FIELD INDEPENDENCE AS RELATED TO INTELLIGENCE AND SPATIAL ABILITY: AN INVESTIGATION INTO INDIVIDUAL, AGE AND SEX DIFFERENCES

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A Dissertation

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Doctor of Philosophy

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by

Joy Carolyn Bowd

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ABSTRACT

This research examined the hypothesis that differences in field independence can be accounted for by differences in general intelligence (g) and spatial ability (k). A previous factor analytic study (Vernon, 1972) supporting this hypothesis used field independence tests to help define the spatial ability factor thus providing a circular definition. This study re-examined this conclusion. A battery of ability tests was administered to 192 subjects, the spatial ability factor being defined only on non-field independence tests. It was found that general intelligence and spatial ability factors account for almost eighty percent of the shared variance among Rod-and-Frame test, Group Embedded Figures test and Block Design test, supporting the hypothesis.

Crossgroup research is important for validation of the field independence construct. A method for demonstrating qualitative equivalence or psychometric invariance prior to making crossgroup quantitative comparisons was established. This confirmed the field independence tests as invariant across age and across sex groups, with one exception. Then age group differences on each test were shown to be accounted for by age group differences on g and k, as predicted. Factors g and k could not account for the one sex difference obtained on the Rod-and Frame test.

The results as a group support the hypothesis, with implications for future research designs of investigating separately the two dimensions involved. They support those who maintain that

the field independence dimension is unwarranted, being redundant with previously established concepts.

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To my mother and father

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CHAPTER 1

INTRODUCTION

The purpose of this investigation was to determine whether field independence represents a construct distinct from general intelligence and spatial ability and to examine test differences between age and sex groups to determine whether group differences in field independence tests can be accounted for by group differences in general intelligence and spatial ability.

More specifically, it was first determined whether or not the construct of field independence, referring to the variance shared by several measures, represents a construct distinct from general intelligence (g) and spatial ability (k). Then the qualitative equivalence or psychometric invariance of field independence tests across age and sex groups was assessed, to determine the validity of crossgroup quantitative comparisons on the tests. Finally diferences between age and sex groups on field independence tests were studied, to ascertain whether or not these differences could be accounted for by group differences in general intelligence and spatial ability.

STATEMENT OF THE PROBLEM

The field-dependence-independence concept, since its introduction over two decades ago (Witkin, Lewis, Hertzman, Machover, Meissner & Wapner, 1954) has generated much research. This perceptual-personality dimension, later proposed to be part of 'psychological differentiation' by Witkin, Dyk, Faterson, Goodenough & Karp, (1962), was characterized as an ability to overcome an embedding context. Recent literature reviews (Vernon, 1972; Witkin & Berry, 1975; Horn, 1976) and research bibliographies (Witkin, Oltman, Cox, Ehrlichman, Hamm & Ringler, 1973; Witkin, Cox, Friedman, Hrishikesan & Siegel, 1974; Witkin, Cox & Friedman, 1976) indicate that over 2500 field independence studies had been reported up to 1976. The concept stimulated much research, as P. E. Vernon has noted,

> partly because it seems to provide a new and far-reaching dimension of cognition, distinct from intelligence, and partly because this perceptual characteristic links, not only with thinking, memorizing, etc. but also with personality and child-rearing. (Vernon, 1972, p. 366)

Despite the extensive research conducted, "a considerable gap still exists between the empirical findings and their adequate conceptualization" (Dubois & Cohen, 1970, p. 416). Or, as Fine and Danforth (1975) phrase it, "what has apparently been demonstrated over the past 10 yr. is the reliability of a relationship of questionable validity" (p. 692). Wachtel (1972) in a re-examination of the concepts of field independence and differentiation points to two separate strands in the theory. One emphasizes style and direction of development and the organization of personality, the other centers around abilities and the across-the-board quality of certain developmental limitations. The tests themselves directly assess not a style of functioning but an ability to function well in certain types of tasks.

The concern that the empirical relationships found between field independence tests and many other measures may result from a common relationship between the measures employed and general intelligence was raised by Zigler (1963a, 1963b) in reviewing Witkin's book. Significant relationships between field independence-type tests and measures of intelligence have been reported by many investigators (Bieri, Bradburn & Galinsky, 1958; Cohen, 1957, 1959; Corah, 1965; Elliot, 1961; Goodenough & Karp, 1961; Podell & Phillips, 1959; Thurstone, 1944). Most of the research on field independence has not controlled for intelligence. Wachtel noted a need to empirically distinguish correlates of field independence and those of overall IQ, and to examine whether superiority in other specific aspects of intelligence might also yield similar relationships. Cronbach (1970) makes a related point. He noted that Witkin measured field independence by radically diverse methods (multimethod approach) and showed that his tests diverge from conventional verbal tests, but failed to carry measures of "ability supposedly distinct from field independence" (p. 297) through his research. Indeed, Cronbach and Drenth (1972) note that Witkin's tests correlate so sharply with tests of fluid ability as to suggest "that what Witkin calls 'field differentiation' is nothing but g, and he offers no evidence to dispel this criticism" (p. 422). If the stability and correlates of measures of field independence rest on their relationship with more generalized intellectual ability, field independence minus the intellectual component may have little or no predictive power.

Contrary to Witkin's conclusion that field independence is a broader explanatory concept, field independence, as measured by these tests, may be part of rather than distinct from intelligence. Vernon (1972) in a factor analytic study, concluded that field independence does not define anything distinct from g and k, as defined by his structure of intelligence model of abilities. Partialling out intelligence and spatial ability factors reduced the correlations among field independence tests to near-zero. His study has been cited by others as evidence for the "nonexistence" of field independence despite the weakness that the spatial ability factor could just as readily be labeled a field independence factor. It was important therefore to reevaluate this conclusion, defining a spatial ability factor only on non-embedding spatial tests. This research, then, examined whether Witkins tests have independent information, whether field independence is a unique construct over and above those of g and k and thus whether predictions could be made from it over and above those made from more conventional constructs.

Field independence is conceived of as the result of a process of individual development; young children perceive in a field dependent fashion and with age become more field independent (Witkin et al., 1954). Intracultural research provides evidence that encouragement of resourcefulness and independence in children leads to greater field independence (Witkin et al., 1962). There has been considerable crosscultural research on field independence. Witkin's differentiation theory has been elaborated in crosscultural context by Berry (1971), Dawson (1971) and Witkin, Price-Williams, Bertini, Christiansen, Oltman, Raminez and Van Meel (1974). It suggests that childrearing practices encouraging independence, together with a mobile hunting ecology, foster the development of field independence. An upbringing of social traditionalism involving conformity to family, religious and political authority, together with a sedentary agricultural ecology, produces field dependence. The crosscultural research has generally been carefully designed and executed, and has provided part of the construct validation of field independence. The theory, then, is based on observed, predicted differences between various groups on field independence tests.

Serious methodological difficulties exist in using tests for comparisons across groups that differ in some respects. Quantitative comparisons across different populations, different age groups, different cultures and so on must be interpretable. MacArthur (1973) re-emphasizes the need for careful attention to the construct validity of what may appear to be the same tests when used in different cultural settings. Baltes (1968) points out for developmental studies that quantitative comparisons on variables across age groups assumes fixed constructs. This is reemphasized by Baltes and Nesselrode (1970) who note age gradients and developmental curves rest on the crucial assumption, which is often untested, of fixed constructs. It would, then, be important to ascertain that the field independence scores obtained can be meaningfully and legitimately compared across groups. This would involve determining the degree to which the basic factor analytic descriptions remain the same when scores are obtained from different populations. This has been referred to as psychometric invariance by Aftanas (1971), metric equivalence by Berry and Dasen (1974) and comparative validity by Irvine (1966). Berry (in press) points out that "the requirement is that behavioral measurements (observations, test data, etc.) should be structured in similar ways <u>within</u> groups before comparisons <u>across</u> groups are allowable". It could be that certain ability constructs are qualitatively similar in different groups and that meaningful quantitative comparisons can be made on the basis of test scores and/or factor scores. Most crosscultural and developmental investigations of field independence have used only one test without first establishing that such test scores can be meaningfully compared. This study determined the psychometric invariance of the loading pattern of the field independence tests across age and sex groups and examined the validity of crossgroup quantitative comparisons of field independence test scores.

If field independence is not a unique construct over and above more conventional constructs, then differences between groups on field independence tests are being given a superfluous interpretation. Specifically, such differences may be artifacts of group differences in intelligence and spatial ability. If so, then controlling for these two variables should eliminate group differences on field independence tests. The research on socialization and ecological correlates of the development of field independence would then be seen to be a version of the research on childhood experiences related to the development of intelligence and the development of spatial ability. This research determined whether age and sex differences in field independence can be accounted for by group differences in general intelligence and spatial ability.

THE DELIMITATIONS

This study attempted to determine whether field independence as measured by the three particular tests used represents a construct distinct from Vernon's (1950) ability constructs of g and k, and did not attempt to determine whether it is distinct from other ability constructs such as Guilford's (1967) structure-of-intellect abilities, or whether it is distinct from other personality constructs.

CHAPTER 2

THE REVIEW OF RELATED LITERATURE

THE CONCEPT OF FIELD INDEPENDENCE

Field independence refers to the ability to overcome a perceptually embedding context and to perceive items as discrete from background (Witkin et al., 1962). Witkin's concept of perceptual field independence is one aspect of a general psychological construct which has been termed the global-articulated dimension of cognitive functioning. The global-articulated dimension is often considered a cognitive style (Witkin et al., 1962) and is defined by Dyk and Witkin as follows:

> We consider perception to be articulated, as contrasted to global, if the person is able to perceive items as discrete from background when the field is structured (analysis), and to impose structure on a field, and so perceive it as organized, when the field has relatively little inherent structure (structuring). The concept of articulation may be applied to experience of an immediately present stimulus configuration (perception) and to experience in the realm of symbolic material (thinking). (1965, p. 22)

Tests of field independence assess the analytical aspect of the dimension in perception. Figure 1 illustrates the hierarchial ordering involved in placing field independence in the psychological differentiation framework. Greater differentiation

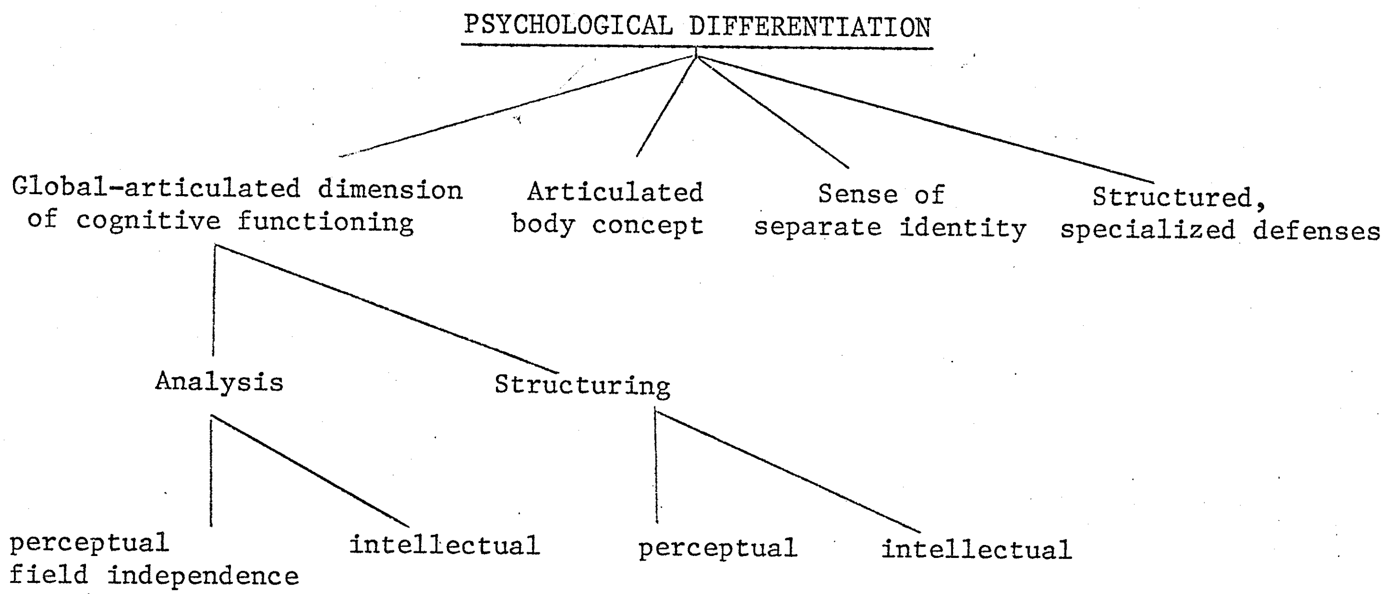


Figure 1

The Place of Field Independence in the Psychological Differentiation Framework

(From Witkin et al., 1971, p.14)

is assumed to be the result of a process of development toward greater psychological complexity. Persons with an articulated cognitive style give evidence of an articulated body concept and a developed sense of separate identity. They are said to show developed differentiation. Field independent boys are more active, resourceful, self-directing and less affected by social norms. They show greater consistency of behavior, use intellectualization as a defense mechanism rather than repression and display greater clarity of thinking in concepts such as space and time (Witkin et al., 1962).

A cognitive style by definition represents a stable preference in the perceptual organization and conceptual categorization of stimuli in the environment (Kagan, Moss & Sigel, 1963). A person's cognitive style then would have important consequences for his behavior. The formation of cognitive skills can reasonably be conceived of as developmental in nature and modifiable by variation in the environment. Greater differentiation is assumed to be the result of a process of development toward greater psychological complexity. Much research has been done defining the parental child-rearing practices which relate to differences in field independence. Witkin and associates (1962) provide evidence that encouragement of resourcefulness and independence in children leads to greater field independence and psychological differentiation.

The field independence concept arose from studies into consistent individual differences in particular situations, particularly the research of the Gestalt psychologists studying the importance of contextual factors in perception. Gottschaldt (1926) studied the perception of simple figures contained within complex patterns. He constructed the Gottschaldt Figure Test and found that ease of perception of the simple figure varied according to the type of complex masking figure used.

Other researchers, using variations of Gottschaldt's figures, turned their attention to an analysis of the data in terms of individual differences. Thurstone (1944) reported correlations of .41 and .43 between two forms of the Gottschaldt Figures Test and his Primary Mental Abilities Space Test. Also, he obtained correlations of .57 and .51 between the two forms of the test and the Kohs Block Design Test, considered to measure non-vebal analytic and synthetic reasoning. Thus the perceptual process involved in the Gottschaldt Figures Test cannot be explained in terms of the structure of the field alone.

Witkin and Asch (1948) began experimenting with situations involving the perceptual property of upright. The experimental situation tested the perception of the direction of a rod in different surrounding fields. This is the Rod-and-Frame test. Again, an orthodox Gestalt interpretation ignoring individual differences was unsatisfactory. Witkin and Asch found that although some subjects judged the direction of the rod independently of the position of the field, others perceived the rod as upright only when it was parallel with the axes of the field.

The concept of field dependence emerged from these studies of situations concerning perception of the upright. The results indicated wide individual differences and field dependence was defined initially by performance in these situations. Various hypotheses were considered in an attempt to account for these individual differences. One hypothesis accounted for the perceptual differences in terms of differences in ability to overcome an embedding context or field. Those people who seem to find it difficult to separate an item from its context were termed field dependent. Those people who were able to separate an item from its context were termed field independent. General population performances ranged in a continuum. To test this hypothesis, and to extend the analysis to situations not involving perception of the upright, Witkin (1950) developed an Embedded Figures Test (EFT) based on the Gottschaldt Figures Test. Again, wide individual differences were observed.

An extensive study by Witkin and co-workers (1954) showed the Embedded Figures Test to be highly related to the Rod-and-Frame Test and to a Body Adjustment Test involving the perception of the position of the body within different fields. These findings of consistency in individual functioning in these situations, supported the hypothesis that ability to overcome an embedding context is central to the field dependence-independence dimension. More recent studies have confirmed these findings (Witkin et al., 1962, p. 44). Correlations between the Embedded Figures Test and a Room Adjustment Test involving the subject sitting at a tilt adjusting the field to a position that he perceived as upright, were not significant. Witkin and co-workers (1954) suggested that perception in the Room Adjustment Test is not based on the ability to overcome an embedding field. Rather, the test requires the subject to evaluate the position of the field itself and there is no surrounding context. The test was dropped from the battery.

One important finding of earlier studies was that young children tended to perceive in a field dependent fashion and, with age, became more field independent (Witkin et al., 1954). This observation placed the research within a developmental framework and implied that the field dependent perception is more rudimentary. Individuals whose perception is relatively field dependent may have made less progress in general development toward greater psychological complexity. The researchers suggested that the aspect of psychological development involved might be degree of differentiation.

Differentiation is viewed as the result of a process of development toward greater psychological complexity and refers to the complexity of the system's structure, to the formal rather than the content aspects of a system.

> Development toward greater differentiation involves progress from an initial relatively unstructured state which has only limited segregation from the environment, to a more structured state, which has relatively definite boundaries, and which is capable of greater specificity of function. (Witkin et al., 1962, p. 22)

Some of the ways in which degree of differentiation may express itself in various psychological areas were investigated. Characteristics of early and later functioning were taken as indicators of level of differentiation. Greater differentiation or more limited differentiation is viewed as the common denomination of the characteristics in each pattern. The hypothesis guiding the research was termed the "differentiation hypothesis" by Witkin and co-workers:

> Specifically, the differentiation hypothesis proposes an association among the characteristics of greater or more limited differentiation, identified in the comparison of early and later functioning in each of several psychological areas: degree of articulation of experience of the self, reflected particularly in nature of the body concept and extent of development of specialized, structured, controls and defenses. Implicit in this hypothesis is the view that greater inner differentiation is associated with greater articulation of experience of the world. (Witkin et al., 1962, p. 16)

The focus of the research was on individual self-consistency with respect to characteristics of differentiation. Indicators of differentiation included a tendency to experience the world as analyzed and structured, a differentiated self reflected in an articulated body concept and measured by figure drawings rated on a sophistication-of-body concept scale, a sense of separate identity, and specialized, structured defenses and controls. Each indicator was operationalized and data were obtained from a battery of tests of perceptual field dependence, a series of problem solving and intelligence tests, projective tests and an interview, and support for the differentiation hypothesis was found.

The results concerning the perceptual and intellectual tests pointed to the existence of a salient cognitive dimension which was termed the global-articulated dimension of cognitive functioning. Differences in the perceptual field dependence-independence dimension appear to reflect differences characterisitic of the individual's general cognitive functioning, intellectual as well as perceptual. The extremes of this cognitive dimension were labelled global field approach and analytical field approach.

Three subtests of the Wechsler Intelligence Scale for Children, Block Design, Picture Completion and Object Assembly, loaded heavily on the same factor as the three tests of perceptual field dependence. All these tests according to the researchers seem to require the ability to overcome an embedding context and this ability, when developed, makes possible an analytical and articulated way of experiencing. When undeveloped it results in a global way of experiencing. The researchers defined the types of experience as follows:

> We have used the term "articulated" for experience which tends to be both analyzed and structured. In contrast, in a "global" way of experiencing, a stimulus field that is highly structured is experienced as strongly cohesive, a stimulus field that is amorphous is experienced as vague. (Witkin, et al., 1962, p. 223)

This observed relationship between perceptual and intellectual tests according to researchers, supported the differentiation hypothesis. Witkin notes:

Thus the field-dependence dimension is represented by performance on portions of standard intelligence tests. The Block Design in fact provides an excellent measure of field dependence, and it has been used for this purpose in several of the cross-cultural studies. (1967, p. 237)

The investigations of Witkin and co-workers thus progressed far beyond the early studies of individual differences in perceptual field dependence. Results of extensive research indicated that an individual's general mode of perceiving was linked to a wide variety of personal characterisitics. Moreover, the patterning of the results suggested a consistency which pervaded a great many areas of psychological functioning - perceptual, intellectual, emotional, motivational and social. The global-articulated cognitive style has been shown to be a consistent feature of aspects of an individual's cognitive functioning, and a tendency toward a more global or more articulated style characterizes an individual's approach to certain perceptual and intellectual tasks.

FIELD INDEPENDENCE AND INTELLIGENCE

The concern that many correlations between field independence and other measures may result from a common relationship between the measures employed and level of cognitive ability was raised over thirteen years ago by Zigler (1963a, 1963b) and has been echoed by many others. The Embedded Figures Test does not correlate highly with Wechsler Vocabulary and Comprehension but, as noted already, correlates well with Block Design, Picture

Completion, Object Assembly and Mazes, which are generally regarded as measures of fluid or analytic abilities and correlates at least .50 with WISC performance IQ (Goodenough & Karp, 1961; Witkin et al., 1962). Cronbach (1970) notes, "Since we know that his tests are substantially correlated with g, we are not at all certain that 'field dependence' is anything more than a measure of general adaptive ability" (p. 297). He adds:

> That is not to say that Witkin's tests have no independent information. The difficulty is that studies have not isolated and validated the significance of the independent contribution of the less-conventional kind of test. (Cronbach, 1970, p. 628)

In discussing validation research of the field independence construct Cronbach remarks that the big question is whether most of the results are simply a function of ability. The personality interpretation, he says, could be called superfluous, but styles of response, resistance to distraction, response to risky, challenging situations, etc., are an important part of what ability tests measure. He refutes the critics who may want to call the ability interpretation superfluous, stating:

> EFT is a test of maximum performance; the low-scoring subjects are doing the best they can. A style can be put aside when it is disfunctional. Since the Low-EFT subject seems unable to shift to an analytical "style", he is showing a deficiency in ability. (Cronbach, 1970, p. 630)

Wachtel (1972) picks up the argument on field independence and cognitive style by pointing to two separate strands of Witkin's theory, one emphasizing style and direction of development and the organization of personality and the other centering around abilities and the across-the-board quality of certain developmental limitations. He also points out that what is most directly assessed is not a style of functioning but an ability to function well in certain types of tasks, that is, a component of intellegence. He points to a need to empirically distinguish correlates of field independence and those of overall IQ.

The distinction between cognitive style and cognitive ability in relation to the global-articulated dimension has been queried by Weisz, O'Neill and O'Neill (1975) who note that it is an important issue in research at the interface of personality and intellectual development. They found that 52% of the childrens' EFT variance was accounted for by its correlation with mental age, and the strength of a second theoretically important relationship derived largely from their mutual correlation with mental age. They call for a reexamination of the large body of research on correlates of field independence cited as validation for the global-articulated cognitive style construct. As they point out, most validation evidence has been gathered without level of cognitive ability or mental age controls. Yet most of the variables are known to vary with mental age.

The relationships between field independence and many other variables, such as general intelligence, spatial ability, creativity, masculinity versus femininity, introversion versus extraversion, etc., have been noted by Vernon (1969) who suggested that, given the substantial correlations found between field independence tests, performance subtests of WISC and WAIS and various tests of spatial abilities, field independence may be subsumed under the constructs of general intelligence (g) and spatial ability (k). Dubois and Cohen (1970) also suggested that field independence should be regarded as _part of_ rather than distinct from intelligence. If this is so, it has implications for the validation research of field independence, for if one wishes to study field independence _per se_ regarded as part of intelligence, no control for intelligence need be employed. It is only if one wished to study the unique, perceptual aspect of field independence distinct from any aspects of intelligence, if indeed there is any unique component, that some type of control must be employed.

The two main structure-of-intelligence theories today are the hierarchial theory of Vernon (1950, 1969) and the multiple factor theory of Guilford (Guilford, 1956, 1967; Guilford & Hoepfner, 1971). The hierarchial view postulates that intellectual structure might best be understood in terms of a hierarchical ordering of abilities, with broad factors that account for performance in a wide range of tasks and, below these, more specific task abilities. Guilford's model postulates a trigram of five operations, operating on four possible contents to produce six possible products, each of the 120 resulting cells representing a separate, orthogonal ability factor (see Figures 2 and 3).

The differences between the hierarchical and multiple factor theories arise partly from the use of objective versus subjective factor methods (Horn, 1967) and the use of heterogeneous versus

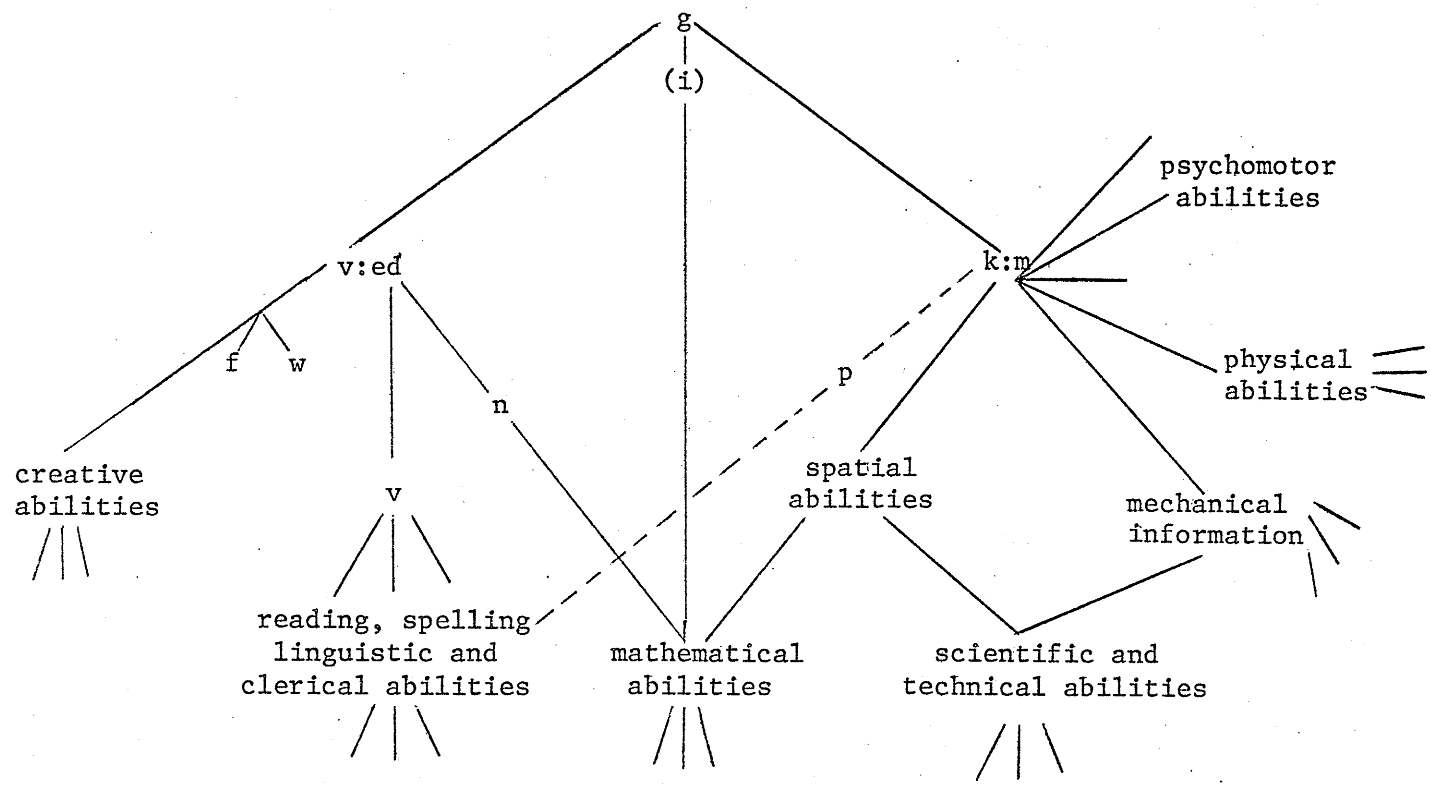


Figure 2

Hierarchical diagram of the main general and group factors underlying tests relevant to educational and vocational achievements

(From Vernon, 1969, p.22)

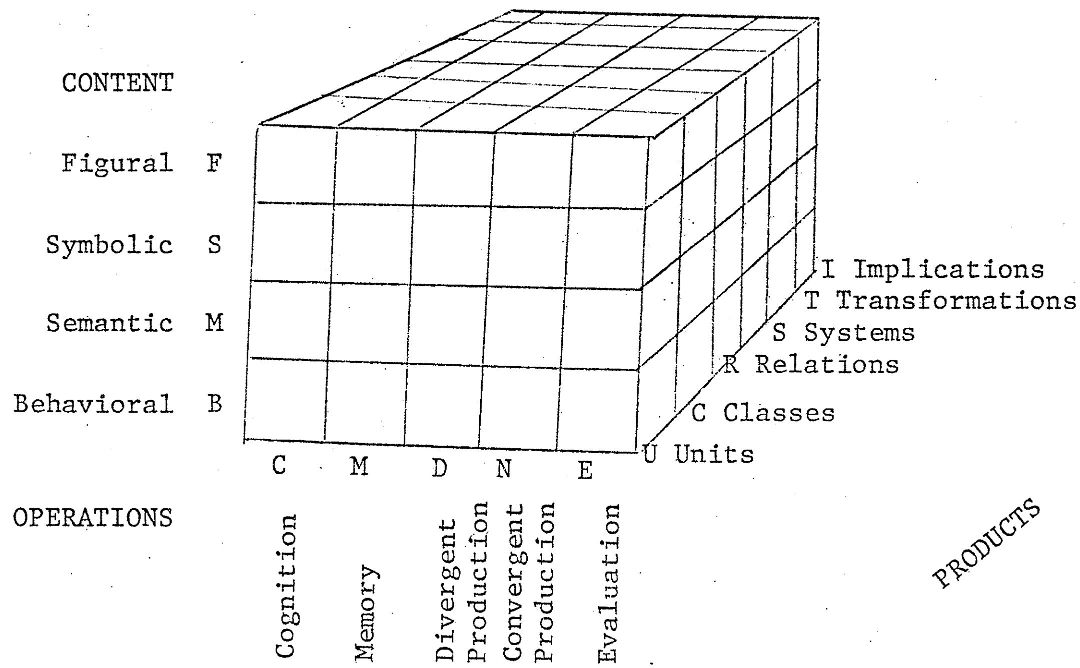


Figure 3

Guilford's model of intellect

homogeneous populations. There is no specific procedure for extracting a hierarchical structure from a correlation matrix. Standard objective procedures together with substantive reasoning are used. Factor markers using standard rotational procedures could be used or a general factor could be extracted first. Guilford uses the subjective procrustian method of rotation to a hypothesized target (Cliff, 1966). Horn (1976) notes that Guilford's structure-of-intelligence (S.I.) theory is under attack primarially because of overly subjective methods of proof are used to support the theory. Subjectively in this context refers to overfactoring and to targeted rotation. Guilford's theoretical framework is rejected for use here as it can not be regarded as based solidly upon empirical evidence (Armstrong & Soelberg, 1968; Guilford, 1974; Horn & Knapp, 1973; Humphreys, Llgen, McGrath & Montanelli, 1969) and standard objective procedures such as varimax give results inconsistent with predictions from the structure-of-intelligence theory (Guilford & Hoepfner, 1969). Pawlik (1973) notes that Guilford's S. I. model presupposes a subject population of 10^{59} individuals (which is 10^{50} times the population of the USA.) if factors are dichotomized into high and low S. I. ability and each "quadrant" of the hyperspace is to be occupied by at least one individual. Most of the space is empty space. He questions whether this is a parsimonious representation of data. A theory must serve a descriptive, reality representation function as well as a heuristic function, and Guilford's theory has been subjected to much criticism on this basis (Carroll, 1968, 1972; Cronbach, 1970; Horn, 1970, 1972; Humphreys, 1962; Thorndike, 1966).

In quest of the relationship between field independence and more conventional intelligence or ability constructs, Vernon's (1950) hierarchial theory of intelligence was used as a model. Cronbach (1970) sees this model as the most promising way to view abilities, and indeed has put forward his own version of a hierarchial structure. The concept of general intelligence however is essentially atheoretical and yields little information about psychological processes whereas the differentiation theory developed around the tests of field independence meets the criteria outlined by Eckensberger for a theory for crosscultural research:

> In basic crosscultural research we should seek the kind of theory that meets the following demands: It should be formulated independent of a special sample. It should explicitly contain assumptions about interactions between individual and his environment. And it should be developmental in nature. (1972, p. 104)

Witkin's theory is developmental and independent of the sample. Vernon (1972) notes that there is no reason why psychologists should not use a construct which overlaps with other constructs provided that it constitutes a measurable, unitary factor and leads to fruitful hypotheses. The field independence construct especially in crossculture research has led to much hypothesis testing research (Witkin, 1967; Witkin & Berry, 1975) and most likely will be retained whether or not it contains information above and beyond g and k. Nevertheless it is of both theoretical and practical interest to determine whether or not the concept of field independence is solely an ability and can be subsumed under Vernon's structure of abilities model. Conversely, this subsuming would represent an important extension of Vernon's model given the extensive research base and would supply parts of the model with a more adequate developmentalist foundation.

Wachtel (1972) warns that the construct 'field independence' refers to variance shared by several measures, and Vernon (1972) notes that any single test is only partially representative. Any study of the construct "field independence" should be cognizant of this. Most previous studies on the relationship between field independence and intelligence have considered only intercorrelations at best, or have used some of Guilford's S. I. abilities as references (Bergman & Engelbrektson, 1973; Mos, Wardell & Royce, 1974).

One study is of particular importance, in addressing the question of whether the field independence construct is simply identical with g and k factors. Vernon (1972) administered reference tests of g and v (verbal), five spatial or field independence group tests, Draw-a-Person (DAP), Rod-and-Frame (RFT) and numerous other tests of divergent thinking, grammar, fluency, creativity, etc., totalling 22 tests of abilities and achievement grades. The correlations he obtained between spatial and perceptual tests were similar to those in the literature. The measures fell into three main groups on two dimensions. One group was held to define a g factor and when this was held constant, a single spatial ability group factor accounted for all the residual correlations among the spatial and field independence tests to within + .05. Vernon concluded that, with the possible exception of the RFT, the tests which included eight spatial or field independence measures do not define a factor distinct from general intelligence and spatial ability. There was no evidence of a perceptual independence ability distinct from spatial ability, Vernon noted. A further study by Hyde, Geiringer and Yen (1975) is relevent. These researchers showed that EFT and RFT shared negligible variance after partialling out spatial ability as measured by the Identical Block Test.

Vernon's hypothesis and research has been cited by others as evidence for the "nonexistance" of field independence (Horn, 1976; Jones, 1974, Satterly, 1976). Vernon did show that field independence tests measured something distinct from g and creativity. However a pure spatial ability factor independent of embeddedness was not defined, insofar as the correlation matrix of all 22 variables was factor analyzed, thus allowing the criterion variables to play a role in constructing the factor space in terms of which their variance has to be explained afterwards, i.e. something is explained at least partly by itself. Vernon's eight spatial and perceptual variables were:

1. Copying Figures
2. Paper Formboard
3. Kohs Blocks
4. Concealed Figures
5. Embedded Figures

6. RFT Errors

7. RFT Bias

8. DAP body sophistication

Of these, variables 3, 5, 6, 7, 8 and possibly 4 have been regarded as <u>measures of field independence</u>. The variables define one factor which Vernon labels a spatial ability group factor, when it just as readily could be labeled a field independence factor. A factor space which is defined as purely as possible by the intended factors must be constructed. The two non-field-independence tests, variables 1 and 2, when factor analyzed with 5 or 6 field independence tests would not lead to a pure spatial ability factor uncontaminated by field independence.

This criticism of Vernon's method is similar to a criticism by Van Hemert (1974) of Bergman and Engelbrektson's (1973) study. They also allowed their criterion variables, i.e. RFT and EFT to play a role in the construction of factors from which the variance of the criteria has to be explained. Van Hemert suggests two procedures to be followed after first defining the factor space as purely possible by the intended factors i.e. without the criterion variables. 1). One can <u>estimate</u> the factor loadings of the criterion variables on the obtained factors and compare the resulting loadings with the hypothesis. 2). One can estimate scores on the obtained factors, compute the correlations of these factor scores with the criterion variables and do a multiple regression analysis (as the factor scores will be correlated). Then one can compare the resulting weights with the hypothesis and evaluate the multiple correlations in predicting the performances on the criterion tests from the constructed factors.

Alternate procedures would be: 1) Obtain factors g and k independent of the field independence tests, and examine whether the correlations between the field independence tests can be eliminated by partialling out the factors g and k; 2) Partial out a g factor, and examine the correlation between an s factor defined on just the spatial ability tests and a field independence factor defined on just the field indpendence tests.

This research retested Vernon's hypothesis that the construct of field independence does not represent a construct distinct from g and k, using some of the methods outlined above. Factors g, k, and v were represented by at least four tests each, none of the tests of k being a field independence test.

PSYCHOMETRIC INVARIANCE OF FIELD INDEPENDENCE TESTS

Serious methodological difficulties exist in using tests for comparisons across groups that differ in some respects. Quantitative comparisons across different populations, different age groups, different cultures, must be meaningful. The crucial assumption of invariant constructs most often remains untested.

Part of the construct validation of field independence is based on observed differences between various groups. The theory of psychological differentiation (Witkin et al., 1954; Witkin et al., 1962) and its extension to the cultural-ecological domain (Berry, 1966, 1971; Berry & Annis, 1974; Witkin, 1967; Witkin & Berry, 1975) has become an important guide for empirical observations. The theory has provided concepts and methods to guide crosscultural and crossgroup research, due largely to the structural nature of differentiation and to its base in socialization. Conversely, results of crossgroup and crosscultural enquiries have provided validation for the theory. Yet it cannot be assumed that tests retain their desirable psychometric properties when used in new cultural settings. Demonstration of the validity of a particular test is never easy, yet most crosscultural researchers do not check whether test scores are valid and hence comparable. As Witkin and Berry (1975) note, in most cases the consequences of transporting an instrument to another cultural group is not established prior to the research application, so a margin of doubt remains about how much "real" differences between the groups are responsible for the observed differences on field independence tests.

In crossgroup research it must be established that similar cognitive constructs may be applied across groups. MacArthur (1973) notes the need for careful attention to the construct validity of what may appear to be the same tests when used in different cultural settings. Other researchers in a different area express similar methodological concerns, for example, Baltes (1968) points out that comparisons on tests across age groups assumes fixed constructs. Unfortunately no established method exists for establishing that certain constructs are similar in different groups and thus that test scores obtained can be meaningfully and legitimately compared. Berry (1972) suggests searching for the possibility of qualitative differences in cognitive competences appropriate to the requirements of a particular culture. Either different groups may produce a different pattern of scores on all dimensions or some groups may have access to unique dimensions. Berry appears to equate examining quantitative differences with the existance of a single universal cognitive ability dimension and assumes that otherwise we can only talk about qualitative differences. However it could be that certain specific cognitive constructs are qualitatively similar in different groups, and thus meaningful quantitative comparisons involving that construct can be made on the basis of test scores. One way to do this is to establish the psychometric invariance of the tests across groups.

Baltes and Nesselroade (1970) argue for establishing qualitative equivalence of the behavioural dimension on which comparisons are to be made via demonstrating invariance of factors across groups. Quantitative comparisons then could be made using factor scores. This approach is also advocated by Buss and Royce (1975) who also suggest assessing cultural boundary conditions of factors. However as Vernon (1969) has noted, investigators making quantitative comparisons across cultures use tests as the dependent variables rather than factors. This certainly is the case for crosscultural research on field independence. Therefore establishing the psychometric invariance of tests across groups is necessary.

The concept of psychometric invariance was defined by Aftanas (1971) as stability of the pattern of factor loadings for a test under conditions of change, so that

... scores obtained can be meaningfully and legitimately compared even when a measure is obtained on persons from different populations, different age groups, different cultures etc. and when different methods of measurement are used, different tests measuring the same thing are used, different methods of administration are used, etc.. (Attanas, 1971, p. 3)

Establishing the psychometric invariance of field independence tests is a necessary prerequisite for comparing test scores between different groups. Irvine, an active crosscultural researcher, argues for the necessity of first establishing the 'comparative validity' of tests, a concept similar to psychometric invariance in this context. Tests have comparative validity when their factor loadings and their measured sources of variance for different cultures and groups agree in kind and amount (Irvine, 1966). Irvine noted that this is evidence for the construct validity of the tests across groups. Irvine (1969) and MacArthur (1968) make subjective evaluations of factor invariance, and do not make quantitative comparisons on the basis of factor scores. Along similar lines, Berry and Dasen (1974) proposed that demonstrating 'metric equivalence', by establishibg similarity of factor loadings of a test in different cultural settings, establishes dimensional identity and hence comparability. Metric equivalence exists when the psychometric properties of two (or more) sets of data from two (or more) groups exhibit essentially the same coherence or structure. As Berry (in press) noted, "... the requirement is that behavioral measurements (observations, test data, etc.) should be structured in similar ways <u>within</u> groups before comparisons <u>across</u> groups are allowable". He notes further that construct validation is made possible by first establishing equivalence. Most crossgroup investigations of field independence have used only one test without first establishing that such test scores can be meaningfully compared. Berry (1976) in discussing metric equivalence of field independence tests, points to two studies (Dawson, 1967; MacArthur, 1973) that showed EFT and Kohs Blocks loaded on one factor for both African and Eskimo samples. However these studies were not designed for establishing equivalence and did not examine the separate sources of variance for each test.

Demonstrating psychometric invariance involves showing that the sources of variability of a test are invariant under conditions of change. Invariance under conditions of remeasurement indicates reliability. Invariance under changes in test administration etc. demonstrates consistency, and invariance of the major sources of variance identified with the construct across population changes illustrates validity. Demonstration of psychometric invariance of a field independence test then would involve demonstrating the degree to which the major sources of variability associated with the test are invariant under systematic changes in subjects, i.e. across groups differing in age, sex, cultural background. It is the complement of determining factorial invariance, differing in the intent of determination of invariance.

Factorial invariance, generally, refers to replicating factors across systematic variations in the selection of variables or subjects (Gorsuch, 1974). It is of concern as a factor can only be considered as an independent psychological variable if it is independent of both the sample of individuals and the sample of tests. Unfortunately there has been some ambiguity in the definition of factorial invariance. Gorsuch (1974, p. 292) defines separately 'factorial replication' as the finding of the same factors across random samples. Thurstone(1947) and others use the term factorial invariance for the concept of replication as well. Gorsuch, however, also uses the term factorial invariance to refer to the concept of psychometric invariance, the invariance of the factorial description of a test when it is used in a new study involving the same common factors (Gorsuch, 1974, p. 297). Thurstone (1947) also used the term in this way.

Harman (1967) has noted the ambiguity inherent in the concept and definitions of factorial invariance, and instead he would substitute three types of factorial similarity. Type 1 is stability of factor pattern matrices across different individuals. Type 2 is constant factorial description of a variable when it is part of either one battery or another, both batteries involving the same common factors. Type 3 is invariant factor scores for an individual when tested with different batteries involving the same factors. This web of definitions is added to by others. For example, Jackson and Morf (1973) distinguish between statistical reliability of factors, that being stability of factor pattern matrices across different individuals (Harman's Type 1), and psychometric reliability of factors, involving stability of factor scores across parallel test batteries (thus involving the same common factors, i.e. Harman's Type 3). Both Jackson and Morf's and Gorsuch's distinctions are not as complete as Harman's, as they omit his Type 2.

It would seem useful to consolidate these various definitions. Harmans Type 2 will be referred to as psychometric invariance, as defined by Aftanas (1971). It involves stability of the test loading pattern, whether for the same subjects and the same tests (a reliability situation), for the same subjects and different tests with the same common factors (across tests), or for different subjects and the same variables (across groups, with either systematic or random differences between the groups). Psychometric invariance then, concerns the stability of the pattern of factor loadings for a test under conditions of change (systematic or random variation).

Harmans' Types 1 and 3, and Gorsuch's factorial invariance and replication can be cross-referenced together as in Figure 4. To the psychometric invariance concept add factorial invariance and factorial replication, as the distinction between systematic or random differences seems potentially more useful than that between same subjects or different subjects. The differentiation then is between the stability of a factor across systematic variations in variables or subjects, and stability of a factor across random variations. Stability of a factor generally refers to similarity of the two factor patterns but in a more exact sense for the case of the same subjects, refers to the correlation between the two sets of factor scores (Gorsuch, 1974, 298, 309). Different results across random samples should represent

	Same subjects Stability of factor scores Harman's Type 3	Different subjects Stability of loading patterns for a factor Harman's Type 1
Factorial invariance	systematic differences in variables	systematic differences in groups
Factorial replication	random differences (reliability situation same Ss same Vars)	random differences in groups

Figure 4

Harman's and Gorsuch's classifications cross-referenced together chance fluctuations around population values. Different results across samples with systematic differences could represent either chance fluctuations or actual differences. But if invariance is found across systematic differences in either variables or samples, then the factors represent a more useful concept. As Gorsuch notes;

> ... to the extent that invariance can be found across systematic changes in either the variables or the individuals, then the factors have a wider range of applicability as generalized constructs. The subpopulations over which the factor occurs could - and probably would - differ in their mean scores or variances across the groups, but the pattern of relationships among the variables would be the same. The factors would be applicable to the several populations and could be expected to generalize to other similar populations as well. (1974, p. 298)

Various methods have been proposed for assessing factorial invariance and factorial replication when the studies use different subjects. Most attempt to estimate what the correlations between the two sets of factor scores would be if one sample was used. Five main methods can be distinguished.

1. Gorsuch (1974) recommends as the best method, collecting a third set of data and applying the factor score weight matrices to get correlations between the two sets of factor scores.

2. Correlations from one sample can be used as estimates of correlations among variables in both samples, then the factor score weight matrices applied to get correlations between the two

sets of factor scores. Variations on this solution have been proposed by Ahmavaara (1954), Hurley and Cattell (1962), Moiser (1938, 1939) and Pinneau and Newhouse (1964). Ahmavaara transforms the first factor matrix to the second factor matrix. The transformation matrix of cosines represents the degree of correlation between the factors. A problem with this method is that rotating from the first to the second matrix does not give the same results as rotating from the second to the first. Kaiser (1960) maintains that the procedure is only defined for different orthogonal rotations of the same unrotated matrix.

3. The coefficient of congruence was proposed by Burt (1948) and Wrigley and Newhouse (1955). The coefficient is:

$$\frac{\sum_{j}^{n} {}_1a_{jp}\ {}_2a_{jp}}{\left(\sum_{j}^{n} {}_1a_{jp}^2\right)\left(\sum_{j}^{n} {}_2a_{jp}^2\right)}$$

Pinneau and Newhouse (1964) criticize this coefficient, claiming if the factors have the same size loadings the coefficient of congruence will be higher even if the patterns are unrelated. Kaiser (1960) notes that the coefficient gives the angle between the the two vectors of factor loadings and to use this as a coefficient of factorial invariance in this case of different subjects, involves assuming that the column of factor loadings defines a factor. He notes this cannot be assumed.

4. Kaiser, Hunka and Bianchini (1971) propose a method that involves locating the variables of one study in space according to their factor loadings, projecting the variables of the second study into the same space, and rotating to maximum cosine between the same variables. The factors from the second study are then

projected into this space, and the cosines of the angles between the two sets of factors represents the correlation between the two sets of factors.

5. Cattell's salient variable similarity index (Cattell, 1949; Cattell, Balcar, Horn & Nesselroade, 1969) is a test of significance for determining whether or not two factors match in the sense that they have the same salient variables. To use this index one first requires external evidence that the two factors should be matched.

The research reported here examined the psychometric invariance of field independence tests across systematic changes in subjects, i.e. across two age groups and across sex groups. Sources of variability of the tests for each group were identified first via factor analysis and these factors established as invariant using Kaiser's method. This method projects the tests from the two groups into the same factor space for maximum overlap. The cosine of the angle between the same test for the two groups gives an index of its constancy or invariance across the two groups (Veldman, 1967). The aim was to determine what the major sources of variance of the tests are, and to determine that they agree in kind and amount across age and sex groups, to establish that valid quantitative comparisons can be made between age and sex groups on field independence tests.

FIELD INDEPENDENCE AND AGE AND SEX GROUP DIFFERENCES

If field independence is not a unique construct over and above g and k, then group differences on field independence tests may be the result of group differences in g and k. Controlling for these two variables should eliminate group differences on field independence tests. If this is the case across cultural groups, the crosscultural research on socialization and ecological correlates of the development of field independence could then be regarded as a version of the research on childhood experiences related to the development of intelligence and of spatial ability. Indeed, Sherman (1967) points out that the developmental curve of field independence closely parallels that of spatial ability. He proposed that sex differences on RFT and EFT may be artifacts of known sex differences in space perception. This hypothesis was tested by Hyde, Geiringer and Yen (1975). Their sample showed a significant sex difference on RFT and no differences on GEFT. Removing differences on Identical Blocks Test, their measure of spatial ability, removed the sex differences on RFT and produced sex differences on GEFT. By removing differences on Identical Blocks Test and on Vocabularly subtest of WAIS (as a rough indicator of general intelligence), they removed sex differences on both RFT and GEFT. It would appear that spatial ability alone may not be sufficient to account for differences on field independence tests. This study then provides some indication that sex differences on field independence tests can be accounted for by g and k. However their measures of g and k are inadequate as they used only one spatial test and a verbal test. The research reported here examined whether sex differences on field independence tests could be accounted for by differences in g and k with g and k more adequately defined by Vernon's (1950) model. This was extended to examine age differences which have been shown to exist on field independence tests (Witkin, et al., 1962) to see if they can be accounted for by differences in g and k.

HYPOTHESIS

It was hypothesized that differences in field independence can be accounted for by differences in general intelligence and spatial ability.

CHAPTER 3

METHOD

The hypothesis was tested by examining three sub-problems, the one set of data being involved in all three and being analyzed in different ways. The data was derived from administration to a sample, of a test battery involving tests of general intelligence, tests of field independence and spatial ability, and verbal ability tests for factor background.

SUB-PROBLEM 1

Sub-problem 1 involved determining whether or not the construct of field independence, referring to the variance shared by several measures, represents a construct distinct from general intelligence (g) and spatial ability (k).

Relationship of sub-problem 1 to the hypothesis: The solution of the sub-problem provided evidence as to whether individual differences in field independence as represented by correlations among field independence tests can be accounted for by differences in general intelligence and spatial ability.

Subjects: The sample consisted of 192 students (95 male, 97 female) enrolled in Introductory Psycholcgy courses at the University of Manitoba. The experiment was outlined to subjects before they volunteered, and they received course credit as a result of their participation.

Procedure: Subjects were administered three field independence tests (Group Embedded Figures Test, Rod-and-Frame Test, Block Design sub-test of the WAIS), five tests of g (Raven's Progressive Matrices, 4 sub-tests of Cattell's Culture Fair test), five spatial ability tests (Space Relations sub-test of the DAT, 2D and 3D sub-tests of MAT, Revised Minnesota Paper Formboard, Blocks sub-test of AGCT), and four verbal tests (Lorge-Thorndike sub-tests) to define a v factor.

Subjects were administered tests in groups of 20 to 30, under standard conditions by the one experimenter, with Block Design test being administered by a second experimenter. Instructions for the group tests were taped for standardization. Group tests were administered first. At the first group testing subjects were administered Group EFT, Ravens, 2 verbal subtests, Blocks, and a Questionnaire, in that order. A week later a second group testing obtained data on Space Relations of DAT, Formboard, 2 verbal subtests, MAT tests, Cattell Form A. This was followed within not more than two weeks by the individual tests of field independence and Cattell Form B. All tests were administered with appropriate time limits and confidentiality was ensured. The Questionnaire was to collect background data such as age, sex, religion and sociometric status. Test descriptions and questionnaire are contained in Appendices A and B.

Data Analysis: The correlations among the non-field-independence tests were factor analyzed, using principal factor and Varimax rotation methods, to obtain a g and a k factor. Factor scores on these two factors were obtained for each subject. The correlations between the field independence tests were examined by partialling out the factors g and k. These partial correlations (Glass & Stanley, 1970) between the field independence tests were tested for significance. If differences in g and k account for correlations among field independence tests, then partialling out g and k will reduce these intercorrelations to zero.

A further analysis involved using the correlations among the field independence tests to obtain the first principal factor and factor scores on this variable for each subject. A multiple regression equation with this variable as dependent variable and factor scores on g and k as independent variables, gave some idea of the relationship between "measured" and "predicted" field independence.

SUB-PROBLEM 2

The qualitative equivalence or psychometric invariance of field independence tests across age and sex groups was assessed, to determine the validity of crossgroup quantitative comparisons on the tests.

Relationship of sub-problem 2 to the hypothesis: The solution of the sub-problem provided evidence as to whether general intelligence and spatial ability are the two main sources of variance in field independence tests for each age and sex group, and whether the amount of variance attributable to each is constant across the groups.

Subjects: The same group that was used in sub-problem 1 was employed.

Procedure: The same data was used that was collected for sub-problem 1.

Data Analysis: Two age groups were obtained by splitting the sample at the median age to form an older group of 98 (mean age 25.9 years) and a younger group of 93 (Mean age 18.4 years). The non field independence tests were factor analyzed for each age and sex group separately using principal factor and varimax methods, to check the factorial invariance of g, v and k factors. The factors were tested for invariance across age and sex groups using the Kaiser et. al. (1971) method. Then the total battery of tests were factor analyzed for each group using the same method. For each pair of groups, the set of tests were projected into the same factor space using Kaiser's method. An index of the psychometric invariance of each test across groups is then given by the cosine of the angle between the same test for the two groups.

SUB-PROBLEM 3

Differences between age and sex groups on field independence tests were studied to ascertain whether or not these differences can be accounted for by group differences in general intelligence and spatial ability.

Relationship of sub-problem 3 to the hypothesis: The solution of the sub-problem provided evidence as to whether group differences in field independence as represented by mean differences on field independence tests can be accounted for by differences in general intelligence and spatial ability.

Subjects:The same group that was used in sub-problem 1 was employed.

Procedure:The same data was used that was collected for sub-problem 1.

Data Analysis:Group differences on the field independence tests were compared. An analysis of covariance was performed for each field independence test (as the dependent variable) with factor scores for g and k as covariates. The resulting group difference, after covarying or controlling for differences on g and k, on each field independence test was tested for significance. If group differences on field independence tests are due to differences in g and k, then covarying for g and k will reduce the group differences on each test to zero.

CHAPTER 4

RESULTS

Correlations among field independence tests were examined to see if partialling out general intelligence and spatial ability would reduce the correlations to zero. The tests were examined to see if general intelligence and spatial ability are the two main sources of variance for older and younger subjects and for males and females. An index of psychometric invariance was obtained to assess the validity of quantitative comparisons across age and sex groups. Differences between age and sex groups on the field independence tests were then examined to see if covarying for age and sex differences in general intelligence and spatial ability would reduce the differences to zero.

DATA EMPLOYED

One hundred and ninetytwo subjects were tested on the majority of the tests. Eight subjects could not be contacted for the individual testing, and seven subjects were not tested on the RFT. Most subjects were tested on the four subtests of Cattell Form A, but due to time constraints only 75 subjects were tested on the four subtests of Cattell Form B (see Appendix A).

The tests were intercorrelated using SPSS Pearson Correlation program. SPSS was used for most analyses (Nie et al., 1975). Correlations, test means and standard deviations, are reported in

Table 1

Correlation matrix for all variables

	$\overline{X}$.	SD	N	Ravmat	CA 1	CA 2	CA 3	CA 4	Blocks	RMPFB
Ravmat	23.35	4.61	192							
CA 1	7.79	1.46	184	.41						
CA 2	6.94	2.11	184	.47	.28					
CA 3	6.06	1.42	184	.43	.34	.30				
CA 4	5.77	1.28	184	.35	.24	.27	.27			
Blocks	29.78	6.39	192	.55	.33	.25	.27	.33		
RMPFB	43.37	8.87	192	.46	.30	.29	.35	.23	.49	
DATSR	52.54	21.67	192	.55	.40	.31	.46	.36	.54	.52
MAT 2D	19.38	4.57	192	.27	.21	.16	.26	.16	.25	.52
MAT 3D	14.44	4.72	192	.54	.39	.24	.34	.28	.45	.51
Ver 1	17.53	4.40	192	.25	.11^{NS}	.23	.20	.17	.28	.20
Ver 2	10.31	3.59	192	.29	.06^{NS}	.25	.29	.29	.32	.25
Ver 3	10.35	3.37	192	.27	.16	.19	.26	.26	.21	.14
Ver 4	12.25	2.87	192	.22	.05^{NS}	.17	.24	.15	.25	.17
KBDT	38.24	7.60	184	.52	.29	.31	.36	.30	.42	.51
RFT	27.04	24.80	177	-.29	-.20	.01^{NS}	-.16	-.10^{NS}	-.25	-.25
GEFTT	12.43	4.50	192	.52	.30	.27	.41	.27	.43	.55

Table 1 (Continued)

(NS: Not significant at =.05)

	DATSR	MAT 2D	MAT 3D	Ver 1	Ver 2	Ver 3	Ver 4	KBDT	RFT	GEFTT
Ravmat										
CA 1										
CA 2										
CA 3										
CA 4										
Blocks										
RMPFB										
DAT SR										
MAT 2D	.33									
MAT 3D	.60	.44								
Ver 1	.25	.26	.24							
Ver 2	.29	.20	.28	.69						
Ver 3	.30	.17	.27	.62	.50					
Ver 4	.25	.23	.22	.64	.54	.65				
KBDT	.48	.48	.59	.22	.31	.26	.26			
RFT	−.33	−.24	−.44	−.04 NS	−.11 NS	−.13	−.14	−.37		
GEFTT	.56	.39	.64	.26	.33	.23	.23	.61	−.40	

Table 1. Very generally, the five spatial tests and Raven's Matrices all intercorrelate at the .40-.60 level, the verbal tests intercorrelate with the spatial tests and Raven's Matrices at the .20-.40 level, and the verbal tests correlate with each other at the .50-.70 level. The Cattell subtests, Forms A and B, intercorrelate with the spatial tests at the .25-.35 level, and intercorrelate with the verbal tests at the .15-.25 level. Of the 210 correlations among the 21 variables, 28 are nonsignificant at the .05 level with individual one-tailed tests of significance, and 21 of these nonsignificant correlations involve the four subtests of Cattell Form B. The vast majority of the correlations are significant at the .001 level, one-tailed. At this point, the four subtests of Cattell Form B were dropped from further analysis, as coefficients involving this test are based on a much smaller number of cases and perhaps even on quite a different subpopulation; the four subtests of Form A were retained.

TEST OF SUB-PROBLEM 1

Before factor analyzing the 14 non-field independence tests, the relevant correlation matrix was tested for significance using Bartlett's test (Gorsuch, 1974, 136). Results, presented in Table 2, indicate that this correlation matrix is significant and suitable for factoring.

The non-field independence tests were factor analyzed using principal axis and Varimax rotation methods via SPSS Factor program, with iterations on the squared multiple correlation

Table 2

Bartlett's test of significance of 14 variable correlation matrix

$$X^2 = -\left(n-1-\frac{2v+5}{6}\right) \text{Log}_e \left|R_{vv}\right|$$

$$= -185.5\ (-5.64)$$

$$= 1046.22$$

$$df = v\,\frac{v-1}{2}$$

$$= 91$$ Significant at .01 level

Where

$\left|R_{vv}\right| = .0034$

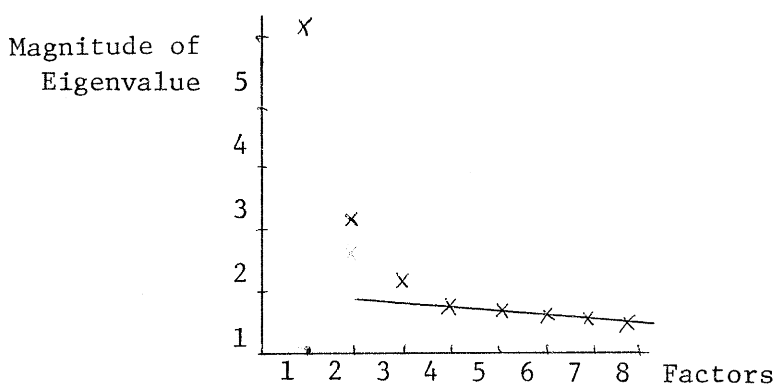
$v = 14$

$n = 192$

Table 3

Cattell's scree test on 14 variable factor solution

Factor	1	2	3	4	5	6	7	8	9	10
Eigenvalue	5.20	2.03	1.08	0.81	0.78	0.73	0.66	0.55	0.49	0.42
Percent of Variance	37.2	14.5	7.7	5.8	5.6	5.2	4.7	3.9	3.5	3.0



communality estimates. Three factors had eigenvalues greater than 1.00 when the correlation matrix was factored first with unities in the diagonal. Gorsuch (1974) notes this widely used and theoretically rationalized method for estimating number of factors is more accurate where the number of variables is small or moderate and the communalities are high, the situation that pertains here. Cattell's (1966) scree test for the number of factors also indicates a three-factor solution is appropriate for this data (see Table 3).

A Varimax rotation of three factors gave the factor structure in Table 4. The first factor is a main factor with 9 of the 14 tests having loadings on it >.20. The first factor, then, is a general factor, accounting for 41.7 percent of common variance. The highest loading is Raven's Matrices, which is a factor marker for g under Vernon's (1950) model. Five tests load only on the first factor: Raven's Matrices and the four Cattell tests, all measures of g.

The second factor is a verbal factor. The four verbal tests have loadings >.70 on this factor while all other tests load less than .20. The second factor is clearly defined, and accounts for 36.9 percent of common variance. The third factor is a spatial factor with the five spatial tests having loadings >.30. All other tests load less than .20 on this factor, which accounts for 21.4 percent of common variance.

This factor structure is close to the hypothesized factor structure. It is clear that the first and third factors define general and spatial factors. Factor scores on these two factors

Table 4

Factor solutions for the 14 variables: 1) Principal axis with Varimax rotation and 2) Maximum likelihood exploratory

Variables	Factors						Communality	
	I		II		III			
	1.P.A.	2.M.L.	1.P.A.	2.M.L.	1.P.A.	2.M.L.	1.P.A.	2.M.L.
1 Ravmat	.76	.75					.64	.62
2 CA1	.53	.53					.31	.30
3 CA2	.48	.47					.26	.25
4 CA3	.49	.50					.31	.30
5 CA4	.46	.46					.25	.24
6 Blocks	.55	.60			.30	.24	.43	.45
7 RMPFB	.42	.47			.66	.61	.62	.60
8 DATSR	.66	.69			.37	.31	.59	.59
9 MAT 2D					.64	.69	.46	.53
10 MAT 3D	.53	.58			.49	.43	.54	.54
11 Ver 1			.84	.85			.74	.75
12 Ver 2	.23	.22	.70	.72			.56	.57
13 Ver 3	.23	.22	.72	.72			.57	.56
14 Ver 4			.77	.75			.62	.59
Eigenvalue	2.87		2.54		1.47		6.90	
Percent of Variance	41.7		36.92		21.37			

(Omitted loadings $\leqslant |.20|$ considered trivial) were obtained using least squares regression complete estimation method using SPSS Factor program.

To authenticate this factor structure, the correlation matrix was factored again, using exploratory maximum likelihood factor analysis (Joreskog & Lawley, 1968) followed by Varimax rotation of three factors. Program UMLA (Joreskog, 1967) was used for the analysis. The results, also in Table 4, indicate very close agreement with the principal axis and varimax solution. Loadings are very similar, often within .01-.02, and nearly always within .05. The data, then, present a clear simple structure.

The intercorrelations among the three field independence tests are significant and of the size reported in the literature. Correlations between the field independence tests and the factor scores for factors I and III were obtained, then factors I and III were partialled out of the intercorrelations among the three field independence tests. This provides a test of sub-problem 1: to determine whether the construct of field independence, referring to the variance shared by the three measures, represents a construct distinct from general intelligence and spatial ability. The results are presented in Table 5 and indicate that g and k account for a large proportion of the shared variance among the field independence tests (79%).

The intercorrelations among the field independence tests were examined further by partialling out the 10 tests that loaded on factors I and III. The partial correlations in Table 5 were obtained.

Prior to factor analyzing the matrix of correlations among the

Table 5

Intercorrelations, partial correlations and variance proportions among the field independence tests taking into account factors g & k

		GEFTT and RFT	GEFTT and KBDT	RFT and KBDT
Zero order correlations	r_{xy}	−.40	.61	−.37
Partialling out g and k	$r_{xy.gk}$	−.21	.28	−.17
partialling out 10 tests		−.17	.25	−.16
Proportion of total variance that is common	r^2xy	.160	.372	.137
Proportion of total variance remaining common after g and k partialled out	$r^2xy.gk$	.044	.078	.029
Proportion of total variance removed by partialling out g & k	$r^2xy-r^2xy.gk$	.116	.294	.108
Proportion of common variance due to g & k	$\frac{r^2xy-r^2xy.gk}{r^2xy}$	.72	.79	.79

Table 6

Bartlett's test of significance of correlation matrix for three field independence tests

$$X^2 = -\left(185-1-\frac{2(3)+5}{6}\right) \text{Log}_e (.5108)$$

$$= (-182.17)(-.6718)$$

$$> 1000$$

$$df = 3$$

Significant at .01 level

Table 7

Principal component solution for field independence tests

Variable	Factor I	Communality
KBDT	.84	.71
RFT	-.71	.50
GEFTT	.85	.73
Eigenvalue	1.93	

Table 8

Multiple correlation between field independence factor scores and g and k factor scores

$$R_{f.g,k} = .73$$

$$R^2_{f.g,k} = .53$$

$$F = 107.9$$

field independence tests, the matrix was tested for significance using Bartlett's test. The results, presented in Table 6, indicate that this correlation matrix is significant and suitable for factoring.

The principal component method was used, and one factor was obtained with an eigenvalue greater than 1.00. Results are presented in Table 7. Factor scores were obtained on this variable for each subject, and a multiple regression was performed with this variable as the dependent variable and factor scores on factors I and III as the independent variables, to give an indication of the relationship between "measured" and "predicted" field independence. Results are outlined in Table 8.

Confirmatory factor analyses of the data were also carried out to extract factors with predefined characteristics (Gorsuch, 1974, p81). In the exploratory solutions, the first factor, although a general factor, is more heavily loaded with the spatial tests than the verbal tests. This can partially be attributed to the tests of g being nonverbal tests. Furthermore, the Cattell tests have low communalities due perhaps to their short length and consequent lower reliability. Pairwise plots of the three factors (see Figures 5, 6 and 7) reflect this situation of the verbal tests loading only factor II and the spatial tests loading both factors I and III. The plots show a clear simple structure between factors I and II, and between factors II and III. If loadings < .20 are considered trivial and in the hyperplane, then for these two pairs of factors, most variables that load high on one factor are in the hyperplane of the other

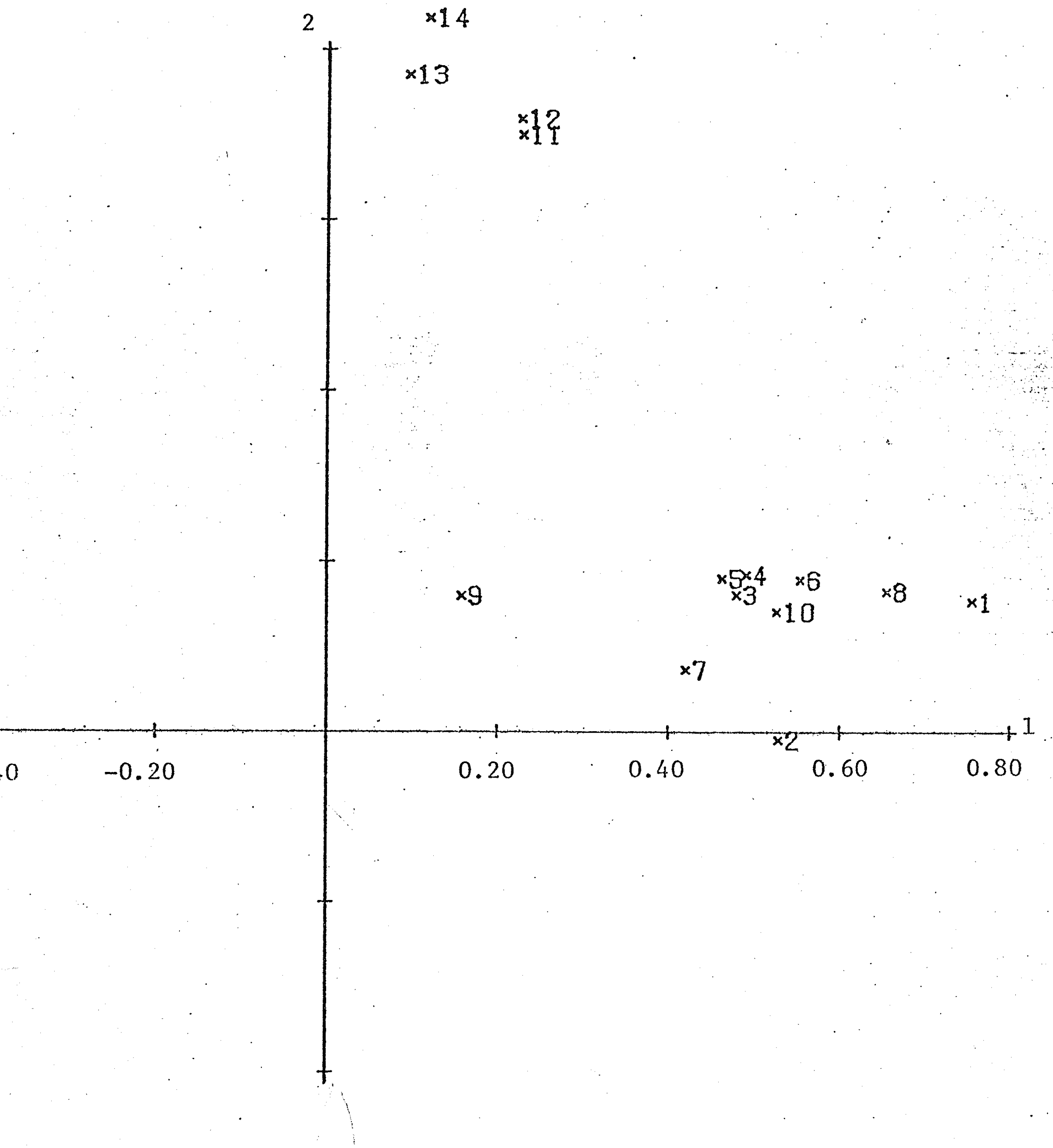


Figure 5

Plot of factors 1 versus 2 for principal axis and Varimax solution of 14 variables

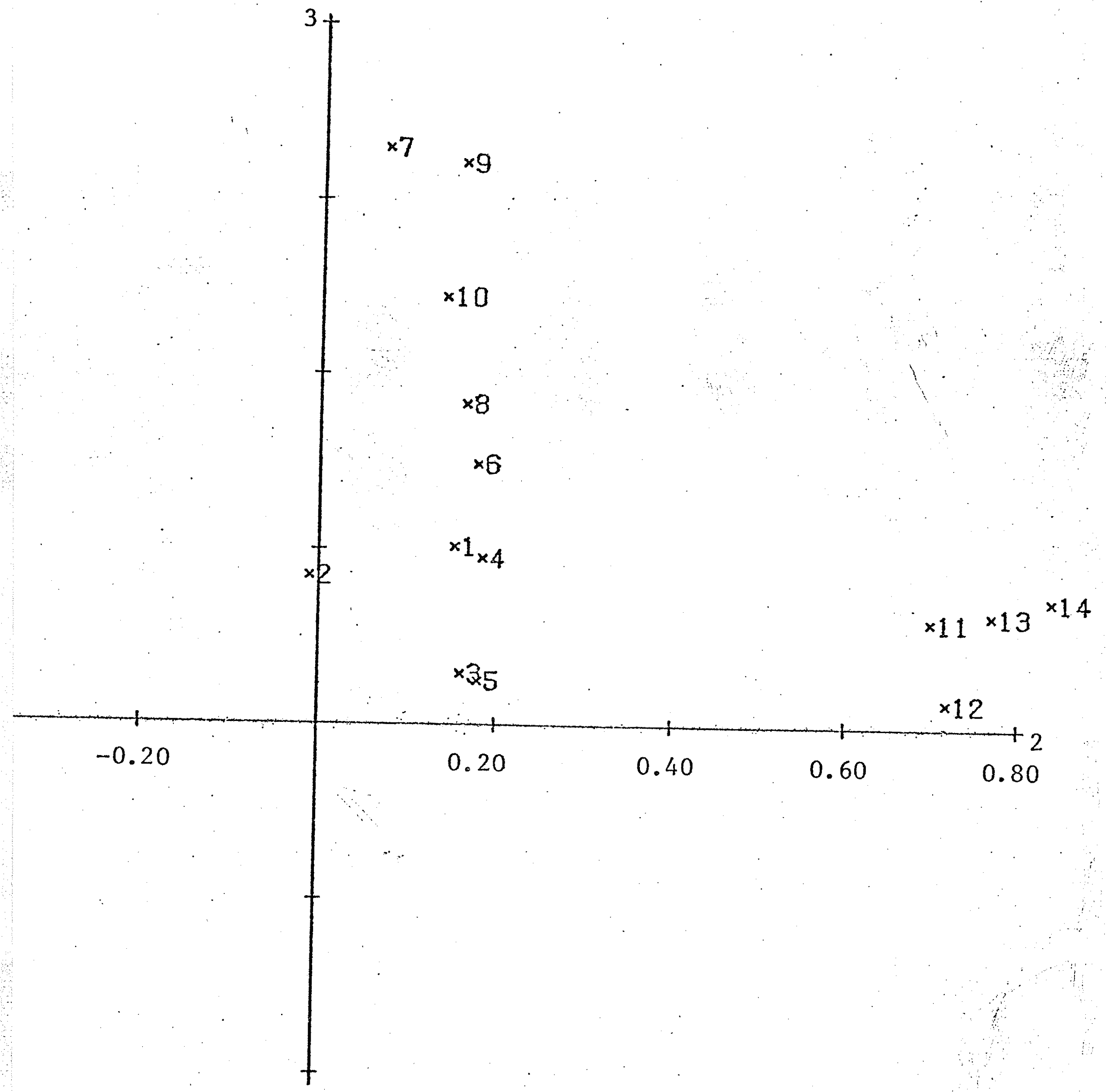


Figure 6

Plot of factors 2 versus 3 for principal axis and Varimax solution of 14 variables

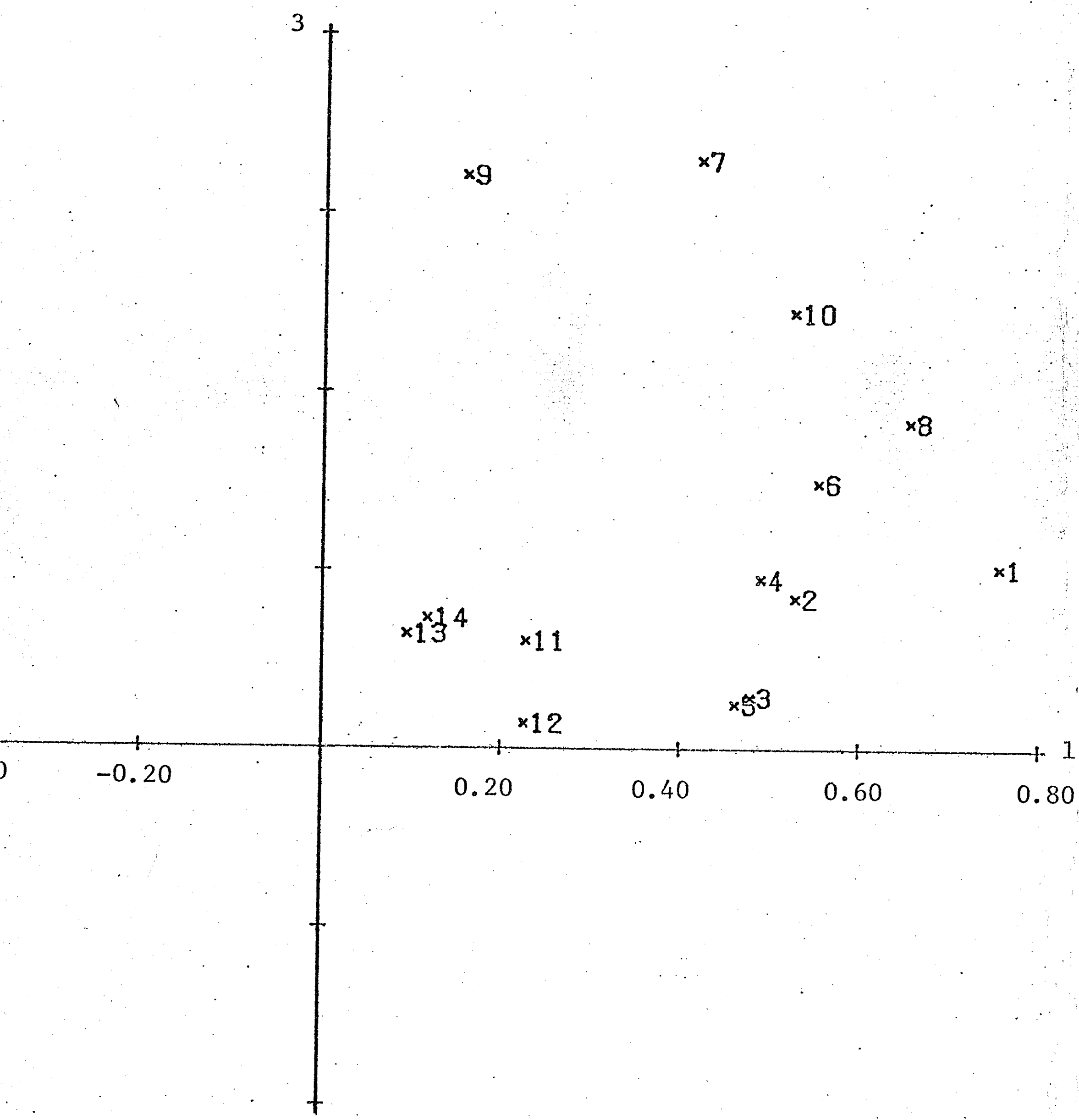


Figure 7

Plot of factors 1 versus 3 for principal axis and Varimax solution of 14 variables

factor and vice versa. The plot of factors I and III, however, shows the five spatial tests loading on both factors.

Given these considerations, a confirmatory analysis was done, redefining the general first factor. Diagonal factor method was used for the first factor, where the first factor is assumed to be the equivalent of one variable (Gorsuch, 1974, p67). Under Vernon's (1950) hierarchial model of abilities, Raven's Matrices is a factor marker for g. This variable, as first factor g, was partialled out of the correlation matrix. The resultant residual partial correlation matrix of verbal and spatial tests with factor g removed, was factor analyzed to obtain factors v and k, following in part the method proposed by Vernon (1972). The loadings of the tests on factor g is given by their correlation with Raven's Matrices divided by the loading of Raven's Matrices on factor I (Fruchter, 1954, p54). Their loadings on factors v and k are given via a principal axis and Varimax analysis. Results are presented in Table 9. This analysis, when compared to the exploratory analysis, has increased slightly the loadings of the spatial tests on the spatial factor, and has increased somewhat the loadings of the verbal tests on the general factor. These redefined, theoretically rationalized factors give basically the same simple structure solution as the exploratory analyses.

TEST OF SUB-PROBLEM 2

Separate principal factor analyses of non field independence tests were performed for each sex group and for the two age

Table 9

Confirmatory factor solution for the 10 variables

Variables	Factor I	Factor II	Factor III	Communality
Ravmat	.84			.64
Blocks	.69		.42	.67
RMPFB	.58		.70	.83
DATSR	.69		.58	.82
Mat 2D	.34		.52	.40
Mat 3D	.68		.60	.83
Ver 1	.33	.84		.83
Ver 2	.36	.68		.62
Ver 3	.34	.72		.64
Ver 4	.28	.76		.67
Eigenvalue	2.94	2.30	1.69	

Loadings ≤ |.20| omitted and considered trivial groups. Three factors were rotated via Varimax. Results were checked for equivalence of the g, v and k factors across the two sex and the two age groups. The method used was that suggested by Kaiser et al. (1971) using a factor match program written by Veldman (1967).

For the two age groups, both unrotated and rotated factor solutions are invariant. The factors show excellent matches, as indicated by the three cosines being >.95 and the remaining cosines being <.20 (see Table 10). Veldman (1967, p237) notes that these cosines may be interpreted as correlations between the factor variables derived from the two analyses. In the unrotated solution, the order of the factors is identical also. In the rotated solution, factor I of one group has become factor II of the other group. The corresponding factors retain their invariance property however.An invariant factor structure, then, was found for the two age groups.

For the two sex groups, the unrotated factor solutions are invariant for all three factors, as indicated by cosines >.95 or <.20 (see Table 11). The order of the factors is identical also. The rotated factor solutions are invariant with respect to the verbal factor (factor 1 for males and factor 2 for females), and this verbal factor bears no relationship with the remaining two factors. However, the Varimax rotation has found slightly different solutions for the remaining two factors. Cosines between corresponding factors have dropped to .92 while cosines with the remaining nonverbal factor have risen to .38. The same unrotated factor structure, then, was found for the two sex

Table 10

Factorial invariance across age groups for 14 variables

Variables	Younger half-Varimax factors			Older half-Varimax factors		
	I Verbal	II General	III Spatial	I General	II Verbal	III Spatial
Ravmat	.25	.58	.32	.73	.12	.34
CA 1	-.03	.60	.09	.48	.00	.30
CA 2	.12	.53	.12	.42	.21	.08
CA 3	.24	.44	.24	.48	.13	.26
CA 4	.14	.36	.11	.56	.22	.01
Blocks	.23	.31	.51	.64	.15	.23
RMPFB	.04	.22	.80	.44	.09	.64
DATSR	.18	.51	.51	.66	.16	.37
MAT 2D	.08	.06	.48	.20	.23	.68
MAT 3D	.21	.45	.54	.49	.10	.50
Ver 1	.72	.13	.22	.09	.92	.13
Ver 2	.66	.21	.27	.24	.73	.07
Ver 3	.79	.29	-.07	.19	.69	.12
Ver 4	.78	.04	.13	.12	.76	.11

Cosines among Varimax factors

		Older half I	Older half II	Older half III
Younger half	I	.02	1.00	-.01
	II	.99	-.03	-.16
	III	.16	.01	.99

Cosines among principal axis factors

		Older half I	Older half II	Older half III
Younger half	I	1.00	.06	.02
	II	.06	-.99	.13
	III	-.01	-.13	.99

Table 11

Factorial invariance across sex groups for 14 variables

Variables	Females - Varimax factors			Males - Varimax factors		
	I Spatial	II Verbal	III General	I Verbal	II Spatial	III General
Ravmat	.68	.19	.40	.12	.35	.60
CA 1	.51	.03	.32	.00	.11	.50
CA 2	.31	.12	.71	.14	.12	.37
CA 3	.57	.10	.26	.32	.07	.49
CA 4	.28	.22	.36	.12	.21	.44
Blocks	.63	.23	.20	.10	.60	.27
RMPFB	.81	-.14	.10	.21	.76	.25
DAT	.78	.15	.13	.20	.51	.57
MAT 2D	.56	.10	.04	.21	.46	.09
MAT 3D	.76	.17	.21	.16	.53	.28
Ver 1	.05	.84	.21	.79	.33	.03
Ver 2	.11	.75	.30	.56	.38	.12
Ver 3	.15	.75	.06	.73	.03	.32
Ver 4	.10	.79	-.08	.79	.19	.18

Cosines among Varimax factors

	Males I	Males II	Males III
Females I	-.04	.92	.39
II	1.00	.06	-.06
III	.08	-.38	.92

Cosines among principal axis factors

	Males I	Males II	Males III
Females I	.98	.18	.05
II	.17	-.98	.13
III	-.08	.12	.99

groups. The rotated factor structure was invariant for the verbal factor, while the remaining two factors exhibited a high degree of correspondence but also some confounding.

The field independence tests were assessed for psychometric invariance across age groups and across sex groups. Separate factor analyses were done for each group, including in the field independence tests. Three factors were rotated via Varimax and results checked for equivalence of the factors using Kaiser's (1971) method. The factors show excellent matches as indicated by corresponding cosines being >.95 (see Tables 12 and 13). The cosine of the angle between the test vectors of the same test for the two groups gives an index of its constancy, or invariance, across the two groups. This provides a test of sub-problem 2: to assess the qualitative equivalence or psychometric invariance of field independence tests across two groups to determine the validity of crossgroup quantitative comparisons on the tests. As can be seen from Tables 12 and 13, field independence tests show excellent invariance across age groups and across sex groups (cosines >.90) with the exception of RFT which shows only moderate correspondence across age groups (cosine =.60).

TEST OF SUB-PROBLEM 3

As a preliminary indication of the effects of age and sex on the field independence tests, the correlations of these variables with the tests were examined. The sex variable has a significant correlation with RFT only, while age correlates significantly with all three field independence tests. Results are in Table

Table 12

Psychometric and factorial invariance across age groups with field independence tests

Variables	Younger half-Varimax factors			Older half-Varimax factors		
	I Spatial	II Verbal	III General	I Spatial	II General	III Verbal
Ravmat	.33	.27	.55	.42	.71	.12
CA 1	.13	-.01	.57	.33	.42	.00
CA 2	.15	.12	.54	-.04	.57	.20
CA 3	.30	.24	.43	.24	.52	.12
CA 4	.12	.14	.35	.18	.47	.22
Blocks	.50	.25	.27	.35	.55	.15
RMPFB	.75	.08	.18	.57	.33	.24
DAT	.54	.21	.46	.50	.44	.11
MAT 2D	.49	.08	.02	.56	.55	.16
MAt 3D	.60	.23	.39	.75	.23	.24
Ver 1	.18	.73	.10	.07	.15	.92
Ver 2	.27	.66	.19	.13	.21	.73
Ver 3	-.08	.79	.28	.17	.15	.69
Ver 4	.12	.79	.02	.12	.11	.76
KBDT	.49	.13	.37	.69	.33	.24
RFT	-.13	-.16	-.08	-.71	.00	.00
GEFTT	.59	.02	.34	.67	.39	.28

Cosines among Varimax factors

		Younger half I	Younger half II	Younger half III
Older half	I	1.00	.05	-.04
	II	.04	.02	1.00
	III	-.05	1.00	-.01

Cosines between corresponding field independence tests

KBDT	RFT	GEFTT
.96	.60	.93

Table 13

Psychometric and factorial invariance across sex groups with field independence tests

Variables	Females - Varimax factors			Males - Varimax factors		
	I Spatial	II Verbal	III General	I Spatial	II Verbal	III General
Ravmat	.63	.20	.44	.37	.11	.61
CA 1	.48	.04	.33	.03	.01	.52
CA 2	.22	.14	.79	.13	.13	.37
CA 3	.52	.09	.36	.12	.31	.43
CA 4	.30	.23	.31	.08	.14	.51
Blocks	.58	.23	.25	.39	.13	.43
RMPFB	.79	-.15	.21	.56	.23	.39
DAT	.70	.14	.25	.46	.21	.58
MAT 2D	.57	.09	.11	.47	.29	.14
MAT 3D	.81	.17	.21	.63	.13	.26
Ver 1	.02	.85	.21	.31	.78	.07
Ver 2	.10	.76	.28	.39	.56	.15
Ver 3	.17	.76	.03	.05	.73	.28
Ver 4	.11	.78	-.07	.19	.80	.16
KBDT	.68	.15	.14	.63	.15	.44
RFT	-.62	-.03	.18	-.51	-.15	.09
GEFTT	.75	.16	.15	.75	.14	.29

Cosines among Varimax factors

	Males I	Males II	Males III
Females I	.94	.00	.35
II	.01	1.00	-.04
III	-.35	.04	.94

Cosines between corresponding field independence tests

KBDT	RFT	GEFTT
1.00	.94	.98

14.

Partial correlations with age, partialling out sex, and with sex, partialling out age, are presented as well. In the sample, age and sex intercorrelate -.25. As sex was scored dichotomously, 0 for females, 1 for males, this indicates a slighter tendency for females to be on the average older than males. Partialling out sex had only a slight effect, while age seems a more potent variable.

The intercorrelations among the field independence tests were then examined for the effects of age and sex. As can be seen in Table 15, partialling out sex has almost no effect on the intercorrelations. Partialling out age reduces the intercorrelations by .03 on the average.

Differences between males and females on each field independence test were examined by t-tests. The tests are nonsignificant except for RFT, confirming the above analysis (see Table 16). For the age groups, t- tests for each field independence test indicates significant differences on these variables. Analyses of covariances were performed on each of these significant differences, covarying for factors I and III. This provides a test of sub-problem 3: to determine whether differences between two groups on field independence tests can be accounted for by group differences in general intelligence and spatial ability.

Results, presented in Table 17, indicate that for the age group differences, covarying factors g and k reduces the difference to nonsignificance. Thus age group differences on field independence tests can be accounted for by g and k age

Table 14

Correlations and partial correlations between field independence tests and age and sex

			KBDT	RFT	GEFTT
Zero order correlations	r_{xa}	Age	-0.18	0.36	-0.23
Zero order correlations	r_{xs}	Sex	N.S.	-0.24	N.S.
Partialling out sex	$r_{xa.s}$	Age	-0.18	0.32	-0.21
Partialling out age	$r_{xs.a}$	Sex	--	-0.17	--

Table 15

Intercorrelations among the field independence tests with sex and then with age partialled out

		KBDT & RFT	KBDT & GEFTT	RFT & GEFTT
Zero order correlations	r_{xy}	-0.37	0.61	-0.40
Partialling out sex	$r_{xy.s}$	-0.37	0.61	-0.39
Partialling out age	$r_{xy.a}$	-0.34	0.59	-0.35

differences. The sex difference on RFT could not be reduced by covarying factors g and k. Sex differences on RFT were not accounted for by sex differences in g and k.

Table 16

t tests of age and sex differences on field independence tests

		KBDT				GEFTT				RFT			
		$\bar{X}$.	N	t	p	$\bar{X}$.	N	t	p	$\bar{X}$.	N	t	p
Sex	M	38.5	93	.48	.63	12.92	95	1.48	.14	21.2	90	-3.25	.00
	F	38.0	91			11.96	97			33.1	87		
Age	Old	37.1	93	-2.08	.04	11.6	99	-2.63	.01	31.5	91	2.54	.01
	Young	39.4	91			13.3	93			22.3	86		

Table 17

Analysis of variance and covariance for age and sex differences on field independence tests with factors g and k as covariates

	KBDT				GEFTT				RFT			
Anova	SS	df	F	p	SS	df	F	p	SS	df	F	p
SV Sex	12.5	1	.21	.64	54.5	1	2.7	.10	6238.0	1	10.7	.00
Res.	10175.6	175			3466.3	175			101978.0	175		
SV Age	263.2	1	4.6	.03	125.4	1	6.5	.01	3758.3	1	6.3	.01
Res.	9924.9	175			3395.4	175			104457.8	175		
Ancova g and k covariates	SS	df	F	p	SS	df	F	p	SS	df	F	p
SV Sex		--				--			6391.2	1	12.8	.00
Res.									85788.8	173		
SV Age	18.5	1	0.6	.45	16.9	1	1.6	.21	1697.1	1	3.3	.07
Res.	55551.6	173			1882.2	173			90483.0	173		

CHAPTER 5

DISCUSSION

The results as a group support the hypothesis that differences in field independence can be accounted for by differences in general intelligence and spatial ability. The research has shown that g and k account for approximately 80% of the shared variance among the field independence tests and approximately 50% of the total variance of the tests. The method used provides a method for establishing metric equivalence or psychometric invariance, i.e., a method for demonstrating that behavioral measures are patterned similarly for two age and two sex groups prior to making comparisons across groups on the tests. This chapter deals in more depth with this method of establishing psychometric invariance and the results. Then the results are discussed in terms of their consequences for the construct validation of the tests.

THE DISTINCTIVENESS OF FIELD INDEPENDENCE

The factor analysis of the intercorrelations among the non-field independence tests revealed three simple structure factors, a general, a verbal and a spatial factor. The general factor is a main factor with the majority of tests loading on it, the highest loading being for Ravens Matrices, which is a factor marker for g under Vernon's model. The five tests of g load only on this factor. Only the spatial tests load the spatial factor and only the verbal tests load the verbal factor. The same structure appeared when the data were analyzed by three different methods namely 1) principal axis and varimax rotation, 2) exploratory maximum likelihood and 3) confirmatory diagonal method for factor I followed by principal axis and varimax for factors II and III. The reappearance of the same factors over different analyses strengthens their interpretation. Harris and Harris (1971) term this method to reduce errors of inference the method of comparable common factors (CCF). Here all three factors replicate over different analyses and thus meet the CCF criterion. The factors then are adequately defined by the non-field independence tests.

The construct of field independence refers to the variance shared by several measures, and the aim of sub-problem 1 was to determine if it represents a construct distinct from g and k. The evidence is that individual differences in field independence, as represented by the correlations among the tests, can be accounted for by differences in g and k. Two of three correlations among the field independence tests are reduced to nonsignificance by partialling out g and k factor scores thus supporting the hypothesis. The remaining significant partial correlation, between Group Embedded Figures Test and Kohs Block Design test, has been reduced significantly from .61 to .28. Further, the results indicate that g and k account for almost eighty percent of the shared variance, as represented by correlations, among the field independence tests. The intercorrelations among the three field independence tests were further examined by partialling out the ten tests that loaded on factors g and k. Results are substantially the same, indicating that the two factors are a suitable and sufficient representation of the ten tests. The multiple correlation of .73 between the first principal component for the field independence tests and factor scores for g and k further substantiate the inference that the factors account for a large proportion of the shared variance, represented here by the first principal component, of the field independence tests. The examination of sub-problem 1, then, leads to the conclusion that individual differences in general intelligence and spatial ability can account for all or nearly all of the shared variance among the field independence tests.

PSYCHOMETRIC INVARIANCE

The three factors, general, verbal and spatial, defined on non-field independence tests were checked for factorial invariance across age and sex groups to first establish that these constructs are similar in the different groups. The factor analyses for the two age groups revealed for both groups a general factor with the majority of tests loading on it. Moreover, for both groups only the verbal tests load the verbal factor, and the spatial tests load a spatial factor. As in the total group solution, the general factor is more heavily loaded with the spatial tests than the verbal tests, the spatial tests load both the general and the spatial factors. The loading of Ravens Matrices on the general factor is not quite so high for both solutions as it was for the total group solution and here it loads slightly on the spatial factor. Therefore, for the two age groups the three simple structure factors are very similar to those for the total group. The order of the factors is the same as in the total group while in the younger group the general and verbal factors reversed order. Corresponding factor variables across the two age groups are highly correlated, as indicated by cosines of 1.00 or .99. Noncorresponding factor variables were not correlated, as indicated by cosines of .01 to .16. Thus, factor invariance of the general, verbal and spatial factors was established across age groups.

The factor analysis for males and females revealed a verbal factor defined only by the verbal tests, and a general factor defined mainly by the tests of g. The general factor for both groups is a weaker factor than for the total group, being the third factor after rotation. The spatial tests for males load a spatial factor, and Ravens Matrices has a small loading on this factor, as was the case for the two age groups. Therefore, for males the factor solution is very similar to the total group solution, the factors being ordered differently. For females, the spatial tests load only the first factor. This factor is loaded also by the tests of g which have generally lower loadings on the general factor. Thus for females the general and spatial factors are less distinct. This is reflected in the cosines among the factors. Corresponding factor variables across the sex groups are highly correlated, as indicated by cosines of 1.00 for the verbal factor and .92 for the general and spatial factors.

Noncorresponding factor variables are not correlated across sex groups except that the spatial factor for females shows some relationship to the general factor for males as indicated by a cosine of .39. The varimax rotation has produced a slightly different solution for the females, and factors I and III could be rotated to increase the loadings of the test of g on the general factor and decrease them on the spatial factor. An examination of cosines among the principal axis factors shows they are highly correlated as indicated by cosines of .98 and .99. There is no confounding present here as noncorresponding principal axis factors are unrelated (cosines of .05 to .18). This substantiates the conclusion that the same factor space is involved across sex groups.

To assess the psychometric invariance of the field independence tests across age groups, further factor analyses were done, this time including the field independence tests in the analyses. The same factors were obtained as were revealed in the factor analyses without these tests. The spatial, general and verbal factors have the same salient variables and similar loadings. The addition of the tests resulted in a reordering of the factors, the spatial factor appearing first. The field independence tests for both age groups load mainly on the spatial factor. The tests have small loadings on the general factor for both age groups and none of the tests load on the verbal factor. An exception is the Rod and Frame Test which does not load on any of the factors in the younger group, and loads spatial but not the general factor in the older group. This patterning of loadings of the field independence tests for the two age groups is reflected in the indices of psychometric invariance. The cosines for Block Design test and for Group Embedded Figures test are .96 and .93 respectively, indicating psychometric invariance across age groups. However, for the Rod and Frame test the cosine is .60 indicating only moderate psychometric invariance across age groups. For the two invariant tests, approximately 50% of the total variance is due to g and k; 38% can be attributed to the spatial factor and 12% to the general factor. Slightly less is due to the spatial factor in the younger group and slightly more in the older group. For the Rod and Frame test, 50% of its variance can be accounted for solely by the spatial factor in the older group. However, none of its variance could be accounted for in the younger group.

The psychometric invariance of field independence tests across sex groups was also assessed. The factor analyses of the battery including the field independence tests for each sex group again gives the same factors that were obtained for the analyses without those tests. The factors have the same salient variables and very similar loadings, the addition of the three tests resulting in the spatial factor appearing first. The three field independence tests load on the spatial factor with negligible loading on the other factors except for Block Design test which loads moderately on the general factor for males. Again the patterning of loadings of the tests for the sex groups is reflected in the index of psychometric invariance.

The cosines for Block Design, Rod and Frame and Group Embedded

Figures test are 1.00., .94 and .98 respectively, indicating psychometric invariance across sex groups. Again, approximately 50% of the total variance of the tests is due to g and k, 44% can be attributable to the spatial factor and 6% to the general factor. The general factor was found to be a weaker factor for the sex groups than for the age groups hence this is slightly less than was due to the general factor for the age groups. For the females, slightly more is attributable to the spatial factor and slightly less to the general factor and vice versa for the males.

The examination of sub-problem 2 then leads to the conclusion that the field independence tests are qualitatively equivalent or psychometrically invariant across age and sex groups, with the exception of Rod and Frame test across age groups. Thus, with this exception, the major sources of variance of the tests agree in kind and amount across age and across sex groups. Further, approximately 50% of the total variance of the tests is due to general intelligence and spatial ability, 40% to spatial ability and 10% to general intelligence.

AGE AND SEX DIFFERENCES

The hyothesis that differences in field independence can be accounted for by differences in general intelligence and spatial ability was examined in a third way. Mean differences on field independence tests across age groups and across sex groups were tested for significance. Across age groups, significant differences were found on all the field independence tests. For each test, adjusting for group differences in g and k by covarying g and k reduced the differences to nonsignificance, thus supporting the hypothesis. No sex differences were found on the Block Design test or on Group Embedded Figures test. Significant sex differences were found on the Rod and Frame test and analysis of covariance did not reduce these differences, contrary to the prediction. The results for sub-problem 3 then lead to the conclusion that age group differences on the three field independence tests can be accounted for by age group differences in general intelligence and spatial ability. Sex differences found on the Rod and Frame test could not be accounted for.

GENERAL IMPLICATIONS

The field independence construct is empirically based upon shared variance. This research demonstrated that this shared variance disappears when variance due to g and k is removed, and that age differences on field independence tests can be accounted for by age differences in g and k, within the limits of the study. These limits include sample used (Canadian university 1st year students) and use of a particular model for definition of g and k, so that established factor markers were used rather than broader measures of the constructs. An attempt was made to broaden the heterogeneity of the sample, and thus the range of the variables and the generalizability of the results, by including part-time students in the sample as well as full-time. The results of this factor analytic study are generalizable within these limits, and therefore would not necessarily apply to other age groups, especially children, and to other cultures or ethnic groups. However much reported research on field independence is conducted using samples and variables similar to those used here.

The position adopted here regarding the results of a factor analytic study is that factor analytic solutions are descriptions of interrelationships in a set of data and depend on the number and types of tests used, the composition of the subject group involved and the mode of analysis adopted rather than some supposed natural ordering of abilities. Indeed abilities themselves as well as the structure attributed to them are seen merely as convenient ways of classifying related performances (Vernon, 1965). In this research, the general and spatial factors accounted for 50% of the total variance of the field independence tests. The general factor accounted for a minority of this variance. This is due to the homogeneity of the subjects tested. Vernon (1950) notes that g is more marked in populations demonstrating more wide ranging levels of ability. Thus the percent of variance of field independence tests due to g is an underestimate or lowerbound, and would be higher for the general population.

P. E. Vernon, in discussing the constructs of field independence, has put forward a model (see Figure 8) summarizing the crossgroup research, with two underlying dimensions separated out. As he notes,

Clearly Witkin's theories and results are of considerable

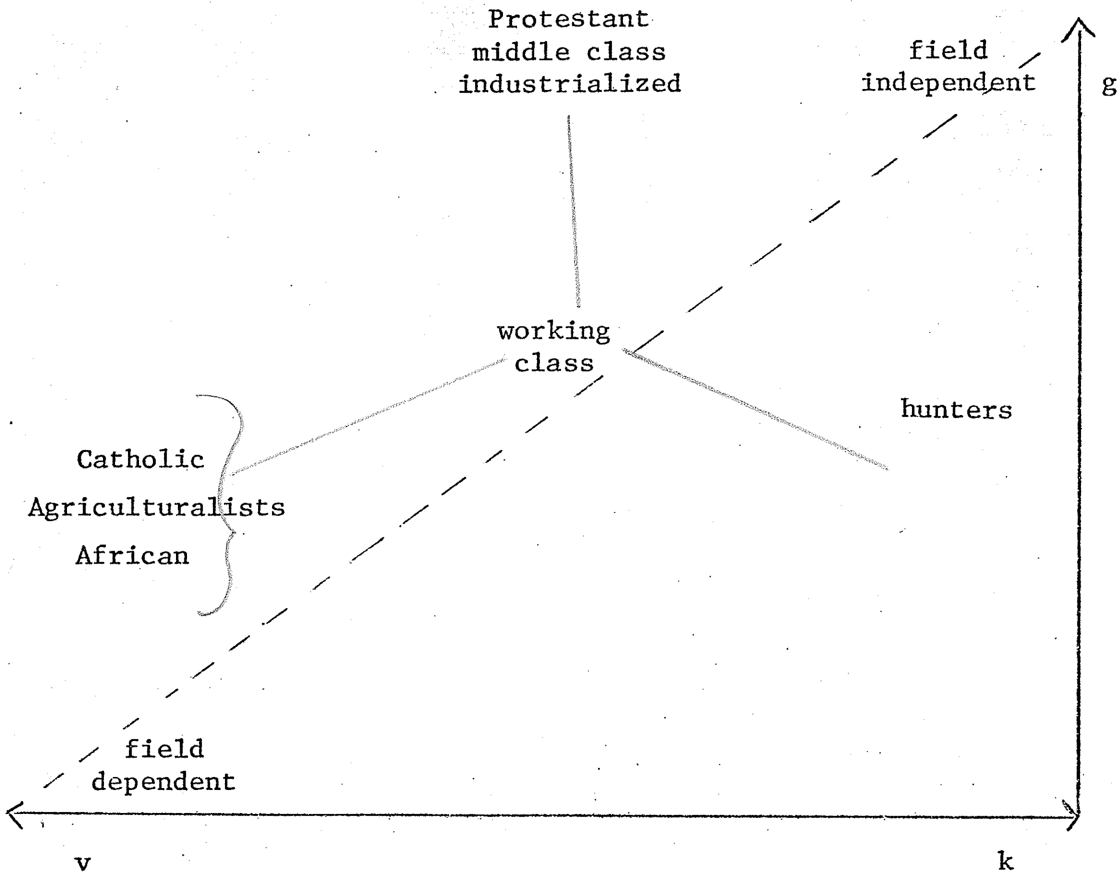


Figure 8

Dimensions of cultural group differences
(Vernon, 1969, p.86)

help in interpreting certain differences both within and between cultures. The main trouble is that he seems to prove too much: there are so many cross-currents and so many possible underlying factors that it is hard to tell whether the measured ability differences should be attributed to general intelligence, to social-class attributes, to sex, to temperament and personality or to neurological characteristics, rather than primarily to mother-child relationships. (Vernon, 1969, p59).

His model together with the research reported here has implications for future research designs in that investigating separately the correlates of each dimension would help elucidate the relationships involved.

The claim that field independence varies independently of verbal ability (Witkin et al., 1962) is in doubt. Significant correlations have been reported between field independence tests and verbal tests (e.g. Kagan & Zahn, 1975; Corah, 1965; Riley & Denmark 1974). Under Vernon's model this would be due to the g factor common to both. This leads to a research design problem. Equating groups for scores on verbal tests while distinguishing them on field independence tests is guaranteed to yield groups differing in overall I. Q. Watchell (1972) suggests checking the consequences of analytic ability by also examining groups equated on analytic I. Q. but differing in verbal I. Q., and groups differing in analytic I. Q. but equated in overall I. Q., to discover what are the correlates of field independence or analytic ability per se, and what are the correlates of outstanding ability in general. Cronbach (1970) made a similar suggestion. He proposed a 2 x 2 design involving fluid ability or field independence and crystallized or verbal-educational ability dichotomized into high and low groups. Both these theorists argue that field independence is an ability more parsimoniously subsumed under some structure of intelligence model and the research designs they propose would broaden the area of investigation. The research reported here strengthens this interpretation and lends evidence to the suggestion of separating out the dimensions involved and investigating separately the correlates of each.

The subsuming of the concept of field independence under g and k of Vernon's model, is strengthened by suggestions that spatial ability tests which do not involve perceptual disembedding, show crosscultural variation as do field independence tests. Crossculture variation has been demonstrated for three-dimensional pictorial perception (Dawson 1967a, 1967b, Jahoda & Stacey 1970). Passalong NGPS (MacArthur 1971), Mazes (Jahoda 1969) Reproducing Designs (Vernon 1965) and Piagetian tasks (Vernon 1965). A considerable number of studies have shown crosscultural variation on Progressive Matrices (Berry 1966, Irvine, 1969, MacArthur 1975, Vernon 1965, 1967, Wober 1966, 1969) and indeed this test has been inappropriately used by some investigators as a measure of field independence even though it does not require perceptual disembedding (Witkin & Berry, 1975). Further indications favoring the interpretation of field independence verified by this study came from the "clear but as yet largely unexplained relationship" (Witkin & Berry, 1975, p71) between increasing acculturation and improvement in scores on field independent tests. Acculturation involves formal education and emphasis on reasoning and thinking skills so the relationship could be due to an increase in measurable g.

Clearly the model of abilities adopted here is that an ability is considered as an overlearned acqusition or habit (Ferguson, 1954). Intelligence is regarded as a summation of the learning experiences of an individual-the totality of concepts and skills, techniques, plans for coping with problems, which have crystallized out of an individual's previous experience (Vernon, 1965). Learning experiences of individuals are to some extent culturally determined, and the term culture itself is generally regarded as referring to learned and shared patterns of behavior characteristic of a group (Berry, 1976). So it should be expected that people reared in different environments will develop different patterns of ability (Ferguson, 1954; Vernon, 1969). As Ferguson states

> cultural factors prescribe what shall be learned at what age; consequently different cultural environments lead to the development of different patterns of ability. (Ferguson, 1956, p121).

Thus crosscultural research involving spatial ability tests could be expected to show a patterning of results similar to that for field independence tests.

Socialization practices also determine to some extent the learning experiences of an individual. The relationship between socialization practices and the development of spatial ability further strengthens the interpretation of field independence in terms of g and k concepts. Strict and protective child rearing practices are known to relate both to the development of field independent chidren (Dyk & Witkin, 1965; Witkin, 1967, Witkin et al., 1973) and to the socialization of children who are better in verbal than quantitative areas (Bing, 1963). In comparison children with a considerable degree of freedom to experiment on their own develop field independence and lower verbal higher nonverbal ability patterns. Furthermore a child's I. Q. is likely to rise when the mother's encourage independence at an early age and use democratic methods of disciplining (Sontag, Baker & Nelson, 1958). This is consonant with the explication of field independence supported by this research.

A further pertinent area of research concerns relationships between spatial abilities and personality traits. For example, Haynes and Carley (1970) report relationships between spatial orientation and visualization tests and 16 PF factors of prominance, cyclothymia, sensitivity, protention. It is proposed here that personality differences and differences in interpersonal behavior between field dependent people, reviewed by Witkin and Goodenough (1977) has broader generalization to personality differences and interpersonal behavior differences between people high and lowon ability dimensions.

The research reported here has further bearing on a line of research of the relevance of field independence to school learning and achievement. The argument has been advanced that knowledge of a child's cognitive style is likely to prove at least as useful as knowledge of his I. Q. in teaching the child (Witkin, 1967; Witkin, Moore, Goodenough & Cox, 1977). This has been persued by Arbuthnot and Gruenfeld (1969) and Witkin, Moore, Oltman, Goodenough, Freedman, Owen and Raskin (1977) who argued that field independence is predictive of educational-vocational interest and that this therefore dispels the notion that it merely reflects ability. However differences in spatial ability and general ability are predictive of educational-vocational interest also. Acheivement and field independence was studied by Kagan and Zahn (1975). They concluded that the school achievement gaps between Anglo-american and Mexican-american children in math achievement and reading achievement can be totally or partly explained by differences in field independence. However they included no other ability measures as predictions to compare their efficiancy against that of field independence. Another study on cognitive styles and school achievement by Satterly (1976) found that knowledge of EFT scores does not make an appreciable addition to the prediction by a verbal reasoning test of intelligencee, of spatial and achievement tests. Thus tests of field independence do not make a significant contribution to the understanding of school achievement beyond that which is predictable from the traditional reasoning tests. This conclusion is supported by Engivel (reported in Horn, 1976) who found that EFT did not add to the multiple prediction of academic achievement when measures of g were also allowed to be predictors. This would be hypothesized given the interpretation of field independence in terms of g and k factors.

Field independence tests then obtain their predictive power by measuring variables other than the ability to separate figures from an embedding context. Field independence tests, it is argued, would not show a different pattern of predictions than what is shown by measures of ability. Field independence minus the ability component has little or no predictive power. Sherman (1974) in discussing the correlation between field independence tests and spatial visualization tests suggests the term "analytical cognitive approach" is misleading and unwarranted. Horn (1976) also suggests dropping the theory "field independence" and proposes instead identifying the correlates and determinants of the ability dimension(s) involved. He questions whether the tests should be regarded as field independence tests or as "representing abilities which have rather different origins than are implied by the perceptual style theories." (Horn, 1976, p449.) However, the view of abilities adopted here does not necessitate negating the work of field independence researchers on origins and the research on socialization and abilities suggests this is the case. Indeed it opens up avenues of research regarding similar origins for the development of other spatial, perceptual, verbal abilities.

CONCLUSION

The research reported here on the relationship between field independence and g and k helps integrate a number of previously unintegrated areas and generates areas for future research. It provides a method for establishing equivalence prior to making cross-group comparisons. It supports Vernon's model of the dimensions of cultural group differences. It has important implications for future research designs in terms of separating out the dimensions of general intelligence and spatial ability, and investigating separately the correlates of each. It shows that the spatial ability literature concerning crosscultural differences, personality differences, development, sex differences and so on is relevant to the field independence literature. And it supports those who maintain that the field independence dimension is unwarranted.

CHAPTER 6

SUMMARY

This research examined the hypothesis that differences in field independence can be accounted for by differences in general intelligence and spatial ability. More specifically, the purpose of this investigation was to determine whether field independence represents a construct distinct from general intelligence and spatial ability, to assess the qualitative similarity or psychometric invariance of field independence tests across age and sex groups, and to examine quantitative comparisons between age and sex groups to determine whether group differences in field independence tests can be accounted for by group differences in general intelligence and spatial ability.

The field dependence-independence construct has generated much research. Despite this, the conceptualization of field independence as a cognitive style is not consonant with what the tests appear to measure, that is, an ability to function well in certain types of tasks involving overcoming an embedding context. Others have raised concerns that the empirical relationships found between field independence tests and many other measures may result from a common relationship between the measures used and general intelligence (Cronbach, 1970; Cronbach & Drenth, 1972; Horn, 1976; Watchell, 1972; Zigler, 1963a, 1963b). Vernon (1972) in a factor analytic study, concluded that field independence tests do not define a construct distinct from g, general ability, and k, spatial ability. However he used field independence tests to help define the spatial ability factor, thus failing to provide a definition independent of the phenomenon to be explained. This study re-examined the conclusion, defining a spatial ability factor only on non-field independence spatial tests.

Part of the construct validation of field independence is based on crossgroup and crosscultural research, raising serious methodological difficulties involving an often untested assumption of fixed constructs (Baltes & Nesselroade, 1970; Berry, in press; McArthur, 1973). The measures should be demonstrated to be qualitatively similar or psychometrically invariant in the different groups prior to making quantitative comparisons across groups. A methodology for so doing was developed further, and it is argued that the method is applicable to studying crosscultural differences as well as developmental differences. This method was used to assess the psychometric invariance of three field independence tests across age groups and across sex groups. Finally, an attempt was made to account for group differences on the field independence tests by group differences in general intelligence and spatial ability.

Approximately 200 subjects were administered three field independence tests (Rod-and-Frame test, Group Embedded Figures test, Block Design test), five tests of general intelligence, five spatial ability tests and four verbal tests. Factors g and k were established as well-defined on the non-field independence tests (the defining test battery). Partialling out factors g and k from the intercorrelations among the field independence tests reduced two of the three to nonsignificance and the third was reduced by a significant amount. Further, the results indicate that g and k account for almost eighty percent of the shared variance, as represented by correlations, among the field independence tests, thus supporting the hypothesis.

Factors g and k were established as invariant across age groups and across sex groups using Kaiser's (1971) method, both for the defining test battery and for the total battery. The cosine of the angle between the same test vectors for the two groups, it is argued, can be used as an index of its psychometric invariance, and hence to establish its qualitative similarity across groups. The tests were demonstrated to be invariant across both sex groups and age groups, with the exception of the Rod-and-Frame test across age groups. Thus the major sources of variance of the tests agree in kind and amount across age and across sex groups. Age group differences were found on all tests and these were reduced to nonsignificance by covarying for g and k, thus being accounted for by age group differences in general intelligence and spatial ability, as predicted. Significant sex group differences were found only on the Rod-and-Frame test, and these could not be accounted for.

The results as a group support the hypothesis that differences in field independence can be accounted for by differences in general intelligence and spatial ability. They support Vernon's (1969) model of the dimensions of cultural group differences, with important implications for future research designs in terms of separating out the dimensions of general intelligence and spatial ability and investigating separately the correlates of each. They imply that the spatial ability literature concerning such things as crosscultural differences, development, sex differences etc. is relevant to the field independence literature. The results support those who maintain that the field independence dimension is unwarranted.

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APPENDIX A

TEST DESCRIPTION

Description of Testing Procedure

Day 1 Variable	Abbreviation	No. of Items	Time Limit
Group Embedded Figures Test	GEFTT	18	10 (2 parts)
Advanced Progressive Matrices	Ravmat	36	40
Lorge-Thorndike: Vocabulary	Ver 1	25	7
Sentence Completion	Ver 2	20	7
Blocks, Army General Classiciation Test	Blocks	56	11
Questionnaire	-	--	--

Day 2 Variable	Abbreviation	No. of Items	Time Limit
Differential Aptitude Test: Space Relations	DAT SR	40	25
Revised Minnesota Paper Form Board	RMPFB	64	20
Lorge-Thorndike: Verbal Classification	Ver 3	20	7
Verbal Analogies	Ver 4	20	7
Multiple Aptitude Test: Two Dimensions	MAT 2D	25	8
Three Dimensions	MAT 3D	25	12
Culture Fair Intelligence Test: Series	CA 1	13	3
Classification	CA 2	14	4
Matrices	CA 3	13	3
Problem Figure	CA 4	10	2.5

Individual Testing	Abbreviation	No. of Items	Time Limit
Wechsler Adult Intelligence Scale: Block Design	KBDT	10	Each trial timed
Rod-and-Frame Test	RFT	8 trials	untimed

Cattell Form B - administered only if time permitted within each individual testing session due to untimed nature of Rod-and-Frame test.

Test Selection

The hierarchial model of Vernon (1950) provided the particular theoretical perspective which guided test selection. The hypothesized factor structure included a general intelligence factor, a spatial ability factor and a verbal ability factor. Four or five tests were selected for each factor on the basis of similarity with the hypothesized factor structure. Thus, tests were selected to define a general intelligence factor and a spatial ability factor. Spatial tests were selected to be independent of overcoming embeddedness. Verbal ability tests were included partly because of the theoretical model adopted and partly as interpretation of a factor is based upon variables which do and do not relate to that factor. Particular tests were selected on the basis of empirical findings demonstrating factor content, construct validity, content validity, and reliability, bearing in mind the particular theoretical formulations and empirical findings of Vernon (1950, 1960).

Advanced Progressive Matrices Test

Raven's (1965) Advanced Progressive Matrices were developed to measure Spearman"s (1904, 1927) general intelligence or g factor. This test is regarded by most British psychologists as the best available measure of g (Anastasi, 1961; Vernon, 1965b).

The test requires the eduction of relations among abstract items. It consists of matrices or designs, with a part removed. The subject must choose one from among six or eight alternative designs that best completes the matrix. Figures are altered from left to right according to one principle, from top to bottom according to another. The subject must identify the principles and use them. The test involves analogies, permutations, and alterations of pattern, and other logical relations. Manual instructions, timing and scoring were followed.

<u>Culture Fair Intelligence Test</u>

Cattell and Cattell (1959) developed this test as a measure of g, and evidence of its validity is impressive (Tannenbaus, 1965).The test consists of four subtests and involves eduction of relations among abstract items. In Series, the subject must complete a sequence of four drawings by choosing one from among six alternative designs. For Classification, the subject must pick out a pair from among five drawings that are different from the other three in some way. Matrices involves choosing the missing part of a matrix design from among six alternatives. In Conditions, a dot is positioned in a particular relationship with respect to different geometrical figures. The subject must find a figure from among the five answer figures in which he could place a dot given the same principles involved in the first placement.

Form A was administered according to the manual instructions for directions, timing and scoring. Form B was included at the end as an attempt to have as many factor markers for factor g as possible. Due to time constraints attributable to the untimed nature of some tests, less than half the subjects were tested on this so it was dropped from the battery. As this leaves factor g still with five marker variables this exclusion is unimportant, as is verified by the close relationship between the exploratory and confirmatory factor analyses.

Army General Classification Test: Blocks

This test was developed by Staff of the Personnel Research Section (1947) of the U. S. Military during World War 2 for screeing and classification purposes. It was released for general use after the war.

The test contains an equal number of vocabulary, arithmetic reasoning and block-counting spatial items. The blocks subtest measures spatial thinking and ability to visualize objects. Subjects are shown a representation of a three dimensional pile of blocks. All blocks in one pile are of equal size but not all are visible. Subjects are required to indicate the number of blocks in each pile. Items in Form AH were administered following manual directions with a time limit of eleven minutes.

Revised Minnesota Paper Form Board Test

Likert and Quasha (1970) developed a multiple-choice format of an earlier paper form board test. The test measures the capacity to visualize and manipulate objects in space and validity studies indicate it is one of the most valid available instruments for measuring this ability (Anastasi, 1961).

Each item consists of two dimensional diagrams cut into separate parts. For each diagram there are five figures with lines indicating the different shapes cut of which they are made. Subjects must choose the figure which is composed of the exact parts that are shown in the original diagram. Published instructions, timing and scoring procedures were followed, and Series AA administered.

Differential Aptitude Test: Space Relations

Bennett, Seashore and Wesman (1966) developed eight ability measures primarily for vocational guidance. The Space Relations subtest evaluates a persons ability to think in spatial terms. It requires mental manipulation of objects in three dimensional space and ability to imagine how an object would appear if rotated in various ways.

The items consist of patterns which can be folded into figures. For each pattern five three dimensional figures are drawn and the subject must indicate which of these five figures can be made out of the pattern shown. Form B was administered following manual instructions and scoring. The time limit was shortened from 30 minutes to 25 as the test was developed for younger students.

Multiple Aptitude Test

Segel and Raskin (1955) developed this battery which is similar in purpose and approach to the Differential Aptitude Test and consists of nine subtests.

Space Relations: Two Dimensions, consists of a row of figures with a completed figure on the left and four groups of pieces to the right. The subject must indicate which one can be fitted together exactly to form the figure shown on the left. Space Relations: Three Dimensions also consists of a row of figures. The one on the left is a completed object drawn in perspective as a three dimensional figure. To the right are four patterns in two dimensions, one of which can form the object on the left.

The subject must indicate the one that would form exactly the object on the left. Published instructions, timing and scoring procedures were followed.

Lorge-Thorndike Test

This consists of a series of tests, Level 1 Form H of which is suitable for college students (Lorge and Thorndike, 1964). This consists of ten subtests, five verbal and five non-verbal, all designed to measure the ability to work with ideas and the relationships among ideas, i.e. abstract intelligence. In Vocabulary test, each item specifies one word. It involves picking from a list of five words, one with the same meaning or most nearly the same meaning as the given word. In Sentence Completion, one word is left out of a sentence and subjects must choose from five answer words the one that makes the truest, most sensible sentence. In Verbal Classification, each item specifies three or four words. Subjects must figure out how they are alike, then choose one word from five alternatives that belongs with that set of words. In Verbal Analogies, a pair of words is given that are related to each other in some way. Subjects must figure out how they are related. Then from five answer words, they must pick out the one that relates to a third word in the same way.

Block Design Test

This subtest of the WAIS (Wechsler, 1955) is a modification of Kohs Block Design test (Kohs, 1923) and is used extensively as a measure of field independence. The test consists of nine blocks with red, white, and red and white sides. The subject is given four or nine blocks and required to assemble them within a time limit to make a given pattern. Ten patterns make up the test, administration being discontinued after three failures. Manual directions, timing and scoring were followed.

Rod-and-Frame Test

A Rod-and-Frame apparatus manufactured by Polymetric Co. (Model V-1260-M2) was used. The apparatus allows independent angular rotation of the square outer frame and of the inner rod by means of remote motor driven controls. A remote indication of tilt angles is provided.

The format of the luminous frame and rod is designed to conform to the size developed by Witkin. The luminous outlines of the frame and upright (white electroluminescent strips) may be varied in brightness, down to complete extinction. The framework of the apparatus is black to reduce reflected light. Testing is done in a dark room after five minutes of dark adaptation, and brightness is set prior to testing s so there is no reflected light from any part of the test area.

Instructions followed were:Have the rod and frame straight up and down when the subject enters. Seat the subject 12 feet from the apparatus. Say

> I'm now going to give you a task that will consist of a luminous square frame and rod. I will darken the room for a pe period of time until your eyes become adjusted to the luminous light. I'm going to tilt both the rod and the frame, and I want you to adjust the rod until you perceive it as being upright, vertical, straight up and down like a plumb

line (demonstrate). To adjust the rod you must use this apparatus (show it) and push this lever back and forth to make it go right or left (demonstrate). You may practice with it now (hand it to him).

Darken the room and switch on the luminous light. After five minutes say "Now I'll adjust the rod and the frame". Turn the luminous lights out and make adjustments. Switch the luminous light on and say "Now adjust the rod to an upright position. Tell me when you are finished. Work conscientiously but do not spent too much time on each judgement". Record the degree of error and proceed again.

Eight trials were given, in random order, Rod L Frame R, Rod L Frame L,Rod R Frame L, Rod R Frame R, then given again in a different random order. Tilt angle was 28 degrees. Subjects sscore was total degrees deviation from true vertical.

Group Embedded Figures Test

This is an adaption of the individual Embedded Figures Test by Witkin, Oltman Raskin and Karp (1971). The modification makes it practical for testing large numbers of subjects. It is modelled as closely as possible on the EFT with respect to mode of presentation and format.

There are 18 complex figures in which the subject must detect and outline a specified simple form. Simple forms are presented on the back cover so that both simple and complex forms cannot be exposed simultaneously. Published instructions, timing and scoring was followed.

APPENDIX E

QUESTIONNAIRE

FACTUAL INFORMATION

Information given will be used for statistical purposes only. It will not be disclosed in any form which would identify you.

Some of the questions are answered by placing a check mark in the appropriate space. Others need a brief written answer. Please don't leave any questions blank.

1. What is your father's occupation? Be as specific as possible, indicating what he does rather than who he works for.

____

____

2. How much formal education did your father have? Please indicate highest level obtained.

_____Under 7 years schooling
_____7 - 9 years schooling
_____10 - 11 years schooling (part high school)
_____High school graduate
_____Some University education
_____University graduate - Bachelor's degree
_____Master's degree and above

3. What other formal vocational training has he received? Please be as specific as possible.

____

____

4. What is your mother's occupation?

____

____

5. Has your mother had steady employment since you were a child?

____ yes
____ no

6. Were you raised by
_____both parents
_____mother only
_____father only
_____other (please specify)_____________________

7. What is your parents religion?

____United ____Mennonite Jewish____Orthodox
____Catholic ____Methodist ____Conservative
____Anglican ____Presbyterian ____Reform
____Ukrainian Orthodox ____Lutheran
____Greek Orthodox ____Other (Please specify)

8. Your age at last birthday __________

9. Sex _____male
_____female

10. Marital status
_____single
_____married
_____divorced
_____separated
_____widowed

11. What is your occupation? Please be as specific as possible.

____

12. In what faculty and area are you obtaining your degree?

____

13. What occupation are you planning upon completion of your university education?

____

14. If you are married, what is your spouse's occupation?

____

15. What is your religion now?

____United ____Mennonite Jewish____Orthodox
____Catholic ____Methodist ____Conservative
____Anglican ____Presbyterian ____Reform
____Ukrainian Orthodox ____Lutheran

____Greek Orthodox ____Other (Please specify)

16. With what religion were you raised as a child?

____United	____Mennonite	Jewish____Orthodox
____Catholic	____Methodist	____Conservative
____Anglican	____Presbyterian	____Reform
____Ukrainian Orthodox	____Lutherian	
____Greek Orthodox	____Other (Please specify)	

17. How severe was the discipline you received at home as a child, compared to others your age?

_____Extremely severe
_____Very Severe
_____Moderately severe
_____Mildly severe
_____Not at all severe