Relevant personality variables with respect to fluid and crystallized intelligence

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RELEVANT PERSONALITY VARIABLES
WITH RESPECT TO
FLUID AND CRYSTALLIZED INTELLIGENCE

by
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B.A., University of Colorado, 1965

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[Signatures and dates]
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CHAPTER I

INTRODUCTION

The theory of fluid and crystallized intelligence was proposed by Cattell in 1940 because he considered Spearman's "g" (1927) to be an inadequate concept. On the basis of his factor analysis of matrices of the results of specific ability tests, Cattell isolated several general factors. Of these, the first two accounted for the most variance. He concluded that these two factors were the two most general factors of intelligence. The first of these two factors he labeled as "fluid intelligence" (abbreviated by Cattell as "Gf"), and the second factor he labeled as "crystallized intelligence" (abbreviated by Cattell as "Gc").

THE RELATIONSHIP BETWEEN FLUID AND CRYSTALLIZED INTELLIGENCE

In the 1968 expression of his theory, Cattell emphasizes the idea that Gf and Gc are not independent. They theoretically interact in the sense that one must have a certain level of Gf in order to organize his experiences in such a way as to acquire a given level of Gc. Therefore, a given level of Gc presupposes, at least, a certain level of Gf. Empirically, measures of Gf and Gc have been found to correlate
at levels of between .42 and .72 (Horn & Cattell, 1966; Cattell, 1968). These strong correlations between the two factors, even though they are predicted by the theoretical relationship between them, raise an important question concerning the discriminant validity of the two concepts. It is possible that Cattell’s discovery of two general factors of intelligence is merely a manifestation of his factor analytic methodology.

Cattell used the oblique structure method, whereas: Spearman used the principle axis method. These two factor analytic methodologies divide the variance in different ways. It is more parsimonious to consider intelligence as a unitary trait. However, it may be more useful, in terms of research and applications, to consider it as a multiple trait. The factor analytic method of choice, then seems to be dependent upon the purposes of the investigator.

Spearman’s purpose seems to have been a parsimonious description of intelligence. According to his theory, the validity of any intelligence test could be estimated by the degree to which it is saturated with the general factor of intelligence "g". Tests highly saturated with "g" could, according to his theory, be considered more useful as measures of intelligence than tests with low "g" saturation. Thus, Spearman’s "g" is theoretically useful in the selection of items in the construction of intelligence tests.

Cattell’s purpose, on the other hand, seems to have been a
multitrait conceptualization of intelligence which is useful in the prediction of facility in the performance of certain kinds of tasks. Moreover, his theory was an attempt to provide a differential account of biological and cultural influences on the performance of a given individual in a given situation. Thus one of his purposes was to reconcile the possibility that an individual, with little or no education, could perform poorly on intelligence tests highly saturated with "g" (and therefore be regarded as unintelligent by the test administrator) and still be regarded as quite intelligent by observers of his ability to solve certain culture-fair (i.e. common to every culture of man) problems with which he is confronted. Cattell's use of oblique structure factor analytic methodology yielded two factors which were consistent with his purposes as outlined above. These factors are Gf and Gc.

Even though the question of discriminant validity raised above is of importance for Cattell's theory, discriminant validity in the Campbell & Fiske sense will not be considered here since there are no variables available which would be predicted to have a significant positive relationship with Gf (for example) which would not also be predicted to have a significant positive relationship or a significant negative relationship with Gc (or vice versa). In order for such discriminant validity to be demonstrated, the theory must predict a significant positive or negative relationship with one variable and a negligible relationship, or a relationship which is of significantly lower magnitude with the other variable.
However, Campbell and Fiske's 1959 conception of discriminant validity may not be the only way of conceptually separating the two variables of fluid and crystallized intelligence. An alternative method of doing so might be via an examination of the ability of the theory to predict significant positive relationships between a given cluster of variables and fluid intelligence on the one hand, and significant negative relationships between the same group of variables and crystallized intelligence on the other hand (and vice versa). Such a procedure would not provide evidence for discriminant validity in the Campbell and Fiske sense. However, it might still provide a basis of separation between the two concepts and show whether or not the theory of fluid and crystallized intelligence is indeed based upon an artifact of Cattell's factor analytic methodology. If the artifactual interpretation is correct, then one would not expect to find a proportion of predicted significant positive or negative correlations greater than that predicted by chance. However, if the artifactual interpretation is incorrect and fluid and crystallized intelligence do represent two distinctive yet positively related factors, then one would expect the proportion of significant positive and negative correlations predicted by the theory to be statistically greater than that predicted by chance.
PURPOSE

The purpose of this study is to investigate Cattell's two hypothesized factors of intelligence along the lines of certain personality characteristics. This is possible because Cattell (1968) describes his two factors in terms of theoretical personality descriptions of persons high in Gf (and presumably low in Gc), and of persons high Gc (and presumably low in Gf). Moreover, the descriptions of the measures of fluid and crystallized intelligence given by Horn and Cattell (1966a) allow predictions of personality variables which might also be measured by these instruments. The aim here is to sharpen and clarify the differences between Gf and Gc. This will involve an attempt to examine the convergent and discriminant validity of Cattell's general theory.

THE THEORY OF FLUID AND CRYSTALLIZED INTELLIGENCE

Since the first expression of the general theory (Cattell, 1940), there have only been four studies concerned with it which have been reported in the literature (Cattell, 1963; Horn & Cattell, (1966a); Horn & Cattell, 1966b; and Cattell, 1968). All of these have been factor analytic in design and have identified clusters of characteristics which are theoretically descriptive of fluid and crystallized intelligence.
Fluid Intelligence

The first major factor of intelligence as described by Cattell's theory is fluid intelligence (Gf). The following is a series of quotes from Cattell (1968) and from Horn & Cattell (1966a) regarding their notions of fluid intelligence.

"fluid intelligence is a general perceiving capacity independent of sensory area, and it is determined by the individual's endowment in cortical neurological connection count development... it represents a process of reasoning in the immediate situation in tasks requiring abstracting, concept formation and attainment, and the perception and education of relations (Horn & Cattell, 1966a)." It "... leads to perceptions of complex relationships in new environments (Cattell, 1968)."

In comparing fluid intelligence to crystallized intelligence, Cattell says: "... surprise burst from situations in which Gc is useless (but in which Gf is valuable) (Cattell, 1968)." Cattell then goes on to describe people who are exceptionally high in Gf as being particularly adept in activities such as playing chess and military strategy, because of their ability to capitalize on the element of surprise.

The Measurement of Fluid Intelligence

In their discussion of measures of Gf, Horn and Cattell state the following:

"Gf will be measured most purely when the task materials are culture fair; that is the fundamentals are either novel for all persons being measured, or exactly common, overlearned elements of a culture, and the aids needed to attain solutions are not made available, by favored educational opportunity, to some persons and not to others among those measured (Horn & Cattell, 1966a)."
According to the theory of fluid and crystallized intelligence, one should be able to measure Gf with Cattell's Culture Faire Test (1959). This test, to be described in greater detail in the "Methods" section of this paper, presents tasks involving a number of geometrical designs (which are either novel for all persons being measured, or exactly common, overlearned elements of a culture). These tasks are presented in four subtests. Each subtest involves reasoning in the immediate situation in tasks requiring abstracting, concept formation and attainment, and the perception and education of relations. As such, if fulfills the requirements for the measurement of Gf as defined above. For these reasons Cattell (1963) has recommended this test for the measurement of Gf.

**Crystallized Intelligence**

The second major factor of intelligence as described by Cattell's theory is crystallized intelligence (Gc). The following is a series of quotes from Cattell (1968) and from Horn & Cattell (1966a) regarding their notions of crystallized intelligence.

"Crystallized intelligence is the principal manifestation of a unitariness in the influence of ... educative ... accultura-
tion influences. At the same level of generality as Gf, and involving an equally broad set of intellectual tasks, the Gc function will indicate breadth of awareness and subtlety of:

1. relations previously perceived,
2. concepts previously attained ... as indicated in tasks requiring recognition or recall of such relations, but it will also represent ability to reason in the immediate sit-
uation in tasks requiring:
   a. abstracting;"
b. concept formation; and
c. the perception and education of relations."

Because of 2a, 2b, and 2c above, Gc and Gf have some common elements and would be expected to correlate positively with each other (See pages 1 - 3).

Horn and Cattell further describe Gc as follows:

"Gc appears as a related circle of abilities that are normally taught at school. (These include:)
1. verbal,
2. mechanical, and
3. reasoning (Horn & Cattell, 1966a)."

"Gc shows itself in judgmental skills that have been acquired by cultural experience such as:
1. vocabulary
2. good use of synonyms,
3. numerical skills,
4. mechanical knowledge,
5. a well stocked memory, and
6. habits of logical reasoning.

Gc stretches across the whole range of cultural acquisition. Mechanical knowledge --- which is negligible or even negative on Gf --- has a measurable effect on Gc (Horn & Cattell 1966a)."

**The Measurement of Crystallized Intelligence**

Horn and Cattell (1966a) describe the measurement of Gc as being in contrast to the measurement of Gf. However, the comparison is not purely a contrast for there are certain identical elements (e.g. abstracting, concept formation, and the perception and education of relations --- See pages 6, 7, & 8). They open their discussion of the measurement of Gc as follows:

"In contrast to Gf, Gc will be measured most purely under conditions in which the Subject must use the concepts and aids representing relatively abstruse elements of the
collective intelligence of a culture. Therefore, Gc will be manifested in recall primaries like:
1. V (Verbal comprehension), and
2. MK (Mechanical knowledge). And also in reasoning primaries like:
1. CMR (Semantic relations),
2. CMC (Semantic classifications),
3. R (Reasoning),
4. Re (Formal reasoning),
5. J (Judgement),
6. EMS (Experimental evaluation) (Horn & Cattell, 1966a)."
"Gc is high on the subtests that traditionally have been built into intelligence tests:
1. vocabulary size,
2. analogies,
3. classification involving cultural knowledge of objects in the problem (Horn & Cattell, 1966a)."

Traditional intelligence tests, Cattell theorizes (1968), are primarily measures of Gc. However, many of the performance items on traditional tests would seem to be heavily contaminated with Gf. Horn and Cattell have preferred to use special ability tests developed by French et. al. (1963) as measures of Gc for their factor analytic investigations. In a personal communication, however, Cattell has recommended his own "Scale 3 Test" (1945) as an adequate test of Gc. This test is composed of six subtests which call for skill in tasks involving: synonyms, classifications, opposites, analogies, completion, and inferences. Thus, according to the criteria for the measurement of Gc, as cited above, Cattell's "Scale 3 Test" appears to be a reasonable instrument for the measurement of Gc. Inspection of that test, however, intuitively suggests some items which seem to be more measures of Gf than of Gc. (e.g. the gunsight problem --- see item 8
The Relationship of Fluid and Crystallized Intelligence to Age

The measurement of intelligence, historically, was originally based on the notion that intelligence increases with age (Binet & Simon, 1908). In keeping with this historical precedent let us look at the way Cattell (1968 p. 62) and Horn and Cattell (1966c p. 218) envisage the relationship between their conception of intelligence and age. A survey of the literature concerning the relationship between age and fluid and crystallized intelligence indicates the following:

Fluid ability follows a biological growth curve which approaches a plateau at about 14 years and declines after about 22 years of age (Cattell, 1968, p. 59). Crystallized intelligence, on the other hand, shows an increase with age and experience (Cattell, 1968, p. 62) and this increase is noticeable throughout the age range sampled (ages 14 through 61) (Horn & Cattell, 1966, p. 218).

The implications of the above findings for performance are given by Cattell as follows:

A middle-aged man handles most situations in our culture more intelligently than he would have when he was 20, but if a younger and an older man were transferred to an absolutely new society, the probably higher fluid intelligence level of the younger man would be likely to show itself (Cattell, 1968, p. 62).

The information presented above may be useful in determining sampling procedures. For example, in order to obtain a group of
subjects relatively high in Gf, but relatively low in Gc, a population of 16 year old subjects would be sampled. In order to obtain a group of subjects relatively high in Gc, but low in Gf, a population of educated 50 year old subjects would be tested.

A SURVEY OF OTHER CONCEPTS RELATED TO FLUID AND CRYSTALLIZED INTELLIGENCE

Introduction

Cattell (1963) has cited several other conceptualizations of notions which seem to be similar to his own notions of fluid and crystallized intelligence. These are the sources that Cattell used to link his theorizing with that of other writers. In some cases they appear to be fairly direct, in some not so direct. Cattell does not draw the relationships specifically for the reader. However, to increase your familiarization with these works, several of the major references which he gives are cited. These include Hebb's (1942) distinction between "A" and "B" components of ability; Ferguson's (1956) distinction between "ability" and "learning set" (referred to by Ferguson as "transfer"); Newland's (1962) distinction between "process" and "Product"; and Hayes' (1962) notion of "experinece-producing drives." In an effort to find what Cattell was referring to, the following quotations were selected as being those most closely related to his descriptions of fluid and crystallized intelligence. Another seemingly related
distinction to be discussed here --- but one which is not mentioned by
Cattell --- is Pavlov's (1932) distinction between the "Artistic" and
"Thinking" types of personality. Each of these concepts will be con-
sidered below:

D. O. Hebb

Within the context of his paper on "The Effect of Early and Late
Brain Damage upon Test Scores, and the Nature of Normal Adult
Intelligence (1942)" Hebb states the following:

In any test performance there are two factors involved, the relative importance of which varies with the test: one
factor being present intellectual development; the other
being the lasting changes of perceptual organization and be-
havior induced by the first factor during the period of
development. Roughly, the one concerns the power of
"reasoning", of synthesis and invention; the other "skill"
(that is a factor due to experience). The contrast is not
between intelligence and knowledge, but between capacity
to develop new patterns of response similar to Gf, and the
functioning of those already developed similar to Gc (p. 289).

Hebb's conception of A and B factors of development seems re-
lated to Cattell's notion of fluid and crystallized intelligence in the
following ways:

1. Hebb's factor A seems related to fluid intelligence
   because:
   a. It involves the power of reasoning, synthesis and
      invention. (Hence the implication of performance in
      novel situations.)
   b. It involves neural maturation.

2. Hebb's factor B, on the other hand, seems related to
crystallized intelligence because:

a. It involves skill (i.e. a factor due to experience)

b. It involves the establishment of routine modes of response to common problems.

G. A. Ferguson

In his 1956 article "On Learning and the Abilities of Man,"

Ferguson summarizes his 1954 theory as follows:

1. The abilities of man, including the reasoning, number, perceptual, and spatial abilities, and whatever is subsumed under intelligence, are attributes of behavior, which through learning have attained a crude stability or invariance in the adult, and, as they develop in the child, exhibit considerable stability over limited periods of time at particular age levels.

2. Biological factors in the formation of ability . . . fix limiting conditions. The implication is that within these boundaries the range of variation attributed to learning is substantial. Thus emphasis is diverted from biological to environmental determination in the formation of ability.

3. Cultural factors prescribe what shall be learned and at what age; consequently different cultural environments lead to the development of different patterns of ability. Those abilities which are culturally valid, and correlate with numerous performances demanded by the culture, are those that show a marked increment with age.

4. Abilities emerge through a process of differential (non-linear) transfer and exert their effects differentially in learning situations. Those that transfer and produce their effects at one stage of learning may differ from those at another.

5. The concept of a general intellective factor, and the high correlations between many psychological tests, are explained by the process of positive transfer, the distinctive abilities which emerge in the adult in any culture being those that tend to facilitate rather than inhibit each other. Learning itself is viewed as a process whereby the abilities of man become differentiated, this process at any stage being facilitated by the abilities already possessed by the individual,
Although certain similarities between Ferguson's concepts of "ability" and "transfer", on the one hand, and Cattell's concepts of "fluid" and "crystallized" intelligence on the other, may exist; particularly in terms of Ferguson's consideration of chronological and cultural influences; at least two seemingly important differences must be pointed out:

1. Abilities are influenced by environment and culture, while fluid intelligence is strictly determined by the number of neurological connections existing in the cortex. Thus fluid intelligence is unaffected by environmental or cultural factors except as these provide some alteration in the number of neurological connections existing in the cortex through injury or surgery. Cattell's conception of fluid intelligence may be one of the biological factors constituting Ferguson's concept of the formation of ability.

2. Transfer seems differentiated from crystallized intelligence by the fact that transfer is a process expressed by a mathematical function. Crystallized intelligence, on the other hand, seems to refer to the effect of transfer and fluid intelligence on the ability of the subject to perform a given task.

T. E. Newland

Newland's notion of the distinction between "process" and "product" is conveniently expressed by a series of direct quotes from his article on the "Psychological Assessment of Exceptional Children and Youth." These include the following:
... in certain instances, at least in the cases of the blind and in some of the orthopedically handicapped, learning potential may be meaningfully sampled only, or primarily, in terms of process rather than in terms of product (p. 71).

It is quite likely that predicting school learning solely or primarily on the basis of samples of psychological process (classification, education of correlates, and the like) may be much more defensible in the case of young children than in the case, say, of high-school level children. ... learning at the higher level ... depends not only upon the pupil's being adequate as regards the psychological processes essential to his learning but also to his having benefited from those processes by learning some things (products) which are needed in order to learn higher things (p. 72).

The term "basic capacity," or "basic intelligence," is used to denote more nearly the biologically inherent learning potential of an organism. We continually hope that the behavior which reflects it is as little culturally contaminated as possible but have the constantly lingering suspicion that it is at least a little so distorted.

It seems desirable, then, to distinguish between basic capacity and manifest capacity. We shall use the term "manifest capacity" to denote that performance level which is immediately and most easily apparent in the test situation, the interpretation of which is unaffected by any qualitative explanations. It is the test indication of what the client did --- how he scored according to standardized procedure of test administration. It invokes no guessing by the examiner as to how much better or worse the client really is. It is the unmitigated performance at the time of testing (p. 78).

Why not also consider "basic process" vs. "manifest process" and "basic product" vs. "manifest process"?

... Many of these tests appear to sample process more heavily than "product": ... the Leiter International Performance Scale, the Raven Progressive Matrices ... (p. 90)

Both of these should be good measures of Gf. The Raven Progressive Matrices test is very similar to Cattell's Culture Fair Test.

Interestingly related to this conceptualization, which was arrived at clinically, is Cattell's position, on the basis
of results obtained by factor analysis, a fluid general ability, perhaps somewhat similar to the author's "process" and a crystallized general ability, quite similar to the author's "product". p. 112, footnote 4.

It is apparent from the above that Newland and Cattell have considerable agreement with one another. Both consider "process" to be similar to "fluid intelligence" and "product" to be similar to "crystallized intelligence".

K. J. Hayes

Hayes introduces his "motivational-experiential theory (of performance)" by an illustration of its basic units; experience-producing drives (EDPs) as follows:

Consider a pair of human, fraternal, twins with unusually similar hereditary make up. Suppose that the only significant differences in genetic composition happen to be of a type which cause these individuals to differ motivationally --- not with respect to the so called homeostatic drives, but rather with respect to their tendencies to engage in certain kinds of intrinsically-motivated activities. Specifically, twin A displays a strong preference for linguistic activity. At the age of 2 years he is unusually talkative, and at 8 years he does an unusual amount of reading. Twin B, on the other hand, shows an equally strong preference for athletic activity. The twins' brains do not differ appreciably in size, or biochemistry, or capacity to form associations or develop complex neural circuits. In the course of time, A acquires a larger vocabulary than B, as well as a larger store of linguistically transmitted information --- simply because he devotes more time to relevant activities. At the age of 16, both twins are given the Stanford Binet, and twin A is found to have a considerably higher I.Q. than B (p. 301).

Three alternative interpretations of this story may be noted. The first would be that it is absurd, since activity preferences are acquired, not inherited. A second reaction might be that this case simply illustrates a limitation of present intelligence tests. Although the twins really had the same intelligence, their test scores were distorted
by irrelevant personality factors. The third interpretation summarizes the theory to be considered: Intelligence is acquired by learning, and inherited motivational make up influences the kind and amount of learning which occurs. The hereditary basis of intelligence consists of drives rather than abilities as such (p. 302).

The next point to consider is whether the presumed hereditary differences in motivation can cause important differences in experience. ... Berlyne (1960) and White (1959) have reviewed the literature on the class of motives variously known as exploratory, manipulatory, curiosity, play, etc. Much of the literature has emphasized two points: (a) These cannot reasonably be considered secondary or acquired motives. (b) Despite their diversity of expression, they serve the common biological function of promoting learning in the well nourished and otherwise satiated organism. A special term may be useful to distinguish these motives from derived or secondary motives on the one hand, and from the traditional "biogenic" or "homeostatic" drives on the other. They have previously (Hayes & Hayes, 1954, p. 296) been referred to as experience-producing drives (EPDs) ... (p. 305).

The argument supporting the motivational-experiential theory involves four main points: (a) Differences in motivation may be genetically determined. (b) These motivational differences, along with differences in environment, cause differences in experience. (c) Differences in experience lead to differences in ability. (d) The differences commonly referred to as intellectual are nothing more than differences in acquired abilities (p. 307).

In an ideal organism, EPD make up would be a function of age, so that activities appropriate to infantile learning would be replaced by activities conducive to the later learning of more complex skills; and it may be supposed that real organisms would have evolved mechanisms for making such changes. It may also be supposed that EPD strength in general would tend to drop as the individual approaches maturity, and achieves mastery of more useful skills. Such a decline in EPD strength would have survival value in relieving the sophisticated individual of risks which would no longer be justified (p. 307).

Experience-producing drives may be altered by brain damage and the resulting change in behavior may suggest a
loss of intellectual capacity. If EPDs are altered by early brain damage, all subsequent intellectual development may be effected. Brain damage which alters EPDs after intellectual development is complete may effect performance on tests which are sensitive to motivation. . . . "Mental growth" is not a direct result of the spontaneous, physical growth of the brain, but is rather a result of the gradual accumulation of knowledge at a rate determined by an individual's EPDs (p. 338).

This paper has reviewed the literature relevant to a motivational-experiential theory which proposes that: (a) manifest intelligence is nothing more than an accumulation of learned facts and skills Gc, and (b) innate intellectual capacity Gf consists of tendencies to engage in activities conducive to learning rather than inherited intellectual capacities, as such. These tendencies are referred to here as experience-producing drives (EPDs) (p. 337).

Cattell (1963) cited Hayes' (1962) concept of experience-producing drives as similar to his own theory of fluid and crystallized intelligence. An examination of Hayes' article, however, suggests that there may be a general analogy between Cattell's theory of fluid and crystallized intelligence, and Hayes' motivational-experiential theory. At the same time there appears to be a more specific analogy between Cattell's "crystallized intelligence" and Hayes' "manifest intelligence" on the one hand, and Cattell's "fluid intelligence" and Hayes' "latent intellectual potential" on the other.

I. P. Pavlov

In addition to the related concepts cited by Cattell (1963) the following conception of Pavlov is considered (by this author) to be related to the concepts of fluid and crystallized intelligence. In what
follows, the "artist" type is considered to be a manifestation of relatively high fluid intelligence. The "thinking" type, on the other hand, is considered to be a manifestation of relatively high crystallized intelligence:

Life definitely reveals two categories of people—artists and thinkers. Between them is a marked difference. The artists, including all types, as writers, musicians, painters, actors etc., comprehend reality as a whole, as a continuity, a complete living reality, without any divisions, without any separations. The other group, the thinkers, pull it apart, kill it so to speak, making out of it a temporary skeleton and then only gradually putting it together anew, piecemeal, and thus try to give it life in order that they might also succeed. (Pavlov 1932, p. 112)

. . . the eidetic imagery observed in children is, some may think, a characteristic of all kinds of artists. Such a whole creation of reality cannot be completely attained by a thinker. This is why it is so exceedingly rare that there is united in one person a great artist and a great thinker (e.g. Goethe & Leonardo da Vinci). They are usually represented by separate individuals. Of course the average person occupies a middle position (p. 113).

And we know that there are numbers of people who operate only with words from which they deduce everything without coming into contact with reality. And from this they wish to base their own life as well as to direct the lives of others (p. 162).

Thanks to this second signal of signals (language) and to its constant effects in various aspects of life, all of the human race can be separated into several types: artists, thinkers, and a middle type (p. 163).

**Conclusion**

Five other theories conceptually related to Cattell's theory of fluid and crystallized intelligence have been cited above. The extent to which they are supported by research evidence is also suggestive
of support for Cattell's theory.

Two of the theories (Hayes, 1962 & Pavlov, 1942) are specifically concerned with the relationship presumed to exist between fluid and crystallized intelligence. All of these related theoretical propositions lend credence to the purpose of this study to investigate the separation of fluid and crystallized intelligence with the aid of personality variables.

DESIGNATION OF VARIABLES FOR THIS STUDY

In order to accomplish the purpose of this study --- that of investigating the separation of fluid and crystallized intelligence with the aid of measures of various personality variables --- the following seven personality variables which seem (for reasons to be discussed below) to be logically associated with either fluid intelligence (Gf), or crystallized intelligence (Gc) have been selected. Six of these are contained in form AA of the Personality Research Form (PRF) by Jackson (1965), (See Appendices B & C). These include the scales of: "change" (C), "cognitive structure" (CS), "impulsivity" (I), "order" (O), "sentience" (S), and "understanding" (U). The seventh variable is an operationally defined measure of "spontaneous change" (SC) which was derived from Means' Spontaneous Change Test (Means, 1965; and Means & Harper, 1968). (See Appendices D & E)

Cattell's Culture Fair Test (1959) will be used to measure fluid
intelligence (Gf). His Scale 3 Test (1935) will be used to measure crystallized intelligence (Gc) (See Appendix A). These two measures of intellectual ability, along with the two tests measuring the seven personality variables mentioned above, will be discussed further in the "Methods" section of this paper.

THE THEORETICAL RELATIONSHIP PRESUMED TO EXIST BETWEEN THE PERSONALITY AND THE INTELLECTUAL VARIABLES:

PERSONALITY VARIABLES PREDICTED TO BE MOST HIGHLY RELATED TO FLUID INTELLIGENCE (Gf)

In an effort to establish a basis from which to infer the personality variables which should relate to fluid and crystallized intelligence, the research of Horn & Cattell is relevant. According to Horn & Cattell (1966a) the conditions for the measurement of Gf are optimal when:

"... the task materials are culture fair; that is the fundamentals are either; novel for all persons being measured, or exactly common, overlearned elements of a culture, and the aids needed to attain solution are not made available, by favored educational opportunity, to some persons and not to others among those measured (Horn & Cattell, 1966a)."

Scales from Jackson's PRF (1966) which are logically "synonymous" with the above description of Gf measures will be presented below. This matching of personality variables with Horn and Cattell's description of Gf is the closest approximation which can be achieved on a logical basis. In the following, each scale will be accompanied
by a list of 15 adjectives which Jackson (1966) presents as descriptive of that scale.

1. **Change (C)**
   
a. **Personality Description of High Scorers:**
   
   Likes new and different experiences; dislikes routine and avoids it; may readily change opinions or values in different circumstances; adapts readily to changes in environment.

   b. **Adjectives Descriptive of High Scorers:**
   
   inconsistent, fickle, flexible, unpredictable, wavering, mutable, adaptable, changeable, irregular variable, capricious, innovative, flighty, vacillating, inconsistent.

2. **Impulsivity (I)**
   
a. **Personality Description of High Scorers:**
   
   Tends to act on the 'spur of the moment' and without deliberation; gives vent readily to feelings and wishes; speaks freely; may be volatile in emotional expression.

   b. **Adjectives Descriptive of High Scorers:**
   
   hasty, rash, uninhibited, spontaneous, reckless, irrepressible, quick-thinking, mercurial, impatient, incautious, hurried, impulsive, foolhardy, excitable, impetuous.

3. **Sentience (S)**
   
a. **Personality Description of High Scorers:**
   
   Notices smells, sounds, sights, tastes and the way things feel; remembers these sensations and believes that they are an important part of life; is sensitive to many forms of experience; may maintain an essentially hedonistic or aesthetic view of life.
b. Adjectives Descriptive of High Scorers:

aesthetic, enjoys physical sensations, observant, earthy, aware, notices environment, feeling, sensitive, sensual, open to experience, perceptive, responsive, noticing, discriminating, alive to impressions.

4. Spontaneous Change (SC)

This variable is derived from a measure of spontaneous change devised by Means (1965) and by Means and Harper (1968). It has been found to be positively related to Raimy's Personal Observations of Normal Actions ($r = +0.46$) (Means & Harper, 1965); and voluntary time in a think tank ($r = 0.58$) (Means & Harper, 1968). It also has a low positive correlation with I.Q. (Ammons Quick Test, 1962) ($r = 0.22$), and a negative correlation with the F Scale of Authoritarianism ($r = -0.39$) (Means, 1965). Little other research has been done on this variable. Its hypothesized relationship to Gf is based primarily on the connotation of "flexibility" and on its positive relationship with multiple source information processing tasks ($r = +0.48$) (Means & Harper, 1968).

PERSONALITY VARIABLES PREDICTED TO BE MOST HIGHLY RELATED TO CRYSTALLIZED INTELLIGENCE (Gc)

As in the case of fluid intelligence, Horn and Cattell (1966a) also describe the conditions which are theoretically optimal for the

---

1 Personal communication, J. R. Means, 1969.

2 On a sample of institutionalized males.
measurement of crystallized intelligence. These exist when:

... the subject must use the concepts and aids representing relatively abstruse elements of the collective intelligence of a culture ... Gc is high on subtests that traditionally have been built into intelligence tests:

1. vocabulary size,
2. analogies,
3. classification involving a cultural knowledge of objects in the problem (Horn & Cattell, 1966a).

Scales from Jackson's PRF which are logically "synonomous" with the above description of Gc measures will be presented below. Each scale will be accompanied by a personality description and a list of 15 adjectives which Jackson (1966) presents as descriptive of high scorers on each scale:

1. **Cognitive Structure (CS)**
   a. Personality Description of High Scorers:

   Does not like ambiguity or uncertainty in information; wants all questions answered completely; desires to make decisions based upon definite knowledge, rather than upon guesses or probabilities.

   b. Adjectives Descriptive of High Scorers:

   precise, exacting, definite, seeks certainty, meticulous, perfectionistic, clarifying, explicit, accurate, rigorous, literal, avoids ambiguity, defining, rigid, seeks structure.

2. **Order (O)**

   a. Personality Description of High Scorers:

   Concerned with keeping personal effects and surroundings neat and organized; dislikes clutter, confusion, lack of organization; interested in developing methods for keeping materials methodically organized.
b. Adjective Descriptive of High Scorers:

neat, organized, tidy, systematic, well ordered, disciplined, prompt, consistent, orderly, clean, methodical, scheduled, planful, unvarying, deliberate.

3. Understanding (U)

a. Personality Description of High Scorers:

Wants to understand many areas of knowledge; values synthesis of ideas; variable generalization; logical thought, particularly when directed at satisfying intellectual curiosity.

b. Adjectives Descriptive of High Scorers:

inquiring, curious, analytical, exploring, intellectual, reflective, incisive, investigative, probing, logical, structuring, theoretical, astute, rational, inquisitive.

GENERAL HYPOTHESES

Two major classes of hypotheses follow directly from the relationship described in the preceding section i.e. those concerning convergent validity, and those concerning discriminant validity. The general hypotheses within each class are enumerated below.

Hypotheses of Convergent Validity

1. Those people who score above the median on Gf should have significantly higher mean scores for the variables of: change (C), sentience (S), and spontaneous change (SC), than those who score below the median on Gf.

2. Those people who score above the median on Gc should have a significantly higher mean score for the variable of understanding (U)
than those who score below the median on Gc.

3. There should be a significant positive correlation between Gf and Gc and between each pair of the members within each of the following two groups of variables:

1. Gf, C, I, S, SC;
2. Gc, CS, O, U.

Hypotheses of Discriminant Validity

1. Those people who score below the median on Gf should have significantly higher mean scores for the variables of cognitive structure (CS), and order (O), than those who score above the median on Gf.

2. Those people who score below the median on Gc should have a significantly higher mean score for the variable of impulsivity (I) than those who score above the median on Gc.

3. There should be a significant negative correlation between each pair of the members between each of the following two groups of variables (with the exception of that pair consisting of Gf and Gc):

1. Gf, C, I, S, SC;
2. Gc, CS, O, U.
CHAPTER II

METHOD

Subjects

A total of 140 male subjects between the ages of 18 and 22 years were recruited from the Autumn Quarter (1970) Introductory Psychology Class at the University of Montana. Of these, 38 failed to complete all of the measurements required in the counterbalanced order and were rejected from the study. This left a sample total of 102 subjects who completed all four of the measures administered.

All subjects were administered the scales for Gf, Gc, SC, and the PRF in the counterbalanced order (See Appendix D). Each subject was either required to participate in 5 hours of experimentation or to write a term paper in order to obtain credit for the introductory psychology class for which he was enrolled. As a result of full participation in this study, each subject received the required 5 hours of experimental credit necessary to satisfy the course requirement.

Testing was conducted between the hours of 7:00 P.M. and 9:30 P.M., on two different dates. Two of the measures were presented to groups of either 10 or 20 subjects on each date as required by the counterbalanced schedule (See Appendix D).
Psychometric Instruments

1. The Test of "g": Culture Fair, Scale 3, Form A, 1959.

According to Cattell (1968) this test, being culture fair, is an appropriate measure of Gf. In addition to the fact that it is "culture fair," this test was selected to measure Gf in this study because it is readily administered to groups of subjects.

This test is a series of four subtests consisting of several geometric designs. The first design is a model. This is followed by a number of other geometric designs, one of which has some stimulus dimension in common with the model. The subject's task is simply to identify the design which has some important stimulus dimension in common with the model which the other designs lack.

The test has been constructed in two parallel forms, A and B, and either form can be administered on a group or an individual basis. It was standardized in 1961 on a sample consisting of 3140 American High School students, equally divided among freshmen, sophomores, juniors, and seniors, and young adults in a stratified job sample. The mean raw score of this sample was 22.1 and the standard deviation was 5.25 (Cattell, 1959, Table 2, p. 48).

Standardization was also performed on a sample of 1097 undergraduate college students, mainly sophomores, from four large universities (two north central state universities, one southern state university, and a medium sized private college). The mean raw score for this
sample was 26.1 and the standard deviation was 4.60 (Cattell, 1959, Table 5, p. 51).

2. **Cattell Intelligence Tests, Group and Individual, Scale III, Form A 1935.**

Cattell's Scale III (1935) has been recommended by Cattell as an appropriate measure of Gc. The test was first published in 1930, and revised in 1935. Cattell (1952) expresses the general goals in designing this test as follows:

"It has been the object of the designer of these tests to produce a set of intelligence scales capable of testing the whole range of intellectual development, from that of the normal child of eight to that of the gifted adult, and constructed throughout on uniform principles.

The wide range of ability concerned is met by three scales of increasing difficulty. Scale I is suitable for normal children of ages eight to eleven, Scale II is for ages eleven to fifteen and Scale III for mental ages of fifteen years and upward — i.e. for adults of average and more than average ability."

To accomplish his goal of generality, the entire series of three scales has been constructed with the following aims in mind:

"A. to include only those types of tests already proved to be most highly saturated with "g".

B. to expect only a bare minimum of (general) knowledge on the part of the subject as a working basis for the mental operations dealt with by the test.

C. to assume a much more limited vocabulary than has hitherto been demanded in most intelligence tests.

D. to diminish the effects of verbal facility, as far as is compatible with retaining high "g" saturation."
E. to arrange successive items in each test in order of increasing difficulty, so that the examinee is not held up by too difficult examples while easier ones await him.

F. to facilitate the use of scales for large numbers of subjects by rendering the scoring as simple as possible by means of mechanical aids.

G. to provide before the test proper a brief introductory test --- the results of which are discarded --- . . ."

The entire test, including directions and rest periods, requires 90 minutes to administer. It is composed of six subtests named as follows:

I. Synonyms,
II. Classifications,
III. Opposites,
IV. Analogies,
V. Completion,
VI. Inferences.

Raw scores are computed for each subtest. These are added together to form a total raw score. This total is then converted into an M.A. through the use of normative tables.

This test was first standardized in 1934 on 2000 adults, compounded in a stratified sample from various occupations to represent the general population. This sample yielded a standard deviation of 26 IQ points. A restandardization was performed in 1950 on 1000 cases accumulated between 1934 and 1950. This sample yielded a standard deviation of 24 IQ points.
This scale is reproduced in Appendix A. It seems to be somewhat contaminated with Gf, but is being used in this study because it generally meets the requirements for the measurement of Gc, and because it is the only standardized group measure of Gc recommended by Cattell.

3. Jackson's Personality Research Form (PRF), 1966, Form AA.

The Personality Research Form (PRF) is a true-false questionnaire constructed in two sets of parallel forms. Form A and its parallel Form B are composed of 300 items. These are organized into the following 15 scales consisting of 20 items each:

1. Achievement,
2. Affiliation,
3. Aggression,
4. Autonomy,
5. Dominance,
6. Endurance,
7. Exhibition,
8. Harmavoidance,
9. Impulsivity,*
10. Nurturance,
11. Order,*
12. Play,

*Scales used in this study
13. Social Recognition,

14. Understanding,*

15. Infrequency.

Forms A and B are known as the short forms of the PRF and require an average of 30 to 45 minutes to administer.

Forms AA and its parallel Form BB are composed of 440 items. These are organized into 22 scales of 20 items each. The first 15 scales are the same as those in forms A and B. The remaining seven scales are:

1. Abasement,

2. Change,*

3. Cognitive Structure,*

4. Defendence,

5. Sentience,*

6. Succorance,

7. Desirability.

Forms AA and BB are known as the long forms of the PRF and require about 40 to 70 minutes to administer. Because three of the scales to be used in this study are only contained in the long forms, Form AA has been chosen for this study.

Under the influence of Loevinger (1957), Cronbach and Meehl (1955), and Campbell and Fiske (1959); Jackson constructed the PRF so that it

*Scales used in this study
would meet the requirements of construct validity (Jackson, 1966).

Loevinger (1957) emphasized the importance of the "substantive", "structural," and "external" components of construct validity. In accordance with this emphasis, four interrelated principles were established by Jackson as guidelines to the construction of the PRF (Jackson, 1966). These are:

1. **The importance of psychological theory.** In line with this principle, Jackson selected the personality theory proposed by Murray (1938). This theory was selected by Jackson because it contained a sufficient variety of well defined personality variables.

2. **The importance of scale homogeneity as well as generalizability.**

3. **The necessity for suppressing response style variance.**

4. **The importance of fostering convergent and discriminant validity.**

Since this study is concerned with one of the components of construct validity (the external component), and since this component involves convergent and discriminant validity, the PRF is considered of particular value to this study.

4. **The Spontaneous Change Test (SC)** [Adapted from Means, (1965), and Means and Harper (1968)]

The 1965 version of this test was developed, by Means, to quantitatively assess the extent to which a subject responds flexibly and spontaneously in a task requiring his arrangement of four straight lines of different lengths, on a blank sheet of white circular paper 25
cm in diameter, over a series of 10 trails. The responses were scored according to a system of 9 criteria.

In 1968, Means and Harper revised the scoring system with less of an emphasis on structure, and more of an emphasis on change. This revised scoring system consisted of two criteria: the angular displacement of three lines using the longest (4th line) as one leg of the angle. The second criterion was spatial displacement. This was measured by the distance between the center of each line and every other line (this score was corrected for the original distances presented in the model). Spontaneous change was defined as the sum of these two scores.

Due to the large number of subjects to be used in this study, use of the 1965 or 1968 measures of spontaneous change would be so time consuming as to make its inclusion impractical. Therefore, an abbreviated version of the spontaneous change test was developed. Using essentially the same set of instructions as the 1965 and 1968 (See Appendix E) versions; and essentially the same scoring system as the 1968 version, (see Appendix F) the task was modified to involve two lines instead of four. These lines were presented to each subject on a model consisting of a white sheet of circular paper 25 cm in diameter. One line was 3.0 cm long, and the other was 7.5 cm long. These were arranged in order of increasing length. The lines were parallel and had one end on an imaginary line passing through the center of the
paper. The lines were separated by 3 cm and extended upwards towards the word "Example" which was typed approximately 2 cm from the edge of the paper.

The subjects were instructed to arrange the two lines seen on the model on the first sheet of circular paper in any way which was most agreeable to them. They were also instructed to keep the lines they drew about the same length as the lines seen on the model. After they finished this, they were instructed to rearrange the two lines on a second sheet of circular paper in any way which was most pleasing to them. This procedure was continued until each subject had rearranged the lines of the model on each of the 10 sheets of circular paper. The subjects' responses were then scored according to a procedure which accounts for the degree of angular and spatial displacement of each line between circular papers N-1 and N. This procedure is outlined in Appendix F.

The spontaneous change test is considered particularly valuable to this study because it provides a direct behavioral measurement of a theoretically important variable. This version has the advantage of being simpler and easier to score than earlier versions. It has the disadvantage, however, of lacking the richness and variability of the earlier versions.
CHAPTER III

RESULTS

After the data were gathered according to the procedure described in the METHODS section, the general hypotheses of convergent and discriminant validity were tested by the following procedures:

A. An analysis of variance with 1 and 98 degrees of freedom (K = 2, N = 102) where the critical F ratio for the significance level where p < .01 is 6.94. Specific hypotheses for these analyses were formulated on the basis of a 2x2 contingency table constructed for each of the 7 personality variables. The intellectual variables were represented as being high (above the median) or low (below the median) for the two dimensions of Gf and Gc.

B. A 12x12 correlation matrix was constructed to test the correlational hypotheses. All correlational predictions were directional. Thus, they either predict a positive correlation (where $0 < r_{xy} < 1.00$), or a negative correlation (where $0 > r_{xy} > -1.00$). Fisher's Z statistic was used to compute the critical $r_{xy}$ (where p < .01). Given an N of 102, the critical $r_{xy} = 0.23$.

The proportion of significant positive intercorrelations was then compared with that proportion predicted on the basis of chance. The
latter was computed from the product of the probability of obtaining a significant correlation by chance ($0.01$) and the probability of obtaining a positive correlation by chance ($0.50$). Thus, the proportion of significant positive intercorrelations expected on the basis of chance is 

$$0.01 \times 0.50 = 0.005.$$ 

I. Results of Specific Convergent Validity Hypotheses:

A. Those people who scored above the median on Gf should have higher mean scores on the variables listed below than those who scored below the median on Gf. Thus, there should be a significant Gf effect for each of the following variables:

1. Change (C)

<table>
<thead>
<tr>
<th>effect</th>
<th>prediction</th>
<th>$F$</th>
<th>result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gf</td>
<td>significant</td>
<td>2.115</td>
<td>nonsig.</td>
</tr>
<tr>
<td>Gc</td>
<td>nonsig.</td>
<td>2.303</td>
<td>nonsig.</td>
</tr>
<tr>
<td>GfxGc</td>
<td>nonsig.</td>
<td>0.243</td>
<td>nonsig.</td>
</tr>
</tbody>
</table>

2. Sentience (S)

<table>
<thead>
<tr>
<th>effect</th>
<th>prediction</th>
<th>$F$</th>
<th>result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gf</td>
<td>significant</td>
<td>1.009</td>
<td>nonsig.</td>
</tr>
<tr>
<td>Gc</td>
<td>none</td>
<td>1.306</td>
<td>nonsig.</td>
</tr>
<tr>
<td>GfxGc</td>
<td>none</td>
<td>0.929</td>
<td>nonsig.</td>
</tr>
</tbody>
</table>

3. Spontaneous Change (SC)

<table>
<thead>
<tr>
<th>effect</th>
<th>prediction</th>
<th>$F$</th>
<th>result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gc</td>
<td>significant</td>
<td>0.064</td>
<td>nonsig.</td>
</tr>
<tr>
<td>Gf</td>
<td>none</td>
<td>0.501</td>
<td>nonsig.</td>
</tr>
<tr>
<td>GfxGc</td>
<td>none</td>
<td>3.261</td>
<td>nonsig.</td>
</tr>
</tbody>
</table>

B. Those people who scored above the median on Gc should have a significantly higher mean score for the variable of understanding
than those who scored below the median on Gc. Thus, there should be a significant Gc effect for the variable of understanding (U).

<table>
<thead>
<tr>
<th>effect</th>
<th>prediction</th>
<th>F</th>
<th>result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gc</td>
<td>significant</td>
<td>0.064</td>
<td>nonsig.</td>
</tr>
<tr>
<td>Gf</td>
<td>none</td>
<td>14.793</td>
<td>p &lt; .001</td>
</tr>
<tr>
<td>GfxGc</td>
<td>none</td>
<td>1.947</td>
<td>nonsig.</td>
</tr>
</tbody>
</table>

The analyses of variance produced no results in favor of the conclusion that the theory of fluid and crystallized intelligence has convergent validity. The one significant result was the Gf effect for the personality variable of "understanding" (p < .001). This is evidence that this variable is associated with fluid intelligence rather than with crystallized intelligence as was expected.

C. There should be a significant positive correlation between the following pairs of variables:

1. The Gf Group:

<table>
<thead>
<tr>
<th>r</th>
<th>result</th>
</tr>
</thead>
<tbody>
<tr>
<td>xy</td>
<td></td>
</tr>
<tr>
<td>a. Gf vs Gc</td>
<td>.37*</td>
</tr>
<tr>
<td>b. Gf vs C</td>
<td>.20</td>
</tr>
<tr>
<td>c. Gf vs I</td>
<td>.25*</td>
</tr>
<tr>
<td>d. Gf vs S</td>
<td>.12</td>
</tr>
<tr>
<td>e. Gf vs SC</td>
<td>-.03</td>
</tr>
<tr>
<td>f. C vs I</td>
<td>.36*</td>
</tr>
<tr>
<td>g. C vs S</td>
<td>.33*</td>
</tr>
<tr>
<td>h. C vs SC</td>
<td>.00</td>
</tr>
</tbody>
</table>

*p < .01
2. The Gc Group:

\[ r_{xy} \]

- **a.** Gc vs Gf \[ .37^* \]
- **b.** Gc vs CS \[ .00 \]
- **c.** Gc vs O \[ -.07 \]
- **d.** Gc vs U \[ .33^* \]
- **e.** CS vs O \[ .70^* \]
- **f.** CS vs U \[ .07 \]
- **g.** O vs U \[ .02 \]

\[ * p < .01 \]

Of the predicted positive intercorrelations, .35 were both positive and significant at the .01 level. This proportion is significantly greater than that (.005) expected on the basis of chance (\( p < .01 \)) and is interpreted as supportive of the conclusion that the theory of fluid and crystallized intelligence has convergent validity.

**II. Results of Specific Discriminant Validity Hypotheses:**

A. Those people who scored **below** the median on Gf should have higher mean scores on the variables listed below than those who scored above the median on Gf. Thus, there should be a significant Gf effect for each of the following variables:
1. Cognitive Structure (CS)

<table>
<thead>
<tr>
<th>effect</th>
<th>prediction</th>
<th>F</th>
<th>result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gf</td>
<td>significant</td>
<td>0.016</td>
<td>nonsig.</td>
</tr>
<tr>
<td>Gc</td>
<td>none</td>
<td>3.403</td>
<td>nonsig.</td>
</tr>
<tr>
<td>GfxGc</td>
<td>none</td>
<td>3.070</td>
<td>nonsig.</td>
</tr>
</tbody>
</table>

2. Order (O)

<table>
<thead>
<tr>
<th>effect</th>
<th>prediction</th>
<th>F</th>
<th>result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gf</td>
<td>significant</td>
<td>0.176</td>
<td>nonsig.</td>
</tr>
<tr>
<td>Gc</td>
<td>none</td>
<td>1.816</td>
<td>nonsig.</td>
</tr>
<tr>
<td>GfxGc</td>
<td>none</td>
<td>0.047</td>
<td>nonsig.</td>
</tr>
</tbody>
</table>

B. Those people who scored below the median on Gc should have a significantly higher mean score for the variable of impulsivity (I) than those who score above the median on Gc. Thus, there should be a significant Gc effect for the variable of impulsivity (I).

<table>
<thead>
<tr>
<th>effect</th>
<th>prediction</th>
<th>F</th>
<th>result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gc</td>
<td>significant</td>
<td>3.542</td>
<td>nonsig.</td>
</tr>
<tr>
<td>Gf</td>
<td>nonsig.</td>
<td>1.018</td>
<td>nonsig.</td>
</tr>
<tr>
<td>GcxGf</td>
<td>nonsig.</td>
<td>5.611</td>
<td>nonsig.</td>
</tr>
</tbody>
</table>

The analyses of variance produced no significant results in favor of the conclusion that the theory of fluid and crystallized intelligence has discriminant validity.

C. There should be a significant negative correlation between the following pairs of variables:

<table>
<thead>
<tr>
<th>r&lt;sub&gt;xy&lt;/sub&gt;</th>
<th>result</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Gf vs CS</td>
<td>-.12</td>
</tr>
<tr>
<td>2. Gf vs O</td>
<td>-.13</td>
</tr>
<tr>
<td>3. Gf vs U</td>
<td>.10</td>
</tr>
<tr>
<td>4. C vs Gc</td>
<td>.16</td>
</tr>
<tr>
<td></td>
<td>results</td>
</tr>
<tr>
<td>---</td>
<td>---------</td>
</tr>
<tr>
<td>5.</td>
<td>C vs Cs</td>
</tr>
<tr>
<td>6.</td>
<td>C vs O</td>
</tr>
<tr>
<td>7.</td>
<td>C vs U</td>
</tr>
<tr>
<td>8.</td>
<td>I vs Gc</td>
</tr>
<tr>
<td>9.</td>
<td>I vs Cs</td>
</tr>
<tr>
<td>10.</td>
<td>I vs O</td>
</tr>
<tr>
<td>11.</td>
<td>I vs U</td>
</tr>
<tr>
<td>12.</td>
<td>S vs Gc</td>
</tr>
<tr>
<td>13.</td>
<td>S vs CS</td>
</tr>
<tr>
<td>14.</td>
<td>S vs O</td>
</tr>
<tr>
<td>15.</td>
<td>S vs U</td>
</tr>
<tr>
<td>16.</td>
<td>SC vs Gc</td>
</tr>
<tr>
<td>17.</td>
<td>SC vs CS</td>
</tr>
<tr>
<td>18.</td>
<td>SC vs O</td>
</tr>
<tr>
<td>19.</td>
<td>SC vs U</td>
</tr>
</tbody>
</table>

Of the predicted negative intercorrelations, .21 were both negative and significant at the .01 level. This proportion is significantly greater than that (.005) expected on the basis of chance (p < .01) and is interpreted as supportive of the conclusion that the theory of fluid and crystallized intelligence has discriminant validity. Two major unexpected contradictions were significant positive correlations between the personality variable of "understanding" and the variables of "sentience"
and "change". The latter two were predicted to be members of the Gf group and were thus expected to correlate negatively with variables predicted to be members of the Gc group such as "understanding". It is interesting to note that these two correlations (.36 and .32, respectively) are both higher than the correlation between "understanding" and the instruments used to measure Gf (r = .10).

CONVERGENT VALIDITY

\[ Z = \frac{P - P}{\sqrt{P(1 - P)}} \]

where \( P \) = expected proportion (.005)

\( P \) = obtained proportion

\( N \) = total number of predictions for \( p \)

<table>
<thead>
<tr>
<th>Variable</th>
<th>( \sum ) ( \Sigma ) ( \rho / \Sigma \rho )</th>
<th>( p )</th>
<th>( Z )</th>
<th>( p(\text{same diff. by chance}) )</th>
<th>interp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gf</td>
<td>2/5</td>
<td>.40</td>
<td>3.95</td>
<td>( p &lt; .01 )</td>
<td>sig.</td>
</tr>
<tr>
<td>C</td>
<td>2/4</td>
<td>.50</td>
<td>14.14</td>
<td>( p &lt; .01 )</td>
<td>sig.</td>
</tr>
<tr>
<td>I</td>
<td>2/4</td>
<td>.50</td>
<td>14.14</td>
<td>( p &lt; .01 )</td>
<td>sig.</td>
</tr>
<tr>
<td>S</td>
<td>1/4</td>
<td>.25</td>
<td>7.00</td>
<td>( p &lt; .01 )</td>
<td>sig.</td>
</tr>
<tr>
<td>Sc</td>
<td>0/4</td>
<td>.00</td>
<td>-0.14</td>
<td>( p = .44 )</td>
<td>nonsig.</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gf group</td>
<td>7/21</td>
<td>.33</td>
<td>21.67</td>
<td>( p &lt; .01 )</td>
<td>sig.</td>
</tr>
<tr>
<td>Gc</td>
<td>2/4</td>
<td>.50</td>
<td>14.14</td>
<td>( p &lt; .01 )</td>
<td>sig.</td>
</tr>
<tr>
<td>Cs</td>
<td>1/3</td>
<td>.33</td>
<td>8.13</td>
<td>( p &lt; .01 )</td>
<td>sig.</td>
</tr>
<tr>
<td>O</td>
<td>1/3</td>
<td>.33</td>
<td>8.13</td>
<td>( p &lt; .01 )</td>
<td>sig.</td>
</tr>
<tr>
<td>U</td>
<td>1/3</td>
<td>.33</td>
<td>8.13</td>
<td>( p &lt; .01 )</td>
<td>sig.</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gc group</td>
<td>5/13</td>
<td>.38</td>
<td>18.75</td>
<td>( p &lt; .01 )</td>
<td>sig.</td>
</tr>
<tr>
<td>Total</td>
<td>12/34</td>
<td>.35</td>
<td>28.75</td>
<td>( p &lt; .01 )</td>
<td>sig.</td>
</tr>
</tbody>
</table>

Convergent

Propportion of significant negative correlations where positive correlations were predicted (contradictions) compared with that expected (.005).

\( \sum \rho / \Sigma \rho \) \( p = 0.41 \) \( p > 0.01 \) nonsig.

The proportion of significant contradictions of convergent validity does not differ significantly from that predicted by chance.

Total nonsig. 22/34 = .65  \( Z = -32.00 (p < .01) \) sig.
TABLE B: A SUMMARY OF THE SIGNIFICANCES OF THE DIFFERENCES BETWEEN THE OBTAINED PROPORTION OF SIGNIFICANT NEGATIVE CORRELATIONS AND THAT EXPECTED BY CHANCE (.005).

**DISCRIMINANT VALIDITY**

\[ Z = \frac{P - \bar{P}}{\sqrt{\frac{P(1-P)}{N}}} \]

where \( P \) = expected proportion (.005)

\( \bar{P} \) = obtained proportion

\( N \) = total number of predictions for \( P \)

<table>
<thead>
<tr>
<th>Variable</th>
<th>( \bar{P} )</th>
<th>( r/\sqrt{\bar{P}(1-\bar{P})} )</th>
<th>( p )</th>
<th>( Z )</th>
<th>( p ) (same diff. by chance)</th>
<th>interp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gf</td>
<td>0/3</td>
<td>.00</td>
<td>-0.12</td>
<td>p = .45</td>
<td>nonsig.</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>2/4</td>
<td>.50</td>
<td>14.14</td>
<td>p &lt;&lt; .01</td>
<td>sig.</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>2/4</td>
<td>.50</td>
<td>14.14</td>
<td>p &lt;&lt; .01</td>
<td>sig.</td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>0/4</td>
<td>.00</td>
<td>-0.14</td>
<td>p = .44</td>
<td>nonsig.</td>
<td></td>
</tr>
<tr>
<td>Sc</td>
<td>0/4</td>
<td>.00</td>
<td>-0.14</td>
<td>p = .44</td>
<td>nonsig.</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gf group</td>
<td>4/19</td>
<td>.21</td>
<td>12.81</td>
<td>p &lt;&lt; .01</td>
<td>sig.</td>
<td></td>
</tr>
<tr>
<td>Gc</td>
<td>0/4</td>
<td>.00</td>
<td>-0.14</td>
<td>p = .44</td>
<td>nonsig.</td>
<td></td>
</tr>
<tr>
<td>Cs</td>
<td>2/5</td>
<td>.40</td>
<td>3.95</td>
<td>p &lt;&lt; .01</td>
<td>sig.</td>
<td></td>
</tr>
<tr>
<td>O</td>
<td>2/5</td>
<td>.40</td>
<td>3.95</td>
<td>p &lt;&lt; .01</td>
<td>sig.</td>
<td></td>
</tr>
<tr>
<td>U</td>
<td>0/5</td>
<td>.00</td>
<td>-0.16</td>
<td>p = .44</td>
<td>nonsig.</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gc group</td>
<td>4/19</td>
<td>.21</td>
<td>17.83</td>
<td>p &lt;&lt; .01</td>
<td>sig.</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>8/38</td>
<td>.21</td>
<td>17.83</td>
<td>p &lt;&lt; .01</td>
<td>sig.</td>
<td></td>
</tr>
</tbody>
</table>

Proportion of significant positive correlations where negative correlations were predicted (contradictions) compared with that expected (.005).

<table>
<thead>
<tr>
<th>Variable</th>
<th>( \bar{P} )</th>
<th>( r/\sqrt{\bar{P}(1-\bar{P})} )</th>
<th>( p )</th>
<th>( Z )</th>
<th>( p ) (same diff. by chance)</th>
<th>interp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>U</td>
<td>2/5</td>
<td>.40</td>
<td>12.34</td>
<td>p &lt;&lt; .01</td>
<td>sig.</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>4/38</td>
<td>.11</td>
<td>-6.17</td>
<td>p &lt;&lt; .01</td>
<td>sig.</td>
<td></td>
</tr>
</tbody>
</table>

The proportions of significant contradictions of discriminant validity was significantly greater than that predicted by chance. All contradictions involved the personality variable of understanding (U).

The total proportion of nonsignificant discriminant correlations is .69. This is significantly lower than that predicted by chance (.99).

Total nonsig. \( 26/38 = .69 \quad -20.81 \quad (p << .01) \quad \text{sig.} \)
SUPPLEMENTARY RESULTS

1. PREFACE: In this section, an attempt was made to further investigate the relationship between the theory of fluid and crystallized intelligence by deliberately removing a considerable portion of the error variance. This was accomplished by selecting one group of subjects with scores above the median on the personality variables of Change (C), Impulsivity (I), and Sentience (S); and with scores below the median on the personality variables of Cognitive Structure (CS) and Order (O). This group was designated the "High Gf Prototypic Group" (Group 1, N = 19).

A second group of subjects was selected with scores above the median on the personality variables of Cognitive Structure (CS), and Order (O); and with scores below the median on the personality variables of Change (C), Impulsivity (I), and Sentience (S). This group was designated the "High Gc Prototypic Group" (Group 2, N = 11). These two groups were formulated on the basis of the theory as expressed in the hypotheses of the main part of the study.

2. HYPOTHESES AND RESULTS:

\[ \text{SC}_1 (\bar{X} = 77.05) > \text{SC}_2 (\bar{X} = 64.27), \quad t_{28df} = 9.750 \quad p < .001. \]

\[ \text{Gf}_1 (\bar{X} = 28.10) > \text{Gf}_2 (\bar{X} = 27.00), \quad t_{28df} = 0.790 \quad \text{nonsig.} \]

\[ \text{Gc}_2 (\bar{X} = 79.68) > \text{Gc}_1 (\bar{X} = 77.91), \quad t_{28df} = 0.002 \quad \text{nonsig.} \]

\[ \text{U}_2 (\bar{X} = 12.89) > \text{U}_1 (\bar{X} = 11.36), \quad t_{28df} = 1.507 \quad \text{nonsig.} \]
When error variance was systematically reduced through the selection of prototypic groups of high Gf and high Gc subjects, the variable of Gf was not significantly higher in the high Gf prototypic group than in the high Gc prototypic group. Similarly the variable of Gc was not significantly higher in the high Gc prototypic group than in the high Gf prototypic group. This result further supports the conclusion that the measures for Gf and Gc lack discriminant validity.

There was no significant difference for the mean values of the variable of "U" between the high Gc and the high Gf groups. This is contradictory with previous results suggesting a significant relationship between this variable and the Gf group.

The variable SC had a significantly higher mean score in the high Gf group than it did in the high Gc group (p < .001). This finding supports convergent and discriminant validity in both the theory of fluid and crystallized intelligence and the variable of spontaneous change.
CHAPTER IV

DISCUSSION

A. Convergent Validity

In order to evaluate the extent to which convergent validity holds for the theory of fluid and crystallized intelligence, two approaches were taken. The first approach used analysis of variance procedures; the second used correlational procedures.

The analysis of variance procedures produced no results supportive of convergent validity for the theory of fluid and crystallized intelligence with respect to clusters of personality variables presumed to be associated with either fluid or crystallized intelligence. However, the correlational analysis did produce results which are considered moderately supportive of convergent validity for the theory under study.

Within the cluster of personality variables theoretically associated with fluid intelligence (i.e., change, impulsivity, sentience, spontaneous change, and Cattell's Culture Fair Test), .33 of the predicted positive intercorrelations were both positive and significant at the .01 level. This is significantly greater than that (.005) predicted on the basis of chance (p < .01).

When the clusters of personality variables theoretically associated with either fluid or crystallized intelligence (as delineated in the
preceeding two paragraphs) were intercorrelated, the total proportion of predicted positive intercorrelations which were both positive and significant at the .01 level was .35. This proportion is significantly greater than that (.005) predicted on the basis of chance (p < .01).

The conclusion drawn from these data is that there is modest evidence in support of the hypothesis that the general theory of fluid and crystallized intelligence has convergent validity. The adjective "modest" is used because of the low magnitude of the correlations and proportions obtained (range of significant correlation = +.25 to +.70. Mean of significant correlations = +.39), even though these magnitudes were sufficiently high to be called "significant" where p < .01.

B. Discriminant Validity

In order to evaluate the extent to which the factors of fluid and crystallized intelligence might be merely manifestations of Cattell's oblique factor analytic methodology, two approaches were taken. The first approach used analysis of variance procedures; the second used correlational procedures.

The analysis of variance procedures produced no results supportive of discriminant validity for the theory of fluid and crystallized intelligence with respect to clusters of personality variables presumed to be associated with either fluid or crystallized intelligence. Thus, the analysis of variance failed to provide any evidence refuting the conclusion that the factors of fluid and crystallized intelligence are not
merely manifestations of Cattell's oblique factor analytic methodology. The correlational analysis, however, did produce results which are considered moderately supportive of the conclusion that the theory of fluid and crystallized intelligence does have discriminant validity and that the factors of fluid and crystallized intelligence are not artifacts of Cattell's oblique factor analytic methodology.

When the cluster of personality variables theoretically associated with fluid intelligence (i.e., change, impulsivity, sentience, spontaneous change, and Cattell's Culture Fair Test) was intercorrelated with the cluster of personality variables theoretically associated with crystallized intelligence (i.e., cognitive structure, order, understanding, and the Cattell Group Intelligence Test), .21 of the predicted negative intercorrelations were both negative and significant at the .01 level. This proportion is significantly greater than that (.005) predicted on the basis of chance (p < .01).

The conclusion drawn from these data is that Cattell's theory of fluid and crystallized intelligence is capable of differentially predicting the directions of intercorrelations between personality variables theoretically associated with the concepts of fluid or crystallized intelligence .21 of the time. Because this proportion is significantly greater than that proportion (.005) predicted on the basis of chance (p > .01), it is accepted as modest evidence in favor of the conclusions that the theory of fluid and crystallized intelligence does have
discriminant validity and that the factors of fluid and crystallized intelligence are not merely manifestations of Cattell's oblique factor analytic methodology. The evidence for these conclusions is labeled "modest" because of the low (range of significant negative correlations = -.24 to -.62; mean significant negative correlation = -.40) although statistically significant -- magnitudes of the correlations and proportions obtained.

When the specific measures of fluid (the Culture Fair Test) and crystallized (the Cattell Group Intelligence Test) intelligence are considered separately i.e. out of the context of their respective clusters as identified above, it was found that none of the intercorrelations predicted to be negative between each of these two measures and the personality variables predicted to be members of the cluster associated with the other was significant. Thus, there were no significant negative correlations between the measure of fluid intelligence and the cluster of personality variables predicted to be associated with crystallized intelligence (i.e., cognitive structure, order, understanding) nor between the measure of crystallized intelligence and the cluster of personality variables predicted to be associated with fluid intelligence (i.e., change, impulsivity, sentience, and spontaneous change).

The conclusion drawn from this finding is that the instruments used to measure fluid and crystallized intelligence are not capable
of differentially predicting significant negative intercorrelations between the personality variables predicted to be associated with each. Given these data alone, one would have no basis for concluding that the factors of fluid and crystallized intelligence are not merely manifestations of Cattell's oblique factor analytic methodology.

Even though fluid and crystallized intelligence are theoretically and empirically positively correlated, it does not seem unjust to expect negative intercorrelations between one factor of intelligence and the cluster of personality variables predicted to be associated with the other factor. It is possible that the negative intercorrelations predicted were not strong enough to withstand the "wash-out" effects of at least three considerations: 1) the positive correlations obtained between fluid and crystallized intelligence, 2) the contamination of the crystallized intelligence measure (i.e. Cattell's Group Intelligence Test) with fluid intelligence items (see page 10) and 3) the effects of a college sample whose mean fluid and crystallized intelligence are significantly greater than those of the general population.

---

1 The expectation of negative correlations is a more stringent theoretical consideration than that typically required a la Campbell and Fiske (1959). Thus, significant negative correlations, although justifiably predicted, might be too much to expect.
The data obtained suggest that the concepts of fluid and crystallized intelligence are discriminable from each other when correlated with their respective clusters of personality variables. However, when measures of fluid and crystallized intelligence are correlated with the personality variables associated with the other, the correlations are not significantly negative. This suggests that these instruments have contaminating items since the personality instrument (Jackson's Personality Research Form) has already demonstrated negative correlations with many of the relevant theoretical clusters (Jackson, 1966).

The supplementary results indicated that the mean score for the measure of fluid intelligence (Cattell's Culture Fair Test) was not significantly higher in the high Gf prototypic group (X = 28.10) than in the high Gc prototypic group (X = 27.00). Similarly the mean score for the measure of crystallized intelligence (Cattell's Group Intelligence Test) was not significantly higher in the high Gc prototypic group

\[ \text{The sample mean raw score for Gf was 26.15 and the standard deviation was 4.25. This is compared with the population mean (estimated from Cattell's standardization sample, 1959) of 22.1 with a standard deviation of 5.23 (t}_{101\text{df}} = 10.76 \ p < .005).} \]

\[ \text{The sample mean IQ for Gc was 117.55 and the standard deviation was 11.33. This is compared with the population mean (estimated from Cattell's standardization sample, 1952) of 100 with a standard deviation of 24.0 (t}_{101\text{df}} = 13.82 \ p < .005).} \]
than in the high Gf prototypic group ($\bar{X} = 79.68$). These results support the conclusion drawn above that these instruments are not separable from each other on the basis of personality variables predicted to be differentially associated with each.

Support for the convergent and discriminant validity of the general theory of fluid and crystallized intelligence was provided by the supplementary results concerning the variable of spontaneous change (SC). The results indicated that this variable had a significantly higher mean score in the high Gf prototypic group ($\bar{X} = 64.27$) than in the high Gc prototypic group ($\bar{X} = 77.05; p < .001$). The fact that this relationship did not appear in the analysis of variance or the correlational analysis is probably explained by the fact that the massive error variance present in the analysis of variance and correlational analysis obscured relationships which manifested themselves only when the error variance was sharply reduced. The latter was accomplished through the formation of prototypic groups represented by the theory.

The only statistically significant finding from the analysis of variance was for the Gf effect for the variable of "understanding" ($F = 14.79; p < .001$). This unexpected relationship was supported by findings of significant positive correlations between "understanding" and two of the variables (i.e., "change" and "sentience") which are considered members of the Gf cluster. However, the correlation between "understanding" and the measure of Gf was not significant...
(r = .10) nor were the mean "understanding" score significantly greater for the Gf prototypic group (X = 12.89 in the supplementary results) than the Gc prototypic group (X = 11.36; \( t_{28df} = 1.51 \) nonsig.). These findings are contradictory and are extremely difficult to interpret without the benefit of data obtained from a more representative sample whose mean Gf and Gc scores do not differ significantly from those of the general population.
CHAPTER V

SUMMARY

The theory of fluid and crystallized intelligence was investigated in terms of predicted relationships between scores on instruments used to measure fluid and crystallized intelligence and selected variables of personality derived from the theory. Of particular interest was the question of whether or not the factors of fluid and crystallized intelligence are merely manifestations of Cattell's oblique factor analytic methodology (i.e. could they more parsimoniously be considered a single factor than two factors). This is essentially a question of discriminant validity.

A total of 102 male subjects each received some combination of measures of fluid intelligence (Gf), crystallized intelligence (Gc), the Personality Research Form (Jackson, 1965) --- which contains scales of "change" (C), "cognitive structure" (CS), "impulsivity" (I), "order" (O), "sentience" (S) and "understanding" (U) in a fixed repeating order --- and a version of the Spontaneous Change Test (Means, 1965) designed for this study. These instruments were administered according to a counterbalanced schedule (See Appendix C).

A 2 X 2 analysis of variance for each of the seven personality variables C, CS, I, O, S, U, and SC, on the two intellectual variables
(Gf and Gc) failed to support hypothesis of convergent or discriminant validity. However, 12 X 12 correlation matrix provided modest support for the following conclusions:

A. The theoretical factor of fluid intelligence has convergent validity.

B. The theoretical factor of crystallized intelligence has convergent validity.

C. The general theory of fluid and crystallized intelligence does have discriminant validity in the sense that the factors of fluid and crystallized intelligence are discriminable from each other on the basis of the predicted directions of the correlations between personality variables theoretically associated with each.

D. The specific instruments used to measure fluid and crystallized intelligence (i.e. Cattell's Culture Fair Test and Cattell's Group Intelligence Test) are not discriminable from each other on the basis of the predicted directions of their correlations with personality variables theoretically associated with each. An explanation of this finding was offered in terms of at least three considerations:

1) The positive correlation between these two measures may have obscured differential negative relationships between these variables and variables of personality.

2) The contamination of the crystallized intelligence measure (i.e. Cattell's Group Intelligence Test) with fluid intelligence items (see page 10).
3) The effects of a college sample whose mean fluid and crystallized intelligence are significantly greater than those of the general population.

Supplemental data resulting from a systematic attempt to reduce error variance supported the conclusions that:

A. The measures of fluid and crystallized intelligence (i.e. Cattell's Culture Fair and Group Intelligence Tests) are not discriminable from each other in terms of significant differences between mean scores on these measures across groups of subjects having scores on personality measures conforming to patterns of the high Gf or the high Gc prototypic groups.

B. The general theory of fluid and crystallized intelligence has convergent and discriminant validity. The mean score of the spontaneous change test was significantly higher for the group of subjects whose pattern of personality scores corresponded to the high Gf prototypic group than the group of subjects whose pattern of personality scores corresponded to the high Gc prototypic group.

There were contradictory results for the variable of "understanding" which both suggested and refuted the conclusion that "understanding" should be more properly considered a member of the Gf cluster rather than the Gc cluster. Presently these results are interpreted as possible manifestations of phenomena associated with a sample of college students whose mean Gf and Gc scores are significantly above those of the general population.


Hayes, K. J., Genes, drives, and intellect. Psychological Reports. 1962, 10, 299-342.


Loevinger, J., Objective tests as instruments of psychological theory. Psychological Reports, 1957, 3, 635-694.


APPENDIX A

CATTELL INTELLIGENCE TESTS, GROUP AND INDIVIDUAL

SCALE III, FORM A, 1935

by

R. B. CATTELL
Cattell Intelligence Tests

Practice Test
(for Scales II and III)
(Time allowed: 5 minutes.)

Begin here
Take up your pencil and put a line under one of these three words that means the same as small: Young, little, low.
Yes, little is the right one.

Now choose the right word in each of these and put a line under it:
\[ \text{Drop} \quad \text{means the same as (break, fall, rise).} \]
\[ \text{Speak} \quad \text{means the same as (talk, shout, laugh).} \]

Look at these four words:
\[ \text{Dog, cat, stone, cow.} \]
Stone is underlined because it is not the same sort of thing as the others. Find one thing in each line below that is different from all the others and underline it:
\[ \text{Tom, Dick, Jack, Mary.} \]
\[ 3, B, 2, 4 \]
\[ \text{Plate, cup, orange, jug.} \]
Black is the opposite of white. Put a line under the best opposite in each line below:
\[ \text{Good is the opposite of (big, poor, bad).} \]
\[ \text{Up is the opposite of (tall, down, less).} \]

Read this:
\[ \text{Boot is to foot as glove is to hand.} \]

Now underline the right word below:
\[ \text{House is to man as nest is to (dog, bird, cat).} \]
\[ \text{Spade is to dig as knife is to (cut, hand, sharp).} \]
\[ \text{Dog is to bone as cow is to (milk, tree, grass).} \]

A word has been left out of this sentence:
\[ \text{Some boys —— strong.} \]
Put a line under one of these three words that ought to go into it:\[ \begin{align*}
\text{(are) } & \quad \text{(is) } \quad \text{(am)}
\end{align*} \]

Do the same here:
When the sun shines the sky is generally\[ \begin{align*}
\text{(green) } & \quad \text{(yellow) } \quad \text{(blue)}
\end{align*} \]

Jack is bigger than Tom. Harry is not as big as Jack. Who is biggest? Put a cross in the square by the right answer:
[ ] Jack  [ ] Tom  [ ] Harry

You can alter any answers you think you have not made correctly.
DO NOT TURN OVER THIS PAGE TILL YOU ARE TOLD TO DO SO

1. Name ..........................................
   (Surname last)
2. Age last birthday ...................................
   (in figures)
3. Birthday ....................................
   (Month and day)
4. Form or Standard ...................................
5. School .............................................
6. Town ..............................................
7. To-day's date .....................................
   19......

INSTRUCTIONS

The questions in this test are to find out how clearly you can think; they are not concerned with how much you know. Work through them as carefully and quickly as you can. Once you have started you must not ask any questions, but if you read through the instructions at the beginning of each test you will always know exactly what you have to do. Each test has to be finished in a certain time, so do not waste time on examples that you cannot do. If you get to the end of a test before time is called, you must not turn to the next page unless you are told to do so at the bottom.

You will not have to write anything at all, but only to underline certain words and place crosses in certain squares.

(Do not write below this line.)

REMARKS, Etc.

1. ........................................................
2. ........................................................
3. ........................................................
4. ........................................................
5. ........................................................
6. ........................................................

SCORES

Test 1. .............................................
'' 2. .............................................
'' 3. .............................................
'' 4. .............................................
'' 5. .............................................
'' 6. .............................................
Total .............................................
Mental age ...........................................
Actual age ...........................................
I.Q. ...................................................
TEST 1
SYNONYMS
(Time allowed: 8 minutes.)

INSTRUCTIONS. Look at the first word in the line. Then look at the five words or phrases in brackets which follow it, and choose from them the word or phrase that has most nearly the same meaning as the first word. When you have found it underline it.

Here are two examples already done:

1. Sad means the same as (unlucky, quiet, unhappy, hurt, lost).
2. Mend means the same as (help, repair, patch, make, improve).

Now work right down the page in the same way.

1. Forbid means the same as (contradict, hinder, prohibit, restrain, defend).
2. Achieve means the same as (finish, win, acquire, accomplish, find).
3. Escort means the same as (accompany, watch, follow, join, defend).
4. Honest means the same as (reasonable, right, upright, kind, outspoken).
5. Faith means the same as (sincerity, belief, honesty, credit, ignorance).
6. Many means the same as (frequent, several, numerous, various, herds).
7. Angular means the same as (blunt, stiff, abrupt, branching, cornered).
8. Continue means the same as (persevere, endure, last, go on, stay).
9. Increase means the same as (grow, become greater, spread, rise up, magnify).
10. Zeal means the same as (enthusiasm, energy, activity, passion, speed).
11. Excite means the same as (move, irritate, interest, arouse, attract).
12. Careful means the same as (exact, heedful, strict, anxious, dutiful).
13. Indistinct means the same as (imperfect, doubtful, hidden, unclear, faint).
14. Distribute means the same as (allot, spread, give, divide, settle).
15. Awake means the same as (watchful, cautious, conscious, alive, energetic).
16. Refuse means the same as (deny, decline, oppose, object, repel).
17. Blend means the same as (mix, combine, mingle, confuse, add).
18. Act means the same as (deed, feat, crime, achievement, performance).
19. Space means the same as (distance, size, room, measure, content).
20. Responsible means the same as (accountable, trustworthy, concerned, liable, worried).

If you have time to spare you may go over the test again to make sure that your answers are correct. This applies to every test in the Scale.

DO NOT TURN TO THE NEXT PAGE
TEST 2
CLASSIFICATION

(Time allowed: 11 minutes.)

INSTRUCTIONS. Look at these five words:

Dog, elephant, sparrow, cow, lion.

They are all names of animals except 'sparrow,' so 'sparrow' is underlined. In the test you must underline in each row the word or phrase that does not belong to the same class as the other four—that is, pick out the word or phrase most unlike the others in meaning and underline it.

Here is another example:

Hot, freezing, warm, cool, wet.

Now continue.

1. Run, skate, dance, slide, sit.
2. Carpenter, bricklayer, decorator, farmer, plumber.
3. Hurt, diseased, damaged, worried, crippled.
4. Bag, basket, hat, pocket, bucket.
5. Everywhere, far, there, somewhere, here.
6. Captain, secretary, king, president, duke.
7. Sword, gun, helmet, spear, pistol.
8. United, steady, agreed, tied, combined.
9. Examine, compare, analyse, conclude, study.
11. Any, few, some, most, all.
13. Wise, lovely, base, kind, dishonest.
14. Page, brick, word, table, musical note.
15. Once, only, alone, first, second.
17. Father, grandmother, sister, grandson, daughter.
18. Rest, feed, breathe, move, have offspring.
19. Monotonous, uneven, zigzag, wide, regular.
20. Candle, sun, moon, electric light, gaslight.

Treat the geometrical figures on the next page in the same way. The first example is done for you.
TEST 3
OPPOSITES

(Time allowed: 8 minutes.)

INSTRUCTIONS. Look at the first word in the line. Then pick out from among the five words or phrases in brackets the one that is most nearly opposite in meaning to the first word.

Here are two examples already worked out:

(1) Dry is the opposite of (cold, slimy, wet, flooded, cloudy).
(2) Full is the opposite of (hollow, light, thin, lean, empty).

Now underline the opposites in the examples below.

1. Hinder is the opposite of (lighten, disentangle, help, favour, improve).
2. Grow is the opposite of (die, return, starve, diminish, wrinkle).
3. Common is the opposite of (strange, rare, valuable, peculiar, quaint).
4. Wicked is the opposite of (heavenly, polite, righteous, unselfish, quiet).
5. Allow is the opposite of (refuse, deny, forbid, punish, remove).
6. Complete is the opposite of (partial, empty, spoilt, small, indefinite).
7. Exceed is the opposite of (shame, shrink, just miss, fall short of, disappoint).
8. Unlike is the opposite of (similar, equal, inseparable, twin, balanced).
9. Unaided is the opposite of (befriended, watched, helped, accompanied, paid).
10. Apology is the opposite of (refusal, satisfaction, irritation, insult, letter).
11. Interrupted is the opposite of (continuous, entire, assisted, gradual, repeated).
12. Improve is the opposite of (destroy, stain, cheapen, injure, bend).
13. Coarse is the opposite of (polite, thin, refined, nice, sharp).
14. Supply is the opposite of (sale, demand, hunger, poverty, hindrance).
15. Recover is the opposite of (decay, return, die, relapse, ruin).
16. Restore is the opposite of (damage, undermine, break, pull down, lapse).
17. Abstract is the opposite of (particular, peculiar, personal, special, simple).
18. Beyond is the opposite of (here, there, within, near by, including).
19. Reveal is the opposite of (lose, find, hide, drop, stray).
20. General is the opposite of (isolated, private, special, personal, peculiar).

DO NOT TURN TO THE NEXT PAGE
TEST 4
ANALOGIES
(Time allowed: 11 minutes.)

INSTRUCTIONS. First read this example:

'Fish' is to 'water' as 'bird' is to (land, wave, air, branch, wind).

Water is the medium in which fish move, so air is underlined, because it is the medium in which birds move.

Read this example also:

'Wear' is to 'clothes' as 'eat' is to (hat, table, mustard, food, fork).

Now work out the following examples in the same way.

1. 'Safe' is to 'danger' as 'alone' is to (sadness, hope, company, enemy, desert).
2. 'Kind' is to 'good' as 'polite' is to (brave, strong, loyal, well behaved, spirited).
3. 'Place' is to 'position' as 'pattern' is to (square, shape, colour, beauty, curves).
4. 'Own' is to 'rich' as 'know' is to (wise, kind, conceited, old, absent-minded).
5. 'Tired' is to 'work' as 'happy' is to (sleep, rest, success, exercise, eating).
6. 'Probable' is to 'possible' as 'expect' is to (believe, know, hope, watch, despair).
7. 'Speech' is to 'hear' as 'picture' is to (know, appreciate, paint, measure, sec).
8. 'Ruin' is to 'accident' as 'wound' is to (blood, knife, skin, hate, bandage).
9. 'Listen' is to 'hear' as 'look' is to (notice, see, observe, learn, watch).
10. 'Combine' is to 'mix' as 'team' is to (colours, liquids, enemies, army, crowd).
11. 'Event' is to 'truth' as 'portrait' is to (likeness, colour, beauty, skill in painting, artist).
12. 'Surprise' is to 'strange' as 'fear' is to (angry, peculiar, dirty, anxious, terrible).
13. 'Umbrella' is to 'raindrops' as 'army' is to (enemy, warfare, invasion, country, general).
14. 'Message' is to 'information' as 'bullet' is to (rifle, aim, soldier, death, lead).
15. 'Soon' is to 'never' as 'near' is to (not far, seldom, far away, widely, nowhere).
16. 'Justice' is to 'laws' as 'idea' is to (judge, words, feelings, principles, memories).

Turn to next page. Treat the geometrical figures in the same way. The first example is done for you.
22. $\exists$ is to $\Rightarrow$ as $\exists$ is to $\triangle$ and $\exists$

23. $\bullet\bullet\bullet\bullet\bullet$ is to $\square\square\square\square\square$ as $\square\square\square\square\square$ is to $\square\square\square\square\square$ $\square\square\square\square\square$

24. $\square$ is to $\square$ as $\triangle$ is to $\triangle$ and $\triangle$

25. $\bigcirc$ is to $\bigcirc$ as $\bigtriangleup$ is to $\bigtriangleup$ and $\bigtriangleup$
TEST 5

COMPLETION

(Time allowed: 10 minutes.)

INSTRUCTIONS. In the following passages some of the words have been left out. You have to fill in the blanks, with one word to each dotted gap, so that the whole piece sounds sensible and right. Do not actually write words in the spaces, but, in each case, choose one from the row by the side that is numbered the same as the blank you are dealing with, and underline it.

1. In spite of . . . (1) . . . in firearms and our increased knowledge of the . . . (2) . . . of wild beasts . . . (3) . . . game hunting . . . (4) . . . one of the most . . . (5) . . . of sports.

2. A good . . . (1) . . . is one who not only . . . (2) . . . our pleasures with us, but also stands by us in . . . (3) . . . ; for although . . . (4) . . . may be depended upon to . . . (5) . . . us in light-hearted . . . (6) . . . , only real friends can be expected to . . . (7) . . . our misfortunes.

3. A . . . (1) . . . man will often . . . (2) . . . to give advice even on subjects about which he . . . (3) . . . little; for his sense of his own importance is pleasurably . . . (4) . . . by the . . . (5) . . . that another person is depending upon him.

4. . . . (1) . . . it is a . . . (2) . . . to do to each . . . (3) . . . to his deserts, . . . (4) . . . good for good as well as repressing . . . (5) . . . by evil, it necessarily . . . (6) . . . that we should treat all . . . (7) . . . well (when no higher duty forbids) who have . . . (8) . . . equally well of us.

(1) improvements, explosions, flaws, fashions.
(2) teeth, food, colour, habits.
(3) big, tame, preserved, ball.
(4) cheapens, remains, weakens, seems.
(5) jolly, hopeless, dangerous, peculiar.
(1) story, friend, dog, mother.
(2) enjoys, spoils, spends, divides.
(3) water, joy, trouble, amusement.
(4) nobody, acquaintances, relatives, everyone.
(5) join, watch, scorn, worry.
(6) kindness, amusement, sorrow, jokes.
(7) regret, endure, share, know.
(1) kind, conceited, proud, ignorant.
(2) begin, pretend, ask, try.
(3) cares, knows, thinks, talks.
(4) aroused, awakened, soothed, increased.
(5) hope, belief, knowledge, mistake.
I. Half the pupils in a school have passed the matriculation examination. A quarter of the pupils can swim. A third of the boys play in football teams. Three-quarters of the school are under seventeen years of age. Which one of the following statements is certainly true?

(1) All the boys who swim also play in football teams. □
(2) Some boys under seventeen can swim. □
(3) A quarter of the pupils have both passed matriculation and can swim. □
(4) Half the girls in the school are over seventeen years of age. □
(5) Some pupils under seventeen have passed matriculation. □

2. A man bought a horse for £20 and gave in payment a cheque for £30. The horsedealer persuaded a shopkeeper to change the cheque for him, and the buyer, having received his £10 change, rode off on the horse and was not seen again. Later the cheque was found to be valueless, and the horsedealer had to refund the shopkeeper the amount he had received. The horsedealer had himself bought the horse for £10. How much did the horsedealer lose altogether?


3. In my aquarium I have all together in the same tank (1) garpa fish, which will eat both tennel fish and eels, (2) tennel fish, which eat eels, and (3) eels, which will feed on the dead bodies of garpa fish. The tennel fish can swim much too fast to be caught by garpa fish, even in a tank. If no other food is given them, which will be the last kind (or kinds) of fish left alive in the tank?

(1) Eels. □  (2) Garpa fish and tennel fish. □  (3) Tennel fish. □

4. It is said that the age at which people marry in England is steadily rising. because

(1) People do not start earning until later in life than formerly. □
(2) People do not fall in love so early. □
(3) A man needs to earn more when he is married than when he is single. □
(4) Women are less attractive. □
5. All firs are coniferous trees. All coniferous trees are evergreens. Mark a cross against the true statement below.

(1) All evergreens are coniferous. □
(2) All coniferous trees are firs. □
(3) Only a few coniferous trees are evergreens. □
(4) All evergreens are firs. □
(5) All firs are evergreens. □

6. A man, pointing to a portrait, exclaimed, "I have no sisters or brothers, but that man's father is my father's son."

The man whose portrait he was looking at was

(1) His father. □ (2) Himself. □ (3) His son. □ (4) His uncle. □

7. A man who cannot read, write, or spell has just received a letter which he must answer at once. His three friends all know how to read and write, but one is deaf, another is blind, and the third is dumb. With whose aid will he be able to read and reply to the letter most effectively?

He will need

(1) The dumb man. □
(2) The dumb man and the deaf man. □
(3) The blind man and the dumb man. □
(4) The deaf man and the blind man. □
(5) The blind man. □
(6) The deaf man. □

8. The sights of my gun need adjusting, for when I aim directly at the target the bullets always go to the left. Which of the following adjustments can I make in order that the gun may fire more accurately? Indicate more than one if more than one satisfy the required conditions.

(1) Move the front sight a little to the right. □
(2) Move the back sight a little to the right. □
(3) Move both sights a little to the right. □
(4) Move the back sight a little to the left. □
(5) Move the front sight a little to the left. □

9. There are two secret codes. In each of them one secret sign always stands for one letter of the alphabet. Below you will find the words TUB and BUT written in the first code, but you do not know which word comes first. The words TEA and PIP have been written in the second code, together with one of the words that have already been written in the first code (TUB or BUT).

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CONTINUE ON NEXT PAGE
The second word in the first code is the same as the second word in the second code. Now, one of the words below is the word beat written in the second code. Find out which it is and mark a cross in the square against it.

(1) Φ Η Χ Κ. □ (2) Φ Η Π Κ. □ (3) Κ Η Π Φ. □ (4) Κ Η Χ Φ. □ (5) Φ Χ Κ Π. □

10. In the west end of the town all the houses have either electric light or gas, but not both. So far the only houses with electric light are in the west end of the town. Which of the following can I say with certainty?

(1) In other parts of the town some houses have both oil and gas lighting. □
(2) There is no gas lighting in the east of the town. □
(3) There are no houses in the town with both gas and electric light. □
(4) There are more houses with gas than with electric light. □
(5) The newest houses have both gas and electric light. □

11. Smith and Jones started off together to walk to a neighbouring town. Smith covered the first half of the distance at a speed one mile an hour faster than that of Jones. He covered the second half of the distance at a speed one mile an hour slower than Jones. Jones walked at a constant speed all the way.

Indicate which of the following statements you consider to be true.

(1) They finished together. □
(2) Smith finished first. □
(3) Jones finished first. □
(4) Smith and Jones were together at the half-way point. □

12. A clerk, in writing down a sum of money at the bottom of a column, accidentally put the pence in the shillings column and the shillings in the pence column. As a result of this there was an error of 1s. 10d. when the column was totalled. The next day he again entered a sum of money with the shillings and pence in the reverse order, but he was surprised to find that although the sum entered was quite different from that entered wrongly the day before, the error in the total for the column was exactly the same (1s. 10d.). Place a cross against the two sums of money that he entered up wrongly.

(1) 3s. 1d. □ (2) 3s. 8d. □ (3) 3s. 4d. □ (4) 7s. 6d. □ (5) 5s. 7d. □ (6) 2s. 1d. □

If you have time you may run over the questions in this test again, but you must not turn back to earlier tests.
APPENDIX B

SCALES OF THE PRF LONG FORM

JACKSON (1966)
APPENDIX B

SCALES OF THE PRF LONG FORM

JACKSON (1966)

I. Abasement

A. Description of High Scorer:

Shows a high degree of humility; accepts blame and criticism even when not deserved; exposes himself to situations where he is in an inferior position; tends to be self-effacing.

B. Defining Trait Adjectives:


II. Achievement

A. Description of High Scorer:

Aspires to accomplish difficult tasks; maintains high standards and is willing to work toward distant goals; responds positively to competition; willing to put forth effort to attain excellence.

B. Defining Trait Adjectives:

striving, accomplishing, capable, purposeful, attaining, industrious, achieving, aspiring, enterprising, self-improving, productive, driving, ambitious, resourceful, competitive.

III. Affiliation

A. Description of High Scorer:

Enjoys being with friends and people in general; accepts people readily; makes efforts to win friendships and maintain associations with people.
B. Defining Trait Adjectives:

neighborly, loyal, warm, amicable, good-natured, friendly, companionable, genial, affable, cooperative, gregarious, hospitable, sociable, affiliative, good-willed.

IV. Aggression

A. Description of High Scorer:

Enjoys combat and argument; easily annoyed; sometimes willing to hurt people to get his way; may seek to "get even" with people whom he perceives as having harmed him.

B. Defining Trait Adjectives:

aggressive, quarrelsome, irritable, argumentative, threatening, attacking, antagonistic, pushy, hot-tempered, easily-angered, hostile, revengeful, belligerent, blunt, retaliative.

V. Autonomy

A. Description of High Scorer:

Tries to break away from restraints, confinement, or restrictions of any kind; enjoys being unattached, free, not tied to people, places, or obligations; may be rebellious when faced with restraints.

B. Defining Trait Adjectives:

unmanageable, free, self-reliant, independent, autonomous, rebellious, unconstrained, individualistic, ungovernable, self-determined, non-conforming, uncompliant, undominated, resistant, lone-wolf.

VI. Change - See Text

VII. Cognitive Structure - See Text

VIII. Defendence

A. Description of High Scorer:

Readily suspects that people mean him harm or are against him; ready to defend himself at all times; takes offense
easily; does not accept criticism readily.

B. Defining Trait Adjectives:

self-protective, justifying, denying, defensive, self-condoning, suspicious, secretive, has a "chip on the shoulder," resists inquiries, protesting, wary, self-excusing, rationalizing, guarded, touchy.

IX. Dominance

A. Description of High Scorer:

Attempts to control his environment, and to influence or direct other people; expresses opinions forcefully; enjoys the role of leader and may assure it spontaneously.

B. Defining Trait Adjectives:

governing, controlling, commanding, domineering, influential, persuasive, forceful, ascendant, leading, directing, dominant, assertive, authoritative, powerful, supervising.

X. Endurance

A. Description of High Scorer:

* Willing to work long hours; doesn't give up quickly on a problem; persevering, even in the face of great difficulty; patient and unrelenting in his work habits.

B. Defining Trait Adjectives:

persistent, determined, steadfast, enduring, unfltering, persevering, unremitting, relentless, tireless, dogged, energetic, has stamina, sturdy, zealous, durable.

XI. Exhibition

A. Description of High Scorer:

Wants to be the center of attention; enjoys having an audience; engages in behavior which wins the notice of others; may enjoy being dramatic or witty.
B. Defining Trait Adjectives:

colorful, entertaining, unusual, spellbinding, exhibitionistic, conspicuous, noticeable, expressive, ostentatious, immodest, demonstrative, flashy, dramatic, pretentious, showy.

XII. Harmavoidance

A. Description of High Scorer:

Does not enjoy exciting activities, especially if danger is involved; avoids risk of bodily harm; seeks to maximize personal safety.

B. Defining Trait Adjectives:

fearful, withdraws from danger, self-protective, pain-avoidant, careful, cautious, seeks safety, timorous, apprehensive, precautionary, unadventurous, avoids risks, attentive to danger, stays out of harm's way, vigilant.

XIII. Impulsivity - See Text

XIV. Nurturance

A. Description of High Scorer:

Gives sympathy and comfort; assists others whenever possible, interested in caring for children, the disabled, or the infirm; offers a "helping hand" to those in need; readily performs favors for others.

B. Defining Trait Adjectives:

sympathetic, paternal, helpful, benevolent, encouraging, caring, protective, comforting, maternal, supporting, aiding, ministering, consoling, charitable, assisting.

XV. Order - See Text

XVI. Play

A. Description of High Scorer:

Does many things "just for fun", spends a good deal of time participating in games, sports, social activities, and other
amusements; enjoys jokes and funny stories, maintains a light-hearted, easy-going attitude towards life.

B. Defining Trait Adjectives:

playful, jovial, jolly, pleasure-seeking, merry, laughter-loving, joking, frivolous, prankish, sportive, mirthful, fun-loving, gleeful, carefree, blithe.

XVII. Sentience - See Text

XVIII. Social Recognition

A. Description of High Scorers:

Desires to be held in high esteem by acquaintances; concerned about reputation and what other people think of him; works for the approval and recognition of others.

B. Defining Trait Adjectives:

approval seeking, proper, well-behaved, seeks recognition, courteous, makes good impression, seeks respectability, accommodating, socially proper, seeks admiration, obliging, agreeable, socially sensitive, desirous of credit, behaves appropriately.

XIX. Succorance

A. Description of High Scorer:

Frequently seeks the sympathy, protection, love, advice, and reassurance of other people; may feel insecure or helpless without such support; confides difficulties readily to a receptive person.

B. Defining Trait Adjectives:

trusting, ingratiating, dependent, entreatimg, appealing for help, seeks support, wants advice, helpless, confiding, needs protection, requesting, craves affection, pleading, help-seeking, defenseless.

XX. Understanding - See Text
XXI. Desirability

A. Description of High Scorer:

Describes self in terms judged as desirable; consciously of unconsciously, accurately or inaccurately, presents favorable picture of self in responses to personality statements.

B. Defining Trait Adjectives:

None

XXII. Infrequency

A. Description of High Scorer:

Responds in implausible or pseudo-random manner, possibly due to carelessness, poor comprehension, passive non-compliance, confusion, or gross deviation.

B. Defining Trait Adjectives:

None
APPENDIX C

A SCHEDULE FOR COUNTER BALANCING

THE ORDER OF PRESENTATION

OF PSYCHOMETRIC INSTRUMENTS
APPENDIX C
A SCHEDULE FOR COUNTER BALANCING
THE ORDER OF PRESENTATION
OF PSYCHOMETRIC INSTRUMENTS

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N = 120

SYMBOLS

F . . . . Cattell's Culture Fair Test of Intelligence (Gf)

C . . . . Cattell's Group Intelligence Test (Gc)

P . . . . Jackson's Personality Research Form (PRF - Form AA)

S . . . . Spontaneous Change Test (SC) \[ Derived from Means (1965, 1968) \]
APPENDIX D

THE SPONTANEOUS CHANGE TEST

INSTRUCTIONS TO SUBJECTS

ADAPTED FROM J. R. MEANS (1965)

AND MEANS & HARPER (1968)
APPENDIX D

INSTRUCTIONS*

The first task we will give you is one on which we think you can have some fun. We would like you to arrange two lines of unequal length in any manner you wish on ten separate sheets of paper. Notice how the tip sheet (labeled "Example") has two lines of unequal length. In your arrangements we would like you to keep the lines approximately the same length as in the example. You may place the lines on the paper in any way you wish, you may cross them, put the ends together, leave them apart --- anything you wish. Try to make the task pleasant and fun for yourself by making each arrangement so that you like it.

*Adapted from Means (1965), and Means and Harper (1968)
APPENDIX E
THE SPONTANEOUS CHANGE TEST
SCORING PROCEDURE

ADAPTED FROM MEANS AND HARPER (1968)
APPENDIX E
SPONTANEOUS CHANGE
SCORING SYSTEM*

A. Angular Displacement:

The absolute value of the difference in the acute angle formed by the 3.0 cm and the 7.5 cm lines between any given circle of paper and the circle of paper immediately preceding it. One point is given for each 10° difference up to a maximum of 90°.

\[ A = \frac{\sum (|a_m - a_{c1}| + |a_{c1} - a_{c2}| + |a_{c2} - a_{c3}| + \ldots + |a_{c9} - a_{c10}|)}{10} \]

where: \( a_m \) = angle on circle 1 (angle of the two lines on the model) = 0

\( a_{c1} \) = angle on circle 2

\( a_{c2} \), etc.

\( a_{c10} \) = angle on circle 10.

B. Spatial Displacement:

Distance is measured from the center of each line. Spatial displacement is the sum of the absolute values of the differences in the distances between the 3.0 cm line and the 7.5 cm lines between any given circle of paper and the circle of paper immediately preceding it. One point is given for each cm difference in distances.

\[ B = \frac{\sum (|d_m - d_1| + |d_1 - d_2| + |d_2 - d_3| + \ldots + |d_9 - d_{10}|)}{10} \]

where: \( d_m \) (the distance between the two lines on the model) = 3 cm

\( d_1 \) = the distance between the two lines on circle 1.

\( d_2 \) = the distance between the two lines on circle 2.

\( d_3 \), etc.

\( d_{10} \) = distance between the two lines on circle 10.

*adapted from Means and Harper (1968)