

PSYCHOMETRIC DISCRIMINATION BETWEEN
RESEARCH PHYSICISTS AND UNIVERSITY
SCIENCE STUDENTS ON CERTAIN COGNITIVE
AND PERSONALITY VARIABLES

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ERRATA SHEET

- Page iv, line 8: Instead of 'Aslo ...', read 'Also ...'.
- Page 11, line 1: Instead of '... IQ scores and Ph.D.'s only a fraction ...', read '... IQ scores and Ph.D.'s yet only a fraction ...'.
- Page 23, line 16: Instead of '... by McCarrey (1976) ...', read '... by McCarrey and Edwards (1973) ...'.
- Page 53, line 5: Instead of '... mentioned above the MAT ...', read '... mentioned above and the MAT ...'.
- Page 53, line 9: Instead of '... high spatial component and in such ...', read '... high spatial component and as such ...'.
- Page 65, line 18: Instead of '... to one group of the other ...', read '... to one group or the other ...'.

ABSTRACT

This research, using a battery of cognitive and personality discriminators, successfully separated potential research scientists from a restricted university population.

The sample was composed of 45 research physicists from the National Research Council of Canada and 41 undergraduate engineering students from the Faculty of Science at the University of Ottawa. The cognitive discriminators utilized included the Miller Analogies Test and Guilford's Number Relations, Associational Fluency, Expressional Fluency and Match Problems I and II tests. The personality discriminators utilized included the Eysenck Personality Inventory and Cattell's Sixteen Personality Questionnaire tests. Statistically, a linear discriminant function of the 24 variables was obtained. This was followed by the elimination of redundant variables using a step-wise method of elimination. A classification procedure was then developed to assign individuals to either group in the optimum manner. Then, a tentative cross-validation study was made to check the stability of both the discriminant function and the critical selection score in classification procedure.

The results indicated that a combination of ten cognitive and personality discriminators successfully separated the two samples giving a multiple correlation of .828 and 95.35%

correct classifications. Research scientists were found to have significantly higher scores on such cognitive ability variables as the Miller Analogies Test and Guilford's Associational Fluency, Expressional Fluency and Match Problems I tests. They also scored higher on measures of imaginativeness and introversion. In addition, they showed less anxiety when compared to the student group.

Suggestions for future research were given.

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Rapid development in modern science and technology calls attention to the role of creative scientists in the economic and general survival of society. To maximize national resources, all scientists with creative potential should be detected and utilized. At present, the opportunity for creative work is given only after a period of struggle and a demonstrated output of scientific work. Many potential contributors are discouraged in the process and switch to non-creative fields of endeavour. Those who break through the social barriers and who are given opportunity for creative work arrive there too late to give their best years to creative work. In either case there is a considerable social and personal loss.

It is therefore important to devise a method for any early detection of scientists with creative research potential. So far, this has been unsuccessful despite the existence of numerous intelligence and creativity tests. In terms of personality, the popular myth still exists that creative people are generally odd or abnormal.

The need for research on the methods of selecting creative scientific researchers has been recognized.

This research will then attempt to demonstrate that a battery of certain cognitive and psychological tests can successfully separate those individuals who have creative research ability.

CHAPTER I
REVIEW OF THE LITERATURE

This chapter presents the theoretical background of the study. It begins by examining the current status of creativity research. Following this, Guilford's approach to creativity is discussed. Then, the personality and cognitive factors of creative scientists are examined. This is followed by an examination of the relationship between introversion and ability. Finally, the research objectives are discussed together with the hypotheses concerning the selection of personality and cognitive variables relevant to scientific research.

1. Review of the Conceptual Background in the
Study of Creativity

In the past, creativity has interested many people such as philosophers, writers and other thinkers. However, it is only in recent times that the behavioural sciences have attempted to make an objective study of creativity and the creative person. Guilford (1950) reviewed the state of creativity research by examining the index of Psychological Abstracts for each year since its inception. Of the 121,000 titles listed in the past 23 years only 186 were indexed as relating to creativity.

Since 1959, scientific research on the nature of creativity and the creative person has generated a large number of studies in many areas of the social sciences. Razik (1965) counted some 4,176 articles on this topic alone.

However, after reviewing the literature in this field, one can only conclude that there is a great deal of confusion to be found. Theorists such as Golann (1963), Mednick (1962), Taylor (1960), Torrance (1959), Vernon (1963), Yamamoto (1961; 1965) have put forth theories that tend to contradict one another resulting in little clarity and a lot of confusion and disagreement. Researchers tend to agree with Mackler and Shontz (1965) that:

the major criticism of all the theories is that each view gives only a piecemeal explanation of creativity ... However no theory, narrow or broad, adequately describes the process of creativity. No small wonder that creativity is a confusing theoretical and research area.
(p. 236)

Much of the disagreement arose from the number of approaches used and from the different areas in which creativity is studied. Some researchers have made attempts to integrate and to organize these different areas by providing a conceptual framework that one can work from.

Although this study was not investigating theories or relationships between theories it was found useful, for the purposes of clarity, to provide a brief overview of the research done in the field of creativity.

According to Roweton (1970) the definitional approach accounted for at least 70% of all the studies ever done on creativity. While not particularly experimental in nature, this approach simply reflected the opinions and judgements by various writers regarding the nature of the creative process. These opinions tended to be philosophical in nature in an attempt to define what creativity is.

A second major approach dealt with categorizing the different theories of creativity. In one such category one can find the various psychoanalytic theories. For Freud (1958), creativity was a substitute for instinctual satisfactions. Sublimation helped in this process by transferring instinctual desires into directions that could not be frustrated by external reality. By fantasizing, the creative individual was able to produce new creations in the arts and sciences. Other psychoanalysts such as Kris (1952) and Schafer (1958) emphasized ego processes as opposed to the id processes discussed by Freud.

In particular, Kris developed the importance of ego regression in fostering the creative process:

Central to artistic ... creativeness, is a relaxation ("regression") of ego functions. ... In fantasy and dreams, in states of intoxication and fatigue, such functional regression is especially prominent; in particular, it characterizes the process of inspiration (Kris, 1952, p. 253).

The psychoanalyst Kubie (1958) developed the concept of the preconscious system. For Kubie it is the essential factor in creativity. Preconscious processes are influenced by both conscious and unconscious processes. He dismissed the concept of sublimation as being an inaccurate assumption.

The association theory constitutes another category. Mednick (1962) presented an associative interpretation of the process of creative thinking. He stated:

We may proceed to define the creative thinking process as the forming of associative elements into new combinations which either meet specified requirements or are in some way useful. The more mutually remote the elements of the new combination, the more creative the process or solution (Mednick, 1962, p. 221).

In the third category, one finds the gestalt theory. It was developed by such theorists as Wertheimer (1945), Arnheim (1947) and Mooney (1958). This theory views creativity as an insight, given as a sudden flash which occurs when the individual restructures his perceptual field so that the path to the goal is perceived clearly.

The interpersonal theory makes up a further category. This theory emphasizes the creative person as an innovator whose products are acknowledged or recognized by others. Several theorists who propounded this view included Adler (Ansbacher and Ansbacher, 1956) with his concept of "the creative power of the individual", Moreno (1953), Fromm (1959), Rogers (1959) and Maslow (1959). For these theorists, creativity occurs in the psychologically healthy person.

Finally, one finds the trait theory of creativity. It diverges markedly from the previous theories that were discussed. According to this theory, traits are characteristics of individuals. It is any distinguishable and enduring way in which one individual differs from another. Guilford's (1959) research exemplifies this approach.

Golann's research (1963) characterized a third major approach. For him, creativity can be studied under four aspects. First, there is creativity as a product where the creative action alters meaning itself by introducing into it some new element of meaning and significance. Second, there is the process where the study of creativity is viewed by how one arrives at the creative act. Third, there is measure-

ment where the attempt is made to devise or adapt tests to measure creative abilities. Fourth, there is the personality where the emphasis is upon studying the personality characteristics of creative people.

The philosophic approach constituted a fourth attempt at providing a conceptual framework in studying creativity. On the one hand, humanistic philosophies state that it is necessary to study the whole individual when one studies creativity. This system is subjective in approach. Positivistic philosophies, on the other hand, emphasize that one can study causal laws even when dealing with the individual. This approach is essentially highly empirical in nature.

The foregoing was a brief overview of the approaches used to study creativity. The next section deals with Guilford's approach to creativity as particularly relevant to this thesis.

2. Guilford's Approach to Creativity.

Guilford stated that:

in its narrow sense, creativity refers to the ability that are more characteristic of creative people. Creative abilities determine whether the individual has the power to exhibit creative behaviour to a noteworthy degree (Guilford, 1950, p. 444).

He further elaborated on this:

creative personality is then a matter of those patterns of traits that are characteristic of creative persons. A creative pattern is manifest in creative behaviour which includes such activities as inventing, designing, contriving, composing and planning. People who exhibit these types of behaviour to a marked degree are recognized as being creative (Guilford, 1950, p. 444).

Guilford described creative thinking as invention which is a form of production. When one invents one generally gets away from conventional answers. Guilford called this process divergent-production which includes the factors of fluency, flexibility, originality and elaboration.

Guilford made a distinction between creative production and creative potential. Example of creative production would be such things as a poem, a painting or a scientific theory. Creative potential, on the other hand, is the person's readiness to produce new ideas and products. This readiness depends upon many factors, especially the information stored in the memory. A disposition to enable one to use this information in new ways constitutes an individual's creative potential. Several of the more important dispositions include temperament, attitudes, aptitudes, interests and needs.

Guilford's theory of creativity centers around his structure of intellect model (1959). It is three-dimensional in nature and has three basic parameters: operation, product and content. Each of these parameters are divided into categories. For example, there are five kinds of operations, six kinds of products, and four classes of content. In graphical form this model becomes a cube subdivided into 120 different areas (5x6x4) each of which would be represented as a specific test.

The first principle regarding the structure of intellect is that primary abilities differ according to the kind of material or context dealt with by the individual. These are four in number: symbolic, figural, behavioural and semantic. Within each of the four categories as to content, factors differ with respect to the kinds of operations performed on the material. There are five kinds of operations. They are cognition, memory, divergent thinking, convergent thinking and evaluation. Applying the different kinds of contents yields six kinds of products. They are units, classes, relations, systems, transformations and implications. Guilford saw creativity in terms of factors from the

divergent-production category and of certain other operations when they produced transformations. Divergent-production tests are to be distinguished from convergent-production tests. He wrote that:

The convergent-thinking class of abilities takes its name from the kinds of tests involved. In general they call for one right answer (at least one keyed answer), which can be determined closely, if not exactly from the information given (Guilford, 1959, p. 376).

More recently he stated that "in accordance with the information given in the item, the examinee must converge upon the one right answer" (Guilford, 1967, p. 62).

One realizes that what Guilford has termed convergent production seems to correspond very closely to most conventional tests of intelligence but Guilford does not seem to think too highly of conventional intelligence tests. This point is clearly made in the following statement regarding the nature of divergent-production tests:

Since divergent-production tests require examinees to produce their own answers, not to choose them from alternatives given to them, it is not surprising that any such tests would be conspicuous by their absence in modern tests of intelligence, particularly after machine scoring came into the picture. Their absence from individual tests is also well known, a fact that can probably be traced to Terman's early experience (1906) with his seven "bright" and seven "stupid" children that were not discriminated by a test of creative

imagination in line with other tests. In recent years it has become known that children of high IQ can be either high or low on divergent-production tests. With only seven cases in his "bright" group, Terman could have had an adverse selection on divergent-production, which precluded any superiority of this group over his low one, particularly if the judges who selected the bright children did not include imagination among their signs of brightness. For whatever reasons, the divergent-production abilities have historically been outside the domain of intelligence tests and conceptions of intelligence (Guilford, 1967, p. 138-139).

This distinction is important to make since the question of the relation of creativity to intelligence often arises.

The next section of this review briefly discusses this question.

3. The Relation of Creativity to Intelligence

The usual conception of intelligence is that which is measured by intelligence tests such as the Wechsler-Bellevue, the Stanford-Binet, etc. Guilford doubted whether divergent-production abilities were adequately covered or even represented to any real degree by conventional intelligence tests. Guilford quoted a study done by Taylor (1960) which supported his view. In this study, Taylor studied 239 research scientists and engineers. He found that these groups did have high

IQ scores and Ph.D.'s only a fraction of these groups were considered creative as rated by their supervisors. For Guilford, the evidence indicated that although the qualities needed to score well on traditional intelligence tests would be useful to the creative scientist or engineer these qualities by themselves would be insufficient for creative production.

The low correlation between creativity and IQ that has been noted by several studies also seems to be found in studies of younger age groups. Getzels and Jackson (1962) studied a group of high school students (N=449). Two experimental groups were chosen from this number. The first group consisted of 28 students who were in the top 20% of their class on measures of intelligence (IQ=150). On measures of creativity they fell below the top 20% of their class. The second group consisted of 24 students who were in the top 20% of their class on measures of creativity. On measures of intelligence they fell below the top 20% of their class (IQ=127). The IQ tests used were the Stanford-Binet and the Wechsler Intelligence Scale for Children. The creativity tests used were taken or adapted from Guilford and Cattell. The results of the study indicated that the school

achievement scores of both groups were equally superior to the achievement scores of the school population as a whole. Getzels and Jackson concluded that a distinction could be made between the dimensions of creativity and intelligence as contributors to academic success.

MacKinnon (1962) in his research found little or no connection between adult IQ and adult achievement above a minimum level which for him lay in the region of 120 IQ. This means that once the subjects produced IQ scores above this level the relationship between IQ and originality was virtually zero. He commented:

Over the whole range of intelligence and creativity there is, of course, a positive relationship between the two variables. No feeble-minded subjects have shown up in any of our creative groups. It is clear, however, that above a certain required minimum level of intelligence which varies from field to field and in some instances may be surprisingly low, being more intelligent does not guarantee a corresponding increase in creativeness. It just is not true that the more intelligent person is necessarily the more creative one (MacKinnon, 1962, p. 488).

The next section discusses the personality and cognitive factors that go to make up the creative scientist.

4. Personality and Cognitive Factors of Creative Scientists.

The personality findings for scientists are considered from a general standpoint and by special areas. From the

research it appears that scientists generally are reserved in nature, that is, they lack a warm sentimentality. They possess high intelligence; they are very serious and sober people and they show exacting standards of a strong self-sentiment. They tend to be skeptical about conventional moral values and they have low guilt proneness. They are also radical and self-sufficient. Cattell and Drevdahl (1955) used the Sixteen Personality Factor Questionnaire (16PF) to compare eminent researchers with eminent teachers and administrators. They found that creative scientists, regardless of discipline, tended to be more dominant (factor E) and to have stronger initiative than the less creative ones. The creative scientists, in comparison with the other groups, showed greater motivation to be successful intellectually. In relation to students and the general male population, scientists were found to be more reserved and introspective (factor F) but also more self-sufficient and resourceful (factor Q₂).

Using the 16PF source traits, the pattern is highly functional for creative work. A high relation-perceiving ability (factor B) is necessary for a high level performance. The pattern of low anxiety coupled with a

high emotional stability and self-discipline (factors C, L, O, Q₃ and Q₄) would seem to indicate why this group can concentrate upon creative efforts. The adventurous temperament (factor H) combined with interpersonal coolness and reserve (factor A) as well as sober, precision-oriented desurgency (factor F) and high self-sufficiency (factor Q₂) obviously produce a highly functional combination of traits. A high degree of dominance (factor E) seems necessary to enable the person to go against majority opinion, and a low attachment to conventional moral values (factor G) probably also contributes in this direction. Finally, a high sensitivity (factor I) and a strong willingness to contemplate new ideas and techniques (factor Q₁) seems certainly to fit the picture of the creative researcher. Certain abilities in the cognitive realm such as fluency and flexibility studied by Guilford et. al. (1956) help to complete the picture of the creative scientist. It appears that besides a certain critical level of intelligence, creative ability, as stated by Cattell (1970, p. 215), "... is a combination of temperament, forcefulness and independence, with a generally invariant (introverted), restrained personality".

Drevdahl (1956) considered the factors that were important for creativity. He found that creative persons are superior to non-creative persons in terms of verbal facility, fluency, flexibility and in their originality. Again, they tended to be more withdrawn and quiescent (reserved) than non-creative persons. They score higher than non-creatives on the factors of radicalism vs. conservatism and self-sufficiency vs. lack of resolution.

In using the 16PF to look at different occupational groups within the sciences, Cattell (1970) found that biologists have a typical scientific profile. There is a high intelligence level coupled with high dominance and high self-sufficiency. Combined with high ego strength, this gives them a high score on independence of mind.

Chemists, although possessing high ego-strength and self-sufficiency, tend not to be so dominant in nature. They also have a strong practical streak in them as well. They show some resemblance to the physicists but are not so extremely introverted.

Physicists tend to be the most conservative of the groups studied (factor Q_1). They show great sensitivity (factor I) as well as an unusual combination of a high degree of venturesomeness (factor H) together with a

strong seriousness factor (factor F) and a strong reserve (factor A). Cattell and Butcher (1968) have stated that this combination of introversion with high independence and low anxiety characterizes some of the most creative scientists in the history of science.

Cattell (1970) has found psychologists to be more radical in their outlook (factor Q_1) less committed to social values (factor G) more surgent or enthusiastic (factor F) and more dominant (factor E). Cattell speculated that perhaps these are necessary qualities in a pioneer science. The higher degree of extraversion found in this group seems natural in a profession that generally deals with people.

Roe and Siegelmon (1964), obtained two 16PF profiles of engineers. It was found that male engineers show the characteristically introverted pattern of those who deal with things rather than with people. In this sense they show a pattern similar to that of the physicists. There is a rather extreme desurgency or soberness, a high self-sufficiency, some shyness or retreat from contacts (factor H) and a disciplined thinking and behaviour pattern (factor Q_3).

In terms of cognitive factors, creative scientists tend to be intelligent. This is as expected. In the

previous studies quoted which used the 16PF, intelligence (factor B) was always skewed positively for this group. MacKinnon (1962) found that a minimum level (i.e. 120 IQ range) is necessary for achievement in scientific research. Embree (1948) and Wrenn (1949) found that average IQ increases at each educational level. For example, the Stanford-Binet IQ for students entering college is 118, for students graduating from college it is 123, for those receiving advanced degrees it is 126, and for those receiving Ph.D. degrees it is 141. As the vast majority of scientific researchers have advanced degrees in their specialities, their IQ levels tend to be well above the average of the general population.

From the above discussion it is clear that creative scientists require a successful blend of cognitive and personality traits. This fact is also recognized by Dr. Gerhard Herzberg, a Nobel Laureate in Physical Chemistry when he says:

There does not seem to be a special talent or creative ability, other than general intelligence, which contributes cognitively (intellectually) to creative production.

A certain level of intelligence is needed but extremely high intelligence is not a prerequisite or a guarantee of success.

An original and significant contribution to science may result from an on and off activity over a number of years. The distinction should perhaps be made between the quality and speed of one's work with the former being more important in the long run.

To understand basic ideas thoroughly and be able to formulate them in a simple manner provides a good start in scientific research.

Scientific discoveries are sometimes made accidentally. Yet, even in those cases, it cannot be said that they are entirely due to chance. The scientist must be well prepared to grasp the opportunity, see the relevance, follow the idea through...

When reading papers in one's own or neighbouring field one gets often stimulated into thinking of something entirely different. Original ideas are sometimes arrived at this way.

Memory of certain details, often judged as unimportant and soon forgotten, plays its role in scientific creativity. The ability to recall these details at the right time and place, and to use them together with available facts often leads to a successful solution.

Curiosity is, of course, important in any scientific research. But one must also have a strong sense of achievement. This is expressed through the desire to make one's life meaningful; to add one's own portion to ever expanding scientific knowledge.

The really essential factor in scientific research is determination, persistence, staying on the job despite difficulties...

Guilford considers creative abilities as special kinds of intellectual abilities. He stated that, "within the factorial frame of reference there is much

room for different types of creative abilities" (Guilford, 1962, p. 451). These different types of abilities appear to depend upon the kinds of information that the person is dealing with. Guilford classifies this information or content into four types: symbolic, semantic, figural and behavioural. By classifying abilities according to content he is describing, in effect, four kinds of intelligence:

The abilities involving the use of figural information may be regarded as "concrete" intelligence. The people who depend most upon these abilities deal with concrete things and their properties. Among these people are mechanics, operators or machines, engineers (in some aspects of their work), artists and musicians.

The the abilities pertaining to symbolic and semantic content, we have two kinds of "abstract" intelligence. Symbolic abilities should be important in learning to recognize words, to spell, and to operate with numbers. Language and mathematics should depend very much upon them, except that in mathematics some aspects, such as geometry, have strong figural involvement. Semantic intelligence is important for understanding things in terms of verbal concepts and hence is important in all courses where the learning of facts and ideas is essential.

In the hypothesized behavioural column of the structure of intellect, which may be roughly described as "social" intelligence, we have some of the most interesting possibilities. Understanding the behaviour of others and of ourselves is largely non-verbal in character... (Guilford, 1959, p. 477-478).

Although Guilford says that different occupational groups may exhibit differing patterns of creative abilities, he does not state what these patterns are statistically.

The next section is a brief discussion of the relationship between introversion and ability.

5. Relationship between Introversion and Ability

As mentioned above creative researchers tend to be more introverted than their non-creative counterparts. It might be of some interest therefore to find whether there is any relationship between introversion and ability. The works of Bendig (1960), Broadbent (1958), Furneaux (1957), Kline (1966) and Savage (1962) appear to support the idea that there is a positive relationship between the two.

Lynn (1959) quotes the research of Furneaux (1957) and Broadbent (1958). Furneaux's research showed that students who do well at the university level score more highly on neuroticism and lower on extraversion. Broadbent studied students graduating at Cambridge. They were divided into those obtaining good and poor degrees. Those who obtained good degrees were found to be significantly more introverted than those who obtained poor degrees. This study also showed that the two groups

did not differ in intelligence as assessed by the A.H.4 test.

Savage (1962) gave 168 male and female students in their first year at an Australian university the Maudsley Personality Inventory. This test measures the dimensions of extraversion and neuroticism. The neuroticism and extraversion scores were related to the results of the students' final examinations. The results obtained showed that the neuroticism and extraversion scores were significantly related to academic performance. It was found that while high neuroticism scores impaired academic performance, an optimum level of neuroticism aided in academic achievement and that there is a U-shaped relationship between the variables. With respect to extraversion, the most successful group of academic achievers had the lowest extraversion scores. A problem, however, still exists as to the interaction of neuroticism and extraversion in relation to academic performance. Further investigations of this are necessary.

Kline (1966) administered the Eysenck Personality Inventory to 110 Ghanaian university students. Their scores on this test were related to a common academic measure among them. This was the grade obtained from

a literature course. It was found that neuroticism was not significantly related to academic performance. Extraversion, however, was found to be correlated negatively and significantly with academic success.

The work done by Eysenck is less conclusive with respect to this finding. In one study (Eysenck 1971) he administered two intelligence tests and a personality inventory adapted from the Eysenck Personality Inventory to 398 male nursing trainees. He found the trainees to be more extraverted ($p < .01$) and less neurotic than the general population. Their intelligence scores, however, were not related to either extraversion or neuroticism.

This negative result is at variance with a previous result (Eysenck 1959) which showed that extraverts had a greater work decrement on a portion of an intelligence test. Having attempted a certain number of items they showed a significant decrease in their efficiency by taking a longer time period to obtain correct solutions. The hypothesis of a relationship between introversion and ability cannot therefore be discarded despite Eysenck's recent result.

The next two sections discuss the research objectives and hypotheses of this study.

6. Research Objectives

The above review of literature has been made to provide a short background for the study of creative research scientists. The concepts introduced in the preceding discussion had thus to be translated into operational terms.

Creativity was defined by reference to a group of accomplished research scientists. Specifically, a sample of research physicists was considered since they are traditionally regarded as being the embodiment of creative scientific thought. The requirements for inclusion to the sample was the possession of a Ph.D., multiple publications and citations. Once selected this group was treated as a whole. No attempt was made to examine the nature of their research products or to rank them according to their degree of creativity. As shown by McCarrey (1976), such ranking of creative products and output would be extremely difficult. To provide a quantitative contrast on certain descriptive variables, a sample of students from applied science was chosen. In this case, the sample was made up of undergraduate engineering students. Since this group was of sufficiently high intelligence one did not expect

great differences on this factor for the two groups. As it was previously shown researchers require a minimum level of intelligence. It was therefore desirable that all subjects in the study satisfied this criterion. There still remained a possible difference in attitude due to the fact that one group chose courses in applied science rather than courses in theoretical science. This situation was also desirable since that choice itself might be an essential characteristic of the researcher's personality. Students at the undergraduate university level were selected so as to exclude any formal experience in scientific research. This was clearly necessary in any comparison of researchers with non-researchers.

The scope of the proposed study limited itself to the elucidation of psychological characteristics of research physicists within the framework of the university population. Apart from the gain in theoretical insight, the results of the study could contribute to applied psychology particularly if the results established a significant discriminant function for the two contrasting groups. Such a function could be of some practical value in selecting, classifying and guiding university students.

7. Hypotheses

The hypotheses in this study are concerned with the explanation of the variability of the dependent variable. In this case it is a dimension of research creativity which is represented as a dichotomy between the NRC physicists, regarded as productive in research, and engineering students who are not assumed to be so. The descriptive variables selected for the purpose of discrimination represent operationally the theoretical expectations or hypotheses as to what is or what is not relevant to scientific research.

The first set of predictors (discriminators) was chosen from a group of divergent-production (creativity) tests as developed by Guilford. These tests would measure verbal and non-verbal abilities. It was expected that research scientists would show a greater degree of ability in these areas than would the engineering students.

The next predictor (discriminator) chosen was the Miller Analogies Test. It has been used by many graduate schools to select candidates for advanced work in many disciplines. It appears to be largely verbal in nature although it contains a few mathematical items. Meer et. al. (1954) found a high correlation of .77 between

the Miller Analogies Test and the Vocabulary sub-test of the Wechsler-Bellvue, a well-known intelligence test. In an analysis of the Miller Analogies Test for a sample of 50 scientific researchers, the above-quoted study also found an overall correlation of .58 between this test and the Wechsler-Bellvue. Since the Miller Analogies Test appears to measure cognitive ability it should provide a discrimination for the two groups under investigation.

The third set of predictors (discriminators) chosen comprises Cattell's Sixteen Personality Factor Questionnaire and the Eysenck Personality Inventory. Much research has made use of the former test in connection with creative scientists (Cattell and Drevdahl, 1954; Guilford et. al., 1956; Drevdahl, 1956; Cattell, 1970). Eysenck's extra-version-introversion scale appears to correlate significantly with several of Cattell's factors (Carrigan, 1960; Adcock, 1965). Therefore, both tests should provide a good measure of discrimination.

CHAPTER II
EXPERIMENTAL DESIGN

This chapter will focus on the measurement tools, the sample, the testing procedures and the statistical methods employed in this study.

1. The Measurement Tools

There were four measurement tools used in this research. They were: Guilford's Divergent Production tests, the Miller Analogies Test, the Eysenck Personality Inventory and Cattell's Sixteen Personality Factor Questionnaire test.

A. Guilford's Divergent Production (DP) Tests

The first chapter of this research presented Guilford's definition of creativity. He defined it as those factors falling in the divergent-production area. He stated, "It is believed that abilities in the divergent production category are among those uniquely important for creative thinking" (Guilford, 1964, p. 123). Further, he also stated that "we might therefore equate creative thinking with divergent-production" (Guilford and Merrifield, 1964).

It should be noted, however, that for Guilford's creativity is much more than divergent-production:

Potential for creativity is not a single thing but, from the standpoint of aptitude, it is a great many intellectual abilities that contribute directly or indirectly to successful creative production. Among the abilities contributing more directly are those in the divergent-production and transformation categories of the structure of intellect. As in problem solving in general, many other abilities may make their contribution at some time (Guilford, 1962, p. 9).

In this research the selection of creativity tests was based on Guilford's writings. The first chapter of this research contained some of his general statements regarding creative expression within certain occupations. Briefly, he stated (Guilford, 1959, 1964, 1968) that mechanics, machine operators, engineers, pictorial artists, musicians and designers utilize the figural mode of creativity. The mathematician and other individuals who work with language and/or numbers utilize the symbolic mode of creativity. The semantic mode of creativity is utilized by those who have to learn facts and ideas such as creative writers, scientists, teachers, planners. Both physicists and engineers must use all three modes in their work. Facility in dealing with ideas, numbers, figures and other semantic data are of crucial importance for success in these two fields.

Each of the creativity tests used in this research was chosen for one of the following reasons: (1) it was the only test available at the time to measure that factor, (2) it represented symbolic content, (3) it represented semantic content, (4) it represented figural content, (5) it was the most objective to score. The specific divergent production tests chosen were:

(1) Number Rules (NR). This test consists of two parts, five minutes per part. The subject is given a starting number and is to relate one or more numbers to it in various ways in order to achieve a given result.

(2) Associational Fluency (AF). This test consists of two parts, two minutes per part. The subject is to write synonyms for each of the several given words.

(3) Expressional Fluency (EF). This test consists of four parts, two minutes per part. The subject is to construct a variety of four word sentences having been given four initial letters.

(4) Match Problems I (MP1). This test consists of one part and takes five minutes to complete.

(5) Match Problems II (MP2). This test consists of two parts, seven minutes per part.

In both Match Problem tests, groups of matches are laid out to form patterns of squares and triangles. The subject's task is to take away a certain number of matches and leave a certain number of squares or triangles remaining. The figures must come out even with no extra matches left over.

A sample of each test can be found in the Appendix.

B. Miller Analogies Test (MAT)

The Miller Analogies Test (henceforth abbreviated MAT) consists of 100 analogy items based on many areas of knowledge: vocabulary, literature, social science, chemistry, biology, physics, mathematics and general information (Miller, 1970). The testee is not required to be a specialist in any of these areas. What the test items require of the testee is that he be able to recognize relationships rather than display enormous erudition. The test itself has a time limit of fifty minutes. There are several alternate forms of this test that can be given. This test is highly confidential in nature and it is closely guarded. It has been universally used by graduate schools in North America to select graduate students for various disciplines. These include engineering and physics

students. One sample of 2251 students, possessing degrees in engineering science and mathematics, has a mean score of 54.9 with SD of 14.7 (Miller, 1970).

C. Eysenck Personality Inventory (Form A)

The Eysenck Personality Inventory (henceforth abbreviated EPI) measures personality in terms of two distinct orthogonal personality dimensions. The dimensions are identified as extraversion-introversion and neuroticism-stability, E and N respectively. Evidence for the independence of the two dimensions is provided by Farley (1967, p. 154-156) and Eysenck and Eysenck (1963, p. 46). Each of these dimensions is measured by twenty-four questions, selected on the basis of item and factor analyses, to which the subject answers "yes" or "no". Briefly, extraversion refers to the outgoing, impulsive, uninhibited and sociable inclinations of a person, and neuroticism refers to the general emotional overresponsiveness and predispositions to develop disagreeable emotional feelings. A response distortion scale (Lie scale) is also included to pick out attempts on the part of testees to answer the questions in a socially desirable manner (Eysenck and Eysenck, 1968). Parallel forms of the inventory are available when retesting is desirable.

Test-retest reliability is reported as high for the EPI (Eysenck and Eysenck, 1968). A group of ninety-two subjects was administered the EPI and retested with this instrument after an interval of one year. The resulting coefficients of reliability are reported as .82 for the extraversion scale and .84 for the neuroticism scale. Another group of twenty-seven subjects was retested after a nine month interval. The resulting coefficients of reliability are reported as .97 for the extraversion scale and .88 of the neuroticism scale. The validity and reliability data presented in the manual appear adequate for use of the test in the present study (Eysenck and Eysenck, 1968).

A sample of the EPI can be found in the Appendix.

D. Cattell's Sixteen Personality Factor Questionnaire

The Sixteen Personality Factor Questionnaire (henceforth abbreviated to 16PF), based on factor analysis, is a multidimensional set of sixteen questionnaire scales arranged in omnibus form (Cattell, Eber and Tatsuoka, 1970). The original data from which the test was developed were sampled from a wide spectrum of human behaviours. The source traits measured by the 16PF are independent; i.e., the correlation between one

and another is usually quite small. These traits are listed in Table 1. Source traits can be defined in this context as factors that affect large areas of overt personality behaviour such as intelligence, emotional stability, supergo strength, surgency and dominance.

The test itself is designed for use with individuals whose ages range from eighteen to sixty. The 16PF is available in six parallel forms each measuring the same sixteen personality dimensions, including intelligence. According to Cattell and Eber (1962), Forms A and B are advocated for research with most univeristy and high school students. Since the sample in this research consisted of university students and Ph.D's in Physics, Form A was used. The test contains 187 items, two of which (the first and the last) are not scored. It takes approximately 50 minutes to complete. Each source trait is measured by items ranging in number from ten to thirteen. These are distributed uniformly throughtout the questionnaire. Each item offers a choice of three responses; testees are instructed to check one response to each item. One response relates to one pole of the relevant factor, one relates to the other pole, and the middle reflects neither poles.

TABLE I
The Primary Traits Measured by the
Sixteen Personality Factors Questionnaire

Code	Title of Variable*
A	Reserved versus Outgoing
B	Dim versus Intelligent
C	Unstable versus Stable
E	Submissive versus Dominant
F	Desurgent versus Surgent
G	Expedient versus Conscientious
H	Shy versus Venturesome
I	Tough versus Tenderminded
L	Trusting versus Suspicious
M	Practical versus Imaginative
N	Forthright versus Shrewd
O	Self-Assured versus Apprehensive
Q ₁	Conservative versus Radical
Q ₂	Group-dependent versus Self-sufficient
Q ₃	Undisciplined versus Controlled
Q ₄	Relaxed versus Tense

* The negative pole of each variable is named first.

The handbook for the 16PF (Cattell et. al. 1970) presents data on the reliability, stability and homogeneity of the scales. The data presented in the Handbook appear adequate for use of the test in this research.

2. The Sample

Two groups were chosen for this research. The first group consisted of 45 research physicists from the National Research Council of Canada, located in Ottawa. The average age of this group was forty-four with a range from thirty to sixty-two. Forty-four were males, one was female. Generally, they were considered an ideal group to choose from. For one thing, they were available in sufficiently large numbers in the Ottawa region. Also, physicists are considered the chief researchers from within the sciences. Physics itself is considered the first among the empirical sciences. It has achieved a level of stability that other sciences do not possess. Physics has a good degree of theoretical orientation; it is highly abstract in nature yet it has many practical or applied applications. This balance is not as prevalent in mathematics which is very abstract or in

geography which tends to be too concrete. All the members of this sample possessed Ph.D's and each had extensive research experience complete with a minimum of several publications and citations.

The second group consisted of 41 engineering students from the Faculty of Science at the University of Ottawa. All members of this sample were in their second or third year of engineering at the undergraduate level. The average age of this group was twenty with a range from seventeen to twenty-six. Thirty-nine were male, two were female. These engineering students, as members of an applied science, must be considered as being quantitative in orientation. Since they were second and third year students, they constituted a selected homogeneous group already committed to their applied science. In engineering a theoretical attitude may be a component of research ability although engineers are conventionally regarded as being professional rather than theoretical in nature.

Both groups were sufficiently fluent in the English language to be able to do the tests given to them.

3. The Procedures

Permission was secured from the administration of the National Research Council to test those physicists who would volunteer their services as subjects for this research. Letters describing the intent of this research were sent to each physicist. Those who volunteered were tested at the NRC facilities. Groups of participants (N ranged from 2 to 6) were administered the battery of tests during a three hour period. The instructions as written on the tests and in the manuals were adhered to. Two administrators were present for all testing sessions.

Cognitive tests were given first followed by the personality tests. First, the M.A.T. was administered. It was followed by Guilford's DP tests which were given in the following order: Number Relations, Associational Fluency (Form A), Expressional Fluency (Form B), Match Problems I and Match Problems II. The personality tests then followed, beginning with the EPI and ending with the 16PF. In most cases the subjects were permitted to finish the 16PF on their own. This decision was taken in order to secure the fullest cooperation from

the scientists themselves as they could spare no more than three hours of their working time. They were instructed to finish the 16PF as soon as possible since these tests would be collected from them within two or three days.

In testing the engineering students, a slightly different pattern was followed. They were visited in their classrooms where the research and its purposes were discussed. Those who volunteered were tested at the Psychology Annex building of the University of Ottawa, located on King Edward Avenue. They were tested individually or in small groups (N ranged from 2 to 6). One administrator was present for all testing sessions. The cognitive and personality tests were given in the same order to the engineering students as they had been given to the physicists. In four cases the individuals were given one extra day to finish the 16PF test. The rest of the sample completed the entire test battery in one session.

4. The Statistical Methods

The predictors (discriminators) were individually examined as to their power to separate the two groups.

This involved the six variables provided by the cognitive tests, the two variables from the EPI and the 16 variables from the 16PF test. There were thus a total of 24 variables each providing a discriminator for comparing the two groups.

The significant differences between the means for two independent samples could be obtained via the t statistic. Thus,

$$t = \frac{|\bar{M}_1 - \bar{M}_2|}{\sqrt{\sigma_{M_1}^2 + \sigma_{M_2}^2}},$$

where M_1 and M_2 are the means of the two samples, and

$\sigma_{M_1}^2$, $\sigma_{M_2}^2$ are the corresponding standard variances

of the means calculated as:

$$\sigma_{M_1}^2 = \frac{\sigma_1^2}{N_1} = \frac{\Sigma x^2}{N_1(N_1-1)} = \frac{\Sigma (X-M_1)^2}{N_1(N_1-1)} \quad (1)$$

$$\sigma_{M_2}^2 = \frac{\sigma_2^2}{N_2} = \frac{\Sigma x^2}{N_2(N_2-1)} = \frac{\Sigma (X-M_2)^2}{N_2(N_2-1)} \quad (2)$$

The signs \sum_1 and \sum_2 indicate the summation over all the values in the first and second sample respectively.

Since it is known that the F test in the analysis of variance involving two samples (hence having one degree of freedom between groups) is directly related to the t test ($F = t^2$), and since it was more convenient in the computer program to employ the F test, all calculations and results were derived from the F test involving the ratio of the between group to within group variance. It should be noted however that if the t value is required from the quoted F , the square root of the F value can be taken. The significance is indicated on both the .05 level and the .01 level. For the present number of cases at the .05 level, F has to be about four or more to be significant. For the number of cases at the .01 level, F has to be about seven or more to be significant. Of course, the corresponding t values are the square roots of the F values. These correspond to about two ($\sqrt{4}$) at the .05 level and about 2.65 ($\sqrt{7}$) at the .01 level respectively.

According to Porebski (1966), in the case of two groups, the efficiency of the discriminant function and

multiple regression models are equivalent. By assigning constant zero-one scores to the members of the two groups respectively, one can create a pseudo-dependent variable. Thus, the problem of classification into the two groups can be presented as a problem of prediction of the so created pseudo-variable. In addition, the efficiency of discrimination can be evaluated on the metric scale in terms of multiple (discriminatory) correlation. Its significance can be tested from

$$F = \frac{N_1 N_2 - p - 1}{p} \cdot \frac{R^2}{1 - R^2}, \quad (3)$$

where N_1 and N_2 are the number of cases in the two groups respectively and p is the number of predictors (discriminators).

Before the total efficiency of the predictors (discriminators) was assessed it was of interest to examine the efficiency of the discriminators separately for the cognitive tests and for the personality tests. This meant that separate functions of the six cognitive variables and of the 18 personality variables were formed with optimum weights so as to maximize the respective prediction (discrimination). When the

cognitive and personality variables were combined into a single function one had to expect a higher level of predictive efficiency than that provided by either the cognitive or personality test function alone.

With the number of variables measuring similar characteristics and being intercorrelated, one had to expect a considerable degree of overlap and also some redundancy among the predictors. A widely used step-wise method of selecting predictors was not used as its methodological shortcomings had been empirically demonstrated (McInnis, 1975) and had also been recently theoretically pointed out (Porebski, 1976).

Instead of step-wise selection of significant predictors, a systematic method of eliminating variables was used. The latter procedure is dependent on the representation of multiple correlation. Thus,

$$R^2 = \beta_1 r_{o1} + \beta_2 r_{o2} + \beta_3 r_{o3} + \dots \quad (4)$$

is dependent on the decomposition of the R^2 value into the theoretical independent contributions made by each predictor. These independent contributions are determined by the product of the standard partial regression coefficient and the corresponding correlation that the

predictor has with the dependent variable, and may be defined as $V_i = \beta_i r_{oi}$. In accordance with the recommended procedure those variables which had negative V_i were eliminated first. Those which had positive V_i but were non-significant were eliminated next in the order inverse to their size. The procedure adopted a step-wise method of elimination instead of a step-wise method of selection. This was preferred since one could have more confidence in which single variable in a total set of p was redundant rather than in which variable in the same set of p was the best predictor.

The size of the multiple correlation provided a kind of correlational evidence on the efficiency of the predictive function. Since we had a pseudo-dependent variable (having only two values) in this particular case, it became important to ascertain whether this predictive (discriminative) function could successfully classify the individuals into the two groups. It was quite possible that the correlation with the dependent variable might be significant and quite high but if the critical selection value used to assign the individual into either group was inappropriately chosen, the

number of errors of misclassification could be much greater than expected on the basis of the correlation value. Although one could generally expect a high degree of correspondence between the proportion of variance of the dependent variable explained by the predictors (in fact indicated by R^2) and the percentage of errors of misclassification, one type of information could not be automatically deduced from the other. For this reason, the statistical design attempted to determine the best critical value for separating the two groups. It also attempted to express the efficiency of discrimination in terms of the percentage of correct classifications. To achieve this a separate computer program was used. The individuals in the two groups were studied from the point of view of whether or not they fell above or below the critical value. Code numbers were assigned serially to the members of the NRC sample and to the engineering student sample. Those falling above the critical value and belonging to the NRC sample were then listed separately from those who came from the engineering student sample and who fell below this critical value. The total number of

individuals classified correctly when divided by the total number of cases ($N = 86$) provided a measure of the validity of the classification function. The total number of cases minus those who were classified correctly represented the number of misclassifications.

Although the small sample size did not justify the use of any cross-validation procedures, these procedures were tentatively attempted in this study to illustrate the method. Thus, the NRC sample was split into two sub-samples using the odd and even code numbers from the list (vis., sample A and sample B). Similarly, the engineering student group was split into A and B sub-samples. The A segments of both samples were combined. This was regarded as a construction sample. The B segments were reserved for validation purposes. A function of the significant selected variables was then established on the construction sample so as to determine the relative weights of the predictors in the function and the corresponding multiple correlation. Having fitted the function in the construction sample (A segments) the function was then applied to the validation sample (B segments) to see whether the function was still significant and if so, to what

extent. One also examined whether there was any loss in efficiency as determined by the multiple correlation.

In order to use the data fully a double cross-validation procedure was attempted. On one occasion sample A was used as a construction sample and sample B as a validation sample. On the next occasion the roles were reversed. By following this procedure twice the normal amount of information was obtained. This double cross-validation procedure was also applied to the study of the changes in the size of the multiple correlation and in the size of the percentage of correctly classified individuals. The stability of the established function was then determined on the basis of losses from the construction samples to the validation samples in terms of the correlational and classificational evidence.

The ultimate weights assigned to the predictors were based on the combination of the A and B samples. These were the weights recommended for the predictors together with the corresponding critical selection score. They were most useful for future practical application.

CHAPTER III
PRESENTATION OF RESULTS

This chapter presents the results of the statistical methods employed in this study.

The statistical analyses of this research involved two samples, one being a group of NRC physicists (N=45), the other being a group of university engineering students (N=41). Six cognitive tests and two personality tests were used which gave a total of 24 separate variables to discriminate between the two groups.

The first concern was to examine to what extent each of these discriminant (predictive) variables individually separate the two samples that were studied. For this purpose the mean values were calculated separately for the two samples and the differences between these means were tested for significance. The usual statistic in such a case is a statistical t value for independent samples. In this case, for convenience the F value equivalent to t^2 value was used. In this research the level of significance was set on both the .05 level and the .01 level.

Table 2 gives the means and F values for each of the 24 variables. In column one, the first six variables represent the cognitive tests, the next two

Table 2

Means and F values for NRC Physicists and
Engineering Students on Cognitive and Personality Variables

Variable	Means		F Values
	NRC (N=45)	ENG (N=41)	
MAT	67.067	44.902	41.85**
NR	26.733	24.122	3.79
AF	16.022	11.512	25.61**
EF	5.933	2.024	41.48**
M-1	8.600	7.585	7.06**
M-2	12.511	14.195	3.13
E (EPI)	7.044	11.732	37.71**
N	8.356	9.488	1.33
A (I6PF)	6.400	8.195	9.96**
B	10.311	9.024	11.45**
C	15.889	16.463	0.48
E	12.889	13.829	1.22
F	8.400	15.024	55.39**
G	12.156	12.659	0.36
H	12.778	13.098	0.06
I	9.156	7.293	7.27**
L	6.156	8.220	9.11**
M	15.644	12.927	13.14**
N	9.198	8.854	0.39
O	7.267	9.049	6.41*
Q ₁	9.867	9.098	1.48
Q ₂	14.267	11.268	15.60**
Q ₃	12.578	12.976	0.46
Q ₄	11.644	11.341	0.09

* Significant at .05 level

** Significant at .01 level

variables represent the neuroticism and extraversion scales of Eysenck and the remaining 16 variables represent Cattell's personality factors as listed in Table 1.

On the six cognitive variables, only one (Guilford's Match Problem 2) is associated with a high mean for the engineering student group. The difference, however, is not significant as indicated by the F value of 3.13. (It should be noted that the corresponding t value of this is the square root of 3.13). All other differences of these cognitive variables are in favour of the NRC sample. With the exception of Guilford's Number Relations test they are all statistically significant ($p < .01$). The MAT and Guilford's Expressional Fluency test provide the highest level of discrimination.

Regarding the Eysenck Personality Inventory the extraversion scale discriminates significantly ($p < .01$), with the engineering students being more extraverted and the NRC physicists being more introverted. The neuroticism scale yields no significant difference between the two groups. In addition, the Lie scale scores fall within the normal range and similarly provide no significant result.

With respect to Cattell's 16PF test, there are significant differences ($p < .01$) in favour of the engineering students. This group is significantly higher on factor A (outgoing vs. reserved), on factor F (surgent vs. desurgent), on factor L (suspicious vs. trusting), and, at the .05 level, on factor O (apprehensive vs. self-assured). On the other hand, the NRC physicists are significantly higher ($p < .01$) on factor B (intelligent vs. dim), factor I (tender-minded vs. tough-minded), factor M (imaginative vs. practical) and factor Q_2 (self-sufficient vs. group-dependent).

The statistical data pertaining to the six cognitive tests are given in Tables 3 and 4. In the former, the means and standard deviations are presented. In the latter, the intercorrelations of the six cognitive variables are given. It should be noted that these data pertain to the whole sample ($N=86$).

An examination of Table 4 shows a high correlation between Guilford's Expressional Fluency and Associational Fluency tests. These two tests are verbal in nature. If there is a separate factor of creativity in the Guilford tests then all his tests should be highly inter-correlated. Apart from this verbal link however there

Table 3

Means and Standard Deviations for the Six Cognitive Variables for NRC Physicists and Engineering Students (N=86)

Variable	Means	Standard Deviations
Miller Analogies	56.500	19.310
Number Relations	25.488	6.313
Association Fluency	13.872	4.687
Expressional Fluency	4.067	3.416
Match Problems I	8.116	1.831
Match Problems II	13.314	4.462

Table 4
Correlations for Six Cognitive Variables for
NRC Physicists and Engineering Students
(N=86)

Variable	1	2	3	4	5	6
Miller Analogies	1.00	.24	.63	.57	.23	-.06
Number Relations	.24	1.00	.13	.17	.01	-.15
Associational Fluency	.63	.13	1.00	.50	.24	-.03
Expressional Fluency	.57	.17	.50	1.00	.20	-.05
Match Problems I	.23	.01	.24	.20	1.00	.10
Match Problems II	-.06	-.15	-.03	-.05	.10	1.00

do not seem to be high correlations between the various Guilford tests. Rather, the grouping of the tests appear to be dependent on the type of material used in them. For instance, the correlation between the two Guilford's tests mentioned above the MAT is higher than between these verbal and his other non-verbal tests. A specific example of this would be the case of Guilford's Match Problem 2 test. This is a test which has a high spatial component and in such shows no correlation with the Guilford verbal tests.

Tables 5 and 6 give the means, standard deviations and intercorrelations of the 18 personality variables. It should again be noted that the means are based on the raw scores of the total sample (N=86). This type of presentation was preferred to the usual procedure of presenting stanine scores (scores that are expressed in standard deviation units of the population). There are two reasons for this. First, the population standard deviations quoted in the manuals may not be applicable for a Canadian university student population. Second, the standard deviations quoted in Table 5 are based on a too-small number of cases to provide any real basis for Canadian norms. The use of raw scores and mean

Table 5

Means and Standard Deviations for the Eighteen Personality Variables for NRC Physicists and Engineering Students (N=86)

Variables	Means	Standard Deviations
E (EPI	9.279	4.231
N	8.895	4.558
A (16PF)	7.256	2.770
B	9.698	1.867
C	16.163	3.831
E	13.337	3.946
F	11.558	5.279
G	12.395	3.881
H	12.930	5.865
I	8.267	3.316
L	7.140	3.315
M	14.349	3.713
N	9.023	2.391
O	8.116	3.362
Q ₁	9.500	2.938
Q ₂	12.837	3.807
Q ₃	12.767	2.717
Q ₄	11.500	4.730

Table 6A
 Correlations for the Eighteen Personality Variables for NRC
 Physicists and Engineering Students (N=86)

Variable	1	2	3	4	5	6	7	8	9
E	1.0	-.11	.37	-.33	.13	.38	.74	-.05	.49
N	-.11	1.0	.05	-.12	-.35	-.06	-.03	.02	-.38
A	.37	.05	1.0	-.05	-.01	.04	.48	.00	.30
B	-.33	-.12	-.05	1.0	.11	-.18	-.29	.00	-.05
C	.13	-.35	-.01	.11	1.0	.06	.13	.06	.28
E	.38	-.06	.04	-.18	.06	1.0	.34	-.16	.50
F	.74	-.03	.48	-.29	.13	.34	1.0	.01	.49
G	-.05	.02	.00	.00	.06	-.16	.01	1.0	.07
H	.49	-.38	.30	-.05	.28	.50	.49	.07	1.0
I	-.17	.03	.12	.25	-.09	-.24	-.20	.09	-.04
L	.20	.15	.07	-.39	-.35	.29	.26	.02	.09
M	-.20	-.27	-.09	.23	.29	.26	-.22	-.09	.14
N	-.21	.12	.07	.15	-.06	-.34	-.29	.31	-.36
O	.01	.48	.06	-.33	-.49	-.16	.06	-.12	-.41
Q ₁	-.06	.02	.02	-.09	-.03	.41	.00	-.32	.16
Q ₂	-.42	-.12	-.54	.22	-.01	-.07	-.47	.08	-.12
Q ₃	.01	-.26	-.11	.16	.32	-.05	-.06	.33	.11
Q ₄	-.18	.54	-.05	-.03	-.53	-.15	-.08	-.06	-.39

Table 6B
 Correlations for the Eighteen Personality Variables for NRC
 Physicists and Engineering Students (N=86)

Variable	10	11	12	13	14	15	16	17	18
E	-.17	.20	-.20	-.21	.01	-.06	-.42	.01	-.18
N	.03	.15	-.27	.12	.48	.02	-.12	-.26	.54
A	.12	.07	-.09	.07	.06	.02	-.54	-.11	-.05
B	.25	-.39	.23	.15	-.33	-.09	.22	.16	-.03
C	-.09	-.35	.29	-.06	-.49	-.03	-.01	.32	-.53
E	-.24	.29	.26	-.34	-.16	.41	-.07	-.06	-.15
F	-.20	.26	-.22	-.29	.06	.00	-.47	-.06	-.08
G	.09	.02	-.09	.31	-.12	-.32	.08	.33	-.06
H	-.04	.09	1.4	-.36	-.41	.16	-.12	.11	-.39
I	1.0	-.08	.21	.19	-.03	-.21	.04	-.07	.23
L	-.08	1.0	-.18	-.12	.42	.08	-.15	-.17	.17
M	.21	-.18	1.0	-.11	-.38	.26	.13	.00	-.24
N	.19	-.12	-.11	1.0	.05	-.35	.17	.23	.06
O	-.03	.42	-.38	.05	1.0	-.03	-.13	-.28	.55
Q ₁	-.21	.08	.26	-.35	-.03	1.0	.02	-.23	-.08
Q ₂	.04	-.15	.13	.17	-.13	.02	1.0	.20	.02
Q ₃	-.07	-.17	.00	.23	-.28	-.23	.20	1.0	-.44
Q ₄	.23	.17	-.24	.06	.55	-.08	.02	-.44	1.0

values based on them allows one to make direct comparisons of the present results with the results obtained elsewhere which are based similarly on raw scores.

In Table 6A, one can see the correlation between Eysenck's extraversion and neuroticism scales to be $-.11$. This result appears to be consistent with the number of claims that have been made that hospital populations seeking mental treatment tend to be more introverted than extraverted. This, of course, does not preclude the possibility that introverts and extraverts are evenly distributed statistically in the normal population.

Tables 6A and 6B present the correlations found between Eysenck's extraversion-introversion scale (E) and Cattell's 16PF factors that purport to measure the same dimensions. In the 16PF, these factors are A, E, F, and Ω_2 respectively. The correlation between Eysenck's E Scale and Cattell's A factor is $.37$. Other correlations of the E scale are $.28$, $.74$, $.49$, and $-.42$ for factors E, F, H and Ω_2 respectively. It can be seen then that there does appear to be a relatively high degree of congruence between Eysenck's extraversion-introversion scale and Cattell's factors that measure these dimensions. This is consonant with the findings of Carrigan (1960).

Table 6A also indicates the correlation between Eysenck's extraversion scale and Cattell's factor B which measures intelligence. The correlation amounts to $-.33$. Thus extraversion is found to be correlated negatively with intelligence as measured by this factor. This appears to be in agreement with research of Eysenck (1959) and Kline (1966) who found similar results.

Eysenck's neuroticism scale (N) is found correlated with Cattell's factors of the 16PF which measure this trait. The neuroticism scale correlates with factors 0 (.48), Q_4 (.54), C (-.35) and Q_3 (-.26). These scales or factors indicate to some extent a measure of emotional reactivity. They probably have a common underlying factor as reported by Cattell (1970) and others (e.g. Adcock, 1965). There seems to be agreement on this score in the various studies reviewed.

The existence of a correlation between the predictor (discriminatory) variables indicates that there is an overlap between them. In constructing a function of the variables to separate the two samples one has to consider not only the discriminant power of each variable but also their existing degree of intercorrelation so as to compose the function of independent additive elements.

The optimum results can be achieved through a discriminant function or multiple regression function. For convenience, the multiple regression function is used here where the dependent variable is in the form of a binary dichotomy which represents the belonging to the NRC group (code 1) or not belonging to it (code 0).

Since the whole battery of tests has cognitive and personality variables, it was of some interest to see how much discrimination or prediction could be achieved by the cognitive tests alone and by the personality tests alone before they were combined into a single function. These separate functions were obtained using a computer program for multiple regression.

A function of the six cognitive variables alone gave a multiple correlation of .688. A function of the eighteen personality variables alone gave a multiple correlation of .807. It should be noted that in each function above all variables including those which do not make a significant contribution to discrimination (prediction) have been included. By combining the cognitive and personality variables into a single predictive function and by eliminating the redundant variables, only 10 predictors were finally retained.

These gave an overall multiple correlation of .828 with a multiple correlation squared being equal to .685. The latter figure represents the proportion of the variance of the dependent variable (belonging to either the NRC physicists or engineering students' group) explained by the predictors. The intercorrelations and the independent contributions of the 10 predictors to the explanation of the dependent pseudo-variable are to be found in tables 7 and 8 respectively.

The total number of 24 predictors (six cognitive variables plus 18 personality variables) were used originally in a single function. Those predictors which changed the sign of their regression coefficients (weights) from the original direction of correlation with the dependent variable were progressively eliminated. The hypotheses concerning these specific predictors were regarded as being rejected. For example, if an intelligence test would give the NRC physicist sample a higher mean and therefore indicate that those with high scores would have a better chance to be selected to this group, then such a test would not be acceptable in a function of predictors if the only way it should be used would be as a test of 'stupidity' i.e., a test that would give a negative weight.

In addition to the obviously inappropriate and redundant predictors it was also necessary to reject those predictors that were positive but not significant.

The independent contribution resulting from the addition or subtraction of a single predictor was determined by examining the increase or decrease in multiple correlation. The F test used was

$$F = \frac{N - m - 1}{1} \cdot \frac{R_{m+1}^2 - R_m^2}{1 - R_m^2}$$

In the above formula, R_m^2 is the multiple correlation squared resulting from the use of the m predictors. Here R_{m+1}^2 is the multiple correlation squared resulting from the use of $m+1$ predictors. The test was conducted with one degree of freedom since only the contribution of an additional single variable to prediction was studied.

Table 7 contains some of the information already available in Tables 4 and 6. There, the intercorrelations of the cognitive tests and the personality tests are presented separately. The new correlations are only those between the cognitive and personality tests. The final predictors, as shown in Table 7, include four cognitive variables and six personality variables.

Table 7

Intercorrelations of the Predictors Included in the Final Function

Variable	1	2	3	4	5	6	7	8	9	10
1 MAT	1.0	.63	.57	.23	-.43	-.14	-.36	.04	.35	.26
2 AF	.63	1.0	.50	.24	-.22	.02	-.27	.00	.41	.14
3 EF	.57	.50	1.0	.20	-.25	.05	-.27	.15	.19	.02
4 MP1	.23	.24	.20	1.0	-.07	.00	-.13	.05	.10	-.02
5 E(EPI)	-.43	-.22	-.25	-.07	1.0	.37	.74	-.17	-.20	-.42
6 A(16PF)	-.14	.02	.05	.00	.37	1.0	.48	.12	-.09	-.54
7 F(16PF)	-.36	-.27	-.27	-.13	.74	.48	1.0	-.20	-.22	-.47
8 I(16PF)	.04	.00	.15	.05	-.17	.12	-.20	1.0	.21	.04
9 M(16PF)	.35	.41	.19	.10	-.20	-.09	-.22	.21	1.0	.13
10 Ω_2 (16PF)	.26	.14	.02	-.02	-.42	-.54	-.47	.04	.13	1.0

It is seen that the intercorrelations among the cognitive tests alone and among the personality tests alone are higher than between the cognitive and personality tests. A notable exception worth mentioning is the somewhat higher than average correlation of .41 between Guilford's Associational Fluency test and Cattell's M factor of imaginativeness. Since the Associational Fluency test is assumed to measure verbal intelligence it appears that factor M, imaginativeness, is partly related to intelligence. One can also note a positive correlation of .35 between factor M and the MAT. Even higher than this correlation is the one found between the MAT and Eysenck's E scale. It seems to confirm a previously suggested link between intelligence and introversion.

In Table 8, the 10 variables are listed in order of importance in predicting the dependent variable.

It is seen that the highest independent contribution (18.98%) is made by variable 3 (Expressional Fluency) and the lowest significant independent contribution (3.22%) is made by variable 4 (Match Problem 1). The cumulative efficiency of the prediction function is

Table 8

Independent Contribution and Cumulative Contribution
of Ten Predictors (Discriminators) Expressed in Percentage

Variable Number	Name of Variable	Independent Contribution	Cumulative Contributions
3	Expressional Fluency	18.98	18.98
7	Surgency (16PF)	14.82	33.80
1	Miller Analogies	5.31	39.12
5	Extraversion (EPI)	4.97	44.09
2	Associational Fluency	4.57	48.66
10	Self-sufficient (16PF)	4.55	53.22
6	Outgoing (16PF)	4.32	57.54
8	Tender-minded (16PF)	4.31	61.85
9	Imaginative (16PF)	3.43	65.28
4	Match Problems 1	3.22	68.50

68.50% which corresponds to the value of R^2 (multiple correlation squared) obtained from the function of these 10 predictors. The multiple correlation already mentioned is $R = .828$.

The multiple regression function for the ten predictor raw scores (X) is:

$$\begin{aligned} \hat{Y} = & .0024X_1 + .010X_2 + .0486X_3 + .0317X_4 - .0106X_5 \\ & - .0241X_6 - .0224X_7 + .0232X_8 + .0126X_9 + .0152X_{10} \\ & - .2435 , \end{aligned}$$

where the last term is the intercept constant. It is to be added to all predicted scores so that the mean predicted score is equal to the mean of the dependent variable. The variable number in this final function is also included in Table 8. In addition, the table lists the names of the variables.

When the predicted scores for each of the 45 + 41 individuals were calculated, it was found that the optimum allocation of individuals to one group of the other can be achieved, using as the critical selection score for group one the value .498. This is equivalent to taking the top 45 predicted scores and assigning them to group one. The number of so-selected individuals is then equal to the original number of cases in the top

The predicted scores are arranged in order of their value in Table 9. Associated with each score is the serial number of the individual so that numbers 1 to 45 represent the NRC physicist sample while those numbers from 46 to 86 represent the engineering student sample.

It can be seen from the table that only two engineering students qualify for the NRC sample and only two members of the NRC physicist sample fall just below the discriminant function critical score. Thus there are only 4.44% (2 out of 45) misclassified "successes" (those NRC members not assigned to the NRC group) and only 4.88% (2 out of 41) misclassified "failures" (the engineering students not assigned to the student group). The overall success of the classification function is therefore 95.35% (82 out of 86).

Even though the number of cases used in the present study did not warrant further subdivision of the samples for the purposes of cross-validation, an attempt at using this procedure was made. This was done to illustrate this particular method rather than to justify the empirical results above.

The NRC physicist sample was split into odd and even serial numbers. The same procedure was followed

Table 9

Serial Number and Predicted Score for NRC physicists and
Engineering Students

37	1.545	10	1.249	35	1.231	23	1.198	40	1.185
9	1.129	22	1.066	34	1.041	31	1.021	18	.969
26	.969	32	.956	44	.941	36	.924	6	.923
33	.919	42	.919	3	.888	11	.883	21	.879
41	.863	24	.863	29	.858	1	.853	43	.839
4	.831	5	.820	25	.805	8	.797	27	.786
12	.766	45	.742	61	.724	16	.708	7	.683
19	.681	28	.660	15	.643	17	.636	46	.617
14	.606	20	.584	39	.569	38	.543	30	.498
55	.489	13	.455	52	.435	69	.434	72	.429
63	.408	47	.392	85	.388	82	.379	65	.354
2	.318	78	.295	64	.268	68	.267	56	.263
81	.251	67	.240	76	.220	74	.218	75	.199
58	.134	51	.128	83	.122	48	.115	71	.078
66	.076	54	.075	60	.070	59	.061	84	.057
77	.026	53	-.042	50	-.048	57	-.078	62	-.079
79	-.129	86	-.181	70	-.181	73	-.194	49	-.255
80	-.264								

for the engineering student group. The odd serial numbers for the NRC sample (N=23) and the odd serial numbers for the engineering student sample (N=21) were then isolated to constitute a 'construction' sample in which the predictive (discriminant) function using the ten selected variables was established. This function gave a multiple correlation of .859.

Using the regression weights of the construction sample, the function was then applied to the sample comprising the even serial numbers. The latter sample (validation) was thus used to simulate new cases. This procedure was applied to check the stability of the regression weights and of the multiple correlation. The obtained value of the multiple correlation in the validation (even) sample was .761 indicating a slight but not critical decrease in predictive efficiency.

The samples were then interchanged so that the 'even' sample was regarded as a construction sample. Using the same 10 predictor variables the multiple correlation of .831 was found in that sample. The multiple regression weights associated with this new construction sample were then applied to the validation (odd) sample. This resulted in a reduced multiple correlation of .771

indicating as before a reasonable stability of the function despite some expected loss in predictive efficiency.

A similar 'double' cross-validation procedure was used for the errors of classification. The overall success of the classification function for the whole sample was 95.35%. It was of some interest to find out what loss in the efficiency of classification would be if the function established in the 'odd' sample was used to classify the individuals in the 'even' sample and similarly the function established in the 'even' sample was used to classify the individuals in the 'odd' sample. The results from the former cross-validation provided 9.09% of misclassified 'successes', 10.00% of misclassified 'failures' and the overall 90.48% of correct classifications. Those from the latter cross-validation gave the corresponding percentages of 8.70%, 9.52% and 90.91%. Combining the overall percentage of correct classifications in the two cross-validations, about 90.7% were correctly classified. Therefore the drop from the original 95.35% was less than 5%. The stability of the functions was found to be quite high.

For practical purposes of selection of classification the specific functions in the sub-samples would of course be ignored. It is the function established on the whole sample as given above that would be used. It should be noted that it is a remarkable efficient prediction and classification function as evidenced by the multiple correlation of .828 and by 95.35% of correct classifications. In the light of results obtained in the cross-validation study this function appears to be reasonably stable.

CHAPTER IV

DISCUSSION OF RESULTS

This chapter provides a general discussion of the results presented in the previous chapter. It supplements the discussion with specific comments on the relevance of the age factor in the eventual application of these results to the selection of students.

The results of this study indicate that a combination of predictors (discriminators) that were used in this research successfully predict those individuals who are potential research scientists from a restricted university population.

Of the six cognitive variables used, only Guilford's Match Problems 2 test favour the engineering students group. This can be explained by the fact that, due to the nature of engineering work, a strong spatial orientation is required. As this test possesses a large component which measures spatial ability, the engineering students are expected to do better on this test than the research physicists. Physics is less likely to demand this particular ability. All other cognitive variables favour the research scientists. These include the two Guilford tests which measure verbal ability plus the MAT which also possesses a

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high verbal component. One possible reason for the obtained significant differences in verbal scores for the two groups is due to a difference in their educational background. A large number of the research physicists who made up the sample for this study appeared to have completed their education in European schools. Apart from possible differences between European and American educational systems one must admit the possibility that educational standards were stricter in the past than those of today. A further possibility for the significant differences found has to do with the nature of scientific work. Researchers must communicate clearly to others the results of their efforts. Thus, well-developed verbal skills are needed. Finally, the differences may simply be due to the fact of the superior intelligence, on average, of established research physicists. Embree (1948) and Wrenn (1949) found the level of intellectual ability to increase at each education level. It was highest at the Ph.D. level.

The extraversion scale of the EPI discriminates significantly ($p .01$) between the two groups. The engineering students are found to be more extraverted as a group than the NRC physicists. Cattell's 16PF

factors which measure extraversion further support this finding. These factors, namely A, E, F and O_2 correlate .37, .38, .74 and $-.42$ respectively with Eysenck's E scale. This shows a relatively high degree of congruence. This finding is also supported by the research of Carrigan (1960).

The engineering student group is significantly higher on Cattell's F factor than is the physicists group. This means that the engineering students are more happy-go-lucky (as against being serious) than the research scientists. Since the engineering student group is younger than its research counterpart, it would tend to possess greater energy levels than the physicists group. However, one can argue that due to the highly theoretical orientation demanded by research in physics, it is necessary for physicists to cultivate the trait of seriousness if they are to make any real contribution. The general profile shown by the physicists in this study is remarkably similar to that found by Cattell (1970) and Drevdahl (1956). The physicists tend to be reserved, intelligent, serious, trusting, tender-minded, imaginative and self-sufficient.

By contrast, the engineering student group in this

research is found to be more outgoing, suspicious, happy-go-lucky, practical, apprehensive and group dependent.

In addition to the significant discrimination in terms of intelligence and introversion (measured by Eysenck's and Cattell's scales), one should mention significant differences in the factors of tender-mindedness and imaginativeness. It is not surprising that research scientists are more imaginative as the nature of their work requires some originality and creative attitude. Tendermindedness reflects a greater sensitivity of the researchers in comparison with the engineering students who by the nature of their future profession are expected to be more practical.

The two groups do not differ significantly on the neuroticism and lie scales of the EPI. Averages for both of these scales fall within the range of normality as specified by Eysenck and Eysenck (1968, p. 11).

Taken by themselves, Cattell's factor L (trusting versus suspicious) and factor O (apprehensive versus self-assured) of the 16PF indicate significant differences in psychological adjustment (as against anxiety) in favour of the NRC physicists. However, these scales are not included in the final discriminant function.

The level of discrimination provided by these two scales must have fallen below the significance level when the overlap with the other discriminators had been taken into account. The precise reason for this drop in significance cannot be ascertained clearly. Some intuitive evaluation can only be made by reference to the correlations (see Tables 6A and 6B) these two scales have with the finally selected predictors. The pattern of these intercorrelations is too intricate, however, to allow a straight forward explanation. Although the above anxiety scores are not required for the purpose of practical discrimination it is of some theoretical interest to note that the present research has provided no support for certain popular notions that creative scientists are somewhat more neurotic and anxious than the normal person. If anything, the present study indicates that the opposite is true.

Another theoretical point of interest is the relationship between introversion and ability. Here, a positive relationship can be inferred from a negative correlation ($r = -.33$) between Eysenck's E scale and Cattell's factor B which measures intelligence. This conclusion is further supported (see Table 7) by a

negative correlation of Eysenck's E scale with the MAT ($r = -.43$) and with Guilford's tests. Cattell's factor F (happy-go-lucky) of the 16PF also correlates negatively with the same ability tests. The relationship between a personality characteristic and cognitive ability is interesting and probably relevant to the understanding of creative processes. Further research is required to gain this understanding.

The discussion of the results would not be complete without a consideration of the effect of the age factor. One must state that in the present study the prediction (discrimination) is not between two coexisting groups since these groups are sequential in time with respect to age. In order to be an NRC physicist one first has to be a student. Since one follows in sequence from the other, there has to be an age difference between the two groups. Those individuals who complete a Ph.D. in science do not necessarily become immediately NRC research physicists. Often, further training is necessary before this possibility is actualized. This further creates a generation gap. Therefore, if the predictive (discriminant) function is to have any practical utility at all then some adjustment for the age factor must be

made. This cannot be done simply by using age as a discriminator and adjusting statistically the variables so that age is kept constant. Under these circumstances age provides a perfect discrimination between the samples. The statistical elimination of age might result in the obliteration of all relevant differences between the samples. To adjust for age one must seek the evidence of the dependence of psychological characteristics on age from external sources. This would require a separate study of the various psychological characteristics as a function of age over the whole range of variability in the population. Should such a relationship be found to be linear one could make an appropriate correction for the various gains and losses in test scores due to a particular difference in age. The influence of age can be studied, although less adequately, from the present data using 'within' group covariance of descriptive variables with age. Even though such an adjustment is a statistically recognized procedure it may be inadequate in the case (as here) when the co-variability within the two groups occurs within a very narrow range.

In the present analysis, the discriminant variables seem to come from three areas. They are the anxiety-

neuroticism dimension, the cognitive-creative abilities dimension and the introversion-extraversion dimension respectively.

With respect to the anxiety-neuroticism dimension, it is useful to make some quantitative adjustment. Even if it is reasonable to assume that people, as they get older get less anxious, this fact may not be due to age alone but to other factors. At this stage it would be extremely difficult to make any quantitative adjustment on the age variable alone. It is very difficult to know how age affects changes in people in the 21 to 45 year age range because of additional factors such as health, family status, economic security, etc.

With respect to the cognitive-creative abilities dimension, certain general opinions have been made. For one thing, it is reasonable to assume that a person who is 40 years old has better verbal skills than a 21 year old since he has had a longer time period in which to practice these skills. However, it should be kept in mind that since all of the cognitive tests used in this research have a speed component this should favour the 21 year olds. People who are 40 years old generally

have slower reaction times than younger people. It has also been reported that people who have creative ability tend to express this ability early in life. Following this line of reasoning, it is seen that this creative ability would be found in the younger age group. If an adjustment is to be made to cognitive ability scores it may not only be difficult to quantitatively specify the amount of adjustment but even to indicate its direction.

With the introversion-extraversion dimension it is reasonable to assume that people who are older are less outgoing and sociable on the factor of extraversion. However, some writers feel a distinction should be made between the social and physiological components of extraversion. One does not know if the questions dealing with extraversion that are found in the EPI or in the 16PF can be measured according to what degrees each component, social or physiological, is present. There is no research at present available to indicate how much loss, if any, is to be found on the social extraversion dimension alone.

Thus, there is no adequate quantitative information available which deals with this phenomenon. For this

reason, the results were left in their original empirical form. If adequate quantitative information is discovered then the raw scores can be adjusted at some later date. In the meantime they can be most useful in their original, unadjusted form as they can be used for comparison with other raw score data.

At this stage the only possible relevant contribution that can be made is to consider the problem methodologically. A tentative adjustment could be made on the basis of partial information which is available, to see whether the significance level provided by the present discriminators is substantially reduced as a result of this adjustment. It would be futile to attempt this with respect to the various measures of neuroticism, intelligence or ability, limiting the possible adjustment to the age-extraversion relationship. It should be noted that even if all personality variables were excluded from the study the cognitive variables alone would provide a high significant level of discrimination with a multiple correlation of about .7. Any possible adjustment can only reduce slightly the overall level of discrimination as measured by the multiple correlation which is slightly in excess of .8.

If such an adjustment is to be made, the available information exists (Cattell et.al, 1970, p. 82) pertaining to Cattell's adjustment of basic scores where the correction for age is made at the time of scoring. The use of this would mean adjusting or distorting the original raw scores thus not allowing other researchers to make comparisons of their original, unadjusted raw scores with the present results. In addition, adjusting the raw scores obtained from the 1967-68 version of the 16PF using the adjusted figures suitable for only the 1961-62 version would be of questionable wisdom.

There is also an available correlation to be found between age and extraversion ($r = -.24$) in Eysenck and Eysenck (1968). However, it is not known from this source what changes are to be found in any particular age range.

Assuming for methodological reasons, however, that this correlation is valid, for the purpose of adjustment in the present study, one can use it in predicting extraversion scores from age and thereby obtain the residual mean values on extraversion for the two groups respectively, holding the age constant. The predicted score is $\hat{y} = bx$, where \hat{y} is the predicted

deviation score on extraversion, b is the regression coefficient and x is the deviation score on age. The regression coefficient can be equivalently written as $b = r\sigma_y/\sigma_x$ where r is a correlation between age and extraversion (used here as $-.24$), σ_y is the standard deviation of extraversion and σ_x is the standard deviation of age. Using the estimates of the standard deviations and of the mean values from the present study one can adjust the mean of the NRC sample by predicting the extraversion mean scores for the two samples from the corresponding age means. The adjusted extraversion mean for the NRC sample would then be 7.882 and for the student group it would be 10.881. Assuming that the correlational and standard deviation figures are appropriate one can see that the original difference on extraversion (4.688) is reduced to the difference in the adjusted means (2.939). It should be noted that corresponding to this reduction in the difference on the extraversion scale, there would be a reduction within individual variability which would affect the decrease in the significance level to a much lower extent than indicated by the decrease from the original to the adjusted difference. To attempt an estimate of such

a decrease in variability on the basis of present data while using an estimate of correlation given externally may not be appropriate.

The second tentative approach can be made using only the present data and estimating age-extraversion covariance from 'within' samples. Even assuming that the estimates of covariance based on such narrow ranges of variability are valid, there still remains a problem. To obtain the adjusted difference between the means and to judge whether it is statistically significant it is necessary to determine a common 'within' groups regression coefficient. Such a common regression coefficient can be established in a valid manner only if the regression slopes in the two groups are identical or statistically not significant. This does not seem to be possible in the present study where in the NRC physicist sample the relationship between extraversion and age is significantly negative but in the engineering student sample this relationship is not significant and is even in the opposite direction. To apply these tentative procedures is perhaps not that important. It appears that an adjustment for age might lower somewhat the significance

of difference but it is unlikely to reduce it to a non-significant level.

Any attempt at adjusting the correlated extraversion scales of Cattell's 16PF would be too rough to be attempted even for methodological purposes.

A number of additional applied and theoretical problems could be solved by further research. On the applied side it would be of interest to obtain precise age-extraversion norms for a Canadian population, particularly with reference to a university population. On the theoretical side it would be of interest to obtain further insight into the relationship between introversion and ability, if possible, as a function of age. In a more general context it would be useful to find the precise role played by personality and cognitive factors in creative processes; and to see whether these factors have measurable neurometric correlates.

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Appendix I

Sample Questions for the Miller Analogies Test

1. LIGHT:DARK::PLEASURE: (a. picnic, b. day, c. pain, d. night)
2. LEAVE:DEPART:: (a. stay, b. go, c. home, d. come):REMAIN
3. LAUGH: (a. joke, b. cry, c. grin, d. humor)::JOY:SORROW
4. (a.4,b.5,c.7,d.6):12::12:24

Appendix 2
Guilford's Number Rules test

NUMBER RULES — DSR02A

CONFIDENTIAL

NAME (Print) _____ DATE _____
 Last First Middle

GROUP _____

Numbers can be related in different ways. In this test you are to show different ways to start with one number and end with another number.

EXAMPLE:

Starting with 2, get 6	<u>WAYS</u>		
a. Starting with 2	<u>+ 4</u>	= 6	(add 4)
b. Starting with 2	<u>X 3</u>	= 6	(multiply by 3)
c. Starting with 2	<u>X 2 + 2</u>	= 6	(multiply by 2, then add 2)
d. Starting with 2	<u>+ 5 - 1</u>	= 6	(add 5, then subtract 1) NOT ACCEPTABLE

In the example, four different rules are given for starting with the number 2 and getting the number 6. However, answer (d) is not acceptable here because "add 5, then subtract 1" is not different enough from answer (a), "add 4."

Use only these ordinary signs from arithmetic:

1. Use + for addition
2. Use - for subtraction
3. Use X for multiplication
4. Use ÷ for division

The rules you find must be different from each other. Use only whole numbers; do not use fractions, mixed numbers, or decimals. You do not have to explain your ways in words.

There are two parts to this test with five items in each part. There will be space for as many as 4 different rules for each item. You will have 5 minutes for each part.

If you have questions, ask them now, since no questions will be answered after you turn the page.

STOP HERE. WAIT FOR FURTHER INSTRUCTIONS.

1. Starting with 3, get 12

WAYS

- a. Starting with 3 _____ = 12
- b. Starting with 3 _____ = 12
- c. Starting with 3 _____ = 12
- d. Starting with 3 _____ = 12

2. Starting with 9, get 72

WAYS

- a. Starting with 9 _____ = 72
- b. Starting with 9 _____ = 72
- c. Starting with 9 _____ = 72
- d. Starting with 9 _____ = 72

3. Starting with 13, get 28

WAYS

- a. Starting with 13 _____ = 28
- b. Starting with 13 _____ = 28
- c. Starting with 13 _____ = 28
- d. Starting with 13 _____ = 28

4. Starting with 7, get 23

WAYS

- a. Starting with 7 _____ = 23
- b. Starting with 7 _____ = 23
- c. Starting with 7 _____ = 23
- d. Starting with 7 _____ = 23

5. Starting with 5, get 36

WAYS

- a. Starting with 5 _____ = 36
- b. Starting with 5 _____ = 36
- c. Starting with 5 _____ = 36
- d. Starting with 5 _____ = 36

STOP HERE. WAIT FOR FURTHER INSTRUCTIONS.

6. Starting with 4, get 15

WAYS

- a. Starting with 4 _____ = 15
- b. Starting with 4 _____ = 15
- c. Starting with 4 _____ = 15
- d. Starting with 4 _____ = 15

7. Starting with 11, get 30

WAYS

- a. Starting with 11 _____ = 30
- b. Starting with 11 _____ = 30
- c. Starting with 11 _____ = 30
- d. Starting with 11 _____ = 30

8. Starting with 6, get 34

WAYS

- a. Starting with 6 _____ = 34
- b. Starting with 6 _____ = 34
- c. Starting with 6 _____ = 34
- d. Starting with 6 _____ = 34

9. Starting with 19, get 9

WAYS

- a. Starting with 19 _____ = 9
- b. Starting with 19 _____ = 9
- c. Starting with 19 _____ = 9
- d. Starting with 19 _____ = 9

10. Starting with 29, get 7

WAYS

- a. Starting with 29 _____ = 7
- b. Starting with 29 _____ = 7
- c. Starting with 29 _____ = 7
- d. Starting with 29 _____ = 7

STOP HERE. WAIT FOR FURTHER INSTRUCTIONS.

Appendix 3

Guilford's Associational Fluency test

DMR

CONFIDENTIAL

ASSOCIATIONAL FLUENCY 1

FORM B

By J. P. Guilford

NAME (Print) Last First Middle SEX: M F

ORGANIZATION SCORES: I

II

GROUP DATE Total

In this test you are to write words similar in meaning to the given word.

SAMPLE ITEM:

Write words similar in meaning to the word HARD.

HARD:

difficult severe
solid unfeeling
tough
stiff

Notice that the words written above are all somewhat like the word HARD in meaning. In the test you are to write as many words as you can that are similar in meaning to the given word.

WAIT FOR THE SIGNAL BEFORE TURNING THIS PAGE.

Write as rapidly as you can. Avoid using a word more than once for the same item. Your score will be the total number of words you write (similar in meaning to the given word).

There are two parts to this test. You will have 2 minutes for each part.

If there are any questions, ask them now.

STOP HERE. WAIT FOR FURTHER INSTRUCTIONS.

PART I

a. TO SEE

To _____

To _____

To _____

To _____

To _____

To _____

b. TO CUT

To _____

To _____

To _____

To _____

To _____

To _____

c. TO GROW

To _____

To _____

To _____

To _____

To _____

To _____

d. TO PUSH

To _____

To _____

To _____

To _____

To _____

To _____

STOP HERE. WAIT FOR FURTHER INSTRUCTIONS.

PART II

a. TO SPEAK

To _____

To _____

To _____

To _____

To _____

To _____

b. TO DRAW

To _____

To _____

To _____

To _____

To _____

To _____

c. TO FLY

To _____

To _____

To _____

To _____

To _____

To _____

d. TO SEND

To _____

To _____

To _____

To _____

To _____

To _____

STOP HERE. WAIT FOR FURTHER INSTRUCTIONS.

Appendix 4

Guilford's Expressional Fluency test

EXPRESSIONAL FLUENCY

FE-1

DMS

Form A

CONFIDENTIAL

By Paul R. Christensen and J. P. Guilford

NAME				SEX	M	SCORE	I	
(Print)	Last	First	Middle		_____		II	_____
				F	_____		III	_____
							IV	_____
GROUP	_____			DATE	_____		Total	_____

In this test you are to write sentences each made up of four words. Each word must begin with the letter indicated.

SAMPLE ITEM:

<i>keep</i>	<i>u</i>	<i>ps</i>	<i>y</i>	<i>our</i>	<i>i</i>	<i>n</i>	<i>t</i>	<i>erest</i>
<i>Kill</i>	<i>u</i>	<i>seless</i>	<i>y</i>	<i>ellow</i>	<i>i</i>	<i>n</i>	<i>s</i>	<i>ects</i>
<i>Kidnapping</i>	<i>u</i>	<i>psets</i>	<i>y</i>	<i>oung</i>	<i>i</i>	<i>n</i>	<i>f</i>	<i>ants</i>
<i>K</i>	<i>u</i>		<i>y</i>		<i>i</i>			

The task in this item is to write sentences using words that begin with the given letters: K, u, y, and i, in that order. The test contains items similar to this one. You will be required to write as many four-word sentences as you can, using words that begin with the given letters.

WAIT FOR THE SIGNAL BEFORE TURNING THIS PAGE.

All sentences should make sense and be complete. Avoid using the same word twice. Your score will be the number of acceptable sentences you write in the time allowed.

There are four parts to this test. You will have 2 minutes for each part. Are there any questions?

STOP HERE. WAIT FOR FURTHER INSTRUCTIONS.

PART IV

M a r g
M a r g
M a r g
M a r g
M a r g
M a r g
M a r g
M a r g
M a r g
M a r g
M a r g
M a r g
M a r g
M a r g
M a r g
M a r g
M a r g
M a r g

STOP HERE. WAIT FOR FURTHER INSTRUCTIONS.

Appendix 5

Guilford's Match Problems I test

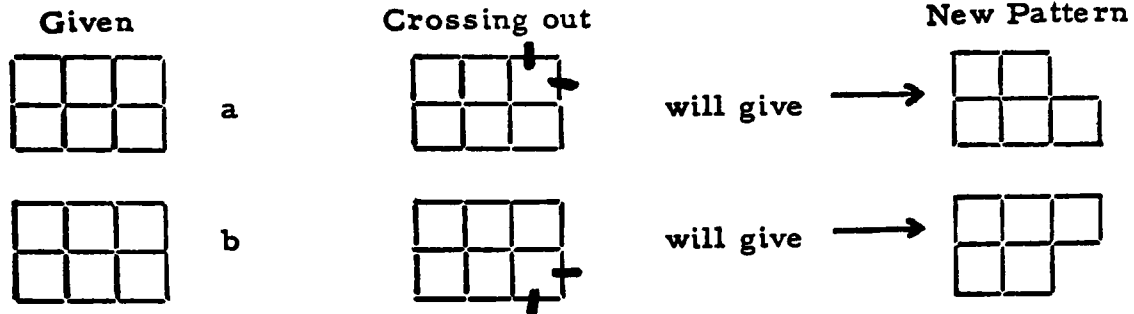
NAME _____

MATCH PROBLEMS (V--Xa-2) DFT

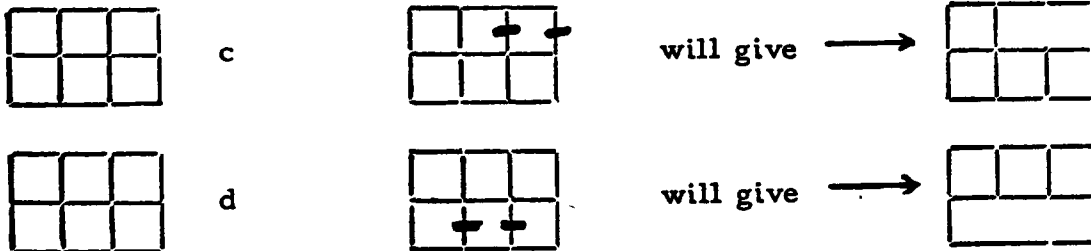
In this test you will see a drawing of matches with no heads. The matches are laid out in squares. You are to cross out some of the matches so that the matches left make a new pattern of squares. Then you are to cross out different matches to make another pattern.

Look at the example:

CROSS OUT 2 MATCHES.
LEAVE ANY NUMBER OF SQUARES.
EVERY MATCH LEFT MUST BE PART OF SOME SQUARE.



These two answers are correct, but both use the same rule. This rule is to cross out two corner matches. Only one of these answers would count. You must use different rules to get the new patterns that will count. Now look at the answers below.



Neither one of these answers is correct. Some of the matches left are not parts of squares in the new pattern. You must cross out the correct number of matches so that each match left is part of some square.

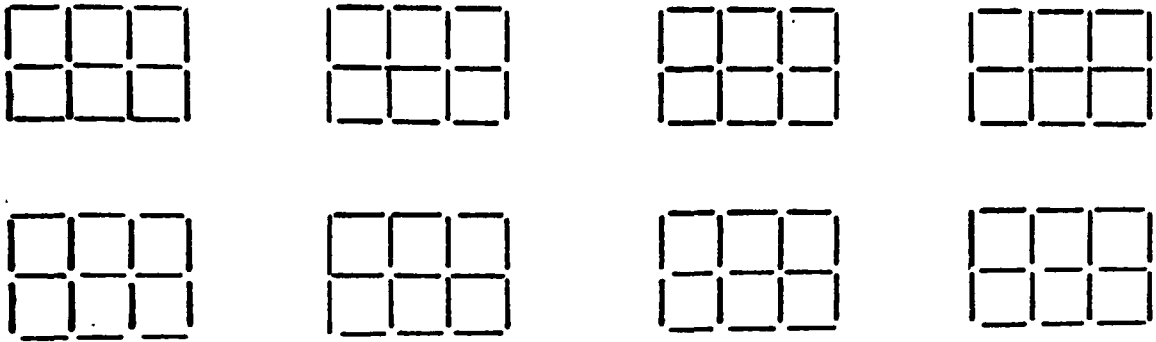
In the test you will see many patterns on which to work. Use a different rule for each answer. In each of your answers, every match left must be part of some square.

You will be told when to begin work and when to stop work. You will have 5 minutes. Work as rapidly as you can.

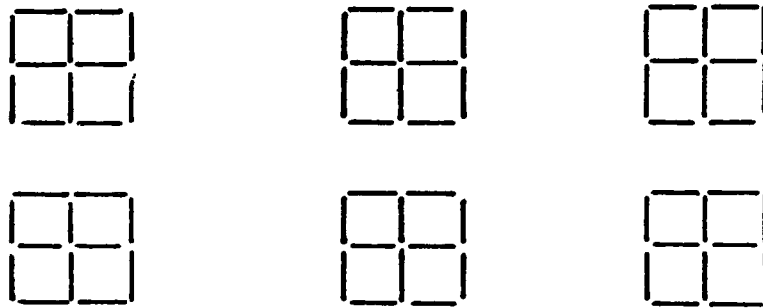
If you have questions, ask them now.

STOP HERE. WAIT FOR FURTHER INSTRUCTIONS.

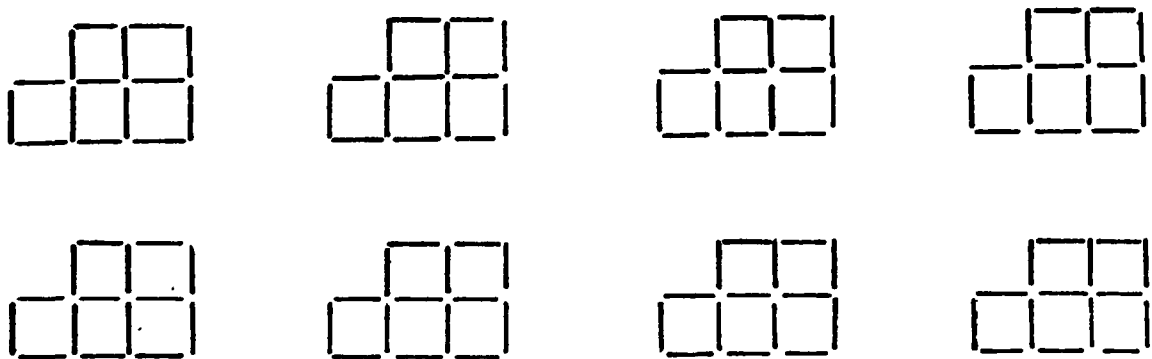
1. CROSS OUT 4 MATCHES.
 LEAVE ANY NUMBER OF SQUARES.
 EVERY MATCH LEFT MUST BE PART OF SOME SQUARE.



2. CROSS OUT 4 MATCHES.
 LEAVE ANY NUMBER OF SQUARES.
 EVERY MATCH LEFT MUST BE PART OF SOME SQUARE.



3. CROSS OUT 5 MATCHES.
 LEAVE ANY NUMBER OF SQUARES.
 EVERY MATCH LEFT MUST BE PART OF SOME SQUARE.



STOP HERE. WAIT FOR FURTHER INSTRUCTIONS.

Appendix 6

Guilford's Match Problems II test

NAME _____

DFT

CONFIDENTIAL

000225

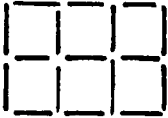
MATCH PROBLEMS II--Xa-1

In this test you will see drawings of matches laid out in patterns. You are to remove some of the matches so that the matches left form new patterns.



Look at this example:

TAKE AWAY 3 MATCHES
LEAVING 4 SQUARES

Given



Solution A





In this example, your instructions appear at the left. The drawing under "Given" is like those you will see in the test. To indicate a solution, you would mark through the matches you want removed. In the example, the solution marked would look like the pattern at the right if the matches were actually removed. Note that only complete squares are left.

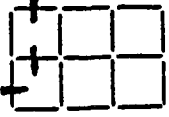

The attempt below is not an acceptable solution:

TAKE AWAY 3 MATCHES
LEAVING 4 SQUARES

Given



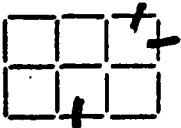
Wrong

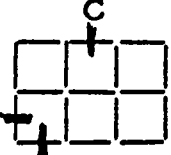
This attempt is wrong because it leaves two matches that are not parts of the required four squares. You must remove matches so that exactly the required numbers of complete squares remain, with no matches left over.

In this test you will add to your score by giving additional different solutions to each problem. Here are some other possible ways of doing the same problem.

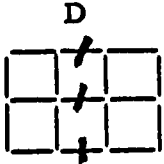
B



C



D



Notice that B and C use the same principle as A in the first example: two matches from a corner and the middle match from the opposite side. In getting really different solutions you apply different principles. Here B and C would not be counted.

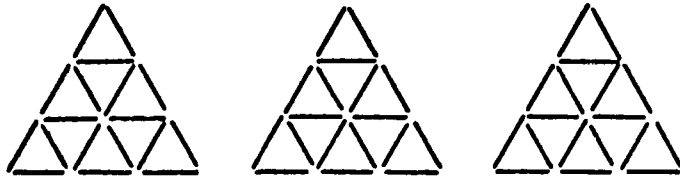
D uses a principle different from that in A, and also meets the rules that all matches remaining are parts of remaining squares, so D is counted as a second acceptable solution.

GO TO THE NEXT PAGE FOR FURTHER INSTRUCTIONS.

MATCH PROBLEMS II (Instructions Continued)

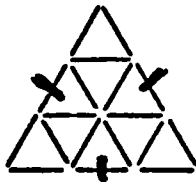
Here is another problem, this time using triangles. Try to find three different solutions.

TAKE AWAY 3 MATCHES
LEAVING 6 TRIANGLES

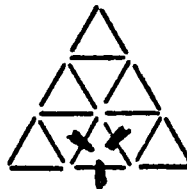


Three solutions are shown below. Notice especially that each solution is in some way a different pattern than the others. All the triangles are complete, no matches being left over.

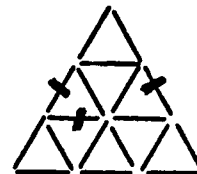
A



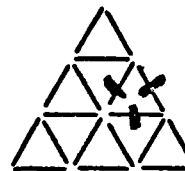
B



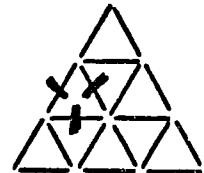
C



Suppose you had given solution B and also



or



You would not be given credit for the additional solution since the pattern is the same as for B. Patterns must be different in order to receive full credit.

There are two parts to this test, with 5 problems in each part. Some problems are based on squares, others on triangles. You are to find three different solutions to each problem. One extra figure is provided for each problem; you may use it in case you think one of your previous solutions is a duplicate or if you make an error. The maximum score on each problem is three points.

You will be allowed 7 minutes per part. Work rapidly. If you have difficulty with one problem, go on to the others and return later if time permits.

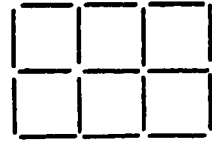
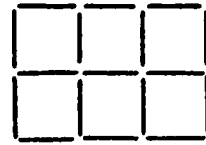
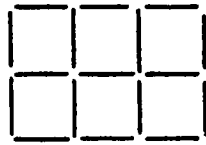
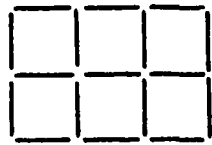
If you have questions, ask them now.

STOP HERE. WAIT FOR FURTHER INSTRUCTIONS.

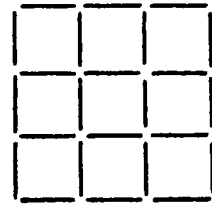
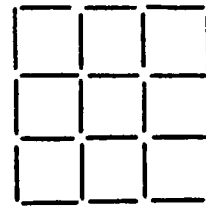
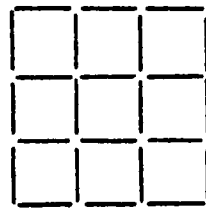
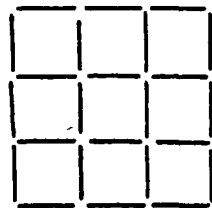
PART I (7 minutes)

GIVE 3 DIFFERENT SOLUTIONS FOR EACH PROBLEM.

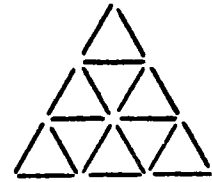
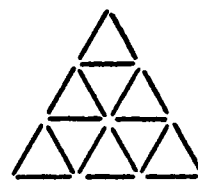
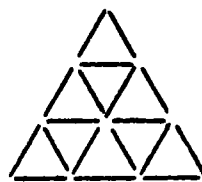
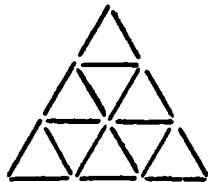
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MATCHES
LEAVING 3
SQUARES



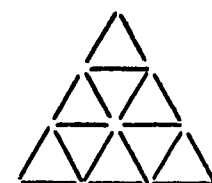
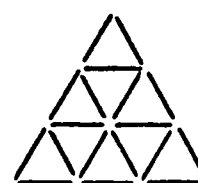
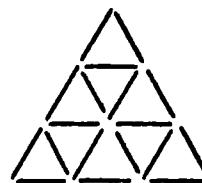
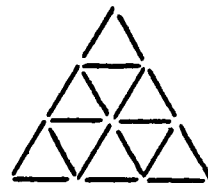
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MATCHES
LEAVING 6
SQUARES



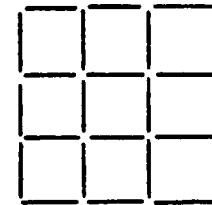
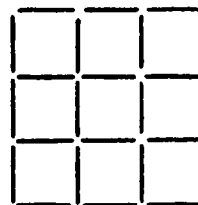
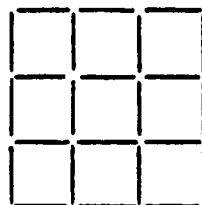
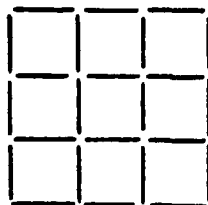
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MATCHES
LEAVING 6
TRIANGLES



4. TAKE AWAY 7
MATCHES
LEAVING 4
TRIANGLES



5. TAKE AWAY 8
MATCHES
LEAVING 5
SQUARES

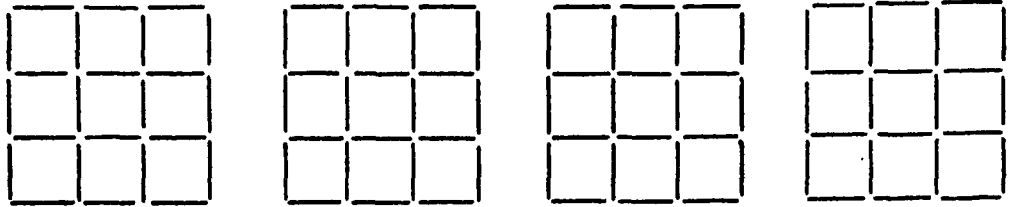


STOP HERE. WAIT FOR FURTHER INSTRUCTIONS.

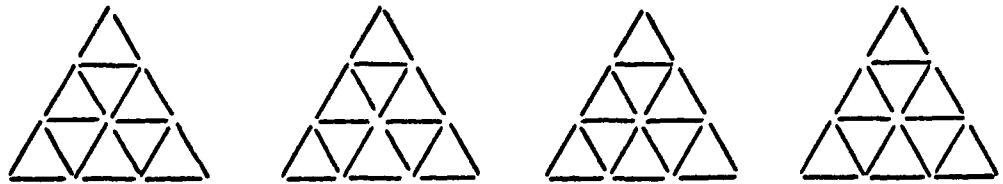
PART II (7 minutes)

GIVE 3 DIFFERENT SOLUTIONS FOR EACH PROBLEM.

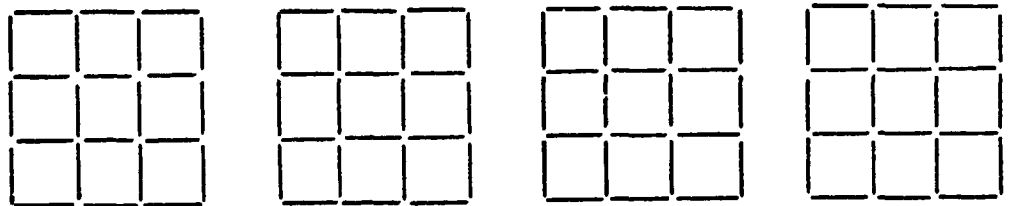
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MATCHES
LEAVING 7
SQUARES



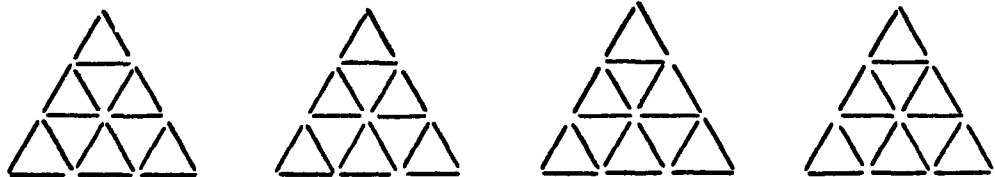
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MATCHES
LEAVING 5
TRIANGLES



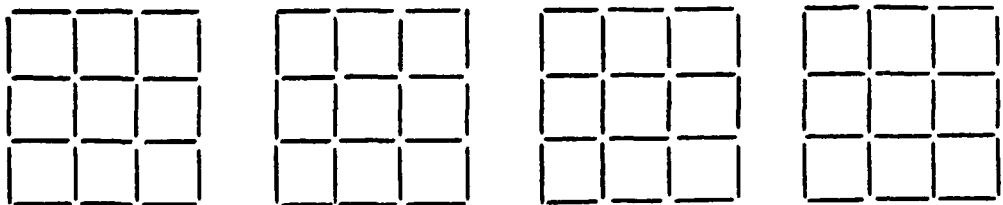
8. TAKE AWAY 5
MATCHES
LEAVING 6
SQUARES



9. TAKE AWAY 8
MATCHES
LEAVING 4
TRIANGLES



10. TAKE AWAY 7
MATCHES
LEAVING 5
SQUARES



STOP HERE. WAIT FOR FURTHER INSTRUCTIONS.

Appendix 7

Eysenck Personality Inventory (Form A)

EYSENCK PERSONALITY INVENTORY

FORM A

By **H. J. Eysenck**
and **Sybil B. G. Eysenck**

Name _____ Age _____ Sex _____

Grade or Occupation _____ Date _____

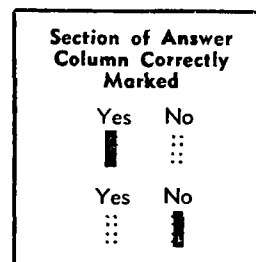
School or Firm _____ Marital Status _____

INSTRUCTIONS

Here are some questions regarding the way you behave, feel and act. After each question is a space for answering "Yes," or "No."

Try and decide whether "Yes," or "No" represents your usual way of acting or feeling. Then blacken in the space under the column headed "Yes" or "No."

Work quickly, and don't spend too much time over any question; we want your first reaction, not a long drawn-out thought process. The whole questionnaire shouldn't take more than a few minutes. Be sure not to omit any questions. Now turn the page over and go ahead. Work quickly, and remember to answer every question. There are no right or wrong answers, and this isn't a test of intelligence or ability, but simply a measure of the way you behave.



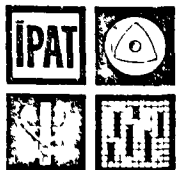
PUBLISHED BY EDUCATIONAL AND INDUSTRIAL TESTING SERVICE
BOX 7234, SAN DIEGO, CALIFORNIA 92107

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- | | | | | |
|---|-----|----|--|--------|
| 1. Do you often long for excitement? | Yes | No | | |
| 2. Do you often need understanding friends to cheer you up? | Yes | No | | |
| 3. Are you usually carefree? | Yes | No | | |
| 4. Do you find it very hard to take no for an answer? . . . | Yes | No | | |
| 5. Do you stop and think things over before doing anything? | Yes | No | | |
| 6. If you say you will do something do you always keep your promise, no matter how inconvenient it might be to do so? | Yes | No | | |
| 7. Does your mood often go up and down? | Yes | No | | |
| 8. Do you generally do and say things quickly without stopping to think? | Yes | No | | |
| 9. Do you ever feel "just miserable" for no good reason? | Yes | No | | |
| 10. Would you do almost anything for a dare? | Yes | No | | |
| 11. Do you suddenly feel shy when you want to talk to an attractive stranger? | Yes | No | | |
| 12. Once in a while do you lose your temper and get angry? | Yes | No | | |
| 13. Do you often do things on the spur of the moment? . . . | Yes | No | | |
| 14. Do you often worry about things you should not have done or said? | Yes | No | | |
| 15. Generally do you prefer reading to meeting people? | Yes | No | | |
| 16. Are your feelings rather easily hurt? | Yes | No | | |
| 17. Do you like going out a lot? | Yes | No | | |
| 18. Do you occasionally have thoughts and ideas that you would not like other people to know about? | Yes | No | | |
| 19. Are you sometimes bubbling over with energy and sometimes very sluggish? | Yes | No | | |
| 20. Do you prefer to have few but special friends? | Yes | No | | |
| 21. Do you daydream a lot? | Yes | No | | |
| 22. When people shout at you, do you shout back? | Yes | No | | |
| 23. Are you often troubled about feelings of guilt? | Yes | No | | |
| 24. Are all your habits good and desirable ones? | Yes | No | | |
| 25. Can you usually let yourself go and enjoy yourself a lot at a gay party? | Yes | No | | |
| 26. Would you call yourself tense or "highly-strung"? | Yes | No | | |
| 27. Do other people think of you as being very lively? | Yes | No | | |
| 28. After you have done something important, do you often come away feeling you could have done better? | Yes | No | | |
| 29. Are you mostly quiet when you are with other people? | Yes | No | | |
| 30. Do you sometimes gossip? | Yes | No | | |
| | | | 31. Do ideas run through your head so that you cannot sleep? | Yes No |
| | | | 32. If there is something you want to know about, would you rather look it up in a book than talk to someone about it? | Yes No |
| | | | 33. Do you get palpitations or thumping in your heart? . . . | Yes No |
| | | | 34. Do you like the kind of work that you need to pay close attention to? | Yes No |
| | | | 35. Do you get attacks of shaking or trembling? | Yes No |
| | | | 36. Would you always declare everything at the customs, even if you knew that you could never be found out? . . . | Yes No |
| | | | 37. Do you hate being with a crowd who play jokes on one another? | Yes No |
| | | | 38. Are you an irritable person? | Yes No |
| | | | 39. Do you like doing things in which you have to act quickly? | Yes No |
| | | | 40. Do you worry about awful things that might happen? . . . | Yes No |
| | | | 41. Are you slow and unhurried in the way you move? | Yes No |
| | | | 42. Have you ever been late for an appointment or work? . . . | Yes No |
| | | | 43. Do you have many nightmares? | Yes No |
| | | | 44. Do you like talking to people so much that you would never miss a chance of talking to a stranger? | Yes No |
| | | | 45. Are you troubled by aches and pains? | Yes No |
| | | | 46. Would you be very unhappy if you could not see lots of people most of the time? | Yes No |
| | | | 47. Would you call yourself a nervous person? | Yes No |
| | | | 48. Of all the people you know are there some whom you definitely do not like? | Yes No |
| | | | 49. Would you say you were fairly self-confident? | Yes No |
| | | | 50. Are you easily hurt when people find fault with you or your work? | Yes No |
| | | | 51. Do you find it hard to really enjoy yourself at a lively party? | Yes No |
| | | | 52. Are you troubled with feelings of inferiority? | Yes No |
| | | | 53. Can you easily get some life into a rather dull party? | Yes No |
| | | | 54. Do you sometimes talk about things you know nothing about? | Yes No |
| | | | 55. Do you worry about your health? | Yes No |
| | | | 56. Do you like playing pranks on others? | Yes No |
| | | | 57. Do you suffer from sleeplessness? | Yes No |

Appendix 8

Cattell's Sixteen Personality Factor Questionnaire



16 PF

WHAT TO DO: Inside this booklet are some questions to see what attitudes and interests you have. There are no "right" and "wrong" answers because everyone has the right to his own views. To be able to get the best advice from your results, you will want to answer them exactly and truly.

If a separate "Answer Sheet" has not been given to you, turn this booklet over and tear off the Answer Sheet on the back page.

Write your name and all other information asked for on the top line of the Answer Sheet.

First you should answer the four sample questions below so that you can see whether you need to ask anything before starting. Although you are to read the questions in this booklet, you must record your answers on the answer sheet (alongside the same number as in the booklet).

There are three possible answers to each question. Read the following examples and mark your answers at the top of your answer sheet where it says "Examples." Fill in the left-hand box if your answer choice is the "a" answer, in the middle box if your answer choice is the "b" answer, and in the right-hand box if you choose the "c" answer.

EXAMPLES:

- | | |
|---|--|
| 1. I like to watch team games.
a. yes, b. occasionally, c. no. | 3. Money cannot bring happiness.
a. yes (true), b. in between, c. no (false). |
| 2. I prefer people who:
a. are reserved,
b. (are) in between,
c. make friends quickly. | 4. Woman is to child as cat is to:
a. kitten, b. dog, c. boy. |

In the last example there *is* a right answer—kitten. But there are very few such reasoning items.

Ask *now* if anything is not clear. The examiner will tell you in a moment to turn the page and start.

When you answer, keep these four points in mind:

1. You are asked not to spend time pondering. Give the first, natural answer as it comes to you. Of course, the questions are too short to give you all the particulars you would sometimes like to have. For instance, the above question asks you about "team games" and you might be fonder of football than basketball. But you are to reply "for the average game," or to strike an average in situations of the kind stated. Give the best answer you can at a rate not slower than five or six a minute. You should finish in a little more than half an hour.
2. Try not to fall back on the middle, "uncertain" answers except when the answer at either end is really impossible for you—perhaps once every four or five questions.
3. Be sure not to skip anything, but answer every question, somehow. Some may not apply to you very well, but give your best guess. Some may seem personal; but remember that the answer sheets are kept confidential and cannot be scored without a special stencil key. Answers to particular questions are not inspected.
4. Answer as honestly as possible what is true of you. Do not merely mark what seems "the right thing to say" to impress the examiner.

DO NOT TURN PAGE UNTIL TOLD TO DO SO

1. I have the instructions for this test clearly in mind.
a. yes, b. uncertain, c. no.
2. I am ready to answer each question as truthfully as possible.
a. yes, b. uncertain, c. no.
3. I would rather have a house:
a. in a sociable suburb,
b. in between,
c. alone in the deep woods.
4. I can find enough energy to face my difficulties.
a. always, b. generally, c. seldom.
5. I feel a bit nervous of wild animals even when they are in strong cages.
a. yes (true), b. uncertain, c. no (false).
6. I hold back from criticizing people and their ideas.
a. yes, b. sometimes, c. no.
7. I make smart, sarcastic remarks to people if I think they deserve it.
a. generally, b. sometimes, c. never.
8. I prefer semiclassical music to popular tunes.
a. true, b. uncertain, c. false.
9. If I saw two neighbors' children fighting, I would:
a. leave them to settle it,
b. uncertain,
c. reason with them.
10. On social occasions I:
a. readily come forward,
b. in between,
c. prefer to stay quietly in the background.
11. It would be more interesting to be:
a. a construction engineer,
b. uncertain,
c. a writer of plays.
12. I would rather stop in the street to watch an artist painting than listen to some people having a quarrel.
a. true, b. uncertain, c. false.
13. I can generally put up with conceited people, even though they brag or show they think too well of themselves.
a. yes, b. in between, c. no.
14. You can almost always notice on a man's face when he is dishonest.
a. yes, b. in between, c. no.
15. It would be good for everyone if vacations (holidays) were longer and everyone *had* to take them.
a. agree, b. uncertain, c. disagree.
16. I would rather take the gamble of a job with possibly large but uneven earnings, than one with a steady, small salary.
a. yes, b. uncertain, c. no.
17. I talk about my feelings:
a. only if necessary,
b. in between,
c. readily, whenever I have a chance.
18. Once in a while I have a sense of vague danger or sudden dread for reasons that I do not understand.
a. yes, b. in between, c. no.
19. When criticized wrongly for something I did *not* do, I:
a. have no feeling of guilt,
b. in between,
c. still feel a bit guilty.
20. Money can buy almost everything.
a. yes, b. uncertain, c. no.
21. My decisions are governed more by my:
a. heart,
b. feelings and reason equally,
c. head.
22. Most people would be happier if they lived more with their fellows and did the same things as others.
a. yes, b. in between, c. no.
23. I occasionally get puzzled, when looking in a mirror, as to which is my right and left.
a. true, b. uncertain, c. false.
24. When talking, I like:
a. to say things, just as they occur to me,
b. in between,
c. to get my thoughts well organized first.
25. When something really makes me furious, I find I calm down again quite quickly.
a. yes, b. in between, c. no.

(End, column 1 on answer sheet.)

6. With the same hours and pay, it would be more interesting to be:
 a. a carpenter or cook,
 b. uncertain,
 c. a waiter in a good restaurant.
7. I have been elected to:
 a. only a few offices,
 b. several,
 c. many offices.
8. "Spade" is to "dig" as "knife" is to:
 a. sharp, b. cut, c. point.
9. I sometimes can't get to sleep because an idea keeps running through my mind.
 a. true, b. uncertain, c. false.
10. In my personal life I reach the goals I set, almost all the time.
 a. true, b. uncertain, c. false.
11. An out-dated law should be changed:
 a. only after considerable discussion,
 b. in between,
 c. promptly.
12. I am uncomfortable when I work on a project requiring quick action affecting others.
 a. true, b. in between, c. false.
13. Most of the people I know would rate me as an amusing talker.
 a. yes, b. uncertain, c. no.
14. When I see "sloppy," untidy people, I:
 a. just accept it,
 b. in between,
 c. get disgusted and annoyed.
15. I get slightly embarrassed if I suddenly become the focus of attention in a social group.
 a. yes, b. in between, c. no.
16. I am always glad to join a large gathering, for example, a party, dance, or public meeting.
 a. yes, b. in between, c. no.
17. In school I preferred (or prefer) :
 a. music,
 b. uncertain,
 c. handwork and crafts.
18. When I have been put in charge of something, I insist that my instructions are followed or else I resign.
 a. yes, b. sometimes, c. no.
39. For parents, it is more important to:
 a. help their children develop their affections,
 b. in between,
 c. teach their children how to control emotions.
40. In a group task I would rather:
 a. try to improve arrangements,
 b. in between,
 c. keep the records and see that rules are followed.
41. I feel a need every now and then to engage in a tough physical activity.
 a. yes, b. in between, c. no.
42. I would rather mix with polite people than rough, rebellious individuals.
 a. yes, b. in between, c. no.
43. I feel terribly dejected when people criticize me in a group.
 a. true, b. in between, c. false.
44. If I am called in by my boss, I:
 a. make it a chance to ask for something I want,
 b. in between,
 c. fear I've done something wrong.
45. What this world needs is:
 a. more steady and "solid" citizens,
 b. uncertain,
 c. more "idealists" with plans for a better world.
46. I am always keenly aware of attempts at propaganda in things I read.
 a. yes, b. uncertain, c. no.
47. As a teenager, I joined in school sports:
 a. occasionally,
 b. fairly often,
 c. a great deal.
48. I keep my room well organized, with things in known places almost all the time.
 a. yes, b. in between, c. no.
49. I sometimes get in a state of tension and turmoil as I think of the day's happenings.
 a. yes, b. in between, c. no.
50. I sometimes doubt whether people I am talking to are really interested in what I am saying.
 a. yes, b. in between, c. no.

(End, column 2 on answer sheet.)

51. If I had to choose, I would rather be:
 a. a forester,
 b. uncertain,
 c. a high school teacher.
52. For special holidays and birthdays, I:
 a. like to give personal presents,
 b. uncertain,
 c. feel that buying presents is a bit of a nuisance.
53. "Tired" is to "work" as "proud" is to:
 a. smile, b. success, c. happy.
54. Which of the following items is different in kind from the others?
 a. candle, b. moon, c. electric light.
55. I have been let down by my friends:
 a. hardly ever,
 b. occasionally,
 c. quite a lot.
56. I have some characteristics in which I feel definitely superior to most people.
 a. yes, b. uncertain, c. no.
57. When I get upset, I try hard to hide my feelings from others.
 a. true, b. in between, c. false.
58. I like to go out to a show or entertainment:
 a. more than once a week (more than average),
 b. about once a week (average),
 c. less than once a week (less than average).
59. I think that plenty of freedom is more important than good manners and respect for the law.
 a. true, b. uncertain, c. false.
60. I tend to keep quiet in the presence of senior persons (people of greater experience, age, or rank).
 a. yes, b. in between, c. no.
61. I find it hard to address or recite to a large group.
 a. yes, b. in between, c. no.
62. I have a good sense of direction (find it easy to tell which is North, South, East, or West) when in a strange place.
 a. yes, b. in between, c. no.
63. If someone got mad at me, I would:
 a. try to calm him down,
 b. uncertain,
 c. get irritated.
64. When I read an unfair magazine article, I am more inclined to forget it than to feel like "hitting back."
 a. true, b. uncertain, c. false.
65. My memory tends to drop a lot of unimportant, trivial things, for example, names of streets or stores in town.
 a. yes, b. in between, c. no.
66. I could enjoy the life of an animal doctor, handling disease and surgery of animals.
 a. yes, b. in between, c. no.
67. I eat my food with gusto, not always so carefully and properly as some people.
 a. true, b. uncertain, c. false.
68. There are times when I don't feel in the right mood to see anyone.
 a. very rarely,
 b. in between,
 c. quite often.
69. People sometimes warn me that I show my excitement in voice and manner too obviously.
 a. yes, b. in between, c. no.
70. As a teenager, if I differed in opinion from my parents, I usually:
 a. kept my own opinion,
 b. in between,
 c. accepted their authority.
71. I would prefer to have an office of my own, not sharing it with another person.
 a. yes, b. uncertain, c. no.
72. I would rather enjoy life quietly in my own way than be admired for my achievements.
 a. true, b. uncertain, c. false.
73. I feel mature in most things.
 a. true, b. uncertain, c. false.
74. I find myself upset rather than helped by the kind of criticism that many people offer one.
 a. often, b. occasionally, c. never.
75. I am always able to keep the expression of my feelings under exact control.
 a. yes, b. in between, c. no.

(End, column 3 on answer sheet.)

76. In starting a useful invention, I would prefer:
 a. working on it in the laboratory,
 b. uncertain,
 c. selling it to people.
77. "Surprise" is to "strange" as "fear" is to:
 a. brave, b. anxious, c. terrible.
78. Which of the following fractions is not in the same class as the others?
 a. $\frac{3}{7}$, b. $\frac{3}{9}$, c. $\frac{3}{11}$.
79. Some people seem to ignore or avoid me, although I don't know why.
 a. true, b. uncertain, c. false.
80. People treat me less reasonably than my good intentions deserve.
 a. often, b. occasionally, c. never.
81. The use of foul language, even when it is not in a mixed group of men and women, still disgusts me.
 a. yes, b. in between, c. no.
82. I have decidedly fewer friends than most people.
 a. yes, b. in between, c. no.
83. I would hate to be where there wouldn't be a lot of people to talk to.
 a. true, b. uncertain, c. false.
84. People sometimes call me careless, even though they think I'm a likable person.
 a. yes, b. in between, c. no.
85. "Stage-fright" in various social situations is something I have experienced:
 a. quite often,
 b. occasionally,
 c. hardly ever.
86. When I am in a small group, I am content to sit back and let others do most of the talking.
 a. yes, b. in between, c. no.
87. I prefer reading:
 a. a realistic account of military or political battles,
 b. uncertain,
 c. a sensitive, imaginative novel.
88. When bossy people try to "push me around," I do just the opposite of what they wish.
 a. yes, b. in between, c. no.
89. Business superiors or members of my family, as a rule, find fault with me only when there is real cause.
 a. true, b. in between, c. false.
90. In streets or stores, I dislike the way some persons stare at people.
 a. yes, b. in between, c. no.
91. On a long journey, I would prefer to:
 a. read something profound, but interesting,
 b. uncertain,
 c. pass the time talking casually with a fellow passenger.
92. In a situation which may become dangerous, I believe in making a fuss and speaking up even if calmness and politeness are lost.
 a. yes, b. in between, c. no.
93. If acquaintances treat me badly and show they dislike me:
 a. it doesn't upset me a bit,
 b. in between,
 c. I tend to get downhearted.
94. I find it embarrassing to have praise or compliments bestowed on me.
 a. yes, b. in between, c. no.
95. I would rather have a job with:
 a. a fixed, certain salary,
 b. in between,
 c. a larger salary, which depended on my constantly persuading people I am worth it.
96. To keep informed, I like:
 a. to discuss issues with people,
 b. in between,
 c. to rely on the actual news reports.
97. I like to take an active part in social affairs, committee work, etc.
 a. yes, b. in between, c. no.
98. In carrying out a task, I am not satisfied unless even the minor details are given close attention.
 a. true, b. in between, c. false.
99. Quite small setbacks occasionally irritate me too much.
 a. yes, b. in between, c. no.
100. I am always a sound sleeper, never walking or talking in my sleep.
 a. yes, b. in between, c. no.

(End, column 4 on answer sheet.)

101. It would be more interesting to work in a business:
 a. talking to customers,
 b. in between,
 c. keeping office accounts and records.
102. "Size" is to "length" as "dishonest" is to:
 a. prison, b. sin, c. stealing.
103. AB is to dc as SR is to:
 a. qp, b. pq, c. tu.
104. When people are unreasonable, I just:
 a. keep quiet,
 b. uncertain,
 c. despise them.
105. If people talk loudly while I am listening to music, I:
 a. can keep my mind on the music and not be bothered,
 b. in between,
 c. find it spoils my enjoyment and annoys me.
106. I think I am better described as:
 a. polite and quiet,
 b. in between,
 c. forceful.
107. I attend social functions only when I have to, and stay away any other time.
 a. yes, b. uncertain, c. no.
108. To be cautious and expect little is better than to be happy at heart, always expecting success.
 a. true, b. uncertain, c. false.
109. In thinking of difficulties in my work, I:
 a. try to plan ahead, before I meet them,
 b. in between,
 c. assume I can handle them when they come.
110. I find it easy to mingle among people at a social gathering.
 a. true, b. uncertain, c. false.
111. When a bit of diplomacy and persuasion are needed to get people moving, I am generally the one asked to do it.
 a. yes, b. in between, c. no.
112. It would be more interesting to be:
 a. a guidance worker helping young people find jobs,
 b. uncertain,
 c. a manager in efficiency engineering.
113. If I am quite sure that a person is unjust or behaving selfishly, I show him up, even if it takes some trouble.
 a. yes, b. in between, c. no.
114. I sometimes make foolish remarks in fun, just to surprise people and see what they will say.
 a. yes, b. in between, c. no.
115. I would enjoy being a newspaper writer on drama, concerts, opera, etc.
 a. yes, b. uncertain, c. no.
116. I never feel the urge to doodle and fidget when kept sitting still at a meeting.
 a. true, b. uncertain, c. false.
117. If someone tells me something which I know is wrong, I am more likely to say to myself:
 a. "He is a liar,"
 b. in between,
 c. "Apparently he is misinformed."
118. I feel some punishment is coming to me even when I have done nothing wrong.
 a. often, b. occasionally, c. never.
119. The idea that sickness comes as much from mental as physical causes is much exaggerated.
 a. yes, b. in between, c. no.
120. The pomp and splendor of any big state ceremony are things which should be preserved.
 a. yes, b. in between, c. no.
121. It bothers me if people think I am being too unconventional or odd.
 a. a lot, b. somewhat, c. not at all.
122. In constructing something I would rather work:
 a. with a committee,
 b. uncertain,
 c. on my own.
123. I have periods when it's hard to stop a mood of self-pity.
 a. often, b. occasionally, c. never.
124. Often I get angry with people too quickly.
 a. yes, b. in between, c. no.
125. I can always change old habits without difficulty and without slipping back.
 a. yes, b. in between, c. no.

(End, column 5 on answer sheet.)

126. If the earnings were the same, I would rather be:
a. a lawyer,
b. uncertain,
c. a navigator or pilot.
127. "Better" is to "worst" as "slower" is to:
a. fast, b. best, c. quickest.
128. Which of the following should come next at the end of this row of letters: xooooxooooxxx?
a. oxxx, b. ooxx, c. xooo.
129. When the time comes for something I have planned and looked forward to, I occasionally do not feel up to going.
a. true, b. in between, c. false.
130. I can work carefully on most things without being bothered by people making a lot of noise around me.
a. yes, b. in between, c. no.
131. I occasionally tell strangers things that seem to me important, regardless of whether they ask about them.
a. yes, b. in between, c. no.
132. I spend much of my spare time talking with friends about social events enjoyed in the past.
a. yes, b. in between, c. no.
133. I enjoy doing "daring," foolhardy things "just for fun."
a. yes, b. in between, c. no.
134. I find the sight of an untidy room very annoying.
a. yes, b. in between, c. no.
135. I consider myself a very sociable, outgoing person.
a. yes, b. in between, c. no.
136. In social contacts I:
a. show my emotions as I wish,
b. in between,
c. keep my emotions to myself.
137. I enjoy music that is:
a. light, dry, and brisk,
b. in between,
c. emotional and sentimental.
138. I admire the beauty of a poem more than that of a well-made gun.
a. yes, b. uncertain, c. no.
139. If a good remark of mine is passed by, I:
a. let it go,
b. in between,
c. give people a chance to hear it again.
140. I would like to work as a probation officer with criminals on parole.
a. yes, b. in between, c. no.
141. One should be careful about mixing with all kinds of strangers, since there are dangers of infection and so on.
a. yes, b. uncertain, c. no.
142. In traveling abroad, I would rather go on an expertly conducted tour than plan by myself the places I wish to visit.
a. yes, b. uncertain, c. no.
143. I am properly regarded as only a plodding, half-successful person.
a. yes, b. uncertain, c. no.
144. If people take advantage of my friendliness, I do not resent it and I soon forget.
a. true, b. uncertain, c. false.
145. If a heated argument developed between other members taking part in a group discussion, I would:
a. like to see a "winner,"
b. in between,
c. wish that it would be smoothed over.
146. I like to do my planning alone, without interruptions and suggestions from others.
a. yes, b. in between, c. no.
147. I sometimes let my actions get swayed by feelings of jealousy.
a. yes, b. in between, c. no.
148. I believe firmly "the boss may not always be right, but he always has the right to be boss."
a. yes, b. uncertain, c. no.
149. I get tense as I think of all the things lying ahead of me.
a. yes, b. sometimes, c. no.
150. If people shout suggestions when I'm playing a game, it doesn't upset me.
a. true, b. uncertain, c. false.

(End, column 6 on answer sheet.)

151. It would be more interesting to be:
 a. an artist,
 b. uncertain,
 c. a secretary running a club.
152. Which of the following words does not properly belong with the others?
 a. any, b. some, c. most.
153. "Flame" is to "heat" as "rose" is to:
 a. thorn, b. red petals, c. scent.
154. I have vivid dreams, disturbing my sleep.
 a. often,
 b. occasionally,
 c. practically never.
155. If the odds are really against something's being a success, I still believe in taking the risk.
 a. yes, b. in between, c. no.
156. I like it when I know so well what the group has to do that I naturally become the one in command.
 a. yes, b. in between, c. no.
157. I would rather dress with quiet correctness than with eye-catching personal style.
 a. true, b. uncertain, c. false.
158. An evening with a quiet hobby appeals to me more than a lively party.
 a. true, b. uncertain, c. false.
159. I close my mind to well-meant suggestions of others, even though I know I shouldn't.
 a. occasionally, b. hardly ever, c. never.
160. I always make it a point, in deciding anything, to refer to basic rules of right and wrong.
 a. yes, b. in between, c. no.
161. I somewhat dislike having a group watch me at work.
 a. yes, b. in between, c. no.
162. Because it is not always possible to get things done by gradual, reasonable methods, it is sometimes necessary to use force.
 a. true, b. in between, c. false.
163. In school I preferred (or prefer):
 a. English,
 b. uncertain,
 c. mathematics or arithmetic.
164. I have sometimes been troubled by people's saying bad things about me behind my back, with no grounds at all.
 a. yes, b. uncertain, c. no.
165. Talk with ordinary, habit-bound, conventional people:
 a. is often quite interesting and has a lot to it,
 b. in between,
 c. annoys me because it deals with trifles and lacks depth.
166. Some things make me so angry that I find it best not to speak.
 a. yes, b. in between, c. no.
167. In education, it is more important to:
 a. give the child enough affection,
 b. in between,
 c. have the child learn desirable habits and attitudes.
168. People regard me as a solid, undisturbed person, unmoved by ups and downs in circumstances.
 a. yes, b. in between, c. no.
169. I think society should let reason lead it to new customs and throw aside old habits or mere traditions.
 a. yes, b. in between, c. no.
170. I think it is more important in the modern world to solve:
 a. the question of moral purpose,
 b. uncertain,
 c. the political difficulties.
171. I learn better by:
 a. reading a well-written book,
 b. in between,
 c. joining a group discussion.
172. I like to go my own way instead of acting on approved rules.
 a. true, b. uncertain, c. false.
173. I like to wait till I am sure that what I am saying is correct, before I put forth an argument.
 a. always,
 b. generally,
 c. only if it's practicable.
174. Small things sometimes "get on my nerves" unbearably, though I realize they are trivial.
 a. yes, b. in between, c. no.
175. I don't often say things on the spur of the moment that I greatly regret.
 a. true, b. uncertain, c. false.

(End, column 7 on answer sheet.)

176. If asked to work with a charity drive, I would
a. accept,
b. uncertain,
c. politely say I'm too busy.
177. Which of the following words does not belong with the others?
a. wide, b. zigzag, c. straight.
178. "Soon" is to "never" as "near" is to:
a. nowhere, b. far, c. away.
179. If I make an awkward social mistake, I can soon forget it.
a. yes, b. in between, c. no.
180. I am known as an "idea man" who almost always puts forward some ideas on a problem.
a. yes, b. in between, c. no.
181. I think I am better at showing:
a. nerve in meeting challenges,
b. uncertain,
c. tolerance of other people's wishes.
182. I am considered a very enthusiastic person.
a. yes, b. in between, c. no.
183. I like a job that offers change, variety, and travel, even if it involves some danger.
a. yes, b. in between, c. no.
184. I am a fairly strict person, insisting on always doing things as correctly as possible.
a. true, b. in between, c. false.
185. I enjoy work that requires conscientious, exacting skills.
a. yes, b. in between, c. no.
186. I'm the energetic type who keeps busy.
a. yes, b. uncertain, c. no.
187. I am sure there are no questions that I have skipped or failed to answer properly.
a. yes, b. uncertain, c. no.

(End of test.)