	-0.090	-0.033	0.125	-0.003	0.051	-0.005
G	0.024	0.005	-0.007	0.036	-0.018	0.027	-0.004	-0.026	0.023
H	-0.010	0.015	-0.025	-0.072	-0.105	0.990	-0.019	0.010	0.009
I	0.020	-0.002	-0.040	0.012	0.027	0.042	-0.033	0.038	-0.053
L	-0.025	-0.151	0.187	0.050	0.133	0.101	0.129	-0.139	0.224
M	-0.020	1.058	0.039	0.036	0.024	-0.010	-0.017	-0.006	-0.013
N	0.041	-0.002	0.001	0.090	0.006	0.066	-0.026	0.057	0.022
O	0.006	0.024	-0.044	0.014	1.078	0.006	-0.002	0.036	-0.005
Q1	-0.008	-0.010	0.005	0.048	0.002	-0.016	1.065	-0.002	-0.020
Q2	-0.004	0.146	-0.096	-0.021	0.018	-0.212	-0.060	-0.132	0.744
Q3	-0.070	-0.011	-0.084	0.838	-0.056	0.089	0.023	0.104	0.022
Q4	0.029	-0.012	0.642	-0.082	0.196	-0.064	0.035	-0.144	0.045

Table 10 part one: Factor-pattern elements for the seventeen-factor solution

	Factor 10	11	12	13	14	15	16	17
Form A								
A	-0.057	0.017	-0.019	0.076	-0.016	0.036	0.562	0.033
B	0.104	0.015	0.961	-0.019	0.066	0.078	0.055	0.169
C	-0.107	0.018	-0.065	0.190	0.019	0.168	-0.046	-0.231
E	-0.018	-0.107	-0.028	0.072	-0.349	0.188	-0.164	0.150
F	-0.026	-0.042	-0.066	0.691	0.061	0.094	-0.129	-0.011
G	0.031	0.255	-0.028	-0.038	-0.022	-0.074	0.067	0.090
H	0.067	-0.014	-0.042	0.091	-0.027	0.039	-0.020	0.023
I	0.893	-0.013	0.021	0.159	0.075	0.175	0.129	-0.078
L	0.010	-0.044	-0.087	0.273	-0.099	0.127	-0.081	0.326
M	0.236	0.171	0.005	-0.061	-0.072	0.392	0.078	-0.167
N	0.131	-0.004	-0.082	-0.200	0.350	-0.089	0.377	0.030
O	0.031	0.152	-0.060	0.039	0.139	-0.318	-0.014	0.212
Q1	-0.251	-0.120	0.019	0.027	0.056	0.410	-0.142	0.192
Q2	0.071	0.011	-0.013	-0.030	0.028	-0.018	-0.044	-0.060
Q3	0.007	0.006	0.016	0.013	0.171	-0.074	-0.066	-0.071
Q4	-0.042	0.014	-0.006	-0.159	0.015	-0.023	0.033	-0.086
Form B								
A	0.038	0.022	0.009	-0.035	0.041	-0.033	-0.007	-0.003
B	-0.091	-0.010	1.000	0.028	-0.063	-0.066	-0.055	-0.131
C	-0.016	-0.021	0.004	0.016	0.024	-0.025	0.004	0.035
E	-0.164	-0.107	-0.038	-0.070	-0.233	0.167	-0.044	0.248
F	-0.047	-0.041	-0.006	0.812	-0.159	-0.104	0.087	0.023
G	-0.041	1.020	0.004	0.020	-0.022	0.036	-0.036	0.020
H	-0.005	0.040	0.034	0.034	0.109	-0.094	0.051	-0.044
I	1.010	-0.010	0.006	-0.131	-0.075	-0.114	-0.102	0.064
L	-0.125	0.042	0.007	0.054	-0.104	-0.012	-0.018	0.619
M	0.006	0.001	-0.006	-0.001	0.028	-0.069	0.012	-0.021
N	-0.037	0.014	0.008	-0.034	0.968	0.040	-0.020	0.022
O	-0.003	-0.016	0.003	0.015	0.008	0.047	-0.003	-0.019
Q1	0.014	-0.007	0.005	-0.014	-0.004	-0.098	0.018	-0.022
Q2	-0.073	-0.019	0.032	-0.102	0.007	0.021	0.016	0.215
Q3	-0.018	0.024	0.033	-0.096	0.008	0.136	0.059	0.022
Q4	0.104	-0.075	0.054	0.181	-0.088	0.001	0.005	-0.046

Table 10 part two: Factor-pattern elements for the seventeen-factor solution split into one triplet and one singlet factor, with factor G form B loaded by the singlet. C, L, O and Q_4 split into a 'general' factor and three singlets. Factor A scales were loaded jointly by two factors, and the form A scale by a singlet in addition. Factor M form B is loaded by a singlet, and the rest of the scales have complex loadings. The same matrix was also rotated by direct oblimin, with such strikingly similar results that the factor pattern in Table 10 is representative of both solutions, being in fact the oblimin results. But once again the optimal resolution method resulted in a collapsed factor space.

14-, 15- and 16-factor solutions for this matrix were also rotated graphically: factor A consolidated into a single factor, but otherwise little improvement resulted. However, in the long and complex process of performing these graphical rotations, certain features not immediately apparent from rotated factor pattern matrices concerning the configuration of projections of test variables onto the factor space became clear. Firstly in each COFA solution the communality of one variable, different in each run, tended to be estimated as noticeably higher than the others with the result that a corresponding singlet factor was found. Secondly, it proved quite impossible to steer factors to load separately the C, L, O and Q_4 scales according to Cattell's model. Thirdly, the only way to separate N from E was to allow the E scales to be loaded by factors corresponding to H and the anxiety scales. In passing, it is worth commenting that since many hours were spent trying to force Cattell's structure unsuccessfully onto these results, corresponding perhaps to many months of labour without oomputer assistance, either the possibilities of rigging results by this means are exaggerated by its critics (e. g. Eysenck and Eysenck 1969 p. 327), or the structure of the present data is uncommonly well marked.

Essentially the use of maximum likelihood factoring and graphical rotation have provided no information over and above the 13-factor image solution for the total group. The unrestricted analyses here reported fall essentially into two groups: those using the Kaiser-Guttman criterion for number of factors, including principal axes, alpha factoring and COFA 7 and 8 factor solutions, all of which yielded similar approximations to the Cattell second-order model, and the remainder, using either the image-factor criterion, the goodness-of-fit test in COFA or simply an arbitrary choice of 16 factors, all of which agree more or less on which pairs of scales are clearly loaded by single factors and which are not. The factor patterns of Tables 7 and 10 respectively represent these two types of solution.

Thus there appears to be partial support from these analyses for Cattell's model. It is not suggested that any of the solutions discussed should be regarded as definitive, as their purpose was simply to facilitate a decision as to whether the expense of computer resources involved in a more adequate test of the model was worthwhile and to gain some idea of whether splitting the sample by sex and discipline would have any serious consequences. While it is difficult to demonstrate concisely, the impression was gained from a study of all the exploratory analyses conducted, of which there were over fifty, that splitting by subgroups tended to result in less correlated, more identifiable factors, without noticeable shrinking of the size of factors associated with scales on which there were large mean differences across the groups. However, this tendency was not so strong as to prevent the 13-factor image solution for the total group giving results very similar indeed to subgroup analyses.

We now turn to what was intended as the definitive procedure for determing the fit of Cattell's model to the data.

CHAPTER 8

Use of unrestricted methods of factor analysis in hypothesis testing may, as has been indicated, lead to the confirmation of an hypothesis, but it is difficult to make an incontrovertible case for disconfirmation, as the history of critical studies of Cattell's work indicates. It is always possible to claim that particular matrices are not suitable for a particular method of factor extraction and/or rotation, since communalities can be estimated but not defined, criteria for rotation are to some extent arbitrary, and there is no way of arranging computational routines to ensure that correlated measurement error is not extracted along with common-factor variance. What is needed is a method whereby an hypothesised model may be specified beforehand and formally tested against the data.

Such a method has been provided by Jöreskog (1970) in the form of the technique of analysis of covariance structures (ACOVS). Recalling the matrix formulation of the common factor model in Chapter 4:

$$\Sigma = \Lambda \Phi \Lambda' + \Psi^2$$

where Λ is the usual matrix of factor-pattern coefficients, Φ is the matrix of factor covariances and ψ is the (diagonal) matrix of unique-factor loadings, elements of any or all of these matrices are directly estimated by maximum-likelihood, subject to whatever constraints are imposed on the model. The ACOVS model, which specifies only the structure of the covariance matrix, may be extended in the usual way to impose a structure on the means, and inparticular to the testing of a model in more than one population simultaneously. The analyses reported in this Chapter were carried out using Jöreskog and Van Thillo's (1970) programs for simultaneous factor analysis in several populations (SIFASP), which are simply revised versions of the original ACOVS programs allowing easier specification of certain parameters.

The ACOVS method satisfies almost entirely the requirements for a decisive analysis. Firstly, covariance matrices are acceptable (indeed preferable), thus allowing for different scale variances across groups. Secondly, Cattell's model may be expressed to varying degrees of strictness in terms of the parameters of the model. Thirdly, a test of the goodness of fit of the hypothesised structure is provided, allowing at least a comparison between alternatives. Fourthly, a structure may be specified in such a way as to exclude correlated error fromthe factor pattern matrix. However, indeterminancy still remains to the extent that a well-fitting factor model is not necessarily the only model that will fit.

The SIFASP program was obtained and modified to suit the size of the problem. Since a 16-factor solution for 32 scales implies 512 independent elements in the factor pattern matrix, 136 in the factor covariance matrix and 32 unique factor variances, there are 680 elements altogether for a single population. However, most of the factor pattern coefficients are implied to be zero, and the major problem was to expand the program to actually allow simultaneous analysis of more than one matrix. Expansion up to the estimation of 300 parameters proved possible, at which size the program occupies 88K words of core storage, rather more than half of which is accounted for by the matrix of approximations to second derivatives in the minimisation procedure used. Since this matrix grows approximately as the square of the number of elements to be estimated, the modified Fletcher-Powell algorithm used in SIFASP is clearly a constraint on the usefulness of the program for large problems.

Variance-covariance matrices were computed for ten groups and combinations of groups as shown in Table 11. These matrices are to be found as Tables A1 to A10 in the Appendix.

	N
Male Arts (MA)	233
Male Science (MS)	312
Female Arts (FA)	396
Female Science (FS)	203
Male Total (MT)	545
Female Total (FT)	599
Arts Total (AT)	629
Science Total (ST)	515
Pooled Within Groups (WG)	1144
Total Group (TG)	1144

Table 11: The ten groups and combinations of groups, with sample sizes, for the restricted analyses

Initially, a strict form of Cattell's model was tested. The four basic sex x discipline groups were analysed in a single run, with each scale specified to be loaded by a single factor, the factor pattern coefficients being constrained to equality across groups but not across forms. The factor covariance matrices were free, but constrained to equality across groups, and unique variances were left entirely free. Starting values for the minimisation were:

Factor pattern coefficients 0.6
Factor covariance matrix: identity matrix
Unique variances: 0.5

There were thus 32 elements to be estimated in a common factor pattern for all groups, and 136 in the factor covariance matrix, again common to all groups; estimated separately for each group were 32 unique variances. The total number of parameters estimated for any group was therefore 200, of which 168 were jointly estimated over all groups.

Since the Fletcher-Powell procedure converges approximately quadratically, it is possible to judge whether a given model is likely to prove satisfactory before the minimisation procedure has actually converged. In the case of this analysis, it was clear that an acceptable value of chi-squared was very unlikely to result, since at the point at which the difference between successive-function evaluations was 5% the corresponding chi-squared value was still approximately six times the number of degrees of freedom.

The ideal procedure to follow at this stage would have been to estimate a unique but unrestricted model, and then successively impose constraints as recommended by Jöreskog (1971), however the size of such a problem exceeds core storage on any computer available to the author in this country, and furthermore it involves the estimation of many more parameters than there are subjects in each subgroup. Therefore the next step was to test the model outlined above on each of the ten groups in Table 11, again specifying two scales per factor and leaving factor covariance matrices and unique variances free, since pilot runs suggested that removal of constraints across groups would lead to a substantial reduction in chi-squared relative to degrees of freedom.

Accordingly, when sufficient computer time became available, this analysis was run to convergence on each of the 10 matrices mentioned above, each run requiring 2-3 hours of processor time on the Hatfield DEC-system 10. The results for each group were strikingly similar, and will be discussed in detail shortly. However, the goodness-of-fit test for the model as estimated still gave highly significant results on each run, and furthermore in every case the program converged to a solution in which the factor covariance matrix was not positive definite.

A number of experimental runs were then tried, changing starting values for the minimisation, and gradually combining specified loadings of factors on scales towards Cattell's second-order factor model. Changes in starting values had no effect on the solution obtained, although using the factor correlation matrices in Table 10.2 of Cattell, Eber and Tatsuoka (1970) as starting values for a sixteen-factor model speeded minimisation noticeably. Reducing the number of factors to thirteen, by specifying loadings of single factors on C, O and Q_4 on the one hand and G and Q_3 on the other, whilst allowing L and N to be completely free, did not improve the goodness of fit, whilst attempts to fit the complete second-order factor model were abortive, resulting in negative variance estimates for one or more factors. Allowing the number of parameters to exceed the sample size did improve the goodness of fit, but not surprisingly the results of such runs were entirely uninterpretable.

It thus remains to interpret the ten separate analyses by subgroups and groups with their apparently poor fit and singular factor covariance matrices. Table 12 gives estimated factor pattern values for each of the groups, all but two loadings per scale having been set to zero by hypothesis - since each scale is loaded only by a single factor, these are also factor-structure coefficients. Table 13 gives an example of a factor covariance matrix (lower triangle) with the off-diagonal elements in the upper triangle rescaled to unit factor variance (i.e. correlations). Since these

FORM A

Scale	Group MA	MS	FA	FS	MT	FT	AT	ST	WG	TG
A	0.85	0.66	0.78	0.67	0.76	0.74	0.78	0.70	0.73	0.77
B	0.74	0.65	0.82	0.95	0.76	0.88	0.78	0.75	0.86	0.78
C	0.78	0.70	0.75	0.65	0.75	0.74	0.77	0.68	0.74	0.74
E	0.74	0.76	0.77	0.82	0.74	0.77	0.79	0.80	0.76	0.79
F	0.91	0.80	0.76	0.86	0.84	0.77	0.80	0.80	0.81	0.81
G	0.75	0.85	0.78	0.69	0.78	0.73	0.74	0.73	0.75	0.74
H	0.97	0.88	0.89	0.91	0.94	0.91	0.94	0.91	0.92	0.93
I	0.62	0.63	0.36	0.53	0.76	0.62	0.61	0.70	0.55	0.82
L	0.54	0.61	0.66	0.54	0.60	0.61	0.61	0.59	0.60	0.61
M	0.52	0.49	0.39	0.35	0.52	0.41	0.43	0.44	0.43	0.46
N	0.43	0.37	0.58	0.35	0.39	0.47	0.52	0.35	0.43	0.45
O	0.82	0.75	0.69	0.65	0.77	0.66	0.76	0.72	0.72	0.75
Q_1	0.75	0.58	0.69	0.48	0.66	0.63	0.77	0.59	0.65	0.69
Q_2	0.63	0.66	0.58	0.58	0.64	0.57	0.58	0.61	0.60	0.59
Q_3	0.82	0.70	0.78	0.62	0.75	0.71	0.78	0.66	0.72	0.73
Q_4	0.84	0.80	0.80	0.76	0.80	0.76	0.83	0.79	0.78	0.81

Table 12 part 1: Estimated factor-pattern coefficients for the ten SIFASP analyses

FORM B

Scale	Group MA	MS	FA	FS	MT	FT	AT	ST	WG	TG
A	0.58	0.69	0.67	0.83	0.78	0.75	0.64	0.74	0.68	0.77
B	0.50	0.44	0.41	0.38	0.41	0.36	0.42	0.38	0.36	0.40
C	0.86	0.68	0.68	0.62	0.75	0.64	0.74	0.64	0.69	0.70
E	0.59	0.68	0.72	0.57	0.65	0.67	0.75	0.69	0.65	0.72
F	0.95	0.85	0.77	0.79	0.91	0.79	0.85	0.84	0.84	0.85
G	0.69	0.69	0.64	0.77	0.69	0.68	0.66	0.74	0.69	0.68
H	0.94	0.84	0.85	0.80	0.89	0.83	0.89	0.82	0.85	0.86
I	0.67	0.61	0.62	0.64	0.67	0.63	0.69	0.69	0.62	0.75
L	0.54	0.60	0.53	0.43	0.57	0.49	0.58	0.54	0.52	0.56
M	0.80	0.74	0.71	0.67	0.76	0.65	0.76	0.71	0.73	0.71
N	0.62	0.51	0.55	0.59	0.55	0.53	0.54	0.51	0.54	0.52
O	0.84	0.80	0.78	0.68	0.80	0.73	0.83	0.77	0.76	0.81
Q_1	0.60	0.55	0.78	0.84	0.58	0.80	0.67	0.61	0.68	0.66
Q_2	0.92	0.60	0.84	0.73	0.74	0.78	0.87	0.67	0.76	0.77
Q_3	0.80	0.71	0.73	0.75	0.74	0.73	0.76	0.71	0.74	0.75
Q_4	0.84	0.72	0.81	0.71	0.77	0.76	0.83	0.73	0.76	0.79

Table 12 part 2: Estimated factor-pattern coefficients for the ten SIFASP analyses

	A	B	C	E	F	G	H	I	L	M	N	O	Q1	Q2	Q3	Q4
A	0.939	-0.044	0.307	0.127	0.350	0.314	0.512	-0.122	-0.070	-0.244	0.096	-0.299	-0.135	-0.519	0.268	-0.146
B	-0.032	0.556	0.007	-0.017	-0.139	-0.118	-0.039	0.301	-0.298	0.193	-0.047	0.033	0.020	0.048	-0.042	0.054
C	0.347	0.006	1.363	0.223	0.254	0.168	0.592	-0.449	-0.655	0.022	0.099	-1.013	0.067	-0.384	0.606	-0.967
E	0.137	-0.014	0.289	1.237	0.745	-0.251	0.727	-0.285	0.606	0.495	-0.885	-0.329	0.612	-0.175	-0.122	-0.034
F	0.407	-0.124	0.356	0.993	1.436	-0.222	0.735	-0.291	0.362	0.107	-0.717	-0.272	0.289	-0.610	-0.164	-0.036
G	0.375	-0.108	0.241	-0.344	-0.327	1.517	0.083	-0.104	-0.114	-0.394	0.438	-0.146	-0.395	-0.191	0.805	-0.226
H	0.576	-0.034	0.802	0.939	1.023	0.118	1.348	-0.294	-0.023	0.183	-0.419	-0.603	0.135	-0.618	0.270	-0.451
I	-0.110	0.209	-0.488	-0.295	-0.325	-0.119	-0.318	0.866	-0.016	0.425	0.108	0.384	-0.238	0.149	-0.272	0.392
L	-0.070	-0.230	-0.793	0.699	0.449	-0.146	-0.028	-0.015	1.074	0.056	-0.476	0.495	0.399	0.211	-0.292	0.687
M	-0.207	0.126	0.023	0.482	0.112	-0.425	0.186	0.347	0.051	0.768	-0.518	-0.162	0.597	0.060	-0.244	-0.043
N	0.101	-0.038	0.125	-1.066	-0.931	0.585	-0.527	0.109	-0.535	-0.492	1.174	0.023	-0.418	0.170	0.468	-0.184
O	-0.354	0.030	-1.444	-0.447	-0.398	-0.219	-0.855	0.436	0.626	-0.173	0.030	1.491	-0.215	0.313	-0.618	0.913
Q1	-0.142	0.016	0.085	0.741	0.377	-0.530	0.170	-0.241	0.450	0.570	-0.493	-0.286	1.185	0.083	-0.137	-0.048
Q2	-0.391	0.028	-0.349	-0.151	-0.569	-0.183	-0.558	0.108	0.170	0.041	0.143	0.297	0.070	0.605	-0.138	0.246
Q3	0.303	-0.037	0.826	-0.159	-0.230	1.158	0.366	-0.296	-0.353	-0.250	0.592	-0.882	-0.174	-0.125	1.364	-0.692
Q4	-0.198	0.056	-1.579	-0.053	-0.061	-0.389	-0.732	0.510	0.995	-0.053	-0.278	1.558	-0.073	0.267	-1.130	1.955

Table 13: Factor covariance (lower triangle) and correlation (upper triangle) matrix for male arts group

matrices vary only slightly from group to group, the rest are presented in the Appendix.

Table 13 suggests several sources of the collapse of the factor space: note particularly the correlations between factors corresponding to C, O and Q_4, between E and N and between G and Q_3. To locate the source of the problem, the matrix was first tested for rank by the method of triangular decomposition, with the result that it appeared to be of full rank. Next the eigenstructure of the matrix was investigated, first by the Jacobi method. This suggested eight positive and eight negative eigenvalues, of approximately matching magnitudes. Since this seemed rather implausible other methods were tried, notably the Householder-Wilkinson tridiagonalisation approach. These indicated 13 positive and three small negative ($\simeq$ -0.1) eigenvalues. The triangular decomposition analysis was then repeated with a higher tolerance criterion, and gave the rank of the matrix as 13. Finally the matrix was reconstituted from the 13 positive eigenvalues and their associated eigenvectors from the Householder-Wilkinson analysis, and found to be identical with the original to two decimal places.

Since in general with ill-conditioned or near-singular matrices numerical analysis methods are particularly sensitive to the numerical accuracy of the computer used, different methods may give different results. However, corroborative evidence is available for a rank of 13 for this matrix. The triangular decomposition analysis proceeds by exhausting sequentially the row and column with the largest residual entries at any stage. Rank is determined by a present criterion level, such that when no entries remain above this value, the number of rows (and columns) exhausted is the rank, and the remaining rows and columns are considered 'non-basic', i.e. they may be expressed as linear composites of the 'basic' vectors. In this case, the vectors corresponding to factors L, N and O are non-basic, and the two smallest (i.e. least independent) basic vectors correspond to Q_3 and Q_4.

In this respect, the results of the SIFASP runs are very like the results of the more traditional factor analyses discussed in the previous Chapter. The same scales consistently fail to be separable into independent factors. However, as has been noted, chi-square values for these analyses are highly significant, suggesting a poor fit of model to data. Table 14 gives the results of the goodness of fit tests. McGaw and Jöreskog (1971), however, suggest that with substantial real data bases, chi-square values may be very much inflated by a combination of slight deviations from multivariate normality and small amounts of correlated measurement error. Since Jöreskog's function for minimisation, whose value at the minimum is the basis of the test of goodness-of-fit,

Group	Chi-squared	Degrees of freedom	$\underline{p}$
MA	549.11	328	0.00
MS	619.43	328	0.00
FA	695.15	328	0.00
FS	475.05	328	0.00
MT	825.58	328	0.00
FT	839.33	328	0.00
AT	965.76	328	0.00
ST	778.87	328	0.00
WG	1248.85	328	0.00
TG	1269.48	328	0.00

Table 14: Test statistics for the ten SIFASP analyses

involves the sample size as a multiplying factor, whereas the degrees of freedom for the chi-squared test are determined by the numbers of fixed and free parameters in the model estimated, taking no account of sample size, large samples in combination with small correlated errors may increase the value of chi-squared out of proportion to the size of the absolute discrepancy.

To overcome this problem, Tucker and Lewis (1971) suggest a 'reliability coefficient' for assessing the acceptability of a model under such circumstances:

$$\hat{\rho} = \frac{M_o - M_i}{M_o - 1}$$

where $M_i = \dfrac{\chi_i^2}{v_i}$ for an i-factor model

The rationale for this statistic lies in the fact that the ratio of chi-squared to degrees of freedom is an estimate of the residual variance under the null hypothesis, hence $\hat{\rho}$ is an estimate of the proportion of residual variance under a zero-common-factor model accounted for by the k-factor model. Table 15 gives values of for each of the ten analyses, together with values of chi-squared for the zero-factor model. Note that with the exception of the FS group (which was the only group for which an 8-factor unrestricted model was acceptable, and whose sample size was close to the number of parameters to be estimated) all values of $\hat{\rho}$ are very

	Zero factor model	16 factor model
	χ^2	$\hat{\rho}$
MA	22541.3	0.9838
MS	28457.25	0.9832
MT	50330.92	0.9839
FA	36671.72	0.9836
FS	18846.62	0.9999762
FT	54622.68	0.9848
AT	58860.1	0.9824
ST	46692.0	0.9854
WG	103228.02	0.9854
TG	105097.7	0.9840
	(528 degrees of freedom)	(328 degrees of freedom)

Table 15: Tucker and Lewis "reliability" coefficients for the restricted analyses

close to each other, and all values are high, suggesting an acceptable fit; there is of course no guarantee that only the particular model tested will yield such favourable results, but since the only a priori model available - the second-order factor model - had already been tried and proved abortive, there seems little point in proceeding to a posteriori model-building at this stage.

Table 16 consists of the residual matrix for the WG run, as an example of the size of the residual covariances remaining after the fitting of Cattell's model; it is in all respects representative of the other residual matrices. Note that residual covariances between corresponding scales in the two forms are effectively zero, that most residuals are well below 0. 1 (absolute values), and that 16 of the 22 residuals above 0. 1 are associated with factors L, M and N, which had poor internal consistency as shown in Chapter 6.

Such a residual matrix is, in effect, an indication of the correlated error between scales under the model fitted. Since the factor covariance matrices were left free in the specification of the model, the fact that certain factors were estimated as being very highly correlated needs to be borne in mind, but with this proviso it is clear that by and large Cattell's claim that the error variance of each scale is made up of many small components rather than a few large components is justified, or at least that such error components as are present are in common to both scales in a pair to reasonably close limits.

Form A	A	B	C	E	F	G	H	I	L	M	N	O	Q1	Q2	Q3	Q4
A	0.000	0.014	0.027	0.034	0.029	-0.045	0.023	0.000	-0.033	-0.063	-0.003	-0.017	0.055	0.036	-0.020	0.019
B	0.014	0.000	0.041	0.003	0.003	0.015	0.014	-0.009	0.024	-0.030	0.026	0.023	0.034	0.008	0.012	0.010
C	0.027	0.041	0.001	-0.019	-0.050	0.057	0.010	0.006	-0.023	-0.115	0.156	0.003	-0.066	-0.058	0.050	0.039
E	0.034	0.003	-0.019	0.001	-0.031	-0.022	-0.041	-0.028	-0.058	0.057	0.039	-0.015	-0.015	0.052	0.082	0.031
F	0.029	0.003	-0.050	-0.031	0.000	-0.036	-0.020	-0.056	-0.078	-0.030	0.080	-0.027	-0.058	0.043	0.013	0.071
G	-0.045	0.015	0.057	-0.022	-0.036	0.000	-0.030	0.080	0.033	0.023	0.031	0.031	0.014	-0.004	-0.033	-0.037
H	0.023	0.014	0.010	-0.041	-0.020	-0.030	0.000	-0.008	-0.096	-0.028	0.117	-0.043	-0.039	-0.006	0.054	0.017
I	0.000	-0.009	0.006	-0.028	-0.056	0.080	-0.008	0.000	-0.066	-0.042	-0.040	0.028	0.017	-0.030	0.031	-0.014
L	-0.033	0.024	-0.023	-0.058	-0.078	0.033	-0.096	-0.066	0.000	0.037	-0.006	-0.014	-0.031	0.078	0.063	0.011
M	-0.063	-0.030	-0.115	0.057	-0.030	0.023	-0.028	-0.042	0.037	0.000	-0.011	0.117	0.011	0.018	0.006	0.115
N	-0.003	0.026	0.156	0.039	0.080	0.031	0.117	-0.040	-0.006	-0.011	0.000	-0.111	0.042	-0.065	0.044	-0.146
O	-0.017	0.023	0.003	-0.015	-0.027	0.031	-0.043	0.028	-0.014	0.117	-0.111	0.001	0.048	0.036	-0.018	-0.036
Q1	0.055	0.034	-0.066	-0.015	-0.058	0.014	-0.039	0.017	-0.031	0.011	0.042	0.048	0.000	0.028	0.042	0.057
Q2	0.036	0.008	-0.058	0.052	0.043	-0.004	-0.006	-0.030	0.078	0.018	-0.065	0.036	0.028	0.000	-0.037	0.018
Q3	-0.020	0.012	0.050	0.082	0.013	-0.033	0.054	0.031	0.063	0.006	0.044	-0.018	0.042	-0.037	0.000	-0.027
Q4	0.019	0.010	0.039	0.031	0.071	-0.037	0.017	-0.014	0.011	0.115	-0.146	-0.036	0.057	0.018	-0.027	0.000
Form B																
A	0.000	-0.014	0.009	-0.076	-0.034	0.067	-0.025	-0.044	-0.067	-0.128	0.074	0.009	-0.038	0.027	0.041	0.032
B	0.023	0.001	0.028	0.016	0.024	0.005	0.016	0.038	0.026	0.009	0.013	0.032	0.025	0.004	-0.032	0.002
C	-0.024	-0.040	0.001	0.037	0.062	-0.083	0.065	0.035	-0.018	-0.079	0.108	-0.001	0.003	-0.082	-0.005	-0.011
E	0.082	-0.009	-0.063	0.001	0.081	-0.032	0.015	-0.009	0.007	0.014	-0.018	0.019	-0.062	-0.055	0.022	0.078
F	0.020	-0.008	-0.058	-0.056	0.000	-0.016	-0.007	-0.041	-0.091	-0.002	0.042	-0.030	-0.029	-0.029	0.034	0.086
G	-0.042	-0.023	0.052	0.047	0.019	0.000	0.031	-0.021	0.057	-0.075	0.007	-0.039	0.039	0.001	0.018	-0.058
H	0.015	-0.024	-0.082	0.028	0.030	0.003	0.000	0.001	0.021	-0.029	0.096	0.025	0.008	-0.052	0.006	0.109
I	0.043	0.001	0.010	0.003	0.038	-0.004	-0.001	0.000	0.009	0.027	-0.044	0.036	0.117	-0.008	-0.043	0.043
L	0.066	-0.035	0.026	0.068	0.113	-0.063	0.042	0.011	0.000	0.103	-0.098	-0.057	-0.003	-0.022	-0.028	0.025
M	0.080	0.004	-0.006	0.010	0.003	0.042	0.013	-0.016	-0.085	0.000	0.034	0.010	0.098	0.017	0.030	0.006
N	-0.048	-0.020	-0.064	0.002	-0.076	-0.011	-0.054	0.044	0.060	-0.074	0.000	0.075	-0.027	0.003	-0.086	0.043
O	-0.004	-0.019	-0.018	-0.011	0.000	0.017	-0.039	-0.034	0.058	0.051	-0.119	0.001	0.026	0.047	-0.031	-0.009
Q1	0.049	-0.033	0.003	0.064	0.033	-0.014	0.009	-0.118	0.005	-0.090	0.014	-0.023	-0.140	0.019	0.036	0.028
Q2	-0.008	-0.004	0.026	0.055	0.028	0.002	0.012	-0.014	0.058	0.061	-0.044	-0.023	-0.014	0.000	0.021	-0.035
Q3	-0.055	-0.001	0.021	-0.044	-0.035	-0.002	-0.021	0.032	0.021	-0.043	0.102	0.042	-0.041	-0.026	0.000	-0.019
Q4	-0.014	-0.012	-0.045	-0.100	-0.091	0.059	-0.107	-0.054	-0.053	0.068	-0.074	0.042	-0.035	0.059	0.018	0.000

Table 16 part one: Residual covariances from pooled within-group restricted analysis

Form A	A	B	C	E	F	G	H	I	L	M	N	O	Q1	Q2	Q3	Q4
	Form B															
A	0.000	0.023	-0.024	0.082	0.020	-0.042	0.015	0.043	0.066	0.080	-0.048	-0.004	0.049	-0.008	-0.055	-0.014
B	-0.014	0.001	-0.040	-0.009	-0.008	-0.023	-0.024	0.001	-0.035	0.004	-0.020	-0.019	-0.033	-0.004	-0.001	-0.012
C	0.009	0.028	0.001	-0.063	-0.058	0.052	-0.082	0.010	0.026	-0.006	-0.064	-0.018	0.003	0.026	0.021	-0.045
E	-0.076	0.016	0.037	0.001	-0.056	0.047	0.028	0.003	0.068	0.010	0.002	-0.011	0.064	0.055	-0.044	-0.100
F	-0.034	0.024	0.062	0.081	0.000	0.019	0.030	0.038	0.113	0.003	-0.076	0.000	0.033	0.028	-0.035	-0.091
G	0.067	0.005	-0.083	-0.032	-0.016	0.000	0.003	-0.004	-0.063	0.042	-0.011	0.017	-0.014	0.002	-0.002	0.059
H	-0.025	0.016	0.065	0.015	-0.007	0.031	0.000	-0.001	0.042	0.013	-0.054	-0.039	0.009	0.012	-0.021	-0.107
I	-0.044	0.038	0.035	-0.009	-0.041	-0.021	0.001	0.000	0.011	-0.016	0.044	-0.034	-0.118	-0.014	0.032	-0.054
L	-0.067	0.026	-0.018	0.007	-0.091	0.057	0.021	0.009	0.000	-0.085	0.060	0.058	0.005	0.058	0.021	-0.053
M	-0.128	0.009	-0.079	0.014	-0.002	-0.075	-0.029	0.027	0.103	0.000	-0.074	0.051	-0.090	0.061	-0.043	0.068
N	0.074	0.013	0.108	-0.018	0.042	0.007	0.096	-0.044	-0.098	0.034	0.000	-0.119	0.014	-0.044	0.102	-0.074
O	0.009	0.032	-0.001	0.019	-0.030	-0.039	0.025	0.036	-0.057	0.010	0.075	0.001	-0.023	-0.023	0.042	0.042
Q1	-0.038	0.025	0.003	-0.062	-0.029	0.039	0.008	0.117	-0.003	0.098	-0.027	0.026	-0.140	-0.014	-0.041	-0.035
Q2	0.027	0.004	-0.082	-0.055	-0.029	0.001	-0.052	-0.008	-0.022	0.017	0.003	0.047	0.019	0.000	-0.026	0.059
Q3	0.041	-0.032	-0.005	0.022	0.034	0.018	0.006	-0.043	-0.028	0.030	-0.086	-0.031	0.036	0.021	0.000	0.018
Q4	0.032	0.002	-0.011	0.078	0.086	-0.058	0.109	0.043	0.025	0.006	0.043	-0.009	0.028	-0.035	-0.019	0.000
Form B																
A	0.000	-0.034	-0.012	-0.030	-0.021	0.018	-0.019	-0.012	0.053	-0.024	0.002	0.012	-0.075	-0.023	0.043	-0.048
B	-0.034	0.000	-0.027	0.002	0.001	-0.013	-0.020	0.011	0.006	0.037	-0.001	-0.011	-0.021	0.001	-0.035	-0.010
C	-0.012	-0.027	0.001	0.036	0.045	-0.010	-0.043	-0.044	0.024	0.068	-0.130	0.015	0.058	0.042	-0.064	0.008
E	-0.030	0.002	0.036	0.001	0.061	0.037	0.046	0.035	-0.002	-0.052	-0.037	0.018	-0.018	-0.106	-0.084	0.002
F	-0.021	0.001	0.045	0.061	0.000	0.071	0.019	0.039	0.093	0.008	-0.013	0.041	0.055	-0.040	-0.009	-0.106
G	0.018	-0.013	-0.010	0.037	0.071	0.000	0.022	-0.084	-0.028	-0.056	-0.026	-0.035	-0.033	0.002	0.039	0.054
H	-0.019	-0.020	-0.043	0.046	0.019	0.022	0.001	0.007	0.101	0.002	-0.125	0.096	0.045	0.011	-0.061	0.008
I	-0.012	0.011	-0.044	0.035	0.039	-0.084	0.007	0.001	0.045	0.016	0.022	-0.015	-0.029	0.028	-0.010	0.007
L	0.053	0.006	0.024	-0.002	0.093	-0.028	0.101	0.045	0.000	0.055	0.004	-0.016	0.034	-0.107	-0.076	0.018
M	-0.024	0.037	0.068	-0.052	0.008	-0.056	0.002	0.016	0.055	0.000	0.002	-0.052	-0.068	-0.032	-0.019	-0.076
N	0.002	-0.001	-0.130	-0.037	-0.013	-0.026	-0.125	0.022	0.004	0.002	0.000	0.093	-0.015	0.054	-0.022	0.136
O	0.012	-0.011	0.015	0.018	0.041	-0.035	0.096	-0.015	-0.016	-0.052	0.093	0.001	-0.043	-0.019	0.012	0.015
Q1	-0.075	-0.021	0.058	-0.018	0.055	-0.033	0.045	-0.029	0.034	-0.068	-0.015	-0.043	0.000	-0.012	-0.037	-0.071
Q2	-0.023	0.001	0.042	-0.106	-0.040	0.002	0.011	0.028	-0.107	-0.032	0.054	-0.019	-0.012	0.000	0.010	0.003
Q3	0.043	-0.035	-0.064	-0.084	-0.009	0.039	-0.061	-0.010	-0.076	-0.019	-0.022	0.012	-0.037	0.010	0.000	0.039
Q4	-0.048	-0.010	0.008	0.002	-0.106	0.054	0.008	0.007	0.018	-0.076	0.136	0.015	-0.071	0.003	0.039	0.000

Table 16 part two: Residual covariances from pooled within-group restricted analysis

Table 17 gives the unique factor loadings for each group: note that there is a tendency for differences in these values between paired scales to reflect differences in homogeneity coefficients (Table 6), the more homogeneous of a pair tending to have a lower unique factor loading, the tendency being more marked in the case of larger differences (e.g. factors B and M).

The results obtained from SIFASP are generally consistent both with analyses discussed in previous chapters and with certain of Cattell's own published findings. For instance, Cattell, Eber and Delhees (1973) reported a factor analysis of scale scores from four forms of the 16PF, on a sample of about 600. This analysis showed rather poor identification of factors E, M, N and O. It has already been remarked that factors E and N were difficult if not impossible to separate by rotation of unrestricted solutions; further in the restricted analyses the factor corresponding to N was not linearly independent of the others, and elements in the residual matrices tended to be larger for N than for other scales. In both forms, alpha coefficients for these scales are very low. Factor M also proved troublesome in rotation, perhaps partly due to the very low homogeneity of this scale in form A, and also has some of the larger residual covariances. The problem of separating C, O, Q_4 and L, the major components of the second-order Anxiety factor, has been constant, and reappears in the restricted analyses; the problem with L has no parallel in Cattell's own work, but Cattell, Eber and

FORM A

Scale	Group MA	MS	FA	FS	MT	FT	AT	ST	WG	TG
A	0.52	0.68	0.54	0.62	0.67	0.58	0.56	0.64	0.61	0.62
B	0.70	0.78	0.58	0.10	0.67	0.45	0.63	0.64	0.51	0.62
C	0.68	0.66	0.69	0.72	0.67	0.72	0.70	0.71	0.70	0.70
E	0.56	0.59	0.61	0.56	0.56	0.59	0.59	0.57	0.58	0.58
F	0.58	0.60	0.53	0.47	0.58	0.49	0.55	0.53	0.53	0.54
G	0.60	0.58	0.64	0.60	0.57	0.59	0.61	0.59	0.58	0.59
H	0.46	0.43	0.39	0.39	0.44	0.39	0.41	0.42	0.42	0.42
I	0.72	0.48	0.75	0.56	0.60	0.71	0.76	0.53	0.67	0.65
L	0.81	0.78	0.78	0.73	0.78	0.76	0.80	0.75	0.77	0.77
M	0.88	0.85	0.90	0.88	0.87	0.90	0.90	0.87	0.88	0.89
N	0.90	0.87	0.80	0.92	0.85	0.80	0.82	0.84	0.83	0.83
O	0.60	0.68	0.64	0.60	0.63	0.61	0.61	0.62	0.62	0.62
Q_1	0.58	0.84	0.73	0.72	0.76	0.73	0.66	0.79	0.73	0.73
Q_2	0.74	0.80	0.80	0.78	0.77	0.78	0.78	0.79	0.78	0.78
Q_3	0.59	0.70	0.65	0.63	0.64	0.62	0.61	0.64	0.63	0.63
Q_4	0.57	0.51	0.52	0.55	0.53	0.52	0.53	0.51	0.52	0.52

Table 17 part 1: Unique factor loadings from the ten restricted factor analyses

FORM B

Scale	Group MA	MS	FA	FS	MT	FT	AT	ST	WG	TG
A	0.72	0.61	0.59	0.62	0.64	0.59	0.63	0.63	0.62	0.62
B	0.77	0.90	0.87	0.98	0.83	0.84	0.80	0.86	0.84	0.83
C	0.69	0.72	0.66	0.64	0.70	0.63	0.66	0.66	0.66	0.66
E	0.65	0.68	0.68	0.71	0.67	0.69	0.68	0.70	0.68	0.69
F	0.52	0.58	0.56	0.52	0.57	0.56	0.55	0.58	0.57	0.57
G	0.76	0.73	0.72	0.62	0.74	0.71	0.74	0.70	0.72	0.73
H	0.53	0.55	0.49	0.50	0.55	0.50	0.51	0.53	0.52	0.52
I	0.63	0.66	0.59	0.64	0.66	0.67	0.64	0.66	0.64	0.67
L	0.79	0.80	0.81	0.85	0.80	0.80	0.79	0.80	0.80	0.80
M	0.57	0.68	0.74	0.65	0.64	0.74	0.65	0.66	0.66	0.68
N	0.87	0.79	0.80	0.82	0.81	0.78	0.82	0.78	0.79	0.80
O	0.52	0.58	0.54	0.58	0.54	0.54	0.53	0.56	0.55	0.54
Q_1	0.76	0.76	0.69	0.64	0.75	0.69	0.76	0.77	0.74	0.76
Q_2	0.52	0.70	0.55	0.67	0.64	0.59	0.52	0.66	0.61	0.61
Q_3	0.67	0.66	0.68	0.56	0.66	0.64	0.67	0.63	0.65	0.65
Q_4	0.57	0.61	0.57	0.59	0.59	0.56	0.56	0.59	0.58	0.58

Table 17 part 2: Unique factor loadings from the ten restricted factor analyses

Delhees had very similar difficulties with C, O and Q_4. They rotated their axes in such a way that corresponding factors were linearly independent but had low loadings on the appropriate scales.

Overall, the results do not unequivocally either confirm or disconfirm Cattell's model, rather they lend partial support. In Cattell's favour we have the following points:

1. The majority of the analyses support about 13 common factors.
2. Many of these factors can be rotated, in the unrestricted analyses, to positions where they load principally nominally equivalent scales.
3. The restricted analyses give a tolerably good fit to Cattell's model, although only, in effect, for 13 factors.
4. The residual variances in the restricted analyses tend to reflect differences in the reliability of scales, estimated either by alpha or by alternate form coefficients.
5. It is at least conceivable that the closeness of the C, O and Q_4 factors is sample specific (and the same argument might also be used for L and N), either because the items in these scales do not efficiently discriminate between the traits with British undergraduates, or because in the present sample responses reflect state rather than trait aspects of anxiety, which may be less differentiated, as argued by Cattell, Eber and Delhees (1973).

Against Cattell we have these considerations:

1. There is a consistent finding that C, O and Q_4 are virtually inseparable, both in this study and in Eysenck's (1972) reanalysis of some of Cattell's data, not to mention the Cattell, Eber and Delhees study.
2. Factor N is so poorly represented, and has such low internal consistency, as to be worthless.
3. The restricted analyses cannot provide a guarantee that the model as fitted is the best or most parsimonious possible.
4. Rotated solutions invariably collapsed when attempts were made to force them to the complete Cattell model.

CHAPTER 9

The results of the restricted analyses in the last chapter are consistent both with the homogeneity analysis of Chapter 6 and with the results of the Cattell, Eber and Delhees study. However, in one respect they differ from many of Cattell's published results, namely in the factor correlation matrices. There is a strong tendency for the correlations between factors to be rather larger than in Cattell's own studies, a feature which has been noted in particular in the cases of factors C, O and Q_4 but which is widespread throughout the matrices. To take but a single instance, the correlation between A and H in the restricted analysis for the male total group was 0.556, whereas the corresponding figure in Table 10.2 of Cattell, Eber and Tatsuoka (1970) is only 0.26. Now one does not expect to find identical factor correlation matrices in separate studies, but a further feature is present in the results of the restricted analyses which is novel, or at least previously unnoticed, namely that if the rows and columns of the factor correlation matrices are suitably reordered, a pattern appears. Table 18 gives one possible reordering of the matrix for the total group, but essentially the same pattern is to be found in all ten analyses. By and large the size of a coefficient is inversely related to its distance from the principal diagonal. Were this pattern to hold throughout we should have here an example of what

	A	Q2	H	C	Q4	Q3	G	M	Q1	E	F	I	B	O	L	N
A	1.000	0.632	0.496	0.180	0.052	0.029	0.154	-0.074	0.037	0.092	0.457	0.283	-0.022	0.184	-0.057	0.047
Q2	0.632	1.000	0.564	0.314	0.147	0.051	0.127	-0.122	-0.062	0.058	0.597	-0.003	-0.068	0.245	-0.250	-0.133
H	0.496	0.564	1.000	0.488	0.352	0.184	-0.019	0.234	0.285	0.675	0.735	-0.130	-0.097	0.578	0.061	-0.403
C	0.180	0.314	0.488	1.000	0.944	0.606	0.144	0.033	-0.006	0.111	0.191	-0.291	0.019	0.964	-0.630	0.101
Q4	0.052	0.147	0.352	0.944	1.000	0.684	0.232	0.060	-0.001	0.049	-0.014	-0.294	0.036	0.903	-0.611	0.190
Q3	0.029	0.051	0.184	0.606	0.684	1.000	0.786	-0.291	-0.218	-0.117	-0.271	-0.261	0.040	0.596	-0.325	0.489
G	0.154	0.127	-0.019	0.144	0.232	0.786	1.000	-0.375	-0.439	-0.355	-0.350	-0.013	0.025	0.094	-0.183	0.529
M	-0.074	-0.122	0.234	0.033	0.060	-0.291	-0.375	1.000	0.628	0.507	0.160	0.394	0.113	0.143	0.010	-0.619
Q1	0.037	-0.062	0.285	-0.006	-0.001	-0.218	-0.439	0.628	1.000	0.697	0.319	-0.163	0.084	0.186	0.491	-0.536
E	0.092	0.058	0.675	0.111	0.049	-0.117	-0.355	0.507	0.697	1.000	0.610	-0.342	-0.105	0.361	0.662	-0.859
F	0.457	0.597	0.735	0.191	-0.014	-0.271	-0.350	0.160	0.319	0.610	1.000	-0.104	-0.193	0.258	0.280	-0.633
I	0.283	-0.003	-0.130	-0.291	-0.294	-0.261	-0.013	0.394	-0.163	-0.342	-0.104	1.000	0.144	-0.384	-0.212	0.171
B	-0.022	-0.068	-0.097	0.019	0.036	0.040	0.025	0.113	0.084	-0.105	-0.193	0.144	1.000	0.004	-0.137	0.061
O	0.184	0.245	0.578	0.964	0.903	0.596	0.094	0.143	0.186	0.361	0.258	-0.384	0.004	1.000	-0.347	-0.086
L	-0.057	-0.250	0.061	-0.630	-0.611	-0.325	-0.183	0.010	0.491	0.662	0.280	-0.212	-0.137	-0.347	1.000	-0.520
N	0.047	-0.133	-0.403	0.101	0.190	0.489	0.529	-0.619	-0.536	-0.859	-0.633	0.171	0.061	-0.086	-0.520	1.000

Table 18: REORDERED FACTOR CORRELATION MATRIX, WITH O,Q2 AND Q4 REVERSED IN SIGN, FOR THE TOTAL GROUP

Guttman has termed a 'simplex', a pattern characteristic of correlations between items arranged in order of difficulty, and tests in order of complexity (Guttman 1966). The order of Table 18, however, ignoring B and I which play no part in the pattern and L, N and O which have been shown not to be linearly independent factors, is not a perfect simplex, particularly at the lower left and upper right corners of the matrix. Nor is the pattern a straightforward circumplex, i.e. with the coefficients first falling and then rising with increasing distance from the diagonal. There is however an approximate circumplex in the part of the matrix between H and F.

The novelty of this finding might lead one to suppose that the pattern is an artefact either of the way the restricted model was specified or indeed of the SIFASP program used. Inspection of the correlations between scale scores reveals some aspects of the pattern, but it is much more clearly apparent when the matrix is corrected for attenuation. The bivariate correction of a correlation for attenuation due to unreliability has been in use for many years, and consists of simply dividing a correlation by the geometric mean of the reliabilities of the variables. Bock and Petersen (1975) have extended this correction to the multivariate case, showing that a maximum likelihood estimate of the correlation matrix of true scores may be obtained by first correcting the coefficients in the usual bivariate way, and then reconstructing the matrix from the positive eigenvalues and associated eigenvectors of the matrix after bivariate correction.

This procedure was applied to the correlations among scale scores for the total group, using as estimates of reliability the alpha coefficients discussed in Chapter 6. The resultant matrix is presented in Table 19. Theoretically, this matrix ought to be rather close to the factor intercorrelation matrix, since both procedures purport to remove error due to unreliability, and so it proves to be. Moreover, it displays most of the features discussed with regard to the factor analyses: note that L, M and N have much the lowest corrected alternate form correlations - these were troublesome in the rotation of unrestricted factor solutions, and had the largest residuals in the restricted analyses; C, O and Q_4 have corrected intercorrelations almost identical with their corrected alternate form correlations; correlations between E and N are close to the alternate form correlation for N; G form A is nearly as highly correlated with Q_3 in both forms as with G form B; and finally the pattern of correlations found in the factor correlation matrices from the restricted analyses is present in very similar form. The similarity of results obtained by these different procedures suggests that we are dealing not with computational artefacts, but with real features of the data. It also suggests that the Bock and Petersen method would be a useful procedure to adopt earlier in the sequence of analysis.

Form A	A	B	C	E	F	G	H	I	L	M	N	O	Q1	Q2	Q3	Q4
Factor A	1.000	-0.091	0.134	0.033	0.404	0.219	0.456	0.270	0.004	0.082	0.119	-0.136	-0.092	-0.581	0.074	-0.077
Factor B	-0.091	1.000	-0.056	-0.167	-0.292	-0.013	-0.178	0.206	-0.244	0.209	0.019	-0.070	0.043	0.085	0.039	-0.081
Factor C	0.134	-0.056	1.000	0.119	0.263	0.084	0.448	-0.295	-0.527	0.194	-0.296	-0.812	0.107	-0.161	0.471	-0.903
Factor E	0.033	-0.167	0.119	1.000	0.641	-0.309	0.711	-0.239	0.661	0.232	-0.871	-0.282	0.696	-0.185	-0.263	-0.075
Factor F	0.404	-0.292	0.263	0.641	1.000	-0.293	0.747	-0.040	0.390	0.148	-0.616	-0.176	0.378	-0.567	-0.272	-0.081
Factor G	0.219	-0.013	0.084	-0.309	-0.293	1.000	0.020	-0.198	-0.228	-0.310	0.367	-0.151	-0.436	-0.107	0.837	-0.186
Factor H	0.456	-0.178	0.448	0.711	0.747	0.020	1.000	-0.105	0.206	0.200	-0.580	-0.460	0.346	-0.482	0.104	-0.355
Factor I	0.270	0.206	-0.295	-0.239	-0.040	-0.198	-0.105	1.000	-0.047	0.424	0.292	0.288	-0.230	0.080	-0.307	0.276
Factor L	0.004	-0.244	-0.527	0.661	0.390	-0.228	0.206	-0.047	1.000	-0.045	-0.384	0.328	0.515	0.021	-0.429	0.541
Factor M	0.082	0.209	0.194	0.232	0.148	-0.310	0.200	0.424	-0.045	1.000	-0.299	-0.269	0.383	0.034	-0.214	-0.216
Factor N	0.119	0.019	-0.296	-0.871	-0.616	0.367	-0.580	0.292	-0.384	-0.299	1.000	0.363	-0.590	0.279	0.275	0.229
Factor O	-0.136	-0.070	-0.812	-0.282	-0.176	-0.151	-0.460	0.288	0.328	-0.269	0.363	1.000	-0.247	0.146	-0.478	0.813
Factor Q1	-0.092	0.043	0.107	0.696	0.378	-0.436	0.346	-0.230	0.515	0.383	-0.590	-0.247	1.000	-0.017	-0.260	-0.123
Factor Q2	-0.581	0.085	-0.161	-0.185	-0.567	-0.107	-0.482	0.080	0.021	0.034	0.279	0.146	-0.017	1.000	0.011	0.104
Factor Q3	0.074	0.039	0.471	-0.263	-0.272	0.837	0.104	-0.307	-0.429	-0.214	0.275	-0.478	-0.260	0.011	1.000	-0.579
Factor Q4	-0.077	-0.081	-0.903	-0.075	-0.081	-0.186	-0.355	0.276	0.541	-0.216	0.229	0.813	-0.123	0.104	-0.579	1.000
Form B																
Factor A	0.953	0.009	0.156	0.215	0.503	0.031	0.549	0.356	0.114	0.244	-0.064	-0.181	0.117	-0.570	-0.059	-0.106
Factor B	-0.022	0.907	-0.060	-0.112	-0.143	0.010	-0.091	0.062	-0.157	0.003	0.006	-0.033	-0.042	0.017	0.061	-0.004
Factor C	0.205	0.115	0.852	0.042	0.086	0.280	0.364	-0.315	-0.488	0.138	-0.190	-0.783	0.014	-0.117	0.558	-0.816
Factor E	-0.089	-0.109	0.167	0.888	0.357	-0.257	0.572	-0.285	0.514	0.275	-0.707	-0.329	0.748	0.040	-0.127	-0.189
Factor F	0.415	-0.287	0.265	0.711	0.952	-0.348	0.753	-0.070	0.430	0.107	-0.645	-0.199	0.367	-0.463	-0.311	-0.109
Factor G	0.254	0.098	0.009	-0.406	-0.313	0.867	-0.058	0.116	-0.286	-0.065	0.387	0.013	-0.478	-0.113	0.629	-0.078
Factor H	0.414	-0.083	0.563	0.586	0.627	-0.007	0.933	-0.116	0.022	0.197	-0.508	-0.517	0.265	-0.378	0.160	-0.463
Factor I	0.166	0.243	-0.249	-0.307	-0.170	-0.051	-0.132	0.933	-0.189	0.281	0.293	0.248	-0.420	0.046	-0.165	0.194
Factor L	-0.177	-0.091	-0.542	0.415	0.010	0.014	-0.011	-0.259	0.749	-0.231	-0.110	0.335	0.430	0.204	-0.191	0.405
Factor M	-0.258	0.194	0.048	0.568	0.209	-0.544	0.256	0.360	0.235	0.719	-0.642	-0.155	0.539	0.112	-0.421	-0.067
Factor N	0.177	0.118	0.268	-0.782	-0.487	0.590	-0.301	-0.041	-0.658	-0.232	0.774	-0.142	-0.477	0.114	0.687	-0.320
Factor O	-0.169	0.035	-0.886	-0.342	-0.258	-0.168	-0.552	0.442	0.267	-0.167	0.413	0.877	-0.271	0.139	-0.518	0.883
Factor Q1	-0.077	0.245	-0.023	0.553	0.239	-0.421	0.254	0.147	0.392	0.609	-0.505	-0.106	0.872	-0.011	-0.297	-0.025
Factor Q2	-0.710	0.138	-0.379	-0.147	-0.684	-0.138	-0.634	-0.007	0.134	-0.016	0.226	0.268	0.108	0.877	-0.090	0.223
Factor Q3	0.105	0.077	0.527	-0.090	-0.216	0.816	0.225	-0.347	-0.353	-0.111	0.119	-0.599	-0.108	0.009	0.959	-0.635
Factor Q4	-0.011	-0.051	-0.765	0.117	0.145	-0.340	-0.184	0.359	0.622	-0.133	0.044	0.677	0.041	0.030	-0.637	0.872

Table 19 part one: Correlation matrix for the total group after multivariate correction for attenuation

Form A	Form B: A	B	C	E	F	G	H	I	L	M	N	O	Q1	Q2	Q3	Q4
Factor A	0.953	-0.022	0.205	-0.089	0.415	0.254	0.414	0.166	-0.177	-0.258	0.177	-0.169	-0.077	-0.710	0.105	-0.011
Factor B	0.009	0.907	0.115	-0.109	-0.287	0.098	-0.083	0.243	-0.091	0.194	0.118	0.035	0.245	0.138	0.077	-0.051
Factor C	0.156	-0.060	0.852	0.167	0.265	0.009	0.563	-0.249	-0.542	0.048	0.268	-0.886	-0.023	-0.379	0.527	-0.765
Factor E	0.215	-0.112	0.042	0.888	0.711	-0.406	0.586	-0.307	0.415	0.568	-0.782	-0.342	0.553	-0.147	-0.090	0.117
Factor F	0.503	-0.143	0.086	0.357	0.952	-0.313	0.627	-0.170	0.010	0.209	-0.487	-0.258	0.239	-0.684	-0.216	0.145
Factor G	0.031	0.010	0.280	-0.257	-0.348	0.867	-0.007	-0.051	0.014	-0.544	0.590	-0.168	-0.421	-0.138	0.816	-0.340
Factor H	0.549	-0.091	0.364	0.572	0.753	-0.058	0.933	-0.132	-0.011	0.256	-0.301	-0.552	0.254	-0.634	0.225	-0.184
Factor I	0.356	0.062	-0.315	-0.285	-0.070	0.116	-0.116	0.933	-0.259	0.360	-0.041	0.442	0.147	-0.007	-0.347	0.359
Factor L	0.114	-0.157	-0.488	0.514	0.430	-0.286	0.022	-0.189	0.749	0.235	-0.658	0.267	0.392	0.134	-0.353	0.622
Factor M	0.244	0.003	0.138	0.275	0.107	-0.065	0.197	0.281	-0.231	0.719	-0.232	-0.167	0.609	-0.016	-0.111	-0.133
Factor N	-0.064	0.006	-0.190	-0.707	-0.645	0.387	-0.508	0.293	-0.110	-0.642	0.774	0.413	-0.505	0.226	0.119	0.044
Factor O	-0.181	-0.033	-0.783	-0.329	-0.199	0.013	-0.517	0.248	0.335	-0.155	-0.142	0.877	-0.106	0.268	-0.599	0.677
Factor Q1	0.117	-0.042	0.014	0.748	0.367	-0.478	0.265	-0.420	0.430	0.539	-0.477	-0.271	0.872	0.108	-0.108	0.041
Factor Q2	-0.570	0.017	-0.117	0.040	-0.463	-0.113	-0.378	0.046	0.204	0.112	0.114	0.139	-0.011	0.877	0.009	0.030
Factor Q3	-0.059	0.061	0.558	-0.127	-0.311	0.629	0.160	-0.165	-0.191	-0.421	0.687	-0.518	-0.297	-0.090	0.959	-0.637
Factor Q4	-0.106	-0.004	-0.816	-0.189	-0.109	-0.078	-0.463	0.194	0.405	-0.067	-0.320	0.883	-0.025	0.223	-0.635	0.872
Form B																
Factor A	1.000	0.043	0.181	0.098	0.514	0.118	0.495	0.222	-0.131	-0.004	-0.008	-0.203	0.160	-0.673	0.009	0.026
Factor B	0.043	1.000	0.059	-0.100	-0.114	0.044	-0.028	0.082	-0.080	0.014	0.084	0.046	0.075	0.026	0.057	0.032
Factor C	0.181	0.059	1.000	0.045	0.103	0.117	0.490	-0.206	-0.475	-0.094	0.409	-0.893	-0.119	-0.358	0.657	-0.806
Factor E	0.098	-0.100	0.045	1.000	0.451	-0.356	0.489	-0.361	0.495	0.571	-0.626	-0.378	0.609	0.136	0.056	-0.056
Factor F	0.514	-0.114	0.103	0.451	1.000	-0.406	0.658	-0.194	0.082	0.216	-0.554	-0.306	0.193	-0.595	-0.236	0.154
Factor G	0.118	0.044	0.117	-0.356	-0.406	1.000	-0.050	0.212	-0.117	-0.335	0.522	0.016	-0.294	-0.133	0.605	-0.230
Factor H	0.495	-0.028	0.490	0.489	0.658	-0.050	1.000	-0.131	-0.133	0.220	-0.156	-0.658	0.184	-0.583	0.269	-0.321
Factor I	0.222	0.082	-0.206	-0.361	-0.194	0.212	-0.131	1.000	-0.344	0.305	0.019	0.391	-0.024	-0.019	-0.213	0.233
Factor L	-0.131	-0.080	-0.475	0.495	0.082	-0.117	-0.133	-0.344	1.000	-0.015	-0.363	0.275	0.243	0.430	-0.102	0.411
Factor M	-0.004	0.014	-0.094	0.571	0.216	-0.335	0.220	0.305	-0.015	1.000	-0.684	-0.057	0.761	0.175	-0.301	0.101
Factor N	-0.008	0.084	0.409	-0.626	-0.554	0.522	-0.156	0.019	-0.363	-0.684	1.000	-0.180	-0.485	-0.037	0.584	-0.494
Factor O	-0.203	0.046	-0.893	-0.378	-0.306	0.016	-0.658	0.391	0.275	-0.057	-0.180	1.000	-0.066	0.316	-0.635	0.799
Factor Q1	0.160	0.075	-0.119	0.609	0.193	-0.294	0.184	-0.024	0.243	0.761	-0.485	-0.066	1.000	0.130	-0.176	0.138
Factor Q2	-0.673	0.026	-0.358	0.136	-0.595	-0.133	-0.583	-0.019	0.430	0.175	-0.037	0.316	0.130	1.000	-0.089	0.130
Factor Q3	0.009	0.057	0.657	0.056	-0.236	0.605	0.269	-0.213	-0.102	-0.301	0.584	-0.635	-0.176	-0.089	1.000	-0.693
Factor Q4	0.026	0.032	-0.806	-0.056	0.154	-0.230	-0.321	0.233	0.411	0.101	-0.494	0.799	0.138	0.130	-0.693	1.000

Table 19 part two: Correlation matrix for the total group after multivariate correction for attenuation

Since in the analysis of scale scores we are dealing with composites formed from scores on mutually exclusive sets of items, let us pursue the questions raised by these analyses to the item level. Remembering that Cattell has consistently claimed that items loaded by a given factor are designedly hetergeneous, a claim vigorously endorsed but otherwise interpreted by his critics, the correlations between items and scales for the items making up scales A, E, F, H, Q_1 and Q_2 were inspected in the light of the interpretations proposed by Cattell for these scales. These six were chosen partly because none of them had been called into question in the analyses so far, and partly because of their consistent place in the pattern of Table 18.

Firstly, an interpretation for each scale was formulated on the basis of its most distinctive item content in the light of Cattell's own interpretation. Then each item in these scales was checked to compare its correlation with the composite formed from all other items in both forms of the same scale with its correlation with all other scales (again at two-form length), excluding L and N on account of their uniformly poor showing throughout. The items were then sorted into four categories:

1. Where the proposed interpretation clearly fitted item content <u>and</u> the item-partial scale correlation was higher than the correlation with any other scale.

2. Where the item-partial scale correlation was higher than the correlation with any other scale, but the interpretation did not clearly match.

3. Where the interpretation matched, but the correlation with another scale was within $\pm$ 0.03 of the item-partial correlation.

4. Where the interpretation did not match, and the item-partial was exceeded by the correlation with another scale.

In a small number of cases the interpretation matched, but the best correlation was with another scale. These items are discussed individually. In what follows, a typical 'matching' item is given for each scale, and where an item correlates about as well or better with another scale, this scale is given in brackets.

<u>Factor A</u>

"If I had to choose, I would rather be

a. a forester
b. uncertain
c. a secondary school teacher" Item 51 form A

Interpretation: preference for occupations and leisure activities which essentially involve social contact.

1. Form A: 3, 26, 51, 76, 101, 176
   Form B: 3, 16, 51, 52, 101, 126, 151, 176

2. Form B: 76 (would prefer to speak to a stranger in a railway carriage rather than stare out of the window)

3. Form A: 126(I)

4. Form A: 27(H), 52(Q_2)
   Form B: 27(I)

Item 151 in form B correlates more highly with I: the choice here is between being an artist and being a secretary running a club. I and M typically show strongly when artistic or abstract intellectual content is involved.

Factor E

"It is more important to:

a. get along smoothly with people
b. in between
c. get your own ideas put into practice"

Item 57 form B

Interpretation: socially assertive

1. Form A: 6, 7, 56, 156, 181
   Form B: 6, 31, 57, 106, 131

2. Form B: 56

3. Form A: 131(F, Q_3), 180(H)
   Form B: 7(Q_1)

4. Form A: 31(Q_1), 32(H), 57(H), 81(G), 155(F)
   Form B: 32(O), 81(H), 155(Q_1), 156(Q_4), 180(I), 181(H)

Item 106 in form A fits the interpretation but correlates better with H; the interpretation of items 180 and 181 in form B is dubious, but on balance they have been placed under 4.

Factor F

"I am well described as a happy-go-lucky, nonchalant person

a. yes
b. in between
c. no "

Item 183 form B

Interpretation: Socially active, carefree and optimistic

1. Form A: 58, 83, 108, 132, 133, 157, 158, 183
   Form B: 8, 33, 58, 83, 132, 158, 183
2. Form A: 8
3. Form A: 33(H), 82(H, Q_2), 107(H, Q_2)
   Form B: 182(E, G, Q_3)
4. Form B: 107(H), 108(H), 133(A, I),157(A)

Item 182 in form A, "I am considered a very enthusiastic person", correlates better with H, but in terms of content is rather more like the interpretation offered. Item 82 in form B is difficult to place between F and H, and in fact correlates better with H.

Factor H

"'Stage-fright' in various social situations is something I have experienced:

a. quite often

b. occasionally

c. hardly ever"

Item 85 form A

Interpretation (for low score): feels threatened when the focus of attention in social situations.

1. Form A: 10, 35, 61, 85, 110, 161
   Form B: 35, 61, 85, 86, 110, 136, 161, 186

2. Form A: 86, 111, 135
   Form B: 10, 36, 135

Note: these items are very typical general extraversion items, e.g. item 135 form A: "I consider myself a very sociable, outgoing person."

3. Form A: 60(E), 186(Q_3)
   Form B: 60(0)

4. Form A: 36(F), 136(F)
   Form B: 111(F)

Factor Q_1

"I think society should let reason lead it to new customs and throw away old habits or mere traditions:

a. yes

b. in between

c. no"

Item 169 form A

Interpretation: socially and politically radical

1. Form A: 46, 120, 169

   Form B: 70, 120, 145

2. Form A: 70

3. Form B: 95(G), 169(E)

4. Form A: 20(I), 21(Q_3), 95(E), 145(E), 170(G)

   Form B: 20(H), 21(M), 45(Q_3), 46(M)

Factor Q_2

"To keep informed I like:

a. to discuss issues with people

b. in between

c. to rely on the actual news reports"

Item 96 form A

Interpretation: does not look to social group for norms of opinion and behaviour.

1. Form A: 71, 96, 122, 146, 171

   Form B: 72, 121, 171

2. Form B: 47

3. None

4. Form A: 47(H), 72(E), 97(A, H), 121(E, H, M)

   Form B: 22(H), 71(H), 96(C), 97(H), 122(F), 146(Q_3)

Item 22 in form A: "Most people would be happier if they lived more with their fellows and did the same things as others", has very low (less than 0. 1) correlations throughout.

In general, when an item did not fit well the proposed interpretation for the scale on which it is scored, its highest correlation could be located by consideration of its content in the light of the interpretations of the other scales. For instance, item 31 in form A, which is scored on E:

"An outdated law should be changed:

a. only after considerable discussion
b. in between
c. promptly"

was clearly more like the typical items of Q_1, and indeed proved to be more highly correlated with Q_1. When such a relationship was not apparent, H tended to be the scale giving the highest correlation. Items with an artistic content tended to correlate well with I, those with abstract intellectual content with M, and those with moral or ethical content with G and/or Q_2. The majority of items categorised under 4 above fit the interpretation proposed for the scale with which they correlate best.

This, admittedly subjectively based, analysis allows the drawing of finer distinctions amongst these scales, as follows:

(1) A, E, F, H and Q_2 all refer to the behaviour of the individual in social contexts, whereas Q_1 refers to attitudes to social and political ideas and conventions.

(2) A, H and Q_2 are in a sense "afferent" factors: they refer to the response of an individual to or in a situation, casting him in a relatively passive role, whereas E, F and Q_1 are more "efferent", referring to the extent that he initiates activity or change, i. e. casting him in a more active role.

(3) A refers to a preference for situations involving social contact, Q_2 to a certain dependence on socially defined reality; H contrasts confidence and shyness but does not imply a tendency to initiate social contact or activity, whereas F implies a readiness to initiate and innovate, but not necessarily to dominate or aggressively maintain one's position, which is the major burden of E. Q_1 refers more to ideas and opinions than to actual behaviour.

Thus interpretations modified only in detail from those provided by Cattell fit rather well 67 of the items scored on these scales, only 11 items which correlate best within the scale on which they are scored do not fit the interpretations, 13 fit the interpretations but correlate about as well with another scale, only 3 fit the interpretation but correlate better with another scale, 3 are doubtful, and the remaining 41 correlate better with other scales and by and large fit the interpretation of the scale with which they correlate best rather than that of the scale on which they are scored.

Now it may be that what is at work here is Cattell's (1972) claimed suppressor action, whereby items not strictly loaded by a given factor are nonetheless scored on the corresponding scale to balance out unwanted variance introduced by other items. On the other hand Cattell has nowhere indicated just which items are supposed to be suppressing what. It seems likely that rescoring of the items in line with the kind of content analysis just attempted could lead to a clearer structure, increase the statistical homogeneity of the scales, which as has been shown relates rather well to their factor validity, reduce the intercorrelations of the scales and maybe even improve the pattern of Table 18. However, such a reanalysis would require a separate study to avoid the possibility that the above results are adventitious.

What can be said is that such an approach to the scales via content analysis and item-scale correlations strips them of any mystery which may be implied by their origins in factor analytic research. There is for each of these scales a core of similar items which tend to be those with the highest correlations with the scale. Eysenck's (1972) comment that Cattell's scales are complex in content, again a point with which Cattell has often implied agreement, is true only to some extent, and the extent to which a scale seems complex is dependent on one's interpretation of item content. For instance, the items of factor A are by and large concerned with occupational preferences, but the overall contrast between each pair is clearly related to the amount of social contact they involve.

For these six scales, then, there appears to be a clear but imperfect link between item content, item-scale correlations and slightly modified versions of the interpretations offered by Cattell. The remaining scales all have similar clusters of core items closely related to their interpretations, but their poorer homogeneity and/or their high correlations with other scales make the comparison of item-scale correlations less promising.

Beyond item content, there is the further question of item format, and in particular Cattell's provision of three response possibilities for each item. The second of these takes various forms: often "in between" is used, or "uncertain". The instructions for the test refer to these second alternatives as "middle, 'uncertain' answers", and exhort the subject to choose, wherever possible, either the first or third, falling back on the second only about once every four or five items.

Percentage figures of responses to each item show that by and large participants in this study did as they were asked, but there were large differences in the use of the middle category. For instance, 51.41% of answers to "I make clever, sarcastic remarks to people if I think they deserve it" (item 7, form A) were "sometimes" rather than "generally" or "never", whereas only 9.56% answered "I occasionally tell strangers things that seem to me important, regardless of whether they ask about them" (item 131, form A) with "in between" rather than "yes" or "no", with the remainder about equally split. Yet the former has a higher correlation with its scale than the latter.

One type of item seems particularly prone to large numbers of middle responses, viz. those with alternatives "often; sometimes; never", "always; occasionally; rarely" and the like. Twenty-eight such items are distributed across the two forms: of these 6 are scored on factor C, 1 on E, 1 on G, 4 on H, 1 on I, 1 on N, 5 on O, 2 on Q_2, 2 on Q_3, and 5 on Q_4. Twenty-three of the twenty-eight have response percentages above 30 for the middle answer, rising as high as 63.39% for item 123 in form A. These items are with only two exceptions the most heavily endorsed in the middle category in each scale; item 124 in form B is one of these exceptions, only 13.01 per cent using the second alternative, but here the choice is "occasionally; hardly ever; never" and over 70% choose "never"; the other exception occurs in factor C form B where item 104 (26.59%) is beaten into third place by item 5 (which itself has "occasionally" as the middle response), and item 4 (a mere 20.96%) is fifth after an item with "in between" as the second alternative.

However, these items show no consistent deficit in their item-scale correlations, nor do items with "often" or "occasionally" in the body of the item show any special statistical features. Such terms are of course eminently open to interpretation by the respondent, and even "never" and "always" may well be subject to fine distinctions: we are of course dealing with self report data, which carries no warranty as to its accuracy, via multiple-choice items which may not allow the individual to specify his most preferred response.

This brings us to the troubled subject of the relevance of questionnaire items to individual respondents. Item content which touches on issues of central concern to one individual may seem hopelessly irrelevant to another on account of its specificity, yet if items are written at a more general level they may fail to capture the distinctions which are most relevant in any given case by being too all-embracing and thus impossible to answer decisively. In other words, not only may "often", "rarely" and the like be interpreted differently, whole items may be relevant in different ways or not at all and be subject to different interpretations accordingly. Bem and Allen (1974) have had some success in improving the performance of personality test scores by the simple means of asking subjects whether or not they regard themselves as consistent in particular respects and whether they find various sorts of item content sufficiently central to their lives to be interpretable as test material. One might read the middle response categories in the 16PF items as providing something of the same kind of information, although it is not treated separately in the scoring procedure, which also does not make provision for the omission of items.

If one accepts that the process of answering a questionnaire item engages conscious processes of thought, whether they be attempts to remember past behaviour, predict future behaviour or articulate a self-concept within the framework provided by the item, then scores must reflect not only patterns of overt behaviour (indeed they may not even do so), but also the processes of interpretation, recall and self-presentation. Cattell shows some appreciation of this fact by referring to questionnaire scores as reflecting the "mental interiors" of factors, and it is of course a major focus of personal construct theory in the tradition begun by George Kelly. Similarly, any attempt to detect faking of response and social desirability response sets implicitly recognises the scope for interpretation of items and self-presentation through responses. If the involvement of conscious processes of interpretation and the like is seen not as an aberration but as part of the normal business of answering a questionnaire, then one would expect consistency in the individual to emerge through the sorting of items into groups having subjectively similar content. The form in which responses are recorded is far from ideal for the detection of such consistency, but the evidence of the analysis of item-scale correlations above suggests that the participants in this study overall sorted in a way more consistent with the author's interpretations of the items than with the scoring key provided by Cattell. Perhaps the fact that many of the analyses reported herein are amongst the most favourable to Cattell in the history of research on his scales outside his own laboratory reflects the homogeneity of the sample, a sample with, one might assume, a fairly uniform life-style and considerable commonality of outlook and experience.

To develop this point of view further, consider first of all the fact that in scoring a questionnaire much of the specificity of item responses is discarded, items being grouped according to the author's notions of similarity, however derived. Next, assuming for the moment the validity of such groupings, the further grouping of scales into second-order factors implies a further loss of specificity. Should this specificity be regarded as unreliability in the sense of random error, or information which is valuable for some purposes but irrelevant for others? Eysenck (1972) sees the specificity of Cattell's first-order factors as unreliability but hints that in the case of those scales which are loaded by the second-order Exvia factor there may be reliable specificity, quoting Frenkel-Brunswik (1942):

> "Different classes of behavioural 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."

For comparison with Eysenck's Table 2 we have Table 19, which shows rather more clearly that twelve of Cattell's scales have sufficient specificity replicable across forms to suggest they may have some utility.

However, if one is interested less in the prediction of individual behaviour and more in the physiological correlates of personality, it would seem reasonable to look to a level of greater generality rather than a level which is sensitive to the cognitive processes of the subject, and of course it has been at the level of second and third order factors in Cattell's terms that the greatest success in finding physiological correlates has been achieved (Cattell and Warburton 1967).

What then is the psychometric status of Cattell's second order factors? Table 18 shows rather little evidence of a cluster structure amongst the first order factors, although this might change after rescoring along content-analytic lines. The largest steps between adjacent coefficients are between H and C and between G and M, which might be read as marking the boundaries between an extraversion-like and a neuroticism-like factor in the first case, and Cattell's second order superego and independence factors in the second. However the evidence is far from compelling, and attempts to rotate principal components of the matrix in Table 18 showed no clear hyperplanes using graphical techniques. In any case the step sizes are not all that large and their presence could as well indicate missing factors as distinct factors at a higher order.

More in line with the interpretation being developed would be Gray's (1973) attempt at a reinterpretation of Eysenck's factors in terms of three major emotional subsystems, represented by distinct neuroanatomical pathways and emerging in conditioning studies and social and psychiatric aspects of behaviour. Particularly if the rescoring suggested above were carried out, one might imagine that H would form the core of Gray's dimension of "susceptibility to punishment", occupying as it does a place between extraversion and neuroticism type factors. Certainly the central item content of H reads very much as susceptibility to perceived threat in social situations. Most likely candidates for his second dimension of "susceptibility to reward" would be E and F, with their connotations of approach, initiation of activity etc. For Gray's third speculative dimension, which he tentatively identified with Eysenck and Eysenck's (1968) dimension of psychoticism, the obvious candidates by exclusion would be G and Q_3, and indeed Montag (personal communication) has carried out a factor analysis of Form A of the 16 PF together with the three Eysenckian scales and found that these two are loaded by the same factor as psychoticism.

It is not being suggested that Gray's three proposed dimensions can be conclusively shown to have a clear place such that they will naturally emerge from questionnaire data. Rather, Table 18 suggests that second order factors could be placed more or less at will. If at the physiological level there are three (or however many) distinct subsystems which have an important role in generating the variety of human personality, the evidence from this study is that they do not appear in questionnaire data as the dominant features. However, the item-scale correlations do suggest that participants in this study effectively sorted the items by content, and put for instance item 157 in form B ("It would be more interesting to live the life of a master printer rather than that of an advertising man and promoter") in factor A (correlation of 0.352) rather than F (correlation of 0.239) where it is scored. In the item content of the proposed candidates amongst Cattell's scales for Gray's dimensions there is a good deal of similarity with his descriptions of behaviour under the control of the three subsystems.

The similarity for the Flight/Fight subsystem is at best slight, but many of the items of H and C read plausibly as referring to behaviour in response to conditioned stimuli for punishment and nonreward (the Stop subsystem), and of F and E to behaviour in response to conditioned stimuli for reward and nonpunishment, the Approach subsystem.

Thus what is being suggested is that there is a role for both the cognitive processes of the individual and biological variables in a comprehensive account of those aspects of personality which are captured by the scales of the 16PF, at the cost of denying Cattell's primary factors their ontological primacy. The first order scales may be viewed as attempts to measure interactions between relatively primitive emotional mechanisms and hypothetical situations, mediated by the cognitive processes of the individual to a greater or lesser extent, on the assumption that a majority of individuals in a given cultural or social group will construe each item in a similar way. Such an account draws together aspects of the determinism implicit in learning theory, physiological approaches to psychology and the trait tradition in the study of personality on the one hand, and the emphasis on individuality, purpose and the central role of each person's cognitive apparatus and strategies characteristic of the work of Kelly and his followers, and more recently Harré, laying the ultimately inevitable imperfections of psychometric techniques at the door of the irreducible individuality of men and women.

The question "how many factors?" then becomes not an ontological question of great scientific significance, but a practical question: how many factors are needed to preserve as far as possible the greatest amount of information about individuals whilst still preserving comparability of scores across individuals? The answer to this will depend not on some fixed rule but rather on the purpose for which a scale is employed and the homogeneity of the subjects involved.

Such a scheme has at least a superficial similarity to Guilford's (1956) structure of intellect model, with three major classificatory factors: situations, interpretations and responses, with the first a function of the forms of social life embedded in a given culture, the second classifiable only insofar as individuals share common perceptions of the possible range of significance of situations within that culture, and the third possibly corresponding to a scheme such as Gray's.

The greater utility which has been claimed for Cattell's first order factors will then be a consequence not of their peculiarly preeminent causal status but of the extent to which they embody trait x situation interactions in their item content in a way which maps on to the constructs of the subjects. More precisely, what is proposed is a trait x situation x interpretation interaction model not unlike Argyle's (1976) account and consonant with Cronbach's (1975) discussion of aptitude-treatment interactions.

The evidence of this study is that to a moderate extent Cattell's scales capture sufficient commonality in such interactions to make them potentially useful instruments at least with undergraduate subjects. In such circumstances, it is not circular to ascribe explanatory status to scores: to say that an individual avoids public speaking because he is low on factor H may be no more than shorthand for "he is rather more than averagely averse to perceived threat in social situations, and he perceives public speaking as a potentially threatening situation", but it is useful shorthand insofar as it brings a variety of possible situations under a general rule, and distinguishes this individual from others who avoid public speaking out of lack of interest or a preference for asserting their importance by way of political intrigue.

However, to the extent to which a person is idiosyncratic in his perceptions and to which a given situation is novel, scores derived from a questionnaire will lose both explanatory value and predictive power, since ultimately the method depends on eliciting self-report of typical behaviour in classes of similar situations. The scope for change in an individuals score on such a test will therefore be twofold: he may become more or less sensitive, say, to threat, or he may change his ideas as to what counts as threatening.

To summarise this speculative account, based tenuously as it is on psychometric evidence from a survey, it has been suggested that trait-situation-interpretation interactions are the stuff of personality assessment. Accurate prediction will involve knowing the situation, the general class into which an individual would place such a situation, and his typical behaviour in situations belonging to that class, and even then one cannot discount the possibility of dynamic change in any of these once the situation is real and he must act rather than predict what his action would be. The remarkable thing about personality questionnaires is not that they work well, which on occasion they have been known to do, but that they work at all.

CHAPTER 10

This study has yielded results some of which were not anticipated at its inception. From a technical, psychometric point of view, the computation of measures of internal consistency and their comparison with alternate form correlations suggested that the scales of the 16PF were a good deal more homogeneous than either Cattell or his critics had led one to suppose. With a small number of exceptions, they were quite as homogeneous as one would expect for scales of the same length, and the close comparability of coefficient alpha and alternate form correlations goes contrary to Cattell's repeated claim that the items are arranged in scales which are parallel across forms but internally heterogeneous. The equally close correspondence between coefficient alpha and the factor pattern coefficients in the restricted factor analysis (correlating 0.92 in the total group) adds to the evidence for the value of internal consistency as a measure of scale adequacy. In other words, both within-scale and between-forms measures agree as to which scales are best. Given these results, the strong similarity between the factor correlation matrices from the restricted analyses and the scale intercorrelation matrix after multivariate correction for attenuation is perhaps more interesting as confirmation of the utility of the latter procedure.

The unrestricted factor analyses proved in the end rather unproductive. As expected, splitting the sample by sex and discipline to decrease the effects of correlated error made rotation easier and yielded a somewhat better approximation to the model under investigation, but the location of the source of collapse of the factor intercorrelation matrices when targeted rotation was attempted proved troublesome. However, the strong similarity of results from a variety of procedures suggested that given relatively reliable variables the controversy over factoring methods, criteria for retention of factors and rotational techniques is sterile.

The use of restricted factor analysis was more informative, and so far as is known this was the first time the method had been applied to Cattell's scales. The extravagance in computer resources of the program used prevented an ideal sequence of analysis, but nonetheless a consistent pattern of results emerged from all ten analyses. Investigation of the rank of the factor correlation matrices from these analyses pointed up some of the problems of the numerical accuracy and idiosyncracies of particular computational algorithms for matrix manipulation, even at 72-bit precision. Having settled on a rank of 13, however, reanalysis of the results of unrestricted analyses using targeted rotational methods gave a structure close to that obtained from the restricted analyses.

The restricted analyses proved rather insensitive to the presence of correlated error variance, which was so problematic in the unrestricted analyses. By far the largest source of residual variance was the unreliability of individual scales; off-diagonal residual covariances were generally small, with a very slight concentration in some of the least reliable scales. The results of these analyses were consistent and consistently interpretable in very similar terms to those of the other analyses.

Perhaps the least expected finding was the pattern demonstrated in Table 18, suggesting that the correlations between factors are systematic, but not necessarily in a sense that makes higher-order factoring an apposite move. There is a possible link here with the failure of attempts to fit Cattell's second-order factor model to the scale covariance matrices using Jöreskog's program. This pattern calls for investigation and replication on another sample.

The results with regard to individual scales are better treated out of their conventional order.

L and N find no support in this study. Their homogeneity is poor, their alternate form reliability equally so, and independent factors to represent them consistently failed to emerge. From the factor correlation matrices, L seems to be a mixture of E and C, whilst N is largely E, with in each case a large component of error variance.

B can be largely ignored: as a short intelligence scale it performed badly, as might be expected on such a selected sample.

M is another scale which is poor in terms of reliability, although the form B scale is better than the form A in terms of internal consistency. The restricted factor analyses placed an independent factor on this pair of scales, but clearly they are unsatisfactory and need more development.

C, O and Q_4 have been mentioned together time after time. At best only two linearly independent common factors could be found, and even they are very highly correlated. A number of possible reasons for this are available. Firstly, it may simply be that in this sample the subjects really did have closely matched levels of three separate traits. Possibly the distinctions implied in the differing item content were not relevant to them. Again, these scales may find their place in the diagnosis of disorders not represented in the sample, or in the interpretation of scores of a minority of individuals who score inconsistently on the three. Perhaps the scores in fact reflect state rather than trait aspects of anxiety as a consequence of the conditions of testing. Finally, if one is unwilling to relinquish Cattell's attractive distinction between ego-strength, guilt-proneness and ergic tension, one may look to improvements in the item content to reinstate them as separate factors. The evidence of this study is, however, that they are all virtually measures of the same thing.

G and Q_3 may also be treated as a pair. They are distinct, but factor G form A is rather closer to factor Q_3, which made for problems in the rotation of unrestricted factor solutions. Internally, the scales are fairly homogeneous, and there is no real problem in accepting them as potentially useful scales which doubtless could benefit from more development.

I was the least troublesome of all the factors: it appeared consistently in all the factor analyses and is adequately reliable for its length. It has been little discussed because there is little to say about it. From the item content one might suspect it to be a measure of aesthetic interest, but otherwise it is unremarkable.

A is remarkable for the homogeneity of its content. All but four of its items are similar in format, and a factor corresponding to the scales is apparent in every factor analysis. The distinction implicit in its content appears to be between seeking and avoiding situations which necessitate social contact.

The isolation of E in the unrestricted factor analyses was made difficult by the closeness of the N scales. Once this problem had been eliminated it emerged clearly. The scales are adequately reliable, although a large number of their items correlate better with other scales.

F is perhaps closest to traditional ideas of extraversion in content. In the unrestricted analyses it was quite a small factor, but this may well be due to the presence of many similar items in H. At 26-item length its coefficient alpha is 0.81, which is far from poor.

H must rank as the most remarkable scale of all. Its total of 26 items reach an alpha of 0.90, which is in excess of many cognitive tests of similar length, yet within the scale are two subsets of items which are distinct in their content.

Q_1 has only 7 items which clearly correlate best with their own scale, of which 6 fit the notion of social and political radicalism. Whilst not one of the most reliable of scales, it figured consistently in all the analyses.

Q_2 was most nearly related to A, was only moderately reliable and only half its items correlated best with their own scale. Nonetheless again it had a consistent and predictable place in all the correlational analyses.

The title of this thesis refers to re-examination and attempted replication of the structure of the 16PF. With regard to replication, there has been partial success, but an examination of internal scale statistics and of both factor correlation matrices and the matrix of correlations between the scales after correction for attenuation suggested that neither Cattell's claims for the internal structure of his scales nor his account of their interrelationships were well supported. Since in over thirty years development he has failed to produce scales which are internally heterogeneous yet reliable, and since the internal consistency of the scales proved to be a good measure of their performance throughout, the way now seems clear for the further development of the scales with the emphasis on homogeneity of content. At the same time, there is scope for the incorporation of more recent theoretical notions as to the sources of differences in observed behaviour across and within situations without discarding the insights Cattell has provided.

APPENDIX
OF
TABLES

Form A	A	B	C	E	F	G	H	I	L	M	N	O	Q1	Q2	Q3	Q4
								Form A								
A	1.003	-0.052	0.192	0.074	0.269	0.199	0.393	-0.084	0.048	-0.006	-0.029	-0.216	-0.117	-0.312	0.182	-0.131
B	-0.052	1.041	-0.034	-0.006	-0.087	-0.059	-0.042	0.187	-0.182	0.158	0.023	-0.038	0.015	0.036	-0.034	-0.015
C	0.192	-0.034	1.059	0.146	0.243	0.036	0.436	-0.196	-0.213	0.124	-0.182	-0.625	0.087	-0.078	0.329	-0.675
E	0.074	-0.006	0.146	0.848	0.485	-0.110	0.560	-0.127	0.253	0.136	-0.343	-0.220	0.355	-0.091	-0.151	-0.061
F	0.269	-0.087	0.243	0.485	1.171	-0.100	0.678	-0.115	0.257	0.118	-0.447	-0.241	0.226	-0.426	-0.082	-0.181
G	0.199	-0.059	0.036	-0.110	-0.100	0.925	0.095	-0.163	-0.047	-0.141	0.059	-0.105	-0.178	-0.081	0.520	-0.136
H	0.393	-0.042	0.436	0.560	0.678	0.095	1.148	-0.133	0.080	0.186	-0.367	-0.457	0.159	-0.328	0.144	-0.384
I	-0.084	0.187	-0.196	-0.127	-0.115	-0.163	-0.133	0.911	0.099	0.199	0.104	0.139	-0.101	0.101	-0.182	0.186
L	0.048	-0.182	-0.213	0.253	0.257	-0.047	0.080	0.099	0.955	0.020	-0.090	0.203	0.197	-0.048	-0.176	0.312
M	-0.006	0.158	0.124	0.136	0.118	-0.141	0.186	0.199	0.020	1.046	-0.004	-0.229	0.247	0.030	-0.042	-0.176
N	-0.029	0.023	-0.182	-0.343	-0.447	0.059	-0.367	0.104	-0.090	-0.004	0.996	0.216	-0.102	0.104	0.044	0.160
O	-0.216	-0.038	-0.625	-0.220	-0.241	-0.105	-0.457	0.139	0.203	-0.229	0.216	1.037	-0.171	0.102	-0.379	0.651
Q1	-0.117	0.015	0.087	0.355	0.226	-0.178	0.159	-0.101	0.197	0.247	-0.102	-0.171	0.909	-0.006	-0.129	-0.027
Q2	-0.312	0.036	-0.078	-0.091	-0.426	-0.081	-0.328	0.101	-0.048	0.030	0.104	0.102	-0.006	0.937	-0.025	0.115
Q3	0.182	-0.034	0.329	-0.151	-0.082	0.520	0.144	-0.182	-0.176	-0.042	0.044	-0.379	-0.129	-0.025	1.010	-0.466
Q4	-0.131	-0.015	-0.675	-0.061	-0.181	-0.136	-0.384	0.186	0.312	-0.176	0.160	0.651	-0.027	0.115	-0.466	1.039
Form B																
A	0.498	0.006	0.110	0.096	0.313	0.067	0.331	0.014	-0.001	0.116	-0.066	-0.197	0.018	-0.278	0.033	-0.111
B	-0.000	0.371	-0.094	-0.030	-0.022	-0.109	-0.070	0.067	-0.105	0.061	-0.002	-0.005	-0.032	0.048	-0.057	0.050
C	0.250	0.081	0.668	0.111	0.197	0.203	0.409	-0.267	-0.301	0.088	-0.139	-0.727	0.065	-0.087	0.456	-0.697
E	0.035	0.011	0.168	0.435	0.310	-0.107	0.447	-0.128	0.140	0.119	-0.187	-0.163	0.314	0.025	-0.103	-0.081
F	0.237	-0.132	0.199	0.582	0.869	-0.121	0.696	-0.131	0.319	0.045	-0.370	-0.175	0.220	-0.363	-0.206	-0.117
G	0.243	0.006	0.022	-0.158	-0.215	0.520	0.021	-0.049	-0.092	-0.051	0.139	-0.030	-0.263	-0.069	0.431	-0.038
H	0.426	0.019	0.514	0.443	0.611	0.031	0.907	-0.216	-0.050	0.187	-0.311	-0.519	0.064	-0.310	0.208	-0.488
I	-0.080	0.127	-0.263	-0.115	-0.218	-0.046	-0.165	0.415	-0.012	0.107	0.101	0.189	-0.250	0.043	-0.067	0.184
L	-0.100	-0.066	-0.319	0.218	0.049	-0.010	-0.034	-0.043	0.291	-0.088	0.012	0.243	0.163	0.063	-0.125	0.287
M	-0.230	0.117	0.018	0.277	0.052	-0.298	0.133	0.245	0.060	0.418	-0.181	-0.146	0.271	0.101	-0.206	-0.045
N	0.133	-0.003	0.124	-0.398	-0.254	0.235	-0.176	-0.029	-0.215	-0.047	0.267	-0.118	-0.195	-0.006	0.368	-0.188
O	-0.208	0.024	-0.652	-0.199	-0.237	-0.110	-0.412	0.213	0.190	-0.126	0.199	0.691	-0.144	0.071	-0.413	0.669
Q1	-0.091	0.034	-0.027	0.162	0.124	-0.217	0.061	0.130	0.126	0.346	-0.009	-0.097	0.449	0.047	-0.104	-0.029
Q2	-0.365	0.035	-0.304	-0.137	-0.590	-0.154	-0.577	0.094	0.030	-0.118	0.171	0.304	0.082	0.580	-0.104	0.245
Q3	0.267	0.025	0.355	0.015	-0.046	0.480	0.229	-0.199	-0.157	-0.063	0.009	-0.459	0.005	-0.041	0.649	-0.473
Q4	-0.083	0.030	-0.630	0.074	0.031	-0.183	-0.244	0.203	0.386	-0.094	0.089	0.575	-0.041	0.033	-0.468	0.709

Table A1 part one: Covariance matrix for male arts group

	Form B: A	B	C	E	F	G	H	I	L	M	N	O	Q1	Q2	Q3	Q4
Form A																
A	0.498	-0.000	0.250	0.035	0.237	0.243	0.426	-0.080	-0.100	-0.230	0.133	-0.208	-0.091	-0.365	0.267	-0.083
B	0.006	0.371	0.081	0.011	-0.132	0.006	0.019	0.127	-0.066	0.117	-0.003	0.024	0.034	0.035	0.025	0.030
C	0.110	-0.094	0.668	0.168	0.199	0.022	0.514	-0.263	-0.319	0.018	0.124	-0.652	-0.027	-0.304	0.355	-0.630
E	0.096	-0.030	0.111	0.435	0.582	-0.158	0.443	-0.115	0.218	0.277	-0.398	-0.199	0.162	-0.137	0.015	0.074
F	0.313	-0.022	0.197	0.310	0.869	-0.215	0.611	-0.218	0.049	0.052	-0.254	-0.237	0.124	-0.590	-0.046	0.031
G	0.067	-0.109	0.203	-0.107	-0.121	0.520	0.031	-0.046	-0.010	-0.298	0.235	-0.110	-0.217	-0.154	0.480	-0.183
H	0.331	-0.070	0.409	0.447	0.696	0.021	0.907	-0.165	-0.034	0.133	-0.176	-0.412	0.061	-0.577	0.229	-0.244
I	0.014	0.067	-0.267	-0.128	-0.131	-0.049	-0.216	0.415	-0.043	0.245	-0.029	0.213	0.130	0.094	-0.199	0.203
L	-0.001	-0.105	-0.301	0.140	0.319	-0.092	-0.050	-0.012	0.291	0.060	-0.215	0.190	0.126	0.030	-0.157	0.386
M	0.116	0.061	0.088	0.119	0.045	-0.051	0.187	0.107	-0.088	0.418	-0.047	-0.126	0.346	-0.118	-0.063	-0.094
N	-0.066	-0.002	-0.139	-0.187	-0.370	0.139	-0.311	0.101	0.012	-0.181	0.267	0.199	-0.009	0.171	0.009	0.089
O	-0.197	-0.005	-0.727	-0.163	-0.175	-0.030	-0.519	0.189	0.243	-0.146	-0.118	0.691	-0.097	0.304	-0.459	0.575
Q1	0.018	-0.032	0.065	0.314	0.220	-0.263	0.064	-0.250	0.163	0.271	-0.195	-0.144	0.449	0.082	0.005	-0.041
Q2	-0.278	0.048	-0.087	0.025	-0.363	-0.069	-0.310	0.043	0.063	0.101	-0.006	0.071	0.047	0.580	-0.041	0.033
Q3	0.033	-0.057	0.456	-0.103	-0.206	0.431	0.208	-0.067	-0.125	-0.206	0.368	-0.413	-0.104	-0.104	0.649	-0.468
Q4	-0.111	0.050	-0.697	-0.081	-0.117	-0.038	-0.488	0.184	0.287	-0.045	-0.188	0.669	-0.029	0.245	-0.473	0.709
Form B																
A	0.853	0.010	0.147	0.091	0.250	0.112	0.300	-0.024	-0.067	-0.068	-0.018	-0.118	0.035	-0.346	0.036	-0.024
B	0.010	0.842	0.023	-0.000	-0.044	-0.068	0.006	0.098	-0.045	0.030	-0.102	0.094	0.029	-0.001	-0.036	0.086
C	0.147	0.023	1.220	0.079	0.160	0.095	0.527	-0.223	-0.323	-0.036	0.225	-0.747	-0.048	-0.356	0.459	-0.667
E	0.091	-0.000	0.079	0.778	0.402	-0.150	0.361	-0.140	0.255	0.294	-0.283	-0.149	0.254	-0.088	0.030	-0.058
F	0.250	-0.044	0.160	0.402	1.171	-0.223	0.615	-0.209	0.095	0.090	-0.402	-0.209	0.120	-0.461	-0.112	0.123
G	0.112	-0.068	0.095	-0.150	-0.223	1.047	0.067	0.087	-0.058	-0.143	0.223	-0.068	-0.152	-0.099	0.415	-0.162
H	0.300	0.006	0.527	0.361	0.615	0.067	1.164	-0.227	-0.069	0.089	-0.080	-0.568	-0.011	-0.541	0.297	-0.374
I	-0.024	0.098	-0.223	-0.140	-0.209	0.087	-0.227	0.832	-0.043	0.201	0.013	0.250	0.011	0.082	-0.164	0.270
L	-0.067	-0.045	-0.323	0.255	0.095	-0.058	-0.069	-0.043	0.911	0.016	-0.195	0.253	0.056	0.220	-0.039	0.268
M	-0.068	0.030	-0.036	0.294	0.090	-0.143	0.089	0.201	0.016	0.962	-0.309	-0.035	0.423	0.060	-0.127	0.048
N	-0.018	-0.102	0.225	-0.283	-0.402	0.223	-0.080	0.013	-0.195	-0.309	1.140	-0.116	-0.269	0.040	0.257	-0.249
O	-0.118	0.094	-0.747	-0.149	-0.209	-0.068	-0.568	0.250	0.253	-0.035	-0.116	0.970	-0.043	0.243	-0.421	0.649
Q1	0.035	0.029	-0.048	0.254	0.120	-0.152	-0.011	0.011	0.056	0.423	-0.269	-0.043	0.925	0.020	-0.077	-0.007
Q2	-0.346	-0.001	-0.356	-0.088	-0.461	-0.099	-0.541	0.082	0.220	0.060	0.040	0.243	0.020	1.121	-0.134	0.177
Q3	0.036	-0.036	0.459	0.030	-0.112	0.415	0.297	-0.164	-0.039	-0.127	0.257	-0.421	-0.077	-0.134	1.079	-0.474
Q4	-0.024	0.086	-0.667	-0.058	0.123	-0.162	-0.374	0.270	0.268	0.048	-0.249	0.649	-0.007	0.177	-0.474	1.031

Table A1 part two: Covariance matrix for male arts group

Form A	A	B	C	E	F	G	H	I	L	M	N	O	Q1	Q2	Q3	Q4
A	0.881	-0.070	0.132	0.079	0.198	0.168	0.344	-0.023	0.088	0.074	-0.066	-0.113	0.004	-0.384	0.068	-0.082
B	-0.070	1.014	-0.040	-0.132	-0.160	-0.031	-0.148	0.126	-0.120	0.074	0.056	0.041	-0.032	0.047	-0.030	-0.015
C	0.132	-0.040	0.966	0.124	0.139	0.096	0.365	-0.163	-0.219	0.104	-0.116	-0.495	0.067	-0.009	0.229	-0.536
E	0.079	-0.132	0.124	0.880	0.441	-0.136	0.503	-0.069	0.339	0.129	-0.279	-0.239	0.365	-0.124	-0.099	-0.095
F	0.198	-0.160	0.139	0.441	0.939	-0.129	0.547	-0.067	0.264	0.067	-0.333	-0.120	0.245	-0.322	-0.093	-0.019
G	0.168	-0.031	0.096	-0.136	-0.129	0.949	0.097	-0.127	-0.094	-0.122	0.046	-0.171	-0.256	-0.164	0.481	-0.165
H	0.344	-0.148	0.365	0.503	0.547	0.097	0.992	-0.101	0.144	0.151	-0.291	-0.428	0.226	-0.308	0.160	-0.316
I	-0.023	0.126	-0.163	-0.069	-0.067	-0.127	-0.101	0.691	-0.052	0.144	0.016	0.133	-0.082	-0.013	-0.118	0.095
L	0.088	-0.120	-0.219	0.339	0.264	-0.094	0.144	-0.052	0.953	-0.083	-0.133	0.145	0.191	-0.066	-0.147	0.262
M	0.074	0.074	0.104	0.129	0.067	-0.122	0.151	0.144	-0.083	0.967	-0.154	-0.184	0.101	0.030	-0.084	-0.124
N	-0.066	0.056	-0.116	-0.279	-0.333	0.046	-0.291	0.016	-0.133	-0.154	0.789	0.155	-0.174	0.148	0.031	0.066
O	-0.113	0.041	-0.495	-0.239	-0.120	-0.171	-0.428	0.133	0.145	-0.184	0.155	0.957	-0.160	0.008	-0.306	0.533
Q1	0.004	-0.032	0.067	0.365	0.245	-0.256	0.226	-0.082	0.191	0.101	-0.174	-0.160	1.047	0.025	-0.091	-0.076
Q2	-0.384	0.047	-0.009	-0.124	-0.322	-0.164	-0.308	-0.013	-0.066	0.030	0.148	0.008	0.025	1.037	0.018	-0.079
Q3	0.068	-0.030	0.229	-0.099	-0.093	0.481	0.160	-0.118	-0.147	-0.084	0.031	-0.306	-0.091	0.018	0.909	-0.309
Q4	-0.082	-0.015	-0.536	-0.095	-0.019	-0.165	-0.316	0.095	0.262	-0.124	0.066	0.533	-0.076	-0.079	-0.309	0.850
Form B																
A	0.443	-0.095	0.147	0.235	0.290	0.013	0.371	0.036	0.131	0.079	-0.181	-0.118	0.059	-0.374	0.050	-0.082
B	-0.109	0.258	-0.043	-0.103	-0.137	-0.031	-0.125	0.078	-0.077	0.022	0.083	-0.037	-0.026	0.048	0.074	-0.020
C	0.107	0.042	0.470	0.057	0.009	0.144	0.243	-0.110	-0.176	0.126	-0.109	-0.476	-0.036	0.047	0.200	-0.465
E	0.058	-0.088	0.193	0.501	0.281	-0.074	0.475	-0.053	0.220	0.138	-0.190	-0.282	0.356	-0.029	0.028	-0.176
F	0.269	-0.141	0.211	0.458	0.669	-0.212	0.579	-0.037	0.213	0.033	-0.288	-0.183	0.193	-0.256	-0.128	-0.111
G	0.179	0.026	0.084	-0.203	-0.129	0.558	0.036	0.046	-0.123	0.059	0.044	-0.064	-0.189	-0.143	0.400	-0.121
H	0.255	-0.100	0.433	0.415	0.420	0.070	0.750	-0.090	-0.000	0.122	-0.252	-0.461	0.203	-0.204	0.187	-0.389
I	-0.011	0.100	-0.125	-0.143	-0.206	0.001	-0.140	0.405	-0.102	0.077	0.056	0.106	-0.163	0.070	-0.063	-0.002
L	-0.062	-0.062	-0.209	0.187	0.123	-0.073	0.071	-0.163	0.351	-0.168	-0.003	0.208	0.222	-0.003	-0.094	0.234
M	-0.086	0.104	0.006	0.224	0.063	-0.181	0.141	0.284	0.006	0.361	-0.135	-0.135	0.151	0.004	-0.107	-0.121
N	-0.032	0.028	0.137	-0.311	-0.194	0.155	-0.217	-0.052	-0.264	-0.053	0.170	-0.044	-0.137	0.149	0.213	-0.114
O	-0.150	0.106	-0.547	-0.202	-0.158	-0.142	-0.416	0.248	0.029	-0.086	0.133	0.565	-0.130	0.004	-0.320	0.511
Q1	-0.002	0.046	-0.011	0.264	0.129	-0.136	0.196	0.036	0.184	0.233	-0.098	-0.040	0.316	-0.025	-0.069	-0.016
Q2	-0.266	0.159	-0.151	-0.104	-0.350	-0.091	-0.338	0.059	0.006	0.060	0.098	0.139	-0.019	0.381	-0.059	0.071
Q3	0.066	-0.046	0.306	-0.009	-0.115	0.486	0.193	-0.107	-0.099	-0.058	0.045	-0.335	-0.128	0.023	0.471	-0.342
Q4	-0.080	0.020	-0.414	0.036	0.092	-0.236	-0.156	0.168	0.258	-0.086	0.009	0.439	0.053	-0.036	-0.323	0.546

Table A2 part one: Covariance matrix for male science group

	Form B															
Form A	A	B	C	E	F	G	H	I	L	M	N	O	Q1	Q2	Q3	Q4
A	0.443	-0.109	0.107	0.058	0.269	0.179	0.255	-0.011	-0.062	-0.086	-0.032	-0.150	-0.002	-0.266	0.066	-0.080
B	-0.095	0.258	0.042	-0.088	-0.141	0.026	-0.100	0.100	-0.062	0.104	0.028	0.106	0.046	0.159	-0.046	0.020
C	0.147	-0.043	0.470	0.193	0.211	0.084	0.433	-0.125	-0.209	0.006	0.137	-0.547	-0.011	-0.151	0.306	-0.414
E	0.235	-0.103	0.057	0.501	0.458	-0.203	0.415	-0.143	0.187	0.224	-0.311	-0.202	0.264	-0.104	-0.009	0.036
F	0.290	-0.137	0.009	0.281	0.669	-0.129	0.420	-0.206	0.123	0.063	-0.194	-0.158	0.129	-0.350	-0.115	0.092
G	0.013	-0.031	0.144	-0.074	-0.212	0.558	0.070	0.001	-0.073	-0.181	0.155	-0.142	-0.136	-0.091	0.486	-0.236
H	0.371	-0.125	0.243	0.475	0.579	0.036	0.750	-0.140	0.071	0.141	-0.217	-0.416	0.196	-0.338	0.193	-0.156
I	0.036	0.078	-0.110	-0.053	-0.037	0.046	-0.090	0.405	-0.163	0.284	-0.052	0.248	0.036	0.059	-0.107	0.168
L	0.131	-0.077	-0.176	0.220	0.213	-0.123	-0.000	-0.102	0.351	0.006	-0.264	0.029	0.184	0.006	-0.099	0.258
M	0.079	0.022	0.126	0.138	0.033	0.059	0.122	0.077	-0.168	0.361	-0.053	-0.086	0.233	0.060	-0.058	-0.086
N	-0.181	0.083	-0.109	-0.190	-0.288	0.044	-0.252	0.056	-0.003	-0.135	0.170	0.133	-0.098	0.098	0.045	0.009
O	-0.118	-0.037	-0.476	-0.282	-0.183	-0.064	-0.461	0.106	0.208	-0.135	-0.044	0.565	-0.040	0.139	-0.335	0.439
Q1	0.059	-0.026	-0.036	0.356	0.193	-0.189	0.203	-0.163	0.222	0.151	-0.137	-0.130	0.316	-0.019	-0.128	0.053
Q2	-0.374	0.048	0.047	-0.029	-0.256	-0.143	-0.204	0.070	-0.003	0.004	0.149	0.004	-0.025	0.381	0.023	-0.036
Q3	0.050	0.074	0.200	0.028	-0.128	0.400	0.187	-0.063	-0.094	-0.107	0.213	-0.320	-0.069	-0.059	0.471	-0.323
Q4	-0.082	-0.020	-0.465	-0.176	-0.111	-0.121	-0.389	-0.002	0.234	-0.121	-0.114	0.511	-0.016	0.071	-0.342	0.546
Form B																
A	0.828	0.037	0.101	0.160	0.327	0.104	0.296	0.029	-0.010	0.027	-0.046	-0.169	0.100	-0.268	0.026	-0.033
B	0.037	0.853	-0.005	-0.055	-0.070	0.039	-0.086	0.040	-0.034	0.039	-0.001	0.026	0.060	0.035	0.017	-0.022
C	0.101	-0.005	0.911	0.096	0.080	0.071	0.359	-0.012	-0.218	0.052	0.130	-0.494	-0.061	-0.121	0.314	-0.450
E	0.160	-0.055	0.096	0.908	0.322	-0.169	0.401	-0.101	0.201	0.239	-0.258	-0.262	0.258	-0.045	0.085	-0.097
F	0.327	-0.070	0.080	0.322	1.100	-0.264	0.546	-0.142	0.123	0.091	-0.291	-0.271	0.095	-0.309	-0.130	0.061
G	0.104	0.039	0.071	-0.169	-0.264	1.008	0.042	0.116	-0.103	-0.014	0.160	-0.005	-0.070	-0.112	0.339	-0.172
H	0.296	-0.086	0.359	0.401	0.546	0.042	1.004	-0.096	-0.040	0.171	-0.115	-0.540	0.152	-0.353	0.202	-0.252
I	0.029	0.040	-0.012	-0.101	-0.142	0.116	-0.096	0.811	-0.228	0.232	-0.004	0.205	-0.028	0.064	0.027	0.065
L	-0.010	-0.034	-0.218	0.201	0.123	-0.103	-0.040	-0.228	0.957	-0.141	-0.142	0.103	0.187	0.088	-0.068	0.211
M	0.027	0.039	0.052	0.239	0.091	-0.014	0.171	0.232	-0.141	0.988	-0.176	-0.035	0.306	0.133	0.007	0.019
N	-0.046	-0.001	0.130	-0.258	-0.291	0.160	-0.115	-0.004	-0.142	-0.176	0.810	-0.069	-0.130	0.047	0.166	-0.204
O	-0.169	0.026	-0.494	-0.262	-0.271	-0.005	-0.540	0.205	0.103	-0.035	-0.069	0.915	-0.072	0.129	-0.342	0.469
Q1	0.100	0.060	-0.061	0.258	0.095	-0.070	0.152	-0.028	0.187	0.306	-0.130	-0.072	0.877	0.074	-0.053	0.094
Q2	-0.268	0.035	-0.121	-0.045	-0.309	-0.112	-0.353	0.064	0.088	0.133	0.047	0.129	0.074	0.819	-0.034	0.050
Q3	0.026	0.017	0.314	0.085	-0.130	0.339	0.202	0.027	-0.068	0.007	0.166	-0.342	-0.053	-0.034	0.909	-0.399
Q4	-0.033	-0.022	-0.450	-0.097	0.061	-0.172	-0.252	0.065	0.211	0.019	-0.204	0.469	0.094	0.050	-0.399	0.850

Table A2 part two: Covariance matrix for male science group

	Form A															
Form A	A	B	C	E	F	G	H	I	L	M	N	O	Q1	Q2	Q3	Q4
A	0.873	0.038	0.093	-0.021	0.213	0.122	0.253	0.071	-0.115	-0.039	0.143	-0.108	-0.043	-0.300	0.079	-0.125
B	0.038	0.991	0.019	-0.046	-0.103	0.094	-0.032	0.025	-0.031	0.025	-0.043	-0.100	0.033	-0.013	0.097	-0.092
C	0.093	0.019	1.080	0.013	0.161	-0.066	0.321	-0.028	-0.338	0.190	-0.059	-0.540	0.032	-0.114	0.277	-0.627
E	-0.021	-0.046	0.013	0.931	0.409	-0.261	0.507	-0.142	0.397	0.097	-0.342	-0.056	0.351	-0.085	-0.260	0.089
F	0.213	-0.103	0.161	0.409	0.804	-0.257	0.495	-0.047	0.158	0.043	-0.236	-0.089	0.234	-0.270	-0.256	-0.019
G	0.122	0.094	-0.066	-0.261	-0.257	0.919	-0.076	0.019	-0.162	-0.175	0.256	-0.040	-0.278	0.034	0.465	-0.045
H	0.253	-0.032	0.321	0.507	0.495	-0.076	0.976	-0.075	0.090	0.096	-0.216	-0.292	0.204	-0.262	0.013	-0.210
I	0.071	0.025	-0.028	-0.142	-0.047	0.019	-0.075	0.758	-0.063	0.082	0.121	-0.003	-0.080	0.034	-0.005	0.028
L	-0.115	-0.031	-0.338	0.397	0.158	-0.162	0.090	-0.063	1.008	-0.071	-0.155	0.258	0.251	0.077	-0.302	0.393
M	-0.039	0.025	0.190	0.097	0.043	-0.175	0.096	0.082	-0.071	0.952	-0.137	-0.169	0.215	0.005	-0.110	-0.137
N	0.143	-0.043	-0.059	-0.342	-0.236	0.256	-0.216	0.121	-0.155	-0.137	0.860	0.045	-0.259	0.078	0.268	-0.008
O	-0.108	-0.100	-0.540	-0.056	-0.089	-0.040	-0.292	-0.003	0.258	-0.169	0.045	0.825	-0.045	0.101	-0.263	0.506
Q1	-0.043	0.033	0.032	0.351	0.234	-0.278	0.204	-0.080	0.251	0.215	-0.259	-0.045	1.014	-0.042	-0.281	-0.011
Q2	-0.300	-0.013	-0.114	-0.085	-0.270	0.034	-0.262	0.034	0.077	0.005	0.078	0.101	-0.042	0.939	0.054	0.103
Q3	0.079	0.097	0.277	-0.260	-0.256	0.465	0.013	-0.005	-0.302	-0.110	0.268	-0.263	-0.281	0.054	0.952	-0.381
Q4	-0.125	-0.092	-0.627	0.089	-0.019	-0.045	-0.210	0.028	0.393	-0.137	-0.008	0.506	-0.011	0.103	-0.381	0.855
Form B																
A	0.508	0.065	0.159	0.072	0.229	0.002	0.297	0.061	-0.022	0.048	0.022	-0.162	0.074	-0.278	0.049	-0.151
B	0.072	0.303	0.021	0.008	-0.025	0.097	0.042	-0.039	-0.001	0.012	-0.024	-0.026	0.030	-0.033	0.077	-0.033
C	0.185	0.060	0.500	-0.055	-0.007	0.162	0.254	-0.057	-0.294	0.077	0.005	-0.402	-0.031	-0.115	0.356	-0.473
E	-0.104	-0.050	0.052	0.540	0.275	-0.237	0.377	-0.128	0.333	0.142	-0.284	-0.075	0.415	0.045	-0.192	0.027
F	0.228	-0.081	0.149	0.460	0.574	-0.271	0.519	-0.111	0.206	0.053	-0.222	-0.081	0.220	-0.239	-0.236	-0.032
G	0.075	0.129	-0.060	-0.250	-0.255	0.473	-0.098	0.079	-0.121	-0.110	0.209	0.017	-0.270	-0.011	0.341	-0.058
H	0.248	-0.014	0.374	0.425	0.419	-0.124	0.768	-0.047	0.008	0.079	-0.176	-0.332	0.136	-0.190	0.039	-0.271
I	-0.013	0.055	-0.053	-0.143	-0.082	0.031	-0.067	0.236	-0.152	0.082	0.090	-0.006	-0.208	-0.065	0.032	-0.009
L	-0.115	0.014	-0.338	0.188	-0.043	0.034	-0.074	-0.037	0.336	-0.071	-0.063	0.238	0.139	0.135	-0.132	0.259
M	-0.242	0.021	0.055	0.301	0.104	-0.301	0.108	0.072	0.153	0.269	-0.324	-0.047	0.209	0.040	-0.236	0.029
N	0.109	0.101	0.094	-0.307	-0.151	0.260	-0.015	0.057	-0.207	-0.062	0.284	-0.066	-0.151	-0.005	0.334	-0.182
O	-0.161	-0.052	-0.541	-0.135	-0.148	-0.022	-0.390	0.071	0.200	-0.099	0.096	0.506	-0.064	0.121	-0.272	0.529
Q1	-0.088	0.150	0.003	0.316	0.133	-0.309	0.148	0.011	0.196	0.304	-0.293	0.007	0.547	0.033	-0.269	0.037
Q2	-0.419	-0.067	-0.185	-0.067	-0.305	-0.017	-0.354	-0.008	0.140	0.005	0.018	0.139	0.124	0.466	-0.034	0.142
Q3	0.078	0.109	0.285	-0.130	-0.197	0.408	0.096	0.007	-0.229	0.001	0.162	-0.325	-0.145	0.016	0.544	-0.364
Q4	-0.063	-0.091	-0.488	0.209	0.136	-0.199	-0.118	0.046	0.463	-0.113	-0.085	0.432	0.120	0.034	-0.433	0.611

Table A3 part one: Covariance matrix for female arts group

Form A	A	B	C	E	F	G	H	I	L	M	N	O	Q1	Q2	Q3	Q4
	Form B															
A	0.508	0.072	0.185	-0.104	0.228	0.075	0.248	-0.013	-0.115	-0.242	0.109	-0.161	-0.088	-0.419	0.078	-0.063
B	0.065	0.303	0.060	-0.050	-0.081	0.129	-0.014	0.055	0.014	0.021	0.101	-0.052	0.150	-0.067	0.109	-0.091
C	0.159	0.021	0.500	0.052	0.149	-0.060	0.374	-0.053	-0.338	0.055	0.094	-0.541	0.003	-0.185	0.285	-0.488
E	0.072	0.008	-0.055	0.540	0.460	-0.250	0.425	-0.143	0.188	0.301	-0.307	-0.135	0.316	-0.067	-0.130	0.209
F	0.229	-0.025	-0.007	0.275	0.574	-0.255	0.419	-0.082	-0.043	0.104	-0.151	-0.148	0.133	-0.305	-0.197	0.136
G	0.002	0.097	0.162	-0.237	-0.271	0.473	-0.124	0.031	0.034	-0.301	0.260	-0.022	-0.309	-0.017	0.408	-0.199
H	0.297	0.042	0.254	0.377	0.519	-0.098	0.768	-0.067	-0.074	0.108	-0.015	-0.390	0.148	-0.354	0.096	-0.118
I	0.061	-0.039	-0.057	-0.128	-0.111	0.079	-0.047	0.236	-0.037	0.072	0.057	0.071	0.011	-0.008	0.007	0.046
L	-0.022	-0.001	-0.294	0.333	0.206	-0.121	0.008	-0.152	0.336	0.153	-0.207	0.200	0.196	0.140	-0.229	0.463
M	0.048	0.012	0.077	0.142	0.053	-0.110	0.079	0.082	-0.071	0.269	-0.062	-0.099	0.304	0.005	0.001	-0.113
N	0.022	-0.024	0.005	-0.284	-0.222	0.209	-0.176	0.090	-0.063	-0.324	0.284	0.096	-0.293	0.018	0.162	-0.085
O	-0.162	-0.026	-0.402	-0.075	-0.081	0.017	-0.332	-0.006	0.238	-0.047	-0.066	0.506	0.007	0.139	-0.325	0.432
Q1	0.074	0.030	-0.031	0.415	0.220	-0.270	0.136	-0.208	0.139	0.209	-0.151	-0.064	0.547	0.124	-0.145	0.120
Q2	-0.278	-0.033	-0.115	0.045	-0.239	-0.011	-0.190	-0.065	0.135	0.040	-0.005	0.121	0.033	0.466	0.016	0.034
Q3	0.049	0.077	0.356	-0.192	-0.236	0.341	0.039	0.032	-0.132	-0.236	0.334	-0.272	-0.269	-0.034	0.544	-0.433
Q4	-0.151	-0.033	-0.473	0.027	-0.032	-0.058	-0.271	-0.009	0.259	0.029	-0.182	0.529	0.037	0.142	-0.364	0.611
Form B																
A	0.778	0.066	0.175	0.052	0.239	0.019	0.312	0.031	-0.146	-0.136	0.068	-0.216	0.044	-0.331	0.003	-0.055
B	0.066	0.787	0.033	0.010	-0.048	0.078	0.065	-0.010	-0.051	-0.047	0.068	-0.032	0.076	0.030	0.120	0.004
C	0.175	0.033	0.833	-0.097	0.029	0.075	0.299	-0.004	-0.285	-0.118	0.227	-0.485	-0.067	-0.235	0.376	-0.514
E	0.052	0.010	-0.097	0.974	0.304	-0.257	0.345	-0.188	0.226	0.379	-0.254	-0.142	0.407	0.200	-0.089	0.117
F	0.239	-0.048	0.029	0.304	0.934	-0.277	0.461	-0.158	-0.008	0.084	-0.211	-0.219	0.128	-0.271	-0.194	0.135
G	0.019	0.078	0.075	-0.257	-0.277	0.934	-0.135	0.058	-0.013	-0.184	0.213	-0.026	-0.279	-0.046	0.354	-0.206
H	0.312	0.065	0.299	0.345	0.461	-0.135	0.960	-0.077	-0.102	0.120	0.031	-0.480	0.134	-0.305	0.104	-0.185
I	0.031	-0.010	-0.004	-0.188	-0.158	0.058	-0.077	0.739	-0.124	0.124	0.043	0.054	-0.072	-0.142	-0.060	-0.005
L	-0.146	-0.051	-0.285	0.226	-0.008	-0.013	-0.102	-0.124	0.892	-0.036	-0.161	0.235	0.148	0.259	-0.060	0.324
M	-0.136	-0.047	-0.118	0.379	0.084	-0.184	0.120	0.124	-0.036	1.025	-0.267	-0.052	0.402	0.139	-0.234	0.070
N	0.068	0.068	0.227	-0.254	-0.211	0.213	0.031	0.043	-0.161	-0.267	0.862	-0.078	-0.169	-0.065	0.258	-0.283
O	-0.216	-0.032	-0.485	-0.142	-0.219	-0.026	-0.480	0.054	0.235	-0.052	-0.078	0.856	-0.028	0.214	-0.337	0.499
Q1	0.044	0.076	-0.067	0.407	0.128	-0.279	0.134	-0.072	0.148	0.402	-0.169	-0.028	1.096	0.128	-0.154	0.144
Q2	-0.331	0.030	-0.235	0.200	-0.271	-0.046	-0.305	-0.142	0.259	0.139	-0.065	0.214	0.128	0.971	-0.014	0.125
Q3	0.003	0.120	0.376	-0.089	-0.194	0.354	0.104	-0.060	-0.060	-0.234	0.258	-0.337	-0.154	-0.014	0.980	-0.428
Q4	-0.055	0.004	-0.514	0.117	0.135	-0.206	-0.185	-0.005	0.324	0.070	-0.283	0.499	0.144	0.125	-0.428	0.934

Table A3 part two: Covariance matrix for female arts group

Form A	A	B	C	E	F	G	H	I	L	M	N	O	Q1	Q2	Q3	Q4
A	0.822	-0.072	0.084	0.111	0.300	0.105	0.348	0.063	0.034	0.060	-0.063	-0.162	-0.027	-0.300	-0.001	-0.067
B	-0.072	0.913	-0.104	-0.051	-0.164	-0.072	-0.125	0.061	-0.025	0.059	-0.059	-0.000	0.064	0.060	-0.047	-0.006
C	0.084	-0.104	0.977	-0.010	0.188	0.036	0.188	-0.004	-0.318	0.059	-0.137	-0.405	0.068	-0.168	0.203	-0.502
E	0.111	-0.051	-0.010	0.944	0.411	-0.208	0.550	0.016	0.322	0.100	-0.291	-0.051	0.279	-0.092	-0.179	0.037
F	0.300	-0.164	0.188	0.411	0.907	-0.158	0.600	0.069	0.200	0.134	-0.191	-0.141	0.156	-0.356	-0.188	-0.126
G	0.105	-0.072	0.036	-0.208	-0.158	0.761	0.001	-0.052	-0.119	-0.097	0.139	-0.015	-0.117	-0.013	0.347	-0.083
H	0.348	-0.125	0.188	0.550	0.600	0.001	1.006	-0.026	0.134	0.013	-0.213	-0.227	0.173	-0.381	-0.030	-0.215
I	0.063	0.061	-0.004	0.016	0.069	-0.052	-0.026	0.658	0.055	0.208	0.008	0.101	-0.055	0.131	-0.135	0.060
L	0.034	-0.025	-0.318	0.322	0.200	-0.119	0.134	0.055	0.806	0.022	-0.080	0.240	0.132	0.042	-0.230	0.344
M	0.060	0.059	0.059	0.100	0.134	-0.097	0.013	0.208	0.022	0.890	-0.071	-0.046	0.060	-0.011	-0.127	-0.108
N	-0.063	-0.059	-0.137	-0.291	-0.191	0.139	-0.213	0.008	-0.080	-0.071	0.860	0.095	-0.145	0.070	0.051	0.076
O	-0.162	-0.000	-0.405	-0.051	-0.141	-0.015	-0.227	0.101	0.240	-0.046	0.095	0.739	-0.100	0.175	-0.163	0.471
Q1	-0.027	0.064	0.068	0.279	0.156	-0.117	0.173	-0.055	0.132	0.060	-0.145	-0.100	0.761	-0.008	-0.032	-0.016
Q2	-0.300	0.060	-0.168	-0.092	-0.356	-0.013	-0.381	0.131	0.042	-0.011	0.070	0.175	-0.008	0.910	-0.064	0.167
Q3	-0.001	-0.047	0.203	-0.179	-0.188	0.347	-0.030	-0.135	-0.230	-0.127	0.051	-0.163	-0.032	-0.064	0.732	-0.223
Q4	-0.067	-0.006	-0.502	0.037	-0.126	-0.083	-0.215	0.060	0.344	-0.108	0.076	0.471	-0.016	0.167	-0.223	0.830
Form B																
A	0.543	0.015	0.081	0.260	0.343	0.063	0.444	0.122	0.047	0.125	-0.050	-0.163	0.024	-0.248	-0.106	-0.081
B	-0.137	0.334	0.005	-0.055	-0.144	-0.013	-0.060	-0.137	-0.055	-0.081	-0.101	-0.085	0.003	-0.005	0.031	-0.044
C	0.111	0.015	0.393	-0.067	0.092	0.090	0.099	-0.077	-0.286	0.082	-0.067	-0.373	-0.010	-0.053	0.149	-0.405
E	0.015	-0.016	-0.009	0.454	0.175	-0.134	0.287	-0.046	0.174	0.125	-0.186	-0.088	0.225	0.013	-0.146	0.019
F	0.313	-0.153	0.222	0.409	0.675	-0.146	0.543	0.059	0.221	0.106	-0.213	-0.158	0.146	-0.249	-0.187	-0.118
G	0.068	-0.096	0.055	-0.358	-0.244	0.509	-0.118	0.002	-0.204	0.004	0.201	0.044	-0.184	0.027	0.329	-0.058
H	0.361	-0.064	0.267	0.397	0.521	0.026	0.738	-0.018	-0.001	0.060	-0.235	-0.249	0.127	-0.316	0.026	-0.274
I	-0.036	0.113	-0.017	-0.133	-0.125	0.077	-0.047	0.360	-0.040	0.097	0.053	0.117	-0.113	0.152	-0.048	0.005
L	-0.098	0.039	-0.275	0.098	-0.125	0.019	-0.090	-0.046	0.224	-0.092	0.031	0.242	0.063	0.213	-0.083	0.356
M	-0.030	0.037	0.040	0.331	0.111	-0.147	0.176	0.218	0.082	0.228	-0.233	-0.032	0.157	0.013	-0.132	-0.059
N	0.031	0.026	0.130	-0.437	-0.222	0.241	-0.189	-0.042	-0.186	-0.130	0.187	-0.036	-0.118	0.026	0.241	-0.094
O	-0.143	-0.028	-0.364	-0.059	-0.189	-0.026	-0.279	0.084	0.218	-0.094	0.100	0.421	-0.043	0.157	-0.123	0.477
Q1	0.075	0.089	-0.018	0.374	0.183	-0.104	0.221	0.064	0.181	0.191	-0.183	-0.088	0.408	-0.079	-0.121	-0.031
Q2	-0.391	0.116	-0.257	-0.193	-0.421	-0.059	-0.468	0.054	-0.033	-0.078	0.128	0.192	-0.098	0.409	-0.056	0.145
Q3	0.112	-0.042	0.246	-0.062	-0.064	0.377	0.100	-0.166	-0.257	-0.093	-0.029	-0.283	0.059	-0.045	0.446	-0.291
Q4	-0.043	0.014	-0.448	0.179	0.072	-0.143	-0.060	0.102	0.432	-0.041	0.003	0.331	0.061	0.081	-0.291	0.513

Table A4 part one: Covariance matrix for female science group

Form A	A	B	C	E	F	G	H	I	L	M	N	O	Q1	Q2	Q3	Q4
	Form B															
A	0.543	-0.137	0.111	0.015	0.313	0.068	0.361	-0.036	-0.098	-0.030	0.031	-0.143	0.075	-0.391	0.112	-0.043
B	0.015	0.334	0.015	-0.016	-0.153	-0.096	-0.064	0.113	0.039	0.037	0.026	-0.028	0.089	0.116	-0.042	0.014
C	0.081	0.005	0.393	-0.009	0.222	0.055	0.267	-0.017	-0.275	0.040	0.130	-0.364	-0.018	-0.257	0.246	-0.448
E	0.260	-0.055	-0.067	0.454	0.409	-0.358	0.397	-0.133	0.098	0.331	-0.437	-0.059	0.374	-0.193	-0.062	0.179
F	0.343	-0.144	0.092	0.175	0.675	-0.244	0.521	-0.125	-0.125	0.111	-0.222	-0.189	0.183	-0.421	-0.064	0.072
G	0.063	-0.013	0.090	-0.134	-0.146	0.509	0.026	0.077	0.019	-0.147	0.241	-0.026	-0.104	-0.059	0.377	-0.143
H	0.444	-0.060	0.099	0.287	0.543	-0.118	0.738	-0.047	-0.090	0.176	-0.189	-0.279	0.221	-0.468	0.100	-0.060
I	0.122	-0.137	-0.077	-0.046	0.059	0.002	-0.018	0.360	-0.046	0.218	-0.042	0.084	0.064	0.054	-0.166	0.102
L	0.047	-0.055	-0.286	0.174	0.221	-0.204	-0.001	-0.040	0.224	0.082	-0.186	0.218	0.181	-0.033	-0.257	0.432
M	0.125	-0.081	0.082	0.125	0.106	0.004	0.060	0.097	-0.092	0.228	-0.130	-0.094	0.191	-0.078	-0.093	-0.041
N	-0.050	-0.101	-0.067	-0.186	-0.213	0.201	-0.235	0.053	0.031	-0.233	0.187	0.100	-0.183	0.128	-0.029	0.003
O	-0.163	-0.085	-0.373	-0.088	-0.158	0.044	-0.249	0.117	0.242	-0.032	-0.036	0.421	-0.088	0.192	-0.283	0.331
Q1	0.024	0.003	-0.010	0.225	0.146	-0.184	0.127	-0.113	0.063	0.157	-0.118	-0.043	0.408	-0.098	0.059	0.061
Q2	-0.248	-0.005	-0.053	0.013	-0.249	0.027	-0.316	0.152	0.213	0.013	0.026	0.157	-0.079	0.409	-0.045	0.081
Q3	-0.106	0.031	0.149	-0.146	-0.187	0.329	0.026	-0.048	-0.083	-0.132	0.241	-0.123	-0.121	-0.056	0.446	-0.291
Q4	-0.081	-0.044	-0.405	0.019	-0.118	-0.058	-0.274	0.005	0.356	-0.059	-0.094	0.477	-0.031	0.145	-0.291	0.513
Form B																
A	1.049	-0.040	0.144	0.099	0.324	0.071	0.398	0.062	-0.075	0.014	0.021	-0.144	0.212	-0.373	0.014	0.020
B	-0.040	0.938	0.094	-0.066	-0.062	-0.029	-0.039	0.007	0.040	-0.047	0.052	-0.045	-0.024	-0.009	0.031	-0.085
C	0.144	0.094	0.733	-0.037	0.073	0.051	0.177	0.009	-0.256	-0.055	0.118	-0.431	-0.086	-0.166	0.301	-0.400
E	0.099	-0.066	-0.037	0.825	0.147	-0.200	0.219	-0.160	0.165	0.261	-0.266	-0.043	0.293	0.091	-0.002	0.121
F	0.324	-0.062	0.073	0.147	0.931	-0.324	0.422	-0.115	-0.101	0.058	-0.209	-0.181	0.166	-0.404	-0.153	0.100
G	0.071	-0.029	0.051	-0.200	-0.324	0.978	-0.051	0.138	0.049	-0.165	0.328	0.040	-0.124	0.001	0.348	-0.158
H	0.398	-0.039	0.177	0.219	0.422	-0.051	0.888	-0.024	-0.164	0.163	-0.070	-0.321	0.125	-0.412	0.165	-0.179
I	0.062	0.007	0.009	-0.160	-0.115	0.138	-0.024	0.830	-0.011	0.182	0.011	0.109	-0.081	0.106	-0.091	-0.016
L	-0.075	0.040	-0.256	0.165	-0.101	0.049	-0.164	-0.011	0.859	-0.057	-0.059	0.233	0.063	0.246	-0.107	0.279
M	0.014	-0.047	-0.055	0.261	0.058	-0.165	0.163	0.182	-0.057	0.848	-0.227	0.016	0.389	0.025	-0.144	0.005
N	0.021	0.052	0.118	-0.266	-0.209	0.328	-0.070	0.011	-0.059	-0.227	0.934	-0.075	-0.126	0.031	0.250	-0.195
O	-0.144	-0.045	-0.431	-0.043	-0.181	0.040	-0.321	0.109	0.233	0.016	-0.075	0.758	0.054	0.169	-0.237	0.399
Q1	0.212	-0.024	-0.086	0.293	0.166	-0.124	0.125	-0.081	0.063	0.389	-0.126	0.054	1.115	-0.187	-0.001	0.121
Q2	-0.373	-0.009	-0.166	0.091	-0.404	0.001	-0.412	0.106	0.246	0.025	0.031	0.169	-0.187	0.956	-0.040	0.055
Q3	0.014	0.031	0.301	-0.002	-0.153	0.348	0.165	-0.091	-0.107	-0.144	0.250	-0.237	-0.001	-0.040	0.865	-0.340
Q4	0.020	-0.085	-0.400	0.121	0.100	-0.158	-0.179	-0.016	0.279	0.005	-0.195	0.399	0.121	0.055	-0.340	0.814

Table A4 part two: Covariance matrix for female science group

Form A	A	B	C	E	F	G	H	I	L	M	N	O	Q1	Q2	Q3	Q4
A	1.021	-0.065	0.129	0.102	0.255	0.172	0.414	0.064	0.103	0.078	-0.057	-0.150	-0.007	-0.380	0.088	-0.097
B	-0.065	1.024	-0.037	-0.079	-0.129	-0.043	-0.104	0.148	-0.147	0.108	0.042	0.007	-0.013	0.043	-0.031	-0.015
C	0.129	-0.037	1.013	0.125	0.174	0.073	0.379	-0.212	-0.226	0.100	-0.142	-0.552	0.062	-0.030	0.280	-0.596
E	0.102	-0.079	0.125	0.872	0.467	-0.127	0.541	-0.062	0.311	0.142	-0.308	-0.229	0.372	-0.117	-0.129	-0.079
F	0.255	-0.129	0.174	0.467	1.044	-0.119	0.617	-0.053	0.270	0.100	-0.383	-0.169	0.249	-0.374	-0.097	-0.086
G	0.172	-0.043	0.073	-0.127	-0.119	0.938	0.091	-0.153	-0.077	-0.133	0.052	-0.143	-0.226	-0.125	0.500	-0.153
H	0.414	-0.104	0.379	0.541	0.617	0.091	1.084	-0.052	0.134	0.187	-0.327	-0.436	0.220	-0.331	0.137	-0.341
I	0.064	0.148	-0.212	-0.062	-0.053	-0.153	-0.052	0.925	0.052	0.216	0.045	0.144	-0.039	0.001	-0.181	0.141
L	0.103	-0.147	-0.226	0.311	0.270	-0.077	0.134	0.052	0.963	-0.025	-0.117	0.172	0.208	-0.068	-0.170	0.285
M	0.078	0.108	0.100	0.142	0.100	-0.133	0.187	0.216	-0.025	1.015	-0.092	-0.200	0.180	0.018	-0.078	-0.143
N	-0.057	0.042	-0.142	-0.308	-0.383	0.052	-0.327	0.045	-0.117	-0.092	0.876	0.181	-0.146	0.131	0.039	0.106
O	-0.150	0.007	-0.552	-0.229	-0.169	-0.143	-0.436	0.144	0.172	-0.200	0.181	0.990	-0.161	0.045	-0.339	0.583
Q1	-0.007	-0.013	0.062	0.372	0.249	-0.226	0.220	-0.039	0.208	0.180	-0.146	-0.161	1.005	-0.001	-0.120	-0.052
Q2	-0.380	0.043	-0.030	-0.117	-0.374	-0.125	-0.331	0.001	-0.068	0.018	0.131	0.045	-0.001	1.001	0.008	0.002
Q3	0.088	-0.031	0.280	-0.129	-0.097	0.500	0.137	-0.181	-0.170	-0.078	0.039	-0.339	-0.120	0.008	0.960	-0.377
Q4	-0.097	-0.015	-0.596	-0.079	-0.086	-0.153	-0.341	0.141	0.285	-0.143	0.106	0.583	-0.052	0.002	-0.377	0.930
Form B																
A	0.594	-0.057	0.090	0.211	0.338	0.024	0.425	0.188	0.120	0.150	-0.141	-0.141	0.099	-0.372	0.002	-0.085
B	-0.077	0.307	-0.060	-0.076	-0.093	-0.063	-0.110	0.054	-0.094	0.032	0.048	-0.024	-0.036	0.052	0.023	0.008
C	0.146	0.059	0.560	0.073	0.083	0.171	0.302	-0.204	-0.237	0.100	-0.120	-0.584	-0.003	-0.004	0.315	-0.565
E	0.077	-0.047	0.172	0.480	0.302	-0.091	0.478	-0.049	0.195	0.142	-0.190	-0.228	0.350	-0.014	-0.037	-0.133
F	0.309	-0.139	0.188	0.525	0.769	-0.178	0.658	-0.009	0.277	0.061	-0.327	-0.175	0.228	-0.318	-0.178	-0.110
G	0.219	0.017	0.053	-0.180	-0.161	0.539	0.036	0.022	-0.105	0.017	0.084	-0.048	-0.214	-0.115	0.408	-0.085
H	0.364	-0.050	0.455	0.436	0.512	0.050	0.836	-0.097	-0.008	0.165	-0.280	-0.482	0.159	-0.260	0.184	-0.428
I	0.038	0.109	-0.208	-0.109	-0.187	-0.026	-0.108	0.506	-0.036	0.123	0.069	0.147	-0.165	0.035	-0.089	0.083
L	-0.032	-0.065	-0.270	0.213	0.105	-0.050	0.052	-0.053	0.341	-0.113	-0.000	0.226	0.217	0.011	-0.122	0.259
M	-0.127	0.108	0.004	0.252	0.064	-0.233	0.149	0.293	0.037	0.393	-0.156	-0.138	0.211	0.039	-0.156	-0.087
N	0.026	0.015	0.135	-0.351	-0.223	0.190	-0.206	-0.057	-0.247	-0.055	0.212	-0.077	-0.167	0.086	0.282	-0.146
O	-0.170	0.070	-0.592	-0.199	-0.190	-0.129	-0.411	0.238	0.099	-0.101	0.160	0.618	-0.134	0.031	-0.361	0.578
Q1	-0.022	0.040	-0.024	0.225	0.132	-0.172	0.148	0.098	0.165	0.288	-0.061	-0.063	0.380	0.000	-0.089	-0.020
Q2	-0.317	0.106	-0.213	-0.121	-0.455	-0.117	-0.445	0.063	0.013	-0.020	0.130	0.208	0.020	0.468	-0.075	0.144
Q3	0.130	-0.015	0.333	-0.005	-0.092	0.484	0.196	-0.174	-0.131	-0.069	0.031	-0.389	-0.081	0.003	0.553	-0.399
Q4	-0.056	0.023	-0.514	0.059	0.073	-0.215	-0.179	0.215	0.321	-0.079	0.041	0.498	0.024	-0.014	-0.392	0.616

Table A5 part one: Covariance matrix for male total group

Form A	A	B	C	E	F	G	H	I	L	M	N	O	Q1	Q2	Q3	Q4
								Form B								
A	0.594	-0.077	0.146	0.077	0.309	0.219	0.364	0.038	-0.032	-0.127	0.026	-0.170	-0.022	-0.317	0.130	-0.056
B	-0.057	0.307	0.059	-0.047	-0.139	0.017	-0.050	0.109	-0.065	0.108	0.015	0.070	0.040	0.106	-0.015	0.023
C	0.090	-0.060	0.560	0.172	0.188	0.053	0.455	-0.208	-0.270	0.004	0.135	-0.592	-0.024	-0.213	0.333	-0.514
E	0.211	-0.076	0.073	0.480	0.525	-0.180	0.436	-0.109	0.213	0.252	-0.351	-0.199	0.225	-0.121	-0.005	0.059
F	0.338	-0.093	0.083	0.302	0.769	-0.161	0.512	-0.187	0.105	0.064	-0.223	-0.190	0.132	-0.455	-0.092	0.073
G	0.024	-0.063	0.171	-0.091	-0.178	0.539	0.050	-0.026	-0.050	-0.233	0.190	-0.129	-0.172	-0.117	0.484	-0.215
H	0.425	-0.110	0.302	0.478	0.658	0.036	0.836	-0.108	0.052	0.149	-0.206	-0.411	0.148	-0.445	0.196	-0.179
I	0.188	0.054	-0.204	-0.049	-0.009	0.022	-0.097	0.506	-0.053	0.293	-0.057	0.238	0.098	0.063	-0.174	0.215
L	0.120	-0.094	-0.237	0.195	0.277	-0.105	-0.008	-0.036	0.341	0.037	-0.247	0.099	0.165	0.013	-0.131	0.321
M	0.150	0.032	0.100	0.142	0.061	0.017	0.165	0.123	-0.113	0.393	-0.055	-0.101	0.288	-0.020	-0.069	-0.079
N	-0.141	0.048	-0.120	-0.190	-0.327	0.084	-0.280	0.069	-0.000	-0.156	0.212	0.160	-0.061	0.130	0.031	0.041
O	-0.141	-0.024	-0.584	-0.228	-0.175	-0.048	-0.482	0.147	0.226	-0.138	-0.077	0.618	-0.063	0.208	-0.389	0.498
Q1	0.099	-0.036	-0.003	0.350	0.228	-0.214	0.159	-0.165	0.217	0.211	-0.167	-0.134	0.380	0.020	-0.081	0.024
Q2	-0.372	0.052	-0.004	-0.014	-0.318	-0.115	-0.260	0.035	0.011	0.039	0.086	0.031	0.000	0.468	0.003	-0.014
Q3	0.002	0.023	0.315	-0.037	-0.178	0.408	0.184	-0.089	-0.122	-0.156	0.282	-0.361	-0.089	-0.075	0.553	-0.392
Q4	-0.085	0.008	-0.565	-0.133	-0.110	-0.085	-0.428	0.083	0.259	-0.087	-0.146	0.578	-0.020	0.144	-0.399	0.616
Form B																
A	1.020	0.004	0.089	0.171	0.370	0.126	0.349	0.117	0.032	0.016	-0.051	-0.141	0.097	-0.314	-0.001	0.007
B	0.004	0.849	0.011	-0.036	-0.068	-0.009	-0.053	0.052	-0.047	0.032	-0.042	0.054	0.044	0.021	-0.002	0.020
C	0.089	0.011	1.046	0.082	0.101	0.078	0.421	-0.120	-0.273	0.009	0.173	-0.602	-0.060	-0.219	0.380	-0.548
E	0.171	-0.036	0.082	0.860	0.373	-0.157	0.395	-0.093	0.238	0.268	-0.272	-0.212	0.261	-0.066	0.054	-0.072
F	0.370	-0.068	0.101	0.373	1.161	-0.239	0.596	-0.124	0.138	0.103	-0.345	-0.241	0.116	-0.379	-0.135	0.102
G	0.126	-0.009	0.078	-0.157	-0.239	1.025	0.058	0.114	-0.077	-0.066	0.185	-0.031	-0.102	-0.108	0.367	-0.164
H	0.349	-0.053	0.421	0.395	0.596	0.058	1.086	-0.120	-0.033	0.144	-0.105	-0.549	0.089	-0.436	0.233	-0.293
I	0.117	0.052	-0.120	-0.093	-0.124	0.114	-0.120	0.886	-0.109	0.236	-0.007	0.228	0.004	0.064	-0.073	0.174
L	0.032	-0.047	-0.273	0.238	0.138	-0.077	-0.033	-0.109	0.960	-0.063	-0.171	0.169	0.140	0.139	-0.067	0.248
M	0.016	0.032	0.009	0.268	0.103	-0.066	0.144	0.236	-0.063	0.980	-0.235	-0.034	0.360	0.100	-0.055	0.037
N	-0.051	-0.042	0.173	-0.272	-0.345	0.185	-0.105	-0.007	-0.171	-0.235	0.951	-0.090	-0.191	0.045	0.207	-0.226
O	-0.141	0.054	-0.602	-0.212	-0.241	-0.031	-0.549	0.228	0.169	-0.034	-0.090	0.937	-0.059	0.177	-0.376	0.546
Q1	0.097	0.044	-0.060	0.261	0.116	-0.102	0.089	0.004	0.140	0.360	-0.191	-0.059	0.899	0.049	-0.068	0.056
Q2	-0.314	0.021	-0.219	-0.066	-0.379	-0.108	-0.436	0.064	0.139	0.100	0.045	0.177	0.049	0.947	-0.074	0.101
Q3	-0.001	-0.002	0.380	0.054	-0.135	0.367	0.233	-0.073	-0.067	-0.055	0.207	-0.376	-0.068	-0.074	0.985	-0.437
Q4	0.007	0.020	-0.548	-0.072	0.102	-0.164	-0.293	0.174	0.248	0.037	-0.226	0.546	0.056	0.101	-0.437	0.932

Table A5 part two: Covariance matrix for male total group

Form A	A	B	C	E	F	G	H	I	L	M	N	O	Q1	Q2	Q3	Q4
A	0.879	-0.002	0.064	0.031	0.246	0.104	0.288	0.133	-0.048	0.032	0.084	-0.120	-0.024	-0.284	0.033	-0.097
B	-0.002	0.963	-0.020	-0.048	-0.124	0.038	-0.064	0.032	-0.031	0.034	-0.049	-0.067	0.042	0.011	0.050	-0.063
C	0.064	-0.020	1.069	-0.002	0.165	-0.020	0.272	-0.086	-0.347	0.108	-0.097	-0.500	0.031	-0.147	0.270	-0.592
E	0.031	-0.048	-0.002	0.936	0.410	-0.246	0.521	-0.071	0.375	0.108	-0.322	-0.053	0.329	-0.083	-0.238	0.074
F	0.246	-0.124	0.165	0.410	0.838	-0.225	0.530	0.004	0.175	0.080	-0.219	-0.105	0.210	-0.296	-0.236	-0.054
G	0.104	0.038	-0.020	-0.246	-0.225	0.869	-0.052	-0.035	-0.155	-0.165	0.211	-0.035	-0.229	0.012	0.432	-0.062
H	0.288	-0.064	0.272	0.521	0.530	-0.052	0.985	-0.048	0.107	0.074	-0.213	-0.269	0.195	-0.300	-0.005	-0.210
I	0.133	0.032	-0.086	-0.071	0.004	-0.035	-0.048	0.891	0.019	0.220	0.112	0.048	-0.038	0.105	-0.097	0.060
L	-0.048	-0.031	-0.347	0.375	0.175	-0.155	0.107	0.019	0.949	-0.015	-0.122	0.256	0.219	0.075	-0.290	0.381
M	0.032	0.034	0.108	0.108	0.080	-0.165	0.074	0.220	-0.015	0.984	-0.099	-0.118	0.181	0.021	-0.143	-0.115
N	0.084	-0.049	-0.097	-0.322	-0.219	0.211	-0.213	0.112	-0.122	-0.099	0.863	0.065	-0.214	0.081	0.186	0.024
O	-0.120	-0.067	-0.500	-0.053	-0.105	-0.035	-0.269	0.048	0.256	-0.118	0.065	0.796	-0.060	0.130	-0.233	0.495
Q1	-0.024	0.042	0.031	0.329	0.210	-0.229	0.195	-0.038	0.219	0.181	-0.214	-0.060	0.934	-0.023	-0.206	-0.008
Q2	-0.284	0.011	-0.147	-0.083	-0.296	0.012	-0.300	0.105	0.075	0.021	0.081	0.130	-0.023	0.936	0.003	0.129
Q3	0.033	0.050	0.270	-0.238	-0.236	0.432	-0.005	-0.097	-0.290	-0.143	0.186	-0.233	-0.206	0.003	0.890	-0.333
Q4	-0.097	-0.063	-0.592	0.074	-0.054	-0.062	-0.210	0.060	0.381	-0.115	0.024	0.495	-0.008	0.129	-0.333	0.848
Form B																
A	0.550	0.045	0.101	0.144	0.273	0.008	0.351	0.163	0.022	0.120	0.012	-0.154	0.074	-0.249	-0.027	-0.117
B	0.003	0.313	0.014	-0.013	-0.065	0.059	0.008	-0.067	-0.018	-0.017	-0.050	-0.045	0.021	-0.023	0.060	-0.036
C	0.149	0.045	0.474	-0.062	0.024	0.142	0.200	-0.092	-0.298	0.062	-0.024	-0.394	-0.030	-0.101	0.294	-0.453
E	-0.057	-0.039	0.025	0.511	0.242	-0.205	0.347	-0.084	0.283	0.145	-0.248	-0.078	0.353	0.037	-0.181	0.026
F	0.256	-0.105	0.173	0.442	0.607	-0.229	0.526	-0.053	0.211	0.071	-0.219	-0.107	0.194	-0.242	-0.219	-0.061
G	0.057	0.054	-0.005	-0.290	-0.254	0.491	-0.107	0.012	-0.159	-0.095	0.199	0.022	-0.249	-0.007	0.348	-0.063
H	0.287	-0.031	0.336	0.415	0.453	-0.074	0.757	-0.033	0.006	0.075	-0.195	-0.303	0.133	-0.232	0.033	-0.271
I	0.022	0.071	-0.084	-0.128	-0.088	0.027	-0.053	0.388	-0.086	0.150	0.096	0.046	-0.153	0.033	-0.027	0.010
L	-0.106	0.022	-0.320	0.158	-0.070	0.027	-0.079	-0.031	0.300	-0.072	-0.030	0.240	0.115	0.163	-0.118	0.293
M	-0.160	0.026	0.040	0.313	0.108	-0.253	0.132	0.146	0.135	0.269	-0.288	-0.039	0.196	0.036	-0.207	0.002
N	0.079	0.076	0.109	-0.351	-0.175	0.255	-0.074	0.015	-0.202	-0.089	0.249	-0.057	-0.142	0.004	0.304	-0.153
O	-0.146	-0.044	-0.489	-0.107	-0.160	-0.028	-0.350	0.098	0.212	-0.084	0.101	0.478	-0.052	0.139	-0.228	0.514
Q1	-0.022	0.128	-0.016	0.338	0.152	-0.244	0.174	0.058	0.198	0.281	-0.250	-0.023	0.505	0.002	-0.227	0.017
Q2	-0.406	-0.005	-0.213	-0.108	-0.343	-0.033	-0.391	0.021	0.084	-0.019	0.056	0.157	0.050	0.448	-0.044	0.144
Q3	0.079	0.059	0.281	-0.110	-0.153	0.401	0.096	-0.077	-0.245	-0.045	0.093	-0.313	-0.081	-0.011	0.517	-0.342
Q4	-0.051	-0.056	-0.479	0.200	0.115	-0.182	-0.098	0.080	0.455	-0.080	-0.052	0.398	0.103	0.053	-0.389	0.579

Table A6 part one: Covariance matrix for female total group

	Form B															
Form A	A	B	C	E	F	G	H	I	L	M	N	O	Q1	Q2	Q3	Q4
A	0.550	0.003	0.149	-0.057	0.256	0.057	0.287	0.022	-0.106	-0.160	0.079	-0.146	-0.022	-0.406	0.079	-0.051
B	0.045	0.313	0.045	-0.039	-0.105	0.054	-0.031	0.071	0.022	0.026	0.076	-0.044	0.128	-0.005	0.059	-0.056
C	0.101	0.014	0.474	0.025	0.173	-0.005	0.336	-0.084	-0.320	0.040	0.109	-0.489	-0.016	-0.213	0.281	-0.479
E	0.144	-0.013	-0.062	0.511	0.442	-0.290	0.415	-0.128	0.158	0.313	-0.351	-0.107	0.338	-0.108	-0.110	0.200
F	0.273	-0.065	0.024	0.242	0.607	-0.254	0.453	-0.088	-0.070	0.108	-0.175	-0.160	0.152	-0.343	-0.153	0.115
G	0.008	0.059	0.142	-0.205	-0.229	0.491	-0.074	0.027	0.027	-0.253	0.255	-0.028	-0.244	-0.033	0.401	-0.182
H	0.351	0.008	0.200	0.347	0.526	-0.107	0.757	-0.053	-0.079	0.132	-0.074	-0.350	0.174	-0.391	0.096	-0.098
I	0.163	-0.067	-0.092	-0.084	-0.053	0.012	-0.033	0.388	-0.031	0.146	0.015	0.098	0.058	0.021	-0.077	0.080
L	0.022	-0.018	-0.298	0.283	0.211	-0.159	0.006	-0.086	0.300	0.135	-0.202	0.212	0.198	0.084	-0.245	0.455
M	0.120	-0.017	0.062	0.145	0.071	-0.095	0.075	0.150	-0.072	0.269	-0.089	-0.084	0.281	-0.019	-0.045	-0.080
N	0.012	-0.050	-0.024	-0.248	-0.219	0.199	-0.195	0.096	-0.030	-0.288	0.249	0.101	-0.250	0.056	0.093	-0.052
O	-0.154	-0.045	-0.394	-0.078	-0.107	0.022	-0.303	0.046	0.240	-0.039	-0.057	0.478	-0.023	0.157	-0.313	0.398
Q1	0.074	0.021	-0.030	0.353	0.194	-0.249	0.133	-0.153	0.115	0.196	-0.142	-0.052	0.505	0.050	-0.081	0.103
Q2	-0.249	-0.023	-0.101	0.037	-0.242	-0.007	-0.232	0.033	0.163	0.036	0.004	0.139	0.002	0.448	-0.011	0.053
Q3	-0.027	0.060	0.294	-0.181	-0.219	0.348	0.033	-0.027	-0.118	-0.207	0.304	-0.228	-0.227	-0.044	0.517	-0.389
Q4	-0.117	-0.036	-0.453	0.026	-0.061	-0.063	-0.271	0.010	0.293	0.002	-0.153	0.514	0.017	0.144	-0.342	0.579
Form B																
A	0.907	0.032	0.151	0.076	0.267	0.017	0.343	0.094	-0.117	-0.073	0.048	-0.180	0.115	-0.341	-0.006	-0.022
B	0.032	0.836	0.052	-0.015	-0.053	0.041	0.030	-0.001	-0.020	-0.046	0.062	-0.035	0.043	0.017	0.089	-0.026
C	0.151	0.052	0.802	-0.079	0.044	0.074	0.257	-0.018	-0.276	-0.101	0.191	-0.470	-0.078	-0.213	0.354	-0.477
E	0.076	-0.015	-0.079	0.924	0.251	-0.242	0.302	-0.168	0.206	0.341	-0.259	-0.106	0.371	0.163	-0.062	0.120
F	0.267	-0.053	0.044	0.251	0.931	-0.292	0.447	-0.143	-0.039	0.075	-0.210	-0.206	0.140	-0.316	-0.180	0.123
G	0.017	0.041	0.074	-0.242	-0.292	0.957	-0.108	0.058	0.006	-0.183	0.253	-0.009	-0.233	-0.032	0.357	-0.193
H	0.343	0.030	0.257	0.302	0.447	-0.108	0.934	-0.057	-0.122	0.135	-0.003	-0.425	0.132	-0.340	0.124	-0.182
I	0.094	-0.001	-0.018	-0.168	-0.143	0.058	-0.057	0.840	-0.080	0.159	0.026	0.088	-0.056	-0.052	-0.087	0.001
L	-0.117	-0.020	-0.276	0.206	-0.039	0.006	-0.122	-0.080	0.880	-0.042	-0.127	0.235	0.121	0.254	-0.077	0.309
M	-0.073	-0.046	-0.101	0.341	0.075	-0.183	0.135	0.159	-0.042	0.967	-0.255	-0.026	0.401	0.102	-0.207	0.050
N	0.048	0.062	0.191	-0.259	-0.210	0.253	-0.003	0.026	-0.127	-0.255	0.885	-0.078	-0.156	-0.033	0.256	-0.254
O	-0.180	-0.035	-0.470	-0.106	-0.206	-0.009	-0.425	0.088	0.235	-0.026	-0.078	0.825	0.003	0.200	-0.306	0.466
Q1	0.115	0.043	-0.078	0.371	0.140	-0.233	0.132	-0.056	0.121	0.401	-0.156	0.003	1.105	0.023	-0.106	0.139
Q2	-0.341	0.017	-0.213	0.163	-0.316	-0.032	-0.340	-0.052	0.254	0.102	-0.033	0.200	0.023	0.965	-0.024	0.102
Q3	-0.006	0.089	0.354	-0.062	-0.180	0.357	0.124	-0.087	-0.077	-0.207	0.256	-0.306	-0.106	-0.024	0.943	-0.400
Q4	-0.022	-0.026	-0.477	0.120	0.123	-0.193	-0.182	0.001	0.309	0.050	-0.254	0.466	0.139	0.102	-0.400	0.893

Table A6 part two: Covariance matrix for female total group

Form A	A	B	C	E	F	G	H	I	L	M	N	O	Q1	Q2	Q3	Q4
A	0.925	0.005	0.125	-0.005	0.233	0.146	0.294	0.040	-0.064	-0.025	0.092	-0.132	-0.088	-0.298	0.110	-0.110
B	0.005	1.008	-0.001	-0.034	-0.097	0.036	-0.037	0.089	-0.088	0.074	-0.017	-0.075	0.024	0.006	0.047	-0.061
C	0.125	-0.001	1.074	0.078	0.191	-0.024	0.371	-0.112	-0.283	0.165	-0.116	-0.584	0.066	-0.105	0.302	-0.657
E	-0.005	-0.034	0.078	0.966	0.435	-0.190	0.562	-0.230	0.377	0.107	-0.389	-0.172	0.413	-0.106	-0.195	-0.024
F	0.233	-0.097	0.191	0.435	0.938	-0.199	0.561	-0.071	0.194	0.070	-0.313	-0.144	0.230	-0.327	-0.192	-0.078
G	0.146	0.036	-0.024	-0.190	-0.199	0.923	-0.005	-0.069	-0.112	-0.163	0.173	-0.077	-0.227	-0.012	0.490	-0.092
H	0.294	-0.037	0.371	0.562	0.561	-0.005	1.057	-0.147	0.105	0.127	-0.297	-0.383	0.220	-0.296	0.075	-0.305
I	0.040	0.089	-0.112	-0.230	-0.071	-0.069	-0.147	0.944	-0.051	0.130	0.180	0.127	-0.172	0.084	-0.105	0.167
L	-0.064	-0.088	-0.283	0.377	0.194	-0.112	0.105	-0.051	1.005	-0.039	-0.155	0.209	0.262	0.021	-0.243	0.332
M	-0.025	0.074	0.165	0.107	0.070	-0.163	0.127	0.130	-0.039	0.985	-0.085	-0.188	0.223	0.015	-0.086	-0.148
N	0.092	-0.017	-0.116	-0.389	-0.313	0.173	-0.297	0.180	-0.155	-0.085	0.942	0.147	-0.243	0.100	0.167	0.094
O	-0.132	-0.075	-0.584	-0.172	-0.144	-0.077	-0.383	0.127	0.209	-0.188	0.147	0.948	-0.142	0.117	-0.326	0.606
Q1	-0.088	0.024	0.066	0.413	0.230	-0.227	0.220	-0.172	0.262	0.223	-0.243	-0.142	1.029	-0.045	-0.202	-0.069
Q2	-0.298	0.006	-0.105	-0.106	-0.327	-0.012	-0.296	0.084	0.021	0.015	0.100	0.117	-0.045	0.942	0.018	0.123
Q3	0.110	0.047	0.302	-0.195	-0.192	0.490	0.075	-0.105	-0.243	-0.086	0.167	-0.326	-0.202	0.018	0.981	-0.433
Q4	-0.110	-0.061	-0.657	-0.024	-0.078	-0.092	-0.305	0.167	0.332	-0.148	0.094	0.606	-0.069	0.123	-0.433	0.971
Form B																
A	0.499	0.042	0.144	0.093	0.259	0.029	0.316	0.026	-0.008	0.072	-0.019	-0.185	0.065	-0.281	0.048	-0.147
B	0.053	0.329	-0.028	-0.033	-0.023	0.015	-0.014	0.037	-0.053	0.031	0.002	0.004	-0.018	0.004	0.018	0.021
C	0.201	0.066	0.568	0.033	0.068	0.183	0.325	-0.171	-0.282	0.079	-0.067	-0.543	0.028	-0.112	0.402	-0.578
E	-0.079	-0.031	0.116	0.590	0.286	-0.169	0.451	-0.253	0.307	0.129	-0.311	-0.182	0.459	0.013	-0.126	-0.090
F	0.223	-0.101	0.173	0.531	0.681	-0.209	0.598	-0.155	0.261	0.048	-0.295	-0.138	0.243	-0.292	-0.215	-0.086
G	0.140	0.084	-0.032	-0.227	-0.240	0.487	-0.060	0.048	-0.116	-0.088	0.191	0.009	-0.277	-0.029	0.370	-0.041
H	0.305	-0.003	0.433	0.462	0.489	-0.060	0.835	-0.152	0.002	0.117	-0.247	-0.426	0.137	-0.243	0.113	-0.377
I	-0.014	0.085	-0.150	-0.216	-0.131	-0.016	-0.148	0.418	-0.143	0.095	0.152	0.135	-0.298	-0.002	-0.035	0.134
L	-0.129	-0.018	-0.315	0.268	-0.010	0.033	-0.022	-0.136	0.355	-0.080	-0.084	0.182	0.210	0.089	-0.103	0.209
M	-0.239	0.056	0.043	0.297	0.084	-0.298	0.120	0.128	0.121	0.323	-0.274	-0.088	0.236	0.061	-0.223	-0.003
N	0.120	0.063	0.103	-0.348	-0.188	0.249	-0.079	0.037	-0.214	-0.056	0.282	-0.078	-0.174	-0.003	0.343	-0.177
O	-0.158	-0.021	-0.597	-0.228	-0.179	-0.070	-0.435	0.221	0.160	-0.105	0.183	0.631	-0.157	0.122	-0.350	0.640
Q1	-0.093	0.106	-0.005	0.271	0.129	-0.272	0.122	0.038	0.176	0.318	-0.196	-0.042	0.521	0.034	-0.203	0.002
Q2	-0.404	-0.030	-0.225	-0.076	-0.410	-0.064	-0.426	0.005	0.108	-0.042	0.062	0.186	0.124	0.502	-0.054	0.165
Q3	0.139	0.077	0.317	-0.049	-0.141	0.440	0.160	-0.107	-0.188	-0.024	0.086	-0.397	-0.064	-0.013	0.592	-0.428
Q4	-0.057	-0.044	-0.550	0.113	0.098	-0.203	-0.189	0.169	0.410	-0.104	0.012	0.522	0.019	0.046	-0.452	0.686

Table A7 part one: Covariance matrix for arts total group

	Form B															
Form A	A	B	C	E	F	G	H	I	L	M	N	O	Q1	Q2	Q3	Q4
A	0.499	0.053	0.201	-0.079	0.223	0.140	0.305	-0.014	-0.129	-0.239	0.120	-0.158	-0.093	-0.404	0.139	-0.057
B	0.042	0.329	0.066	-0.031	-0.101	0.084	-0.003	0.085	-0.018	0.056	0.063	-0.021	0.106	-0.030	0.077	-0.044
C	0.144	-0.028	0.568	0.116	0.173	-0.032	0.433	-0.150	-0.315	0.043	0.103	-0.597	-0.005	-0.225	0.317	-0.550
E	0.093	-0.033	0.033	0.590	0.531	-0.227	0.462	-0.216	0.268	0.297	-0.348	-0.228	0.271	-0.076	-0.049	0.113
F	0.259	-0.023	0.068	0.286	0.681	-0.240	0.489	-0.131	-0.010	0.084	-0.188	-0.179	0.129	-0.410	-0.141	0.098
G	0.029	0.015	0.183	-0.169	-0.209	0.487	-0.060	-0.016	0.033	-0.298	0.249	-0.070	-0.272	-0.064	0.440	-0.203
H	0.316	-0.014	0.325	0.451	0.598	-0.060	0.835	-0.148	-0.022	0.120	-0.079	-0.435	0.122	-0.426	0.160	-0.189
I	0.026	0.037	-0.171	-0.253	-0.155	0.048	-0.152	0.418	-0.136	0.128	0.037	0.221	0.038	0.005	-0.107	0.169
L	-0.008	-0.053	-0.282	0.307	0.261	-0.116	0.002	-0.143	0.355	0.121	-0.214	0.160	0.176	0.108	-0.188	0.410
M	0.072	0.031	0.079	0.129	0.048	-0.088	0.117	0.095	-0.080	0.323	-0.056	-0.105	0.318	-0.042	-0.024	-0.104
N	-0.019	0.002	-0.067	-0.311	-0.295	0.191	-0.247	0.152	-0.084	-0.274	0.282	0.183	-0.196	0.062	0.086	0.012
O	-0.185	0.004	-0.543	-0.182	-0.138	0.009	-0.426	0.135	0.182	-0.088	-0.078	0.631	-0.042	0.186	-0.397	0.522
Q1	0.065	-0.018	0.028	0.459	0.243	-0.277	0.137	-0.298	0.210	0.236	-0.174	-0.157	0.521	0.124	-0.064	0.019
Q2	-0.281	0.004	-0.112	0.013	-0.292	-0.029	-0.243	-0.002	0.089	0.061	-0.003	0.122	0.034	0.502	-0.013	0.046
Q3	0.048	0.018	0.402	-0.126	-0.215	0.370	0.113	-0.035	-0.103	-0.223	0.343	-0.350	-0.203	-0.054	0.592	-0.462
Q4	-0.147	0.021	-0.578	-0.090	-0.086	-0.041	-0.377	0.134	0.209	-0.003	-0.177	0.640	0.002	0.165	-0.428	0.686
Form B																
A	0.806	0.040	0.169	0.083	0.247	0.051	0.313	-0.005	-0.103	-0.110	0.035	-0.193	0.043	-0.333	0.020	-0.052
B	0.040	0.816	0.019	-0.029	-0.057	0.029	0.031	0.063	-0.076	-0.020	0.008	0.043	0.054	0.012	0.051	0.053
C	0.169	0.019	0.985	0.004	0.088	0.078	0.395	-0.118	-0.271	-0.086	0.222	-0.609	-0.055	-0.273	0.417	-0.588
E	0.083	-0.029	0.004	1.020	0.376	-0.233	0.392	-0.282	0.329	0.354	-0.275	-0.238	0.366	0.116	-0.008	-0.009
F	0.247	-0.057	0.088	0.376	1.031	-0.261	0.530	-0.210	0.058	0.088	-0.285	-0.243	0.129	-0.334	-0.152	0.112
G	0.051	0.029	0.078	-0.233	-0.261	0.976	-0.066	0.083	-0.041	-0.169	0.218	-0.030	-0.234	-0.069	0.371	-0.182
H	0.313	0.031	0.395	0.392	0.530	-0.066	1.048	-0.171	-0.058	0.111	-0.014	-0.544	0.086	-0.384	0.188	-0.275
I	-0.005	0.063	-0.118	-0.282	-0.210	0.083	-0.171	0.875	-0.180	0.145	0.041	0.213	-0.056	-0.080	-0.133	0.153
L	-0.103	-0.076	-0.271	0.329	0.058	-0.041	-0.058	-0.180	0.969	-0.011	-0.182	0.169	0.126	0.262	-0.024	0.255
M	-0.110	-0.020	-0.086	0.354	0.088	-0.169	0.111	0.145	-0.011	1.000	-0.283	-0.052	0.410	0.111	-0.192	0.058
N	0.035	0.008	0.222	-0.275	-0.285	0.218	-0.014	0.041	-0.182	-0.283	0.964	-0.083	-0.207	-0.028	0.254	-0.265
O	-0.193	0.043	-0.609	-0.238	-0.243	-0.030	-0.544	0.213	0.169	-0.052	-0.083	0.970	-0.047	0.206	-0.396	0.601
Q1	0.043	0.054	-0.055	0.366	0.129	-0.234	0.086	-0.056	0.126	0.410	-0.207	-0.047	1.033	0.091	-0.120	0.080
Q2	-0.333	0.012	-0.273	0.116	-0.334	-0.069	-0.384	-0.080	0.262	0.111	-0.028	0.206	0.091	1.029	-0.051	0.132
Q3	0.020	0.051	0.417	-0.008	-0.152	0.371	0.188	-0.133	-0.024	-0.192	0.254	-0.396	-0.120	-0.051	1.026	-0.464
Q4	-0.052	0.053	-0.588	-0.009	0.112	-0.182	-0.275	0.153	0.255	0.058	-0.265	0.601	0.080	0.132	-0.464	1.000

Table A7 part two: Covariance matrix for arts total group

Form A	A	B	C	E	F	G	H	I	L	M	N	O	Q1	Q2	Q3	Q4
A	0.899	-0.068	0.115	0.045	0.251	0.140	0.344	0.076	0.038	0.047	-0.046	-0.091	-0.048	-0.374	0.026	-0.036
B	-0.068	0.972	-0.065	-0.103	-0.160	-0.047	-0.139	0.105	-0.084	0.066	0.012	0.027	0.003	0.051	-0.038	-0.009
C	0.115	-0.065	0.969	0.068	0.158	0.072	0.295	-0.096	-0.259	0.085	-0.123	-0.456	0.065	-0.073	0.217	-0.519
E	0.045	-0.103	0.068	0.953	0.414	-0.162	0.521	-0.106	0.362	0.140	-0.303	-0.210	0.373	-0.086	-0.115	-0.086
F	0.251	-0.160	0.158	0.414	0.929	-0.141	0.567	0.007	0.229	0.087	-0.271	-0.115	0.197	-0.342	-0.135	-0.049
G	0.140	-0.047	0.072	-0.162	-0.141	0.873	0.059	-0.101	-0.102	-0.111	0.081	-0.112	-0.198	-0.103	0.428	-0.135
H	0.344	-0.139	0.295	0.521	0.567	0.059	0.995	-0.072	0.140	0.097	-0.260	-0.349	0.205	-0.336	0.085	-0.276
I	0.076	0.105	-0.096	-0.106	0.007	-0.101	-0.072	0.775	-0.053	0.137	0.041	0.183	-0.131	0.007	-0.146	0.142
L	0.038	-0.084	-0.259	0.362	0.229	-0.102	0.140	-0.053	0.912	-0.028	-0.124	0.155	0.193	-0.008	-0.170	0.268
M	0.047	0.066	0.085	0.140	0.087	-0.111	0.097	0.137	-0.028	0.945	-0.130	-0.150	0.104	0.025	-0.094	-0.137
N	-0.046	0.012	-0.123	-0.303	-0.271	0.081	-0.260	0.041	-0.124	-0.130	0.823	0.149	-0.179	0.107	0.033	0.087
O	-0.091	0.027	-0.456	-0.210	-0.115	-0.112	-0.349	0.183	0.155	-0.150	0.149	0.910	-0.174	0.050	-0.263	0.546
Q1	-0.048	0.003	0.065	0.373	0.197	-0.198	0.205	-0.131	0.193	0.104	-0.179	-0.174	0.969	0.034	-0.055	-0.089
Q2	-0.374	0.051	-0.073	-0.086	-0.342	-0.103	-0.336	0.007	-0.008	0.025	0.107	0.050	0.034	0.998	-0.006	-0.004
Q3	0.026	-0.038	0.217	-0.115	-0.135	0.428	0.085	-0.146	-0.170	-0.094	0.033	-0.263	-0.055	-0.006	0.843	-0.288
Q4	-0.036	-0.009	-0.519	-0.086	-0.049	-0.135	-0.276	0.142	0.268	-0.137	0.087	0.546	-0.089	-0.004	-0.288	0.878
Form B																
A	0.516	-0.050	0.123	0.207	0.321	0.031	0.398	0.123	0.075	0.080	-0.114	-0.101	0.013	-0.344	-0.023	-0.049
B	-0.111	0.288	-0.023	-0.094	-0.137	-0.025	-0.100	0.006	-0.074	-0.023	0.014	-0.047	-0.023	0.022	0.054	-0.022
C	0.087	0.029	0.437	0.031	0.035	0.124	0.186	-0.129	-0.205	0.119	-0.102	-0.455	-0.006	0.019	0.186	-0.461
E	-0.021	-0.064	0.109	0.548	0.219	-0.094	0.401	-0.144	0.242	0.163	-0.214	-0.265	0.360	0.022	-0.020	-0.156
F	0.301	-0.145	0.216	0.421	0.675	-0.187	0.563	0.023	0.206	0.054	-0.252	-0.159	0.160	-0.261	-0.156	-0.100
G	0.174	-0.020	0.074	-0.306	-0.162	0.535	-0.025	0.089	-0.181	0.018	0.122	0.016	-0.223	-0.097	0.358	-0.060
H	0.294	-0.086	0.367	0.409	0.458	0.053	0.743	-0.064	0.001	0.098	-0.246	-0.379	0.174	-0.247	0.124	-0.345
I	0.042	0.109	-0.078	-0.207	-0.154	0.027	-0.104	0.482	-0.119	0.054	0.081	0.170	-0.201	0.067	-0.078	0.059
L	-0.106	-0.024	-0.236	0.183	0.016	-0.035	0.008	-0.161	0.319	-0.123	-0.003	0.192	0.186	0.098	-0.080	0.254
M	-0.067	0.077	0.019	0.269	0.081	-0.167	0.154	0.253	0.038	0.309	-0.175	-0.097	0.156	0.009	-0.116	-0.099
N	-0.004	0.028	0.134	-0.363	-0.204	0.188	-0.206	-0.043	-0.235	-0.084	0.178	-0.038	-0.132	0.099	0.222	-0.103
O	-0.099	0.056	-0.471	-0.197	-0.155	-0.099	-0.362	0.256	0.072	-0.112	0.140	0.553	-0.139	0.038	-0.258	0.541
Q1	0.016	0.062	-0.015	0.321	0.146	-0.122	0.206	0.027	0.191	0.222	-0.137	-0.071	0.363	-0.039	-0.085	-0.034
Q2	-0.340	0.140	-0.194	-0.112	-0.385	-0.077	-0.388	0.020	0.007	0.017	0.099	0.135	-0.028	0.405	-0.050	0.077
Q3	0.060	-0.046	0.280	-0.004	-0.102	0.443	0.156	-0.166	-0.145	-0.060	0.006	-0.337	-0.033	0.010	0.468	-0.343
Q4	-0.019	0.021	-0.424	0.042	0.098	-0.202	-0.119	0.212	0.295	-0.091	0.026	0.440	0.014	-0.016	-0.325	0.575

Table A8 part one: Covariance matrix for science total group

	Form B															
Form A	A	B	C	E	F	G	H	I	L	M	N	O	Q1	Q2	Q3	Q4
A	0.516	-0.111	0.087	-0.021	0.301	0.174	0.294	0.042	-0.106	-0.067	-0.004	-0.099	0.016	-0.340	0.060	-0.019
B	-0.050	0.288	0.029	-0.064	-0.145	-0.020	-0.086	0.109	-0.024	0.077	0.028	0.056	0.062	0.140	-0.046	0.021
C	0.123	-0.023	0.437	0.109	0.216	0.074	0.367	-0.078	-0.236	0.019	0.134	-0.471	-0.015	-0.194	0.280	-0.424
E	0.207	-0.094	0.031	0.548	0.421	-0.306	0.409	-0.207	0.183	0.269	-0.363	-0.197	0.321	-0.112	-0.004	0.042
F	0.321	-0.137	0.035	0.219	0.675	-0.162	0.458	-0.154	0.016	0.081	-0.204	-0.155	0.146	-0.385	-0.102	0.098
G	0.031	-0.025	0.124	-0.094	-0.187	0.535	0.053	0.027	-0.035	-0.167	0.188	-0.099	-0.122	-0.077	0.443	-0.202
H	0.398	-0.100	0.186	0.401	0.563	-0.025	0.743	-0.104	0.008	0.154	-0.206	-0.362	0.206	-0.388	0.156	-0.119
I	0.123	0.006	-0.129	-0.144	0.023	0.089	-0.064	0.482	-0.161	0.253	-0.043	0.256	0.027	0.020	-0.166	0.212
L	0.075	-0.074	-0.205	0.242	0.206	-0.181	0.001	-0.119	0.319	0.038	-0.235	0.072	0.191	0.007	-0.145	0.295
M	0.080	-0.023	0.119	0.163	0.054	0.018	0.098	0.054	-0.123	0.309	-0.084	-0.112	0.222	0.017	-0.060	-0.091
N	-0.114	0.014	-0.102	-0.214	-0.252	0.122	-0.246	0.081	-0.003	-0.175	0.178	0.140	-0.137	0.099	0.006	0.026
O	-0.101	-0.047	-0.455	-0.265	-0.159	0.016	-0.379	0.170	0.192	-0.097	-0.038	0.553	-0.071	0.135	-0.337	0.440
Q1	0.013	-0.023	-0.006	0.360	0.160	-0.223	0.174	-0.201	0.186	0.156	-0.132	-0.139	0.363	-0.028	-0.033	0.014
Q2	-0.344	0.022	0.019	0.022	-0.261	-0.097	-0.247	0.067	0.098	0.009	0.099	0.038	-0.039	0.405	0.010	-0.016
Q3	-0.023	0.054	0.186	-0.020	-0.156	0.358	0.124	-0.078	-0.080	-0.116	0.222	-0.258	-0.085	-0.050	0.468	-0.325
Q4	-0.049	-0.022	-0.461	-0.156	-0.100	-0.060	-0.345	0.059	0.254	-0.099	-0.103	0.541	-0.034	0.077	-0.343	0.575
Form B																
A	0.942	0.014	0.100	0.085	0.337	0.123	0.334	0.093	-0.059	0.020	-0.017	-0.120	0.134	-0.329	0.001	0.026
B	0.014	0.886	0.029	-0.072	-0.064	0.020	-0.068	0.039	-0.011	0.005	0.020	0.008	0.024	0.012	0.018	-0.038
C	0.100	0.029	0.850	0.074	0.070	0.043	0.288	-0.035	-0.218	0.011	0.124	-0.492	-0.065	-0.126	0.320	-0.453
E	0.085	-0.072	0.074	0.962	0.231	-0.238	0.331	-0.214	0.228	0.251	-0.265	-0.244	0.290	0.044	0.085	-0.078
F	0.337	-0.064	0.070	0.231	1.036	-0.274	0.495	-0.109	0.024	0.076	-0.257	-0.218	0.118	-0.355	-0.147	0.092
G	0.123	0.020	0.043	-0.238	-0.274	1.031	0.003	0.182	-0.070	-0.076	0.228	0.056	-0.103	-0.090	0.320	-0.124
H	0.334	-0.068	0.288	0.331	0.495	0.003	0.957	-0.070	-0.087	0.168	-0.097	-0.455	0.142	-0.375	0.188	-0.225
I	0.093	0.039	-0.035	-0.214	-0.109	0.182	-0.070	0.909	-0.185	0.207	0.007	0.237	-0.067	0.044	-0.054	0.101
L	-0.059	-0.011	-0.218	0.228	0.024	-0.070	-0.087	-0.185	0.937	-0.106	-0.112	0.122	0.146	0.167	-0.067	0.205
M	0.020	0.005	0.011	0.251	0.076	-0.076	0.168	0.207	-0.106	0.931	-0.196	-0.018	0.339	0.092	-0.050	0.010
N	-0.017	0.020	0.124	-0.265	-0.257	0.228	-0.097	0.007	-0.112	-0.196	0.857	-0.068	-0.129	0.039	0.197	-0.197
O	-0.120	0.008	-0.492	-0.244	-0.218	0.056	-0.455	0.237	0.122	-0.018	-0.068	0.905	-0.037	0.117	-0.326	0.492
Q1	0.134	0.024	-0.065	0.290	0.118	-0.103	0.142	-0.067	0.146	0.339	-0.129	-0.037	0.973	-0.021	-0.025	0.091
Q2	-0.329	0.012	-0.126	0.044	-0.355	-0.090	-0.375	0.044	0.167	0.092	0.039	0.117	-0.021	0.885	-0.023	0.025
Q3	0.001	0.018	0.320	0.085	-0.147	0.320	0.188	-0.054	-0.067	-0.050	0.197	-0.326	-0.025	-0.023	0.903	-0.401
Q4	0.026	-0.038	-0.453	-0.078	0.092	-0.124	-0.225	0.101	0.205	0.010	-0.197	0.492	0.091	0.025	-0.401	0.884

Table A8 part two: Covariance matrix for science total group

Form A	A	B	C	E	F	G	H	I	L	M	N	O	Q1	Q2	Q3	Q4
A	0.892	-0.029	0.122	0.049	0.235	0.147	0.323	0.012	0.000	0.016	0.014	-0.141	-0.043	-0.325	0.083	-0.104
B	-0.029	0.993	-0.030	-0.062	-0.126	-0.001	-0.082	0.092	-0.085	0.071	-0.005	-0.031	0.017	0.027	0.010	-0.040
C	0.122	-0.030	1.026	0.066	0.176	0.017	0.333	-0.095	-0.276	0.130	-0.114	-0.521	0.059	-0.087	0.261	-0.589
E	0.049	-0.062	0.066	0.903	0.434	-0.187	0.524	-0.091	0.339	0.114	-0.316	-0.139	0.343	-0.098	-0.180	-0.001
F	0.235	-0.126	0.176	0.434	0.934	-0.173	0.565	-0.046	0.215	0.081	-0.298	-0.138	0.222	-0.331	-0.164	-0.071
G	0.147	-0.001	0.017	-0.187	-0.173	0.900	0.019	-0.070	-0.113	-0.140	0.138	-0.085	-0.223	-0.051	0.460	-0.103
H	0.323	-0.082	0.333	0.524	0.565	0.019	1.021	-0.085	0.111	0.115	-0.267	-0.351	0.195	-0.309	0.072	-0.275
I	0.012	0.092	-0.095	-0.091	-0.046	-0.070	-0.085	0.753	-0.006	0.145	0.069	0.081	-0.080	0.052	-0.095	0.084
L	0.000	-0.085	-0.276	0.339	0.215	-0.113	0.111	-0.006	0.946	-0.039	-0.122	0.213	0.203	0.006	-0.222	0.332
M	0.016	0.071	0.130	0.114	0.081	-0.140	0.115	0.145	-0.039	0.964	-0.103	-0.163	0.163	0.014	-0.092	-0.136
N	0.014	-0.005	-0.114	-0.316	-0.298	0.138	-0.267	0.069	-0.122	-0.103	0.868	0.119	-0.184	0.101	0.119	0.061
O	-0.141	-0.031	-0.521	-0.139	-0.138	-0.085	-0.351	0.081	0.213	-0.163	0.119	0.889	-0.112	0.089	-0.281	0.537
Q1	-0.043	0.017	0.059	0.343	0.222	-0.223	0.195	-0.080	0.203	0.163	-0.184	-0.112	0.957	-0.010	-0.154	-0.033
Q2	-0.325	0.027	-0.087	-0.098	-0.331	-0.051	-0.309	0.052	0.006	0.014	0.101	0.089	-0.010	0.960	0.007	0.067
Q3	0.083	0.010	0.261	-0.180	-0.164	0.460	0.072	-0.095	-0.222	-0.092	0.119	-0.281	-0.154	0.007	0.913	-0.351
Q4	-0.104	-0.040	-0.589	-0.001	-0.071	-0.103	-0.275	0.084	0.332	-0.136	0.061	0.537	-0.033	0.067	-0.351	0.887
Form B																
A	0.494	0.000	0.132	0.155	0.283	0.029	0.350	0.055	0.036	0.084	-0.064	-0.157	0.050	-0.299	0.019	-0.112
B	-0.029	0.310	-0.023	-0.041	-0.076	0.001	-0.045	-0.003	-0.052	0.008	-0.004	-0.035	-0.003	0.011	0.041	-0.015
C	0.164	0.051	0.507	0.007	0.056	0.153	0.255	-0.118	-0.262	0.093	-0.068	-0.483	-0.009	-0.054	0.297	-0.504
E	-0.010	-0.042	0.103	0.493	0.266	-0.148	0.402	-0.093	0.235	0.133	-0.221	-0.151	0.345	0.015	-0.106	-0.052
F	0.256	-0.121	0.189	0.475	0.678	-0.202	0.576	-0.065	0.234	0.055	-0.269	-0.142	0.199	-0.271	-0.192	-0.086
G	0.136	0.036	0.016	-0.238	-0.211	0.512	-0.041	0.030	-0.130	-0.032	0.148	-0.010	-0.231	-0.052	0.373	-0.071
H	0.306	-0.040	0.400	0.421	0.476	-0.013	0.786	-0.068	-0.008	0.109	-0.235	-0.391	0.138	-0.241	0.111	-0.348
I	-0.030	0.092	-0.109	-0.136	-0.151	0.016	-0.103	0.340	-0.090	0.088	0.076	0.086	-0.187	0.032	-0.028	0.035
L	-0.095	-0.019	-0.288	0.178	0.006	-0.007	-0.029	-0.074	0.311	-0.104	-0.015	0.232	0.153	0.097	-0.111	0.275
M	-0.159	0.066	0.032	0.281	0.083	-0.240	0.134	0.191	0.082	0.317	-0.227	-0.089	0.196	0.038	-0.176	-0.042
N	0.061	0.047	0.118	-0.350	-0.196	0.223	-0.134	-0.008	-0.221	-0.068	0.232	-0.065	-0.150	0.042	0.291	-0.149
O	-0.164	0.011	-0.534	-0.153	-0.176	-0.073	-0.382	0.151	0.154	-0.100	0.128	0.545	-0.094	0.085	-0.287	0.543
Q1	-0.036	0.087	-0.011	0.281	0.139	-0.206	0.156	0.052	0.176	0.273	-0.162	-0.044	0.440	0.000	-0.154	-0.003
Q2	-0.362	0.048	-0.213	-0.114	-0.396	-0.073	-0.415	0.042	0.051	-0.020	0.091	0.182	0.037	0.456	-0.059	0.144
Q3	0.119	0.023	0.298	-0.056	-0.120	0.438	0.150	-0.097	-0.184	-0.045	0.065	-0.348	-0.074	-0.004	0.528	-0.367
Q4	-0.068	-0.017	-0.490	0.129	0.091	-0.196	-0.144	0.122	0.386	-0.089	-0.008	0.445	0.059	0.023	-0.385	0.596

Table A9 part one: Pooled within-group covariance matrix

	Form B															
Form A	A	B	C	E	F	G	H	I	L	M	N	O	Q1	Q2	Q3	Q4
A	0.494	-0.029	0.164	-0.010	0.256	0.136	0.306	-0.030	-0.095	-0.159	0.061	-0.164	-0.036	-0.362	0.119	-0.068
B	0.000	0.310	0.051	-0.042	-0.121	0.036	-0.040	0.092	-0.019	0.066	0.047	0.011	0.087	0.048	0.023	-0.017
C	0.132	-0.023	0.507	0.103	0.189	0.016	0.400	-0.109	-0.288	0.032	0.118	-0.534	-0.011	-0.213	0.298	-0.490
E	0.155	-0.041	0.007	0.493	0.475	-0.238	0.421	-0.136	0.178	0.281	-0.350	-0.153	0.281	-0.114	-0.056	0.129
F	0.283	-0.076	0.056	0.266	0.678	-0.211	0.476	-0.151	0.006	0.083	-0.196	-0.176	0.139	-0.396	-0.120	0.091
G	0.029	0.001	0.153	-0.148	-0.202	0.512	-0.013	0.016	-0.007	-0.240	0.223	-0.073	-0.206	-0.073	0.438	-0.196
H	0.350	-0.045	0.255	0.402	0.576	-0.041	0.786	-0.103	-0.029	0.134	-0.134	-0.382	0.156	-0.415	0.150	-0.144
I	0.055	-0.003	-0.118	-0.093	-0.065	0.030	-0.088	0.340	-0.074	0.191	-0.008	0.151	0.052	0.042	-0.097	0.122
L	0.036	-0.052	-0.262	0.235	0.234	-0.130	-0.008	-0.090	0.311	0.082	-0.221	0.154	0.176	0.051	-0.184	0.386
M	0.084	0.008	0.093	0.133	0.055	-0.032	0.109	0.088	-0.104	0.317	-0.068	-0.100	0.273	-0.020	-0.045	-0.089
N	-0.064	-0.004	-0.068	-0.221	-0.269	0.148	-0.235	0.076	-0.015	-0.227	0.232	0.128	-0.162	0.091	0.065	-0.008
O	-0.157	-0.035	-0.483	-0.151	-0.142	-0.010	-0.391	0.086	0.232	-0.089	-0.065	0.545	-0.044	0.182	-0.348	0.445
Q1	0.050	-0.003	-0.009	0.345	0.199	-0.231	0.138	-0.187	0.153	0.196	-0.150	-0.094	0.440	0.037	-0.074	0.059
Q2	-0.299	0.011	-0.054	0.015	-0.271	-0.052	-0.241	0.032	0.097	0.038	0.042	0.085	0.000	0.456	-0.004	0.023
Q3	0.019	0.041	0.297	-0.106	-0.192	0.373	0.111	-0.028	-0.111	-0.176	0.291	-0.287	-0.154	-0.059	0.528	-0.385
Q4	-0.112	-0.015	-0.504	-0.052	-0.086	-0.071	-0.348	0.035	0.275	-0.042	-0.149	0.543	-0.003	0.144	-0.367	0.596
Form B																
A	0.855	0.028	0.143	0.098	0.280	0.070	0.320	0.024	-0.080	-0.051	0.011	-0.170	0.088	-0.324	0.018	-0.029
B	0.028	0.843	0.031	-0.023	-0.056	0.019	-0.007	0.029	-0.029	-0.008	0.012	0.007	0.044	0.018	0.044	-0.002
C	0.143	0.031	0.915	0.002	0.078	0.074	0.340	-0.048	-0.269	-0.044	0.181	-0.531	-0.065	-0.217	0.363	-0.507
E	0.098	-0.023	0.002	0.889	0.301	-0.201	0.341	-0.150	0.214	0.302	-0.263	-0.158	0.315	0.055	-0.002	0.024
F	0.280	-0.056	0.078	0.301	1.027	-0.271	0.509	-0.156	0.032	0.082	-0.271	-0.224	0.124	-0.344	-0.152	0.106
G	0.070	0.019	0.074	-0.201	-0.271	0.985	-0.031	0.094	-0.036	-0.126	0.221	-0.017	-0.169	-0.067	0.361	-0.179
H	0.320	-0.007	0.340	0.341	0.509	-0.031	1.001	-0.103	-0.089	0.135	-0.049	-0.486	0.108	-0.385	0.181	-0.241
I	0.024	0.029	-0.048	-0.150	-0.156	0.094	-0.103	0.794	-0.116	0.179	0.018	0.145	-0.044	0.004	-0.063	0.068
L	-0.080	-0.029	-0.269	0.214	0.032	-0.036	-0.089	-0.116	0.908	-0.058	-0.145	0.203	0.125	0.202	-0.066	0.273
M	-0.051	-0.008	-0.044	0.302	0.082	-0.126	0.135	0.179	-0.058	0.971	-0.244	-0.032	0.378	0.101	-0.131	0.040
N	0.011	0.012	0.181	-0.263	-0.271	0.221	-0.049	0.018	-0.145	-0.244	0.917	-0.083	-0.171	0.004	0.231	-0.239
O	-0.170	0.007	-0.531	-0.158	-0.224	-0.017	-0.486	0.145	0.203	-0.032	-0.083	0.878	-0.029	0.189	-0.338	0.504
Q1	0.088	0.044	-0.065	0.315	0.124	-0.169	0.108	-0.044	0.125	0.378	-0.171	-0.029	1.005	0.035	-0.083	0.096
Q2	-0.324	0.018	-0.217	0.055	-0.344	-0.067	-0.385	0.004	0.202	0.101	0.004	0.189	0.035	0.957	-0.048	0.103
Q3	0.018	0.044	0.363	-0.002	-0.152	0.361	0.181	-0.063	-0.066	-0.131	0.231	-0.338	-0.083	-0.048	0.960	-0.414
Q4	-0.029	-0.002	-0.507	0.024	0.106	-0.179	-0.241	0.068	0.273	0.040	-0.239	0.504	0.096	0.103	-0.414	0.909

Table A9 part two: Pooled within-group covariance matrix

Form A	A	B	C	E	F	G	H	I	L	M	N	O	Q1	Q2	Q3	Q4
A	0.984	-0.030	0.084	0.019	0.259	0.127	0.337	0.186	0.002	0.055	0.046	-0.091	-0.054	-0.332	0.038	-0.053
B	-0.030	0.991	-0.028	-0.065	-0.126	-0.001	-0.083	0.091	-0.087	0.069	-0.004	-0.030	0.014	0.026	0.010	-0.038
C	0.084	-0.028	1.045	0.072	0.166	0.028	0.326	-0.172	-0.283	0.104	-0.127	-0.537	0.057	-0.090	0.281	-0.607
E	0.019	-0.065	0.072	0.960	0.426	-0.177	0.544	-0.171	0.371	0.123	-0.350	-0.188	0.395	-0.097	-0.159	-0.051
F	0.259	-0.126	0.166	0.426	0.938	-0.177	0.568	-0.002	0.215	0.090	-0.290	-0.125	0.219	-0.333	-0.175	-0.059
G	0.127	-0.001	0.028	-0.177	-0.177	0.903	0.019	-0.114	-0.112	-0.150	0.128	-0.098	-0.218	-0.053	0.470	-0.116
H	0.337	-0.083	0.326	0.544	0.568	0.019	1.034	-0.076	0.127	0.127	-0.276	-0.361	0.218	-0.313	0.069	-0.285
I	0.186	0.091	-0.172	-0.171	-0.002	-0.114	-0.076	1.104	-0.015	0.220	0.146	0.192	-0.125	0.050	-0.186	0.198
L	0.002	-0.087	-0.283	0.371	0.215	-0.112	0.127	-0.015	0.968	-0.021	-0.136	0.191	0.235	0.008	-0.220	0.310
M	0.055	0.069	0.104	0.123	0.090	-0.150	0.127	0.220	-0.021	0.998	-0.095	-0.156	0.180	0.020	-0.113	-0.127
N	0.046	-0.004	-0.127	-0.350	-0.290	0.128	-0.276	0.146	-0.136	-0.095	0.891	0.153	-0.211	0.103	0.099	0.096
O	-0.091	-0.030	-0.537	-0.188	-0.125	-0.098	-0.361	0.192	0.191	-0.156	0.153	0.937	-0.151	0.087	-0.308	0.586
Q1	-0.054	0.014	0.057	0.395	0.219	-0.218	0.218	-0.125	0.235	0.180	-0.211	-0.151	1.004	-0.010	-0.143	-0.073
Q2	-0.332	0.026	-0.090	-0.097	-0.333	-0.053	-0.313	0.050	0.008	0.020	0.103	0.087	-0.010	0.966	0.007	0.066
Q3	0.038	0.010	0.281	-0.159	-0.175	0.470	0.069	-0.186	-0.220	-0.113	0.099	-0.308	-0.143	0.007	0.935	-0.379
Q4	-0.053	-0.038	-0.607	-0.051	-0.059	-0.116	-0.285	0.198	0.310	-0.127	0.096	0.586	-0.073	0.066	-0.379	0.936
Form B																
A	0.595	-0.002	0.088	0.146	0.310	0.009	0.378	0.231	0.054	0.135	-0.042	-0.120	0.061	-0.309	-0.027	-0.074
B	-0.021	0.310	-0.026	-0.060	-0.075	-0.003	-0.053	0.023	-0.062	0.007	0.008	-0.019	-0.020	0.012	0.034	0.001
C	0.124	0.050	0.522	0.031	0.046	0.162	0.255	-0.199	-0.255	0.080	-0.088	-0.511	0.007	-0.053	0.317	-0.533
E	-0.055	-0.046	0.114	0.571	0.255	-0.134	0.427	-0.208	0.277	0.142	-0.268	-0.220	0.413	0.017	-0.077	-0.121
F	0.281	-0.121	0.180	0.482	0.684	-0.204	0.588	-0.033	0.242	0.066	-0.270	-0.140	0.211	-0.278	-0.199	-0.085
G	0.154	0.037	0.016	-0.262	-0.205	0.508	-0.045	0.064	-0.145	-0.041	0.160	0.012	-0.253	-0.060	0.365	-0.050
H	0.313	-0.041	0.396	0.438	0.478	-0.012	0.797	-0.088	0.005	0.117	-0.244	-0.400	0.156	-0.244	0.111	-0.358
I	0.104	0.092	-0.166	-0.209	-0.117	-0.018	-0.101	0.615	-0.106	0.139	0.141	0.179	-0.233	0.029	-0.100	0.131
L	-0.108	-0.021	-0.285	0.230	0.004	0.000	-0.005	-0.128	0.341	-0.093	-0.045	0.190	0.201	0.093	-0.098	0.233
M	-0.145	0.065	0.023	0.285	0.087	-0.243	0.140	0.215	0.088	0.328	-0.226	-0.087	0.203	0.037	-0.182	-0.041
N	0.057	0.047	0.120	-0.355	-0.197	0.223	-0.138	-0.011	-0.225	-0.073	0.234	-0.062	-0.157	0.043	0.291	-0.146
O	-0.105	0.013	-0.554	-0.213	-0.162	-0.089	-0.394	0.284	0.128	-0.091	0.169	0.604	-0.143	0.084	-0.321	0.603
Q1	-0.030	0.086	-0.017	0.293	0.140	-0.207	0.164	0.059	0.187	0.284	-0.166	-0.051	0.453	0.001	-0.157	-0.009
Q2	-0.381	0.047	-0.207	-0.092	-0.400	-0.068	-0.411	-0.001	0.061	-0.020	0.077	0.161	0.054	0.458	-0.048	0.123
Q3	0.078	0.023	0.313	-0.030	-0.130	0.447	0.151	-0.180	-0.176	-0.057	0.044	-0.378	-0.056	-0.003	[illegible]	-0.398
Q4	-0.011	-0.016	-0.508	0.082	0.105	-0.209	-0.149	0.241	0.366	-0.078	0.025	0.494	0.023	0.018	[illegible]	0.645

Table A10 part one: Covariance matrix for total group

	Form B															
Form A	A	B	C	E	F	G	H	I	L	M	N	O	Q1	Q2	Q3	Q4
A	0.595	-0.021	0.124	-0.055	0.281	0.154	0.313	0.104	-0.108	-0.145	0.057	-0.105	-0.030	-0.381	0.078	-0.011
B	-0.002	0.310	0.050	-0.046	-0.121	0.037	-0.041	0.092	-0.021	0.065	0.047	0.013	0.086	0.047	0.023	-0.016
C	0.088	-0.026	0.522	0.114	0.180	0.016	0.396	-0.166	-0.285	0.023	0.120	-0.554	-0.017	-0.207	0.313	-0.508
E	0.146	-0.060	0.031	0.571	0.482	-0.262	0.438	-0.209	0.230	0.285	-0.355	-0.213	0.293	-0.092	-0.030	0.082
F	0.310	-0.075	0.046	0.255	0.684	-0.205	0.478	-0.117	0.004	0.087	-0.197	-0.162	0.140	-0.400	-0.130	0.105
G	0.009	-0.003	0.162	-0.134	-0.204	0.508	-0.012	-0.018	0.000	-0.243	0.223	-0.089	-0.207	-0.068	0.447	-0.209
H	0.378	-0.053	0.255	0.427	0.588	-0.045	0.797	-0.101	-0.005	0.140	-0.138	-0.394	0.164	-0.411	0.151	-0.149
I	0.231	0.023	-0.199	-0.208	-0.033	0.064	-0.088	0.615	-0.128	0.215	-0.011	0.284	0.059	-0.001	-0.180	0.241
L	0.054	-0.062	-0.255	0.277	0.242	-0.145	0.005	-0.106	0.341	0.088	-0.225	0.128	0.187	0.061	-0.176	0.366
M	0.135	0.007	0.080	0.142	0.066	-0.041	0.117	0.139	-0.093	0.328	-0.073	-0.091	0.284	-0.020	-0.057	-0.078
N	-0.042	0.008	-0.088	-0.268	-0.270	0.160	-0.244	0.141	-0.045	-0.226	0.234	0.169	-0.166	0.077	0.044	0.025
O	-0.120	-0.019	-0.511	-0.220	-0.140	0.012	-0.400	0.179	0.190	-0.087	-0.062	0.604	-0.051	0.161	-0.378	0.494
Q1	0.061	-0.020	0.007	0.413	0.211	-0.253	0.156	-0.233	0.201	0.203	-0.157	-0.143	0.453	0.054	-0.056	0.023
Q2	-0.309	0.012	-0.053	0.017	-0.278	-0.060	-0.244	0.029	0.093	0.037	0.043	0.084	0.001	0.458	-0.003	0.018
Q3	-0.027	0.034	0.317	-0.077	-0.199	0.365	0.111	-0.100	-0.098	-0.182	0.291	-0.321	-0.157	-0.048	0.548	-0.415
Q4	-0.074	0.001	-0.533	-0.121	-0.085	-0.050	-0.358	0.131	0.233	-0.041	-0.146	0.603	-0.009	0.123	-0.398	0.645
Form B																
A	0.976	0.028	0.106	0.081	0.316	0.082	0.338	0.154	-0.071	-0.031	0.003	-0.128	0.101	-0.339	-0.020	0.019
B	0.028	0.847	0.024	-0.048	-0.060	0.025	-0.014	0.052	-0.047	-0.009	0.014	0.027	0.040	0.012	0.036	0.012
C	0.106	0.024	0.933	0.036	0.071	0.063	0.341	-0.114	-0.251	-0.048	0.180	-0.565	-0.065	-0.204	0.382	-0.537
E	0.081	-0.048	0.036	0.993	0.309	-0.235	0.364	-0.254	0.283	0.307	-0.270	-0.241	0.331	0.084	0.034	-0.041
F	0.316	-0.060	0.071	0.309	1.040	-0.267	0.518	-0.135	0.046	0.088	-0.274	-0.223	0.129	-0.345	-0.158	0.112
G	0.082	0.025	0.063	-0.235	-0.267	1.000	-0.035	0.126	-0.054	-0.127	0.222	0.008	-0.175	-0.078	0.348	-0.156
H	0.338	-0.014	0.341	0.364	0.518	-0.035	1.008	-0.108	-0.069	0.139	-0.053	-0.498	0.114	-0.381	0.183	-0.247
I	0.154	0.052	-0.114	-0.254	-0.135	0.126	-0.108	1.010	-0.167	0.195	0.017	0.257	-0.043	-0.033	-0.130	0.168
L	-0.071	-0.047	-0.251	0.283	0.046	-0.054	-0.069	-0.169	0.955	-0.051	-0.151	0.151	0.137	0.218	-0.047	0.237
M	-0.031	-0.009	-0.048	0.307	0.088	-0.127	0.139	0.195	-0.051	0.972	-0.245	-0.030	0.381	0.101	-0.134	0.043
N	0.003	0.014	0.180	-0.270	-0.274	0.222	-0.053	0.017	-0.151	-0.245	0.916	-0.079	-0.173	0.002	0.230	-0.237
O	-0.128	0.027	-0.565	-0.241	-0.223	0.008	-0.498	0.257	0.151	-0.030	-0.079	0.949	-0.037	0.164	-0.374	0.562
Q1	0.101	0.040	-0.065	0.331	0.129	-0.175	0.114	-0.043	0.137	0.381	-0.173	-0.037	1.008	0.039	-0.082	0.090
Q2	-0.339	0.012	-0.204	0.084	-0.345	-0.078	-0.381	-0.033	0.218	0.101	0.002	0.164	0.039	0.964	-0.036	0.081
Q3	-0.020	0.036	0.382	0.034	-0.158	0.348	0.183	-0.130	-0.047	-0.134	0.230	-0.374	-0.082	-0.036	0.979	-0.446
Q4	0.019	0.012	-0.537	-0.041	0.112	-0.156	-0.247	0.168	0.237	0.043	-0.237	0.562	0.090	0.081	-0.446	0.959

Table A10 part two: Covariance matrix for total group

	A	B	C	E	F	G	H	I	L	M	N	O	Q1	Q2	Q3	Q4
A	0.939	-0.044	0.307	0.127	0.350	0.314	0.512	-0.122	-0.070	-0.244	0.096	-0.299	-0.135	-0.519	0.268	-0.146
B	-0.032	0.556	0.007	-0.017	-0.139	-0.118	-0.039	0.301	-0.298	0.193	-0.047	0.033	0.020	0.048	-0.042	0.054
C	0.347	0.006	1.363	0.223	0.254	0.168	0.592	-0.449	-0.655	0.022	0.099	-1.013	0.067	-0.384	0.606	-0.967
E	0.137	-0.014	0.289	1.237	0.745	-0.251	0.727	-0.285	0.606	0.495	-0.885	-0.329	0.612	-0.175	-0.122	-0.034
F	0.407	-0.124	0.356	0.993	1.436	-0.222	0.735	-0.291	0.362	0.107	-0.717	-0.272	0.289	-0.610	-0.164	-0.036
G	0.375	-0.108	0.241	-0.344	-0.327	1.517	0.083	-0.104	-0.114	-0.394	0.438	-0.146	-0.395	-0.191	0.805	-0.226
H	0.576	-0.034	0.802	0.939	1.023	0.118	1.348	-0.294	-0.023	0.183	-0.419	-0.603	0.135	-0.618	0.270	-0.451
I	-0.110	0.209	-0.488	-0.295	-0.325	-0.119	-0.318	0.866	-0.016	0.425	0.108	0.384	-0.238	0.149	-0.272	0.392
L	-0.070	-0.230	-0.793	0.699	0.449	-0.146	-0.028	-0.015	1.074	0.056	-0.476	0.495	0.399	0.211	-0.292	0.687
M	-0.207	0.126	0.023	0.482	0.112	-0.425	0.186	0.347	0.051	0.768	-0.518	-0.162	0.597	0.060	-0.244	-0.043
N	0.101	-0.038	0.125	-1.066	-0.931	0.585	-0.527	0.109	-0.535	-0.492	1.174	0.023	-0.418	0.170	0.468	-0.184
O	-0.354	0.030	-1.444	-0.447	-0.398	-0.219	-0.855	0.436	0.626	-0.173	0.030	1.491	-0.215	0.313	-0.618	0.913
Q1	-0.142	0.016	0.085	0.741	0.377	-0.530	0.170	-0.241	0.450	0.570	-0.493	-0.286	1.185	0.083	-0.137	-0.048
Q2	-0.391	0.028	-0.349	-0.151	-0.569	-0.183	-0.558	0.108	0.170	0.041	0.143	0.297	0.070	0.605	-0.138	0.246
Q3	0.303	-0.037	0.826	-0.159	-0.230	1.158	0.366	-0.296	-0.353	-0.250	0.592	-0.882	-0.174	-0.125	1.364	-0.692
Q4	-0.198	0.056	-1.579	-0.053	-0.061	-0.389	-0.732	0.510	0.995	-0.053	-0.278	1.558	-0.073	0.267	-1.130	1.955

Table A11: Factor covariance (lower triangle) and correlation (upper triangle) matrix for male arts group

	A	B	C	E	F	G	H	I	L	M	N	O	Q1	Q2	Q3	Q4
A	0.737	-0.173	0.270	0.310	0.507	0.193	0.566	0.023	0.109	0.019	-0.261	-0.285	0.128	-0.775	0.111	-0.142
B	-0.101	0.464	-0.031	-0.263	-0.292	-0.025	-0.256	0.276	-0.241	0.198	0.152	0.124	0.039	0.246	-0.026	-0.019
C	0.233	-0.021	1.011	0.238	0.208	0.197	0.572	-0.260	-0.502	0.118	0.129	-0.974	-0.020	-0.158	0.560	-0.922
E	0.311	-0.209	0.279	1.364	0.667	-0.248	0.740	-0.186	0.575	0.424	-0.877	-0.443	0.766	-0.192	-0.012	-0.161
F	0.533	-0.244	0.256	0.954	1.502	-0.287	0.746	-0.180	0.376	0.127	-0.759	-0.308	0.350	-0.615	-0.206	-0.020
G	0.200	-0.021	0.240	-0.350	-0.425	1.463	0.105	-0.065	-0.204	-0.211	0.342	-0.194	-0.390	-0.263	0.844	-0.304
H	0.508	-0.182	0.601	0.904	0.956	0.133	1.093	-0.191	0.120	0.258	-0.573	-0.688	0.405	-0.575	0.309	-0.438
I	0.018	0.171	-0.238	-0.198	-0.201	-0.071	-0.182	0.827	-0.331	0.524	-0.035	0.388	-0.122	0.103	-0.177	0.183
L	0.089	-0.157	-0.482	0.641	0.440	-0.236	0.120	-0.287	0.911	-0.212	-0.600	0.243	0.586	0.021	-0.249	0.547
M	0.014	0.116	0.102	0.425	0.134	-0.219	0.231	0.409	-0.174	0.736	-0.488	-0.183	0.582	0.160	-0.117	-0.163
N	-0.225	0.104	0.130	-1.027	-0.933	0.415	-0.601	-0.032	-0.574	-0.420	1.005	0.056	-0.548	0.394	0.438	-0.229
O	-0.268	0.093	-1.075	-0.568	-0.414	-0.258	-0.789	0.387	0.254	-0.172	0.062	1.204	-0.232	0.161	-0.631	0.876
Q1	0.094	0.023	-0.017	0.765	0.367	-0.403	0.362	-0.095	0.478	0.427	-0.470	-0.218	0.731	0.043	-0.213	0.001
Q2	-0.556	0.140	-0.133	-0.187	-0.630	-0.266	-0.503	0.078	0.017	0.115	0.330	0.148	0.031	0.699	-0.035	0.011
Q3	0.100	-0.019	0.593	-0.015	-0.266	1.075	0.340	-0.170	-0.250	-0.106	0.463	-0.730	-0.192	-0.031	1.110	-0.663
Q4	-0.151	-0.016	-1.149	-0.233	-0.031	-0.456	-0.567	0.206	0.647	-0.173	-0.285	1.191	0.001	0.011	-0.865	1.535

Table A12: Factor covariance (lower triangle) and correlation (upper triangle) matrix for male science group

	A	B	C	E	F	G	H	I	L	M	N		Q1	Q2	Q3	Q4
A	0.744	0.100	0.297	-0.013	0.412	0.126	0.426	0.053	-0.231	-0.325	0.239	[illegible]	-0.031	-0.654	0.109	-0.180
B	0.074	0.739	0.072	-0.066	-0.148	0.201	-0.016	0.086	-0.031	0.029	0.061	[illegible]	0.167	-0.073	0.187	-0.135
C	0.280	0.068	1.196	-0.044	0.150	0.074	0.489	-0.082	-0.749	0.022	0.171	[illegible]	-0.036	-0.348	0.621	-0.953
E	-0.013	-0.068	-0.058	1.444	0.665	-0.482	0.657	-0.374	0.682	0.607	-0.765	[illegible]	0.662	0.049	-0.322	0.194
F	0.443	-0.159	0.204	0.996	1.555	-0.495	0.719	-0.249	0.201	0.177	-0.507	-0.262	0.306	-0.488	-0.398	0.081
G	0.149	0.237	0.110	-0.793	-0.845	1.872	-0.161	0.100	-0.182	-0.528	0.639	-0.045	-0.548	-0.031	0.779	-0.217
H	0.431	-0.016	0.627	0.925	1.050	-0.258	1.373	-0.138	-0.008	0.195	-0.218	-0.594	0.240	-0.462	0.091	-0.280
I	0.043	0.070	-0.085	-0.426	-0.294	0.130	-0.153	0.898	-0.353	0.302	0.243	0.084	-0.250	-0.214	-0.022	0.011
L	-0.166	-0.022	-0.681	0.682	0.209	-0.207	-0.008	-0.278	0.692	0.091	-0.475	0.535	0.425	0.377	-0.446	0.791
M	-0.325	0.029	0.028	0.845	0.255	-0.837	0.265	0.331	0.088	1.341	-0.745	-0.159	0.659	0.181	-0.414	0.004
N	0.199	0.051	0.180	-0.887	-0.610	0.844	-0.246	0.222	-0.381	-0.832	0.931	0.011	-0.557	-0.018	0.652	-0.316
O	-0.300	-0.114	-1.181	-0.274	-0.364	-0.068	-0.776	0.089	0.496	-0.205	0.012	1.244	-0.062	0.304	-0.559	0.883
Q1	-0.026	0.141	-0.039	0.780	0.374	-0.734	0.275	-0.232	0.346	0.748	-0.527	-0.068	0.960	0.169	-0.392	0.118
Q2	-0.467	-0.052	-0.315	0.049	-0.504	-0.035	-0.448	-0.168	0.260	0.174	-0.014	0.281	0.137	0.686	-0.017	0.201
Q3	0.128	0.219	0.928	-0.529	-0.678	1.455	0.145	-0.029	-0.507	-0.655	0.859	-0.851	-0.525	-0.019	1.865	-0.692
Q4	-0.177	-0.132	-1.187	0.265	0.115	-0.338	-0.374	0.012	0.750	0.005	-0.347	1.122	0.132	0.190	-1.077	1.298

Table A13: Factor covariance (lower triangle) and correlation (upper triangle) matrix for female arts group

	A	B	C	E	F	G	H	I	L	M	N	O	Q1	Q2	Q3	Q4
A	0.974	-0.033	0.234	0.280	0.521	0.142	0.598	0.129	-0.019	0.039	0.000	-0.315	0.191	-0.685	0.024	-0.085
B	-0.025	0.576	-0.063	-0.058	-0.204	-0.123	-0.124	0.150	-0.003	0.075	-0.003	-0.024	0.117	0.150	-0.066	0.004
C	0.265	-0.055	1.318	-0.080	0.266	0.133	0.303	-0.063	-0.936	0.015	0.168	-0.974	-0.069	-0.408	0.549	-0.971
E	0.337	-0.054	-0.112	1.489	0.557	-0.475	0.663	-0.160	0.607	0.617	-0.968	-0.123	0.604	-0.185	-0.186	0.172
F	0.607	-0.183	0.361	0.803	1.394	-0.365	0.748	-0.051	0.213	0.198	-0.526	-0.315	0.278	-0.686	-0.239	-0.051
G	0.189	-0.126	0.206	-0.782	-0.581	1.821	-0.066	0.092	-0.250	-0.313	0.709	0.022	-0.239	-0.034	0.718	-0.208
H	0.724	-0.115	0.427	0.992	1.082	-0.110	1.503	-0.057	0.023	0.270	-0.399	-0.465	0.275	-0.710	0.117	-0.278
I	0.123	0.110	-0.070	-0.188	-0.058	0.120	-0.067	0.930	-0.019	0.537	-0.002	0.261	-0.069	0.254	-0.278	0.089
L	-0.019	-0.002	-1.090	0.751	0.255	-0.342	0.028	-0.019	1.028	0.065	-0.441	0.727	0.352	0.263	-0.563	1.021
M	0.044	0.065	0.020	0.865	0.269	-0.485	0.380	0.595	0.076	1.320	-0.708	-0.055	0.651	0.011	-0.325	-0.096
N	0.000	-0.002	0.165	-1.012	-0.532	0.820	-0.419	-0.002	-0.383	-0.697	0.734	-0.020	-0.391	0.167	0.497	-0.227
O	-0.351	-0.021	-1.264	-0.169	-0.420	0.033	-0.645	0.284	0.833	-0.071	-0.019	1.278	-0.064	0.405	-0.475	0.912
Q1	0.184	0.087	-0.077	0.720	0.321	-0.315	0.330	-0.065	0.349	0.731	-0.327	-0.071	0.955	-0.250	-0.051	0.060
Q2	-0.604	0.102	-0.418	-0.202	-0.724	-0.041	-0.778	0.219	0.238	0.011	0.128	0.409	-0.218	0.798	-0.108	0.238
Q3	0.028	-0.060	0.753	-0.271	-0.337	1.158	0.171	-0.320	-0.682	-0.446	0.509	-0.642	-0.060	-0.115	1.427	-0.587
Q4	-0.113	0.004	-1.510	0.284	-0.081	-0.380	-0.462	0.116	1.402	-0.149	-0.264	1.397	0.080	0.288	-0.950	1.836

Table A14: Factor covariance (lower triangle) and correlation (upper triangle) matrix for female science group

	A	B	C	E	F	G	H	I	L	M	N	O	Q1	Q2	Q3	Q4
A	0.897	-0.105	0.194	0.269	0.473	0.208	0.556	0.196	0.130	-0.012	-0.129	-0.246	0.093	-0.625	0.090	-0.099
B	-0.068	0.469	0.001	-0.138	-0.205	-0.055	-0.139	0.232	-0.253	0.191	0.052	0.072	0.021	0.149	-0.028	0.008
C	0.206	0.001	1.251	0.209	0.211	0.181	0.548	-0.352	-0.573	0.061	0.114	-0.990	-0.007	-0.272	0.584	-0.947
E	0.280	-0.104	0.257	1.205	0.703	-0.251	0.738	-0.150	0.597	0.463	-0.871	-0.384	0.695	-0.185	-0.076	-0.093
F	0.531	-0.166	0.279	0.914	1.404	-0.254	0.750	-0.130	0.391	0.135	-0.734	-0.286	0.337	-0.632	-0.195	-0.024
G	0.251	-0.048	0.258	-0.350	-0.383	1.620	0.093	-0.083	-0.169	-0.288	0.381	-0.173	-0.401	-0.222	0.819	-0.270
H	0.588	-0.106	0.684	0.904	0.992	0.132	1.245	-0.131	0.096	0.243	-0.500	-0.631	0.285	-0.606	0.264	-0.423
I	0.192	0.164	-0.407	-0.170	-0.159	-0.109	-0.151	1.070	-0.068	0.490	0.000	0.346	-0.048	0.090	-0.256	0.268
L	0.133	-0.187	-0.691	0.706	0.500	-0.232	0.115	-0.076	1.162	-0.064	-0.536	0.347	0.511	0.087	-0.287	0.605
M	-0.009	0.103	0.054	0.399	0.126	-0.288	0.213	0.398	-0.054	0.617	-0.501	-0.173	0.621	0.114	-0.191	-0.100
N	-0.102	0.030	0.107	-0.800	-0.728	0.406	-0.467	0.000	-0.483	-0.329	0.700	0.041	-0.501	0.259	0.452	-0.209
O	-0.275	0.058	-1.305	-0.497	-0.399	-0.259	-0.829	0.422	0.441	-0.160	0.040	1.388	-0.215	0.241	-0.624	0.896
Q1	0.084	0.014	-0.008	0.729	0.381	-0.488	0.304	-0.047	0.526	0.466	-0.400	-0.242	0.912	0.050	-0.197	-0.007
Q2	-0.481	0.083	-0.247	-0.165	-0.609	-0.230	-0.550	0.076	0.076	0.073	0.176	0.231	0.039	0.661	-0.086	0.138
Q3	0.096	-0.022	0.739	-0.094	-0.261	1.179	0.333	-0.300	-0.350	-0.170	0.428	-0.832	-0.213	-0.079	1.279	-0.682
Q4	-0.121	0.007	-1.366	-0.131	-0.036	-0.443	-0.608	0.357	0.841	-0.101	-0.225	1.361	-0.009	0.145	-0.994	1.662

Table A15: Factor covariance (lower triangle) and correlation (upper triangle) matrix for male total group

	A	B	C	E	F	G	H	I	L	M	N	O	Q1	Q2	Q3	Q4
A	0.680	0.034	0.232	0.101	0.451	0.096	0.484	0.215	-0.134	-0.142	0.153	-0.294	0.064	-0.641	0.040	-0.134
B	0.023	0.666	0.029	-0.069	-0.173	0.079	-0.063	0.087	-0.022	0.044	0.044	-0.091	0.144	0.000	0.096	-0.092
C	0.211	0.026	1.221	-0.064	0.181	0.114	0.421	-0.158	-0.806	0.002	0.161	-0.968	-0.059	-0.377	0.609	-0.957
E	0.093	-0.063	-0.079	1.248	0.626	-0.480	0.660	-0.248	0.664	0.626	-0.837	-0.174	0.651	-0.025	-0.297	0.193
F	0.418	-0.159	0.225	0.787	1.266	-0.443	0.728	-0.145	0.201	0.195	-0.522	-0.275	0.298	-0.559	-0.353	0.039
G	0.095	0.077	0.151	-0.642	-0.597	1.435	-0.125	0.031	-0.214	-0.487	0.656	-0.036	-0.463	-0.045	0.772	-0.223
H	0.453	-0.058	0.528	0.837	0.930	-0.170	1.289	-0.090	0.004	0.225	-0.277	-0.547	0.255	-0.542	0.089	-0.275
I	0.182	0.073	-0.179	-0.285	-0.168	0.038	-0.105	1.056	-0.131	0.446	0.190	0.169	-0.094	0.015	-0.158	0.075
L	-0.098	-0.016	-0.792	0.660	0.201	-0.228	0.004	-0.120	0.791	0.097	-0.465	0.594	0.415	0.353	-0.490	0.859
M	-0.111	0.034	0.002	0.662	0.208	-0.553	0.242	0.434	0.082	0.897	-0.748	-0.128	0.694	0.135	-0.418	-0.028
N	0.105	0.030	0.148	-0.780	-0.490	0.656	-0.262	0.163	-0.345	-0.591	0.696	0.007	-0.519	0.048	0.600	-0.295
O	-0.279	-0.085	-1.229	-0.223	-0.355	-0.050	-0.713	0.199	0.607	-0.139	0.007	1.320	-0.053	0.335	-0.535	0.894
Q1	0.052	0.115	-0.064	0.713	0.329	-0.544	0.284	-0.095	0.362	0.644	-0.424	-0.060	0.960	0.042	-0.303	0.109
Q2	-0.472	0.000	-0.372	-0.025	-0.562	-0.048	-0.549	0.014	0.280	0.114	0.036	0.344	0.037	0.797	-0.051	0.212
Q3	0.043	0.102	0.877	-0.433	-0.517	1.205	0.131	-0.211	-0.568	-0.516	0.652	-0.801	-0.387	-0.059	1.699	-0.665
Q4	-0.140	-0.095	-1.338	0.273	0.055	-0.338	-0.395	0.097	0.967	-0.033	-0.311	1.300	0.135	0.240	-1.097	1.602

Table A16: Factor covariance (lower triangle) and correlation (upper triangle) matrix for female total group

	A	B	C	E	F	G	H	I	L	M	N	O	Q1	Q2	Q3	Q4
A	0.856	0.054	0.297	0.024	0.397	0.195	0.456	0.016	-0.187	-0.286	0.176	-0.284	-0.059	-0.614	0.158	-0.154
B	0.037	0.557	0.047	-0.062	-0.149	0.093	-0.028	0.172	-0.137	0.092	0.053	-0.046	0.087	-0.025	0.101	-0.054
C	0.306	0.039	1.243	0.095	0.205	0.113	0.537	-0.277	-0.641	0.016	0.101	-0.971	0.029	-0.360	0.620	-0.953
E	0.025	-0.051	0.117	1.228	0.661	-0.362	0.681	-0.480	0.700	0.520	-0.822	-0.337	0.678	-0.017	-0.178	0.004
F	0.449	-0.136	0.280	0.895	1.494	-0.379	0.727	-0.277	0.261	0.142	-0.617	-0.276	0.322	-0.539	-0.281	0.009
G	0.242	0.093	0.169	-0.538	-0.620	1.794	-0.062	0.008	-0.129	-0.462	0.553	-0.088	-0.480	-0.094	0.787	-0.219
H	0.498	-0.025	0.706	0.890	1.048	-0.098	1.391	-0.256	0.030	0.188	-0.336	-0.603	0.233	-0.513	0.176	-0.368
I	0.015	0.131	-0.315	-0.543	-0.346	0.011	-0.308	1.043	-0.346	0.295	0.289	0.346	-0.332	-0.055	-0.176	0.280
L	-0.164	-0.097	-0.676	0.734	0.302	-0.163	0.033	-0.334	0.895	0.074	-0.507	0.371	0.465	0.322	-0.314	0.612
M	-0.224	0.058	0.015	0.487	0.147	-0.523	0.187	0.255	0.059	0.715	-0.637	-0.150	0.587	0.127	-0.334	-0.015
N	0.163	0.040	0.113	-0.913	-0.756	0.743	-0.397	0.296	-0.481	-0.540	1.005	0.096	-0.528	0.056	0.535	-0.192
O	-0.306	-0.040	-1.263	-0.436	-0.394	-0.137	-0.829	0.412	0.409	-0.148	0.112	1.360	-0.185	0.280	-0.590	0.902
Q1	-0.045	0.054	0.027	0.623	0.326	-0.533	0.228	-0.281	0.365	0.412	-0.439	-0.179	0.688	0.138	-0.266	-0.003
Q2	-0.517	-0.017	-0.365	-0.017	-0.599	-0.114	-0.551	-0.051	0.277	0.098	0.051	0.297	0.104	0.828	-0.062	0.203
Q3	0.182	0.094	0.860	-0.246	-0.427	1.311	0.258	-0.223	-0.370	-0.351	0.667	-0.856	-0.274	-0.070	1.547	-0.698
Q4	-0.183	-0.052	-1.360	0.005	0.014	-0.376	-0.555	0.366	0.741	-0.016	-0.247	1.346	-0.003	0.237	-1.111	1.639

Table A17: Factor covariance (lower triangle) and correlation (upper triangle) matrix for arts total group

	A	B	C	E	F	G	H	I	L	M	N	O	Q1	Q2	Q3	Q4
A	0.742	-0.115	0.223	0.175	0.513	0.208	0.559	0.175	-0.014	0.001	-0.118	-0.194	0.075	-0.742	0.033	-0.043
B	-0.066	0.446	-0.024	-0.174	-0.258	-0.059	-0.193	0.187	-0.145	0.134	0.072	0.061	0.065	0.199	-0.054	-0.007
C	0.200	-0.017	1.087	0.129	0.212	0.170	0.466	-0.199	-0.611	0.089	0.131	-0.954	-0.020	-0.251	0.562	-0.929
E	0.171	-0.132	0.152	1.286	0.559	-0.357	0.669	-0.294	0.617	0.480	-0.906	-0.391	0.740	-0.108	-0.042	-0.115
F	0.595	-0.232	0.298	0.854	1.813	-0.308	0.742	-0.074	0.276	0.147	-0.660	-0.267	0.314	-0.654	-0.237	-0.006
G	0.233	-0.051	0.230	-0.525	-0.538	1.684	0.041	0.044	-0.233	-0.234	0.507	-0.082	-0.359	-0.189	0.787	-0.234
H	0.549	-0.147	0.554	0.865	1.140	0.061	1.301	-0.130	0.076	0.256	-0.512	-0.581	0.358	-0.625	0.226	-0.363
I	0.144	0.119	-0.198	-0.318	-0.095	0.055	-0.141	0.910	-0.304	0.453	0.021	0.420	-0.193	0.067	-0.255	0.253
L	-0.011	-0.090	-0.594	0.652	0.347	-0.282	0.081	-0.270	0.869	-0.106	-0.546	0.301	0.527	0.174	-0.305	0.597
M	0.001	0.079	0.082	0.480	0.174	-0.268	0.257	0.381	-0.087	0.776	-0.579	-0.150	0.595	0.120	-0.181	-0.145
N	-0.103	0.049	0.139	-1.043	-0.903	0.668	-0.593	0.020	-0.517	-0.518	1.031	0.058	-0.522	0.270	0.449	-0.193
O	-0.184	0.045	-1.096	-0.489	-0.397	-0.117	-0.731	0.442	0.309	-0.146	0.065	1.215	-0.226	0.194	-0.582	0.899
Q1	0.066	0.044	-0.021	0.854	0.431	-0.475	0.416	-0.187	0.500	0.534	-0.540	-0.254	1.037	-0.044	-0.114	-0.031
Q2	-0.543	0.113	-0.222	-0.104	-0.748	-0.208	-0.606	0.054	0.138	0.090	0.233	0.182	-0.038	0.722	-0.046	0.063
Q3	0.031	-0.040	0.647	-0.052	-0.352	1.128	0.285	-0.269	-0.314	-0.176	0.504	-0.708	-0.128	-0.043	1.220	-0.644
Q4	-0.047	-0.006	-1.235	-0.167	-0.011	-0.388	-0.528	0.308	0.710	-0.163	-0.250	1.264	-0.040	0.068	-0.907	1.627

Table A18: Factor covariance (lower triangle) and correlation (upper triangle) matrix for science total group

	A	B	C	E	F	G	H	I	L	M	N	O	Q1	Q2	Q3	Q4
A	0.694	-0.024	0.280	0.152	0.453	0.189	0.518	0.029	-0.076	-0.151	0.035	-0.305	0.027	-0.668	0.122	-0.150
B	-0.016	0.637	0.018	-0.091	-0.178	0.022	-0.087	0.176	-0.120	0.112	0.057	-0.012	0.092	0.067	0.035	-0.045
C	0.253	0.016	1.176	0.084	0.212	0.135	0.505	-0.218	-0.681	0.048	0.135	-0.984	-0.015	-0.332	0.589	-0.954
E	0.136	-0.078	0.098	1.160	0.659	-0.368	0.695	-0.284	0.621	0.524	-0.852	-0.283	0.670	-0.102	-0.180	0.051
F	0.431	-0.162	0.263	0.811	1.304	-0.347	0.735	-0.227	0.284	0.145	-0.626	-0.286	0.313	-0.597	-0.261	0.000
G	0.190	0.021	0.177	-0.479	-0.478	1.459	-0.015	0.024	-0.180	-0.362	0.527	-0.099	-0.434	-0.124	0.794	-0.240
H	0.500	-0.080	0.634	0.866	0.971	-0.021	1.340	-0.183	0.027	0.219	-0.378	-0.599	0.263	-0.574	0.191	-0.358
I	0.022	0.129	-0.217	-0.281	-0.238	0.027	-0.195	0.846	-0.220	0.431	0.121	0.277	-0.176	0.068	-0.161	0.160
L	-0.064	-0.097	-0.749	0.679	0.329	-0.220	0.032	-0.205	1.029	-0.008	-0.501	0.468	0.446	0.238	-0.371	0.734
M	-0.111	0.079	0.046	0.499	0.147	-0.387	0.224	0.351	-0.007	0.783	-0.613	-0.150	0.621	0.125	-0.278	-0.064
N	0.025	0.039	0.125	-0.782	-0.609	0.542	-0.373	0.095	-0.433	-0.462	0.726	0.026	-0.507	0.141	0.529	-0.252
O	-0.282	-0.011	-1.183	-0.338	-0.362	-0.133	-0.769	0.283	0.526	-0.147	0.025	1.230	-0.139	0.292	-0.581	0.894
Q1	0.020	0.066	-0.015	0.646	0.320	-0.469	0.273	-0.145	0.405	0.492	-0.387	-0.138	0.802	0.046	-0.242	0.048
Q2	-0.499	0.048	-0.323	-0.099	-0.612	-0.134	-0.596	0.056	0.217	0.099	0.108	0.291	0.037	0.805	-0.069	0.182
Q3	0.127	0.035	0.800	-0.243	-0.373	1.202	0.277	-0.185	-0.472	-0.308	0.565	-0.807	-0.271	-0.078	1.570	-0.671
Q4	-0.151	-0.043	-1.248	0.066	0.000	-0.350	-0.500	0.178	0.898	-0.068	-0.259	1.197	0.052	0.197	-1.015	1.456

Table A19: Factor covariance (lower triangle) and correlation (upper triangle) matrix for pooled within-group analysis

	A	B	C	E	F	G	H	I	L	M	N	O	Q1	Q2	Q3	Q4
A	0.964	-0.022	0.181	0.092	0.457	0.154	0.496	0.283	-0.057	-0.073	0.047	-0.184	0.038	-0.632	0.029	-0.052
B	-0.015	0.472	0.019	-0.105	-0.192	0.025	-0.096	0.144	-0.136	0.113	0.061	-0.004	0.085	0.068	0.040	-0.036
C	0.189	0.014	1.137	0.111	0.191	0.144	0.488	-0.291	-0.630	0.033	0.101	-0.964	-0.006	-0.315	0.606	-0.945
E	0.113	-0.090	0.148	1.561	0.610	-0.355	0.675	-0.342	0.662	0.507	-0.859	-0.361	0.697	-0.058	-0.116	-0.049
F	0.629	-0.185	0.285	1.069	1.966	-0.350	0.735	-0.105	0.280	0.160	-0.633	-0.257	0.319	-0.597	-0.271	0.014
G	0.219	0.025	0.222	-0.642	-0.710	2.094	-0.019	-0.013	-0.184	-0.375	0.529	-0.094	-0.439	-0.127	0.786	-0.231
H	0.581	-0.079	0.621	1.007	1.230	-0.033	1.424	-0.129	0.060	0.234	-0.403	-0.578	0.285	-0.565	0.184	-0.352
I	0.317	0.113	-0.354	-0.487	-0.167	-0.022	-0.176	1.298	-0.212	0.394	0.171	0.384	-0.163	0.003	-0.261	0.294
L	-0.054	-0.090	-0.645	0.794	0.377	-0.255	0.069	-0.232	0.922	0.009	-0.520	0.347	0.491	0.251	-0.326	0.611
M	-0.065	0.070	0.032	0.573	0.203	-0.491	0.253	0.406	0.008	0.818	-0.619	-0.142	0.629	0.122	-0.290	-0.060
N	0.048	0.044	0.112	-1.119	-0.925	0.798	-0.501	0.203	-0.521	-0.584	1.087	0.086	-0.536	0.134	0.489	-0.190
O	-0.203	-0.003	-1.157	-0.508	-0.406	-0.153	-0.777	0.493	0.375	-0.145	0.101	1.267	-0.186	0.245	-0.596	0.904
Q1	0.040	0.063	-0.007	0.943	0.495	-0.688	0.368	-0.201	0.511	0.616	-0.605	-0.227	1.174	0.061	-0.218	0.001
Q2	-0.516	0.039	-0.279	-0.060	-0.696	-0.153	-0.560	0.003	0.200	0.092	0.116	0.229	0.055	0.691	-0.051	0.146
Q3	0.036	0.035	0.827	-0.186	-0.486	1.455	0.281	-0.380	-0.400	-0.336	0.652	-0.858	-0.302	-0.054	1.637	-0.684
Q4	-0.068	-0.033	-1.332	-0.081	0.026	-0.443	-0.555	0.443	0.776	-0.072	-0.262	1.345	0.002	0.161	-1.158	1.749

Table A20: Factor covariance (lower triangle) and correlation (upper triangle) matrix for total group

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THE PRIMARY FACTOR SCALES OF THE 16PF

LOW SCORE DESCRIPTION	FACTOR	HIGH SCORE DESCRIPTION
RESERVED, DETACHED, CRITICAL, ALOOF (Sizothymia)	A	**OUTGOING,** WARMHEARTED, EASY-GOING, PARTICIPATING (Affectothymia, formerly cyclothymia)
LESS INTELLIGENT, CONCRETE-THINKING (Lower scholastic mental capacity)	B	**MORE INTELLIGENT,** ABSTRACT-THINKING, BRIGHT (Higher scholastic mental capacity)
AFFECTED BY FEELINGS, EMOTIONALLY LESS STABLE, EASILY UPSET (Lower ego strength)	C	**EMOTIONALLY STABLE,** FACES REALITY, CALM MATURE (Higher ego strength)
HUMBLE, MILD, ACCOMMODATING, CONFORMING (Submissiveness)	E	**ASSERTIVE,** AGGRESSIVE, STUBBORN, COMPETITIVE (Dominance)
SOBER, PRUDENT, SERIOUS, TACITURN (Desurgency)	F	**HAPPY-GO-LUCKY,** IMPULSIVELY LIVELY, GAY, ENTHUSIASTIC (Surgency)
EXPEDIENT, DISREGARDS RULES, FEELS FEW OBLIGATIONS (Weaker superego strength)	G	**CONSCIENTIOUS,** PERSEVERING, STAID, MORALISTIC (Stronger superego strength)
SHY, RESTRAINED, TIMID, THREAT-SENSITIVE (Threctia)	H	**VENTURESOME,** SOCIALLY BOLD, UNINHIBITED, SPONTANEOUS (Parmia)
TOUGH-MINDED, SELF-RELIANT, REALISTIC, NO-NONSENSE (Harria)	I	**TENDER-MINDED,** CLINGING, OVER-PROTECTED, SENSITIVE (Premsia)
TRUSTING, ADAPTABLE, FREE OF JEALOUSY, EASY TO GET ALONG WITH (Alaxia)	L	**SUSPICIOUS,** SELF-OPINIONATED, HARD TO FOOL (Protension)
PRACTICAL, CAREFUL, CONVENTIONAL, REGULATED BY EXTERNAL REALITIES, PROPER (Praxernia)	M	**IMAGINATIVE,** WRAPPED UP IN INNER URGENCIES, CARELESS OF PRACTICAL MATTERS, BOHEMIAN (Autia)
FORTHRIGHT, NATURAL, ARTLESS, UNPRETENTIOUS (Artlessness)	N	**SHREWD,** CALCULATING, WORLDLY, PENETRATING (Shrewdness)
SELF-ASSURED, CONFIDENT, SERENE (Untroubled adequacy)	O	**APPREHENSIVE,** SELF-REPROACHING, WORRYING, TROUBLED (Guilt proneness)
CONSERVATIVE, RESPECTING ESTABLISHED IDEAS, TOLERANT OF TRADITIONAL DIFFICULTIES (Conservatism)	Q_1	**EXPERIMENTING,** LIBERAL, ANALYTICAL, FREE-THINKING (Radicalism)
GROUP-DEPENDENT, A "JOINER" AND SOUND FOLLOWER (Group adherence)	Q_2	**SELF-SUFFICIENT,** PREFERS OWN DECISIONS, RESOURCEFUL (Self-sufficiency)
UNDISCIPLINED SELF-CONFLICT, FOLLOWS OWN URGES, CARELESS OF PROTOCOL (Low integration)	Q_3	**CONTROLLED,** SOCIALLY PRECISE, FOLLOWING SELF-IMAGE (High self-concept control)
RELAXED, TRANQUIL, UNFRUSTRATED (Low ergic tension)	Q_4	**TENSE,** FRUSTRATED, DRIVEN, OVERWROUGHT (High ergic tension)