The Structure of Intellect Theory: Implications for More Meaningful Mental Test Interpretations

Patricia Chisholm

Loyola University Chicago

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THE STRUCTURE OF INTELLECT THEORY - IMPLICATIONS FOR MORE MEANINGFUL MENTAL TEST INTERPRETATIONS

by

Patricia Chisholm

Submitted to the Graduate School of Loyola University in partial fulfillment of the requirements for the degree of Doctor of Philosophy

Chicago, Illinois
June, 1970
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INTRODUCTION

Divisive conditions abound in most of our present social structures. Abuse and uncontrolled application have undermined the benefits of many modern developments. We stand at the threshold of space. The moon is but the first step in the exploration of the galaxies, a feat made possible through developments in scientific technology. Yet scientific technology is advancing at a pace that threatens the continuation of civilization. Modern man can be eyewitness to any world event. Developments in transcommunication have made the world a closer unit by overcoming geographic distances. Yet the world is faced with an acute sociopolitical schism. Material goods have never been more available. Creature comforts and gross national products have reached undreamed of proportions. Yet our large cities show unmistakable signs of poverty, pollution, and decay.

More knowledge has been acquired than ever thought possible. More people have more opportunity for education and learning than ever before. Billions of dollars have been poured into educational facilities. Yet national evaluations of such researchers as Coleman (1968, 1969) and Jensen (1969) indicate that our schools are not functioning adequately. Under-educated individuals and untrained dropouts abound. Conservation of natural resources, control and direction of technological developments, more breadth and depth in understanding and more effective use of knowledge are critical needs.

The divisive conditions, so prevalent in most of our social structures, are
well entrenched in the field of behavioral science, particularly in the area of intellectual behavior. For the past seventy years, scientists studying the nature of intelligence have amassed more empirical information than in the preceding 1700 years. Their studies have been marked by an increasing awareness of the complexity of mental processes and the identification of numerous factors involved. Yet many contemporary views perpetuate the old concept that mind is simplicity itself, that it can be understood and described in unitary terms.

Scientists in other fields have gathered data, tried to find relationships and agreed upon preliminary generalizations. Behavioral scientists have gathered data but little synthesis has been attempted. The scientists themselves cannot reach a consensus in defining what they seek, much less in agreeing upon preliminary generalizations. Scientists in other fields have organized insights around conceptual frameworks. Behavioral scientists have made but few attempts to supply comprehensive, structural foundations. Scientists in other fields have specified the nature of what their experiments and tests have measured. Disagreements among behavioral scientists have been marked enough to cause the public to adopt the attitude that no one really seems to know what psychological tests measure (McNemar, 1964; Columbia Encyclopedia, 1967).

Never before have so many psychological tests been developed. Yet the antitest critics of the past few years (Gross, 1962; Hoffman, 1962; Black, 1963; Brenton, 1964) have strengthened public skepticism of mental testing. Never before have so many psychological tests been administered. An estimated one hundred million ability tests were used in 1961 (Goslin, 1963). Yet antitesting attitudes are
Evidence from two national opinion surveys dealing with 10,000 high school students (Goslin and Glass, 1967) and 1,500 adults (Brim, 1965) reveal widespread and large-scale antitesting attitudes. Strong feelings range from invasion of privacy to their being culturally unfair. Education and industry are using psychological tests in unprecedented numbers. Yet the general feeling is one of distrust, doubt and antagonism.

We live in an age that demands trained and educated persons. In an increasingly technological society, understanding, evaluating, and utilizing natural resources is crucial. Man's greatest natural resource is his intellectual ability. If man is to overcome divisive social conditions, he must learn to identify, evaluate and channel mental energies in a more effective manner. If civilization is to survive the nuclear age, man must learn more about the nature of intelligence and its evaluation.
CHAPTER I
PROBLEM, PURPOSE AND PROCEDURES

Background

The study of man's behavior has been fraught with controversy since its very beginning. Although psychology emerged as a separate science through combinations of physiology, physics and philosophy, certain prerequisite conditions had to be fulfilled prior to its independence. As psychology began to develop as an independent science in the late 19th century, it inherited problems which had originated in the parent sciences. Problems of metaphysics and epistemology which had caused controversy in philosophy were transmitted to psychology. Problems of individual differences, evolution and heredity which had caused controversy in biology and genetics were perpetuated in psychology. In the process of its own development, psychology generated problems concerned with empirical requirements and scientific method. The area of psychology which dealt with mental measurement gave birth to problems of objectivity, bias, quantification, and environmental influences. The problem of intelligence and its measurement is a complex and controversial one. Controversy can be discerned between psychology and other sciences, within the various areas of psychology, and with its understanding and acceptance by the layman.

Originally, astronomy, physics, chemistry and biology were considered branches of philosophy. As temporal conditions changed, more empirical investigation of phenomena was possible and these sciences became less philosophical and
speculative. Eventually they broke away from philosophy and became independent sciences. Conditions which existed during the late 19th Century were favorable for psychology to gain its independence. Jenkins and Paterson (1961) note three prerequisite conditions:

1) a breaking down of the fixed belief that the "mind" was beyond measurement, followed by the development of methods of measurement;
2) a concern with individuals, as distinct from the search for general laws;
3) the invention of statistical tools for describing, relating, and interpreting measurements, once they were obtained (1961, p. vi).

The first prerequisite was met when the early German experimenters broke through the barriers which had separated the mental from the physical and established psychophysics. They studied the relationship of mental processes to physical events; their concern was sensation and perception. The second prerequisite was met by the birth of those social and political theories which stressed the importance of the individual for what he was. Darwin's theory of evolution added to the significance of individual variability. The third prerequisite was met by the emergence of philosophies which stressed the mathematical formulation of logic, the philosophical study of the bases of mathematics, scientific method and the rapid advance of natural science. Statisticians devised formulae to describe populations and relationships among distributions of criteria in selected populations.

Inherited problems

Among the inherited problems of psychology can be seen problems which had arisen earlier in philosophy and science. From philosophy, psychology inherited the metaphysical problem of mind-body and epistemological problems of perception and reaction time. From science, psychology inherited problems concerned with individual
differences, statistics, evolution, heredity and genetics.

The mind-body problem has existed in philosophy for some time. Plato believed that the mind alone was the source of knowledge. Aristotle was a dualist; he felt that sensations were the source of knowledge. His concept that there was nothing in the mind which was not first somehow in the senses persisted generally through the Middle Ages. From the time of Descartes in the 17th Century through current philosophies, there has been a stream of controversy regarding the mind-body problem. Psychological ideas of the present still contain certain influences of differing metaphysical attitudes. Presently, there is no generally accepted view, nor are there any scientific methods by which a consensus might be reached. It is important to note however, that intelligence cannot be fully comprehended nor fully explained in empirical terms alone. The trend in psychology has been to limit the field of study to that which can be known about behavior through sense experience and which can be observed in experimental or observational conditions. The psychological study of human behavior, then, is centered on those aspects which may be known and verified through sense perception.

The early 19th Century physiologists were concerned with the relationship between the physical qualities of stimuli and the produced sensations, with the physiological processes and perception. Sense physiology contributed considerable impetus to the development of psychology as a separate science. Sense physiology, however, had certain problems in common with philosophy - the problems of epistemology: the origin, nature, structure, methods, validity and limits of knowledge. In addition to being a beneficial influence on psychology, physiology contributed a few problems.
Perception was no more concrete nor observable than mind. Here also, there is no generally accepted view; there is no scientific method by which a decision may be reached. Numerous psychological controversies have involved the relationship of physical traits to mental traits.

The reaction time problem has epistemological implications. The first systematic observation and measurement of individual differences was occasioned by an incident which took place at the Greenwich Observatory (Anastasi, 1965). Attention was directed to differences in the reaction time among individuals. An astronomer named Bessel became interested in measuring what he called the "personal equation" of different astronomical observers. He collected data on several trained observers and concluded that there was not only a personal equation involved, but also a considerable variability in the equation of the same individuals when observed at different times. Bessel's study anticipates the reaction time studies of early psychologists, who believed that the quicker the reaction the higher the intelligence. The reaction time problem indicates the present related problems in psychology concerning variability among observers. The notion that the quicker the reaction time the higher the intelligence has not died. John Ertl, a doctoral candidate at the University of Ottawa, has put together a machine which records and photographs the brain's reactions to a stimulus. The stimulus is a light which is flashed in the subject's eyes. Electrodes attached to the head transmit the stimulus. The photograph comes out in the form of a graph. Study of the lines is supposed to indicate the subject's intelligence. The speed at which the lines appear indicates the quickness of the brain's reaction and its rate of intelligence. His research has been funded by the Ontario
Mental Health Foundation, the Federal Research Council, and recently a $414,400 Ford Foundation Grant made to the Educational Records Bureau (Chicago Tribune, July 4, 1967; Time magazine, July 1967).

Biology made a considerable contribution to the development of psychology. As a science, biology made rapid strides during the latter part of the 19th Century; Darwin's theory of evolution was largely responsible. Darwin amassed a large body of data on animal behavior; ultimately this led to the highly controlled studies of animals conducted by psychologists during the 20th Century. Many psychological problems may be traced to the animal studies. While they have undoubtedly contributed a sizeable amount of information to psychology, the crucial question pertains to the degree of applicability to human behavior.

Darwin's theory stressed the concept of adaptability of the organism to adjust to its environment. Survival of the organism was dependent upon its degree of adjustment. The concern with adjustment to the environment can be discerned in both early and later psychological problems. The initial ferment that the theory of evolution caused led to Galton's application of the theory to humans. Galton's concern with individual differences and the statistical procedures needed to deal with his accumulations of data gave impetus to the development of mental testing. In a later stage in psychology, the influence of adjustment to the environment can be identified with those problems in defining intelligence and with presumptions underlying certain concepts of educational psychology in the United States.

Galton's interest in heredity led to his attempt to show the inheritance of specific mental abilities. The nature-nature problems in psychology have been another
source of disagreement. Heredity was originally considered to be the predominant influence on intelligence. In the early part of the 20th Century, the general idea developed among psychologists concerned with the measurement of intelligence; the idea was that intelligence was genetically fixed - and remained fixed throughout life. Closely related to this concept was the belief of many psychologists in predetermination. They maintained that behavioral development would automatically unfold with the maturation of the anatomical structure of the organism. The various definitions of intelligence promulgated by psychologists during the 1920's and 1930's reflect these assumptions. The influence on the development of intelligence testing is most important. The majority of standard instruments, many of which are still in use, were developed when these assumptions were prevalent.

During the latter part of the 1930's environment was considered to be the predominant influence on intelligence. "Perhaps the most widely known controversy to be found in psychology was over this very issue" (Stott and Ball, 1965, p. 9). For the next ten years the battle raged. At the present time, extreme views have been modified. It is generally agreed that both environment and heredity contribute to the development of intelligence. (This point shall be expanded in later chapters.)

Genetics contributed to both knowledge and controversy in psychology. Mendel's laws of heredity were rediscovered in 1900; these eventually led to concentrated experiments concerned with the mechanisms of heredity. An important body of current knowledge about genetics will have considerable impact on future concepts of intelligence and its measurement. Hopefully, this recent empirical evidence from the field of biochemistry will serve to end some psychological controversies.
Problems related to psychology

A second body of problems relate to psychology as an empirical science. Psychology has the same empirical requirements of control, quantification, objectivity and simplicity as do other sciences. The fact that the subject of psychology is the behavior of living organisms complicates matters considerably. Marx and Hillex (1963) define psychology as that "science which studies relationships between antecedent events or conditions and consequent behavior of organism" (1963, p. 32). Admitting that the definition may appear to be broad, they claim that the field of psychology is broad; there are varying degrees of overlap into other fields. The "tools" of science are drawn from logic and mathematics. The overlap in psychology may be seen in one direction toward the physical and biological sciences, and in another direction toward the social sciences.

The need for control is most essential to an empirical science. The potential degree of control has certain limitations when applied to human behavior. For example, if a psychologist wished to study the relationship of human perception to its dependence on early visual experience, the ideal situation would demand a large supply of babies, who could be deprived of visual stimulation for varying amounts of time during their developmental periods. Obviously, this is an impossibility in an enlightened civilization. The fact is that man does not merely sense the external stimuli, he interprets them as well. The human subject brings with him to the experiment certain previous experiences which cannot be completely controlled.

Another instance can be seen with regard to the problems of studying heredity. If a psychologist wished to study the genetic transmission of memory among humans,
the ideal situation would call for selective breeding among generations of specially
trained subjects. While such control may be possible with generations of rats, the
same manipulation defies such control when applied to humans. There are numerous
problems of control in the study of human behavior. The psychologist cannot always
achieve ideal control, he can only hope to approximate a degree of control.

The empirical requirement of quantification calls for the application of
mathematics and logic to the testable problem. Both mathematics and logic are
essentially abstract, symbolic systems; they assume significance only when applied
to empirical problems which have previously been precisely defined. Due to the
nature of the problems with which psychology deals, it is necessary to use more
limited mathematical systems than those which are employed in some of the other
sciences. As Marx and Hillex (1963) point out, the subject matter of psychology is
concerned with probabilities that are "assessed with statistics that may or may not
be appropriate" (1963, p. 39). They also caution that the subject matter of psychology
may not lend itself to traditional measures and traditional mathematics; they anticipate
the need for different symbolic systems. The psychologist must constantly remember
that psychological measurement can be assigned no meaning beyond the operations that
are performed.

In view of the fact that psychology is quite obviously in need of clarification
and precision, the needs for quantification are stressed. Marx and Hillex (1963)
believe that "quantification has two advantages: mathematical statements are precise
and clear, and the richness of deductive possibilities is greatly increased when
dimensions are quantified" (1963, p. 39). This directs attention to the fact that many
more psychologists will need to develop sophistication in utilizing the mathematics and logic which are necessary to develop appropriate systems, or to coordinate the existing systems and thereby obtain more certitude.

Empirical science demands objectivity. Socrates claimed that the proper study of mankind was the study of man. It might be well noted that the empirical study of man, by man, demands an objectivity that is hard to come by. It is undoubtedly more difficult for the psychological scientist to be unbiased in his attitude toward his subject matter than it is for other scientists in other fields of inquiry. The observer identifies with his subject by virtue of their common humanity; there is a tendency to interpret the observation in terms of the observer's experience; this experience may or may not be true for the subject.

If complexity is defined as "the number of interacting variables that are effective in the determination of some consequence" (Marx and Hillex, 1963, p. 40), then the degree of complexity concerning human behavior becomes quite large. Thus, there are certain ways in which the subject matter of psychology is more complex than the subject matter of other sciences and therefore presents problems of more difficulty. Psychology has the same demands of other empirical sciences, but the nature of the subject matter of psychology tends to exaggerate these problems.

Problems peculiar to mental measurement

The problem most peculiar to mental measurement pertains to the fact that the subject of mental measurement, intelligence, may not be appraised directly. It may only be inferred through the behavior of the subject. According to Anastasi (1964), "a psychological test is essentially an objective and standardized measure of a sample
of behavior" (1964, p. 21). The significant words are "sample," "standardized," and "behavior."

The value of the instrument will depend upon various criteria of the sample. Are there sufficient items to represent an adequate sampling of the behavior? What is the nature of the items? Do they allow for breadth and depth in assessing the behavior? What is the degree of relationship between test items and the behavior the test is supposed to predict? In mental measurement it is not required that the test items necessarily exemplify the studied behavior; it is required only that there be a demonstrated relationship between the two. The so-called "mental ability test" does not really measure ability; it measures performance. Is the performance of the subject, as measured, a valid indication of intelligence, as defined? Problems arise when there is wide variability between the test sample and the predicted behavior, and when there is wide variability between the performance and the definition. Mental ability tests imply a sense of measuring a capacity - but no test can truly measure capacity - it can only measure behavior.

The word "standardized" presents problems. There are implicit demands of uniformity; in the ideal test situation, the only independent variable should be the subject. Also included in the concept of standardization is the establishment of norms. It is the derived norms that give meaning to the test. The subject's performance takes on significance only when compared with the performances of others in a similar or appropriate population who have been measured with the same instrument. Finally, is the test really "objective"? Some aspects of objectivity are related to the standardization demands. Other aspects of objectivity demand that the administration, scoring,
evaluation and interpretation be independent of any degree of subjective judgment on the part of the examiner.

The present intelligence test is by no means a perfect measuring instrument. It measures only some specific aspects of mental behavior; many significant mental behaviors are neglected. Nor do all intelligence tests measure the same behaviors. Further, those aspects of mental behavior which are appraised are measured in a limited way. Current intelligence tests are gross indicators; the result of current measurements are but rough indications of an individual's potential, at best. The range of intellectual behaviors assessed is dependent upon the range of behaviors which the test items cover. The range of the subject's potential is dependent upon the ceiling of the test. Different intelligence tests have markedly different ceilings at different age levels. For example, the following table from Gallagher (1959):

**TABLE 1**

**MAXIMUM OBTAINABLE IQ SCORES AT TWO AGE LEVELS**

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<td>California Test of Mental Maturity Elementary</td>
<td>157</td>
</tr>
<tr>
<td>Lorge-Thorndike Intelligence Test Verbal Battery</td>
<td>147</td>
</tr>
</tbody>
</table>

<sup>a</sup> - Highest score given in norm tables.
There are several other problem sources peculiar to mental measurement; these involve such concepts as reliability, validity, test behavior variables and test bias.

How reliable is a given instrument? The answer depends upon the objective evaluations of the instrument in empirical terms of accuracy and consistency. In general, current measures are termed reliable by means of coefficients of reliability. (The several aspects of score consistency shall be discussed in later chapters.) The majority of current intellectual measures have been designed and standardized so they have norms and yield scores comparable to the Stanford-Binet. (cf. Chapter VI.) Current measures of intelligence are generally consistent with one another. They have been designed to be. It must be noted that certain deficiencies to be found in the one will be found in the others that have been modeled on it.

A valid test is one that does what it claims to do; it measures what it purports to measure. Do current tests of mental ability measure mental ability? No! not really. First, they do not measure ability; they measure performance, as we have seen. Secondly, they do not measure some innate capacity or potential, as is implied in the terminology; they measure the way that a person reacts to specific assigned problems. Measured intelligence means different things at different age levels; the same test may measure different behaviors at different ages; different behaviors are measured by different instruments.

In theory, at least, an intelligence test is not supposed to be a measure of what a person has learned - it is supposed to be an indication of potential, or as has
lately been implied, a measure of a person's ability to learn. (The idea that learning ability and intelligence are not the same thing shall be discussed in Chapter IV.) The problem involved here is the fact that an ability cannot be appraised until it is manifested in behavior. Thus, intelligence tests tend to measure what has been learned. Implications extending from this situation are serious, for it is on the basis of a subject's performance on such tests that inferences are drawn concerning his ability to learn other things at the present time, and predictions are made concerning his ability to learn other things at a future time.

In theory, also, the items on an intelligence test are supposed to involve tasks which require no special training on the part of the subject. The tasks should, theoretically, be based on those experiences considered to be common to every subject taking the test. The demands of the test should not reflect previous training, education, environmental influences or socioeconomic background. Obviously such factors do influence the subject's test behavior; and to the degree that they do, the test is measuring things other than intelligence.

Another source of problems peculiar to mental measurement involve various types of test bias.

Task bias refers to the kind of items contained on the respective intelligence tests. Conceptually, the intelligence test should present a wide variety of tasks to the subject in the hope that an adequate sampling of all important intellectual functions may be obtained. In practice, however, most intelligence tests are overloaded with verbal ability and tend to ignore some other, equally important, intellectual functions. Such instruments may be said to have a verbal ability bias. The subject who has strong
verbal abilities will tend to do well; the subject lacking strong verbal abilities may have an intelligence that is equal to that of the first subject, but little indication can be observed from his results on an intelligence test of this type.

Another aspect of test bias pertains to the age level at the time that the subject is called on to perform certain tasks. Certain tasks are performed more easily and successfully at some ages than at other; psychomotor development is one cause, habitual set, and frequency of use are other causes. The subject whose age is in a different age level than that of the high success group may be penalized. Age bias is related to this problem, particularly in speeded or timed tests. It should be clearly indicated when a test is one of speed, rather than power; interpretation and application for differing age levels should be considered.

Sex bias is usually a hidden bias. The assumption is made that there are no sex differences in intelligence. While this is undoubtedly true with regard to intelligence, in general, there are ample indications that there may well be structural differences in the intelligence of males and females. Research has consistently indicated significant differences between elementary boys and girls in verbal abilities (girls being higher) and perceptual speed abilities (boys being higher). Other sex differences will be discussed regarding the selected instruments in this study. Some test makers have attempted to erase the sex bias by means of statistical procedures or by arranging the test items to compensate for the differences. A fascinating study of masculine-feminine conceptual attitudes indicates that men and women approach problems differently; they tend to "see" things from different perspectives (Platt, 1962).
Numerous research studies indicate the adult female to be consistently superior in tests involving verbal abilities and social relations, in perceiving details rapidly and accurately, and in making quick, manual movements; and the male to be consistently superior in those tests involving spatial, numerical and mechanical abilities (Hobson, 1947; Wechsler, 1958; Gaito, 1959; Levinson, 1963; Shaw, 1965). The sex bias appears to apply, not to overall intelligence, but rather to the task involved and the test used.

The cultural bias of intelligence tests has been a topic of considerable interest lately. There is little question that most current measures of intelligence reflect a middle class, Protestant ethic. The criticism is made that children from different cultural backgrounds are unable to obtain scores which reflect their basic ability. As this point shall be treated in a later chapter, suffice it to say here, that several concerns are involved. First, the use of the test results should be the point of issue; the test indication that the subject is possibly being penalized by his environment, rather than by his lack of ability, should point to diagnostic and remedial procedures. It should be noted that the social situation is the source of discrimination, not the test. Society is penalizing the subject; for the subject, thus far, has been unable to acquire those skills which have been valued by the society. The very fact that the subject is being penalized could be used for his better advantage in indicating the course that his subsequent education should take to provide him with the needed skills. It is next to impossible to construct an instrument which will not reflect cultural aspects and there are some who believe that this is as it should be.

Finally, there exists a body of measurement problems which concern variables
affecting subject behavior in the test situation.

The physical and emotional conditions and attitudes which the subject brings with him to the test situation will affect his behavior on the test. The physical environment in which he must perform the tasks demanded by the test will be an influence on the way in which he responds. The degree of rapport established between the examiner and the subject can influence the test results. The directions given for the performance, as well as the physical provisions for the performance are variables to be considered. Willa Cather once said: "If we could measure desire, we could foretell achievement." The degree of motivation involved in the subject's desire to perform well will affect the test results. The presence of anxiety can be another source of variability in the subject's performance.

The problems of measurement are many. To attempt to measure intelligence is to attempt to appraise an abstract quality by means of a material rule; only the product of intelligence permits investigation. Intelligence has gradually come to be considered as a many-faceted thing; present measures can be used for an estimate of but a few of these facets. Walt Whitman wrote: "I know that this orbit of mine cannot be swept by a carpenter's compass." Herein lies the most crucial problem for the psychometrist; for his orbit is the intellectual behavior of man; and his is the difficulty that comes from having to use static tools to measure dynamic qualities; and his is the danger of tending to equate quantity with quality.

The psychometrist makes the assumption that such a thing as intelligence exists. He has never seen it; but he has observed some evidences of it; he has seen its effects. His predicament in attempting to measure this thing that he has never
The person making the first mental test is in the position of the hunter going into the woods to find an animal that no one has ever seen. Everyone is sure the beast exists, for he has been raiding the poultry coops, but no one can describe him. Since the forest contains many animals, the hunter is going to find a variety of tracks. The only way he can decide which one to follow is by using some preconception, however vague, about the nature of his quarry. If he seeks a large flat-footed creature he is more likely to bring back that sort of carcass. If he goes in convinced that the damage was done by a pack of small rodents, his bag will probably consist of whatever unlucky rodents show their little heads (Cronbach, 1960, p. 163).

It is important to note here that the way in which the psychometrist defines intelligence will influence the kind of items that he uses to trap intelligence. The way in which a psychometrist defines intelligence will depend upon the theory of intelligence that he believes to be most valid. The hunter will seek what he conceives to be game.

The Problem

Psychological testing is commonly misunderstood, frequently abused and seldom utilized most effectively. The fault is shared by theorists and experimenters, testers and interpreters. The situation appears to involve three contributing conditions:

1) The development of psychological testing has been marked by fractionalization and disagreement. As a result public skepticism and antagonism have developed. Research on the nature of intelligence and its measurement has resulted in considerable gains in amassing information. Such gains have been acquired at the expense of synthesis. Fragmentation of ideas, preoccupation with a single aspect and lack of a conceptual framework characterize the field of psychological testing. Psychometrists have moved in ever narrowing directions, until they have lost sight of what they set out to measure, thus steering psychological appraisal further and further.
away from the mainstream of contemporary psychological thought (Anastasi, 1967).

The technology of testing has far outrun its psychological theory. Isolation of psychological testing from other areas of behavioral research and from practical applications have weakened general confidence in psychological testing.

2) People using test results often lack essential knowledge; this causes ineffective utilization, misunderstood implications, and abuse of test data. The largest single group of test users is comprised of classroom teachers. When one considers the serious life-long effects on an individual which result from information derived from psychological tests, the imperative need for responsible and accurate interpretation is obvious. A recent survey (Goslin, 1967) centered on teachers' and school administrators' opinions and practices regarding ability testing in elementary and secondary schools. The misconceptions that school personnel harbor about ability tests are astounding. Goslin's data reveal, only too clearly, that many test users do not understand the use or intent of the measuring instrument.

Not only the intent of a psychological test, but also the basic concepts of empirical techniques and the meaning of statistical evidence, must be clearly understood by educational personnel. There is little indication that such knowledge is a part of the average teachers' repertoire. Stanley (1964) comments that "people in virtually all fields of education can expect increased emphasis on and use of statistical techniques" (1964, p. 53). Prior to that, Walker (1950) noticed that "the conclusion seems inescapable that some aspects of statistical thinking which were once assumed to belong in rather specialized technical courses must now be considered part of the general cultural education" (1950, p. 30). How can effective utilization exist when
basic concepts are not understood? How can better tests be requested when current
tests are misinterpreted?

3) **Psychological testing has developed without a systematic theoretical**
founda

**tion** (Guilford, 1967, p. vii). The few attempts to express a general theory of
intelligence and its measurement have failed in the past; due primarily to lack of
supportive data and misunderstanding of concepts as well as results of experiments.
Many psychologists still persist in maintaining narrow, pragmatic concepts of
intelligence; this is revealed in their theories and published tests. The past history of
psychometrics reveals a critical lack of breadth in various fundamental concepts. Few
theorists have even considered the relationship between parts of intelligence and the
total structure. Few theorists have considered intelligence within the framework of
personality, of which intelligence is but one part. Test interpretation based on limited
data and isolated concept has limited use. If a test and its interpretation is based on
a theory which lacks a systematic and comprehensive theoretical foundation, how can
obtained information be expressed within a standard framework? How can general,

**Purpose**

The purpose of this dissertation is to contribute to better understanding of
psychological testing by providing a more comprehensive perspective and by offering
an interpretive technique which can facilitate more effective use of test results.
To overcome past limitations, such technique should be easily grasped by both
specialist and non-specialist and should be based on a systematic theoretical foundation. The purpose involves three main objectives:

1) To alleviate some of the antagonism and improve confidence in psychological testing through a better understanding of the nature of intelligence and its measurement. A synthesis of the major evolving theories of intelligence with emphasis upon persistent trends should decrease the fragmentation that has hindered understanding. If it can be shown that evolving theories reflect inherited problems, contemporary attitudes, empirical demands, and temporal limitations, a reevaluation of opinion should emerge. If defects in evolving theories can be attributed to lack of breadth in concept and lack of relationship in structure, the need to use a comprehensive systematic theoretical foundation should be grasped. Confidence in psychological testing can be increased when one better understands the relationships between a theory of intelligence and its practical application as a psychological test.

2) To apply an interpretive technique to psychological tests that can lead to more effective use of test data. If it is possible to identify specific behaviors from various psychological tests, more insights about intellectual operations can be obtained. As such insight increases, more concrete application becomes possible. Appraisals and recommendations may be made in terms of specific behaviors. When test data is understood as representing a sample of identified behaviors, a better perspective for decision making is provided. Intellectual behaviors may be related or contrasted to other behaviors, thus misleading views of global connations should decrease. If an interpretive technique indicates that various psychological tests are repeatedly identifying the same intellectual behaviors, the test user can request tests to identify
other intellectual behaviors. Such pressure can lead to the development of better tests: tests which offer increased variety of tasks, tests designed to evaluate more behaviors, tests that furnish information easily used to promote intellectual growth.

3) To base the interpretive technique on a theoretical model of intelligence that is comprehensive, systematic and firm. If such a model can be shown to be comprehensive, the critical lack of breadth which impaired previous theories may be avoided. If such a model can be shown to be systematic, the structural relationships can be provided. If such a model can be shown to have a firm, empirical base, it can be rooted in the mainstream of contemporary psychology. If a theoretical model meets these criteria, it seems valid to use it as the basis for an interpretive technique. It establishes a framework, or uniform scheme, applicable to various evaluations.

Procedures

The paper has been developed in this way:

1) General requirements of empirical investigation were discussed as they apply to the psychological theorists. By establishing basic guidelines, a theory of intelligence and the means used to test the theory could be evaluated according to the degree of meeting generally accepted criteria. Selected historical background was presented to indicate inherited problems in trying to study intelligence and associated problems in trying to understand the nature of intelligence. Certain traditional misconceptions contained in a theory of intelligence could be identified in this way. A brief evolutionary exposition of the major theories of intelligence and its measurement followed. Synthesis was the desired objective. Emphasis was placed on the increasingly expanding composition of intellectual functioning and the progressive discernment
of these factors. The focus of attention was the way in which developing theories con-
tained some important elements of earlier theories; attention was directed to the ways
later theorists expanded the concepts.

2) Guilford’s Structure of Intellect Theory (SI theory) was offered as a
tenable foundation for an interpretive technique to be applied to selected instruments.
SI theory was considered comprehensive when it could be shown to mark a logical
culmination and extension of earlier theories and when it could be shown to allow for
treatment of all aspects of intelligence. It was considered systematic when it could be
shown to include numerous phenomena within a logically ordered structure. It was
considered firm when it could be shown to have an empirically based foundation com-
patible with contemporary psychology.

Guilford’s SI theory was analyzed and detailed; first, as it has developed;
then, as it has been applied experimentally; finally, as it has been tested by the
multivariate method of factor analysis to identify specific intellectual behaviors.
Guilford’s notational system was investigated; its implications and constructive uses
were discussed.

Guilford’s theory was evaluated as it related to the evolving concepts of
intelligence and current psychological thought. SI theory was considered regarding the
degree to which it met scientific requirements of theory and conformed to Guilford’s
claims. Traditional concepts were reinterpreted according to SI theory to underscore
synthesis and comprehensiveness. Some of the ways in which SI theory may be
applied to current psychological thought were given to provide a sound rationale for
its application to current psychological tests. Implications for psychological measure-
3) Guilford's theory and notational system were applied to the following standardized psychological tests:

- The Wechsler Adult Intelligence Scale
- The Wechsler Intelligence Scale for Children
- The Stanford-Binet Intelligence Scale - Form LM
- SRA Primary Mental Abilities Tests (1962 Revision)
- Lorge-Thorndike Intelligence Tests - Form A (Levels 1-5)
- California Test of Mental Maturity - Long Form (1963 Revision, Level 5)
- Otis-Lennon Mental Abilities Tests (Elementary II Level, Intermediate Level, and Advanced Level)

The measures were selected in recognition of their wide usage and because they were based on specific theories of intelligence. The application of SI theory as an interpretive technique was used to show how tests which measure limited aspects of intelligence have been perpetuated as comprehensive evaluations. Better interpretations may be made when data is understood to be derived from limited, rather than global, indicators of intelligence. The application of the SI notational system to each item on a test was used to accomplish two objectives: first, to provide a uniform method of analysis which can be applied to various tests; and second, to identify specific intellectual behaviors that are being measured. If individual items from selected tests can be identified in the same way, problems of consistency can be overcome. If test interpretation can be based on specific intellectual behaviors, more effective use can be made of data derived from instruments having a stable history.

4) Information obtained by application of SI theory to each of the selected instruments was presented in several ways:

- A pie-shaped diagram was used to show the proportion of intellectual behaviors measured to intellectual behaviors theorized. Evaluation and interpretation
of test data can be guided by the amount of information known in comparison to the amount of information that is not known.

- A summary table was used to indicate the specific behaviors measured by each test item. Reference to the table permits interpretation and evaluation in terms of specific behaviors. The specific behaviors that have been measured can be identified. The analysis of pass-fail patterns can indicate those behaviors the subject has developed and those behaviors that are not yet a part of his repertoire.

- Test data sheets were provided to facilitate construction of a more meaningful profile of ability and performance. Data obtained from standard measures can be reorganized around a new framework. Evaluations can be based on what is known about specific behaviors. Recommendations can be made in terms of concrete behavioral objectives. A concluding part of the profile requires the interpreter to indicate intellectual behaviors which have not been appraised and which seem to warrant investigation. In this manner, evaluation can easily be used as an ongoing process.

The interpretive aids emphasize simplicity of communication and facility in use. It is hoped that the use of such devices can overcome some of the present limitations in psychological measurement and serve to check some of the prevalent misconceptions. The interpretive aids provide a structure that can help the test user (with or without expertise) determine:

- which specific intellectual behaviors have been appraised by a specific instrument

- how much intellectual behavior has been appraised in comparison with the total structure of intellectual behavior

- which intellectual behaviors have not been appraised by a specific instrument, thereby placing a limitation on the application of the results
Depending upon the conditions, the test user can make decisions concerning the direction that future learning should take, or what remediation may presently be needed. Evaluations of test data within the suggested framework can serve to increase understanding the nature of intelligence and can serve to guide the extent to which current information may be used.
CHAPTER II
EVOLVING THEORIES OF INTELLIGENCE

The Psychologist as Scientist

"One finds that he needs to know about the past; not in order to predict the future, but in order to understand the present."

- E. G. Boring

By definition, the main objective of any science is a factual, objective, empirical account of something. A scientist, by definition, is one who seeks a particular kind of knowledge concerning a subject; he uses scientific method in trying to establish fact, his conclusions are based on careful evaluation of all available evidence. Scientific method is characterized by control; by using control, the scientist attempts to identify the reasons for what he observes, or the causes of what he observes. A scientific observation involves an experiment which is a planned and controlled situation. In order to identify causes and reasons, the scientist must deal with dependent and independent variables. Generally, the independent variables are those factors which the scientist believes will influence the results of the experiment. Those factors which are directly measured or observed scientifically are called dependent variables. His observation will try to establish which changes in the dependent variables can be attributed, with a reasonable degree of confidence, to the independent variables. This necessitates the elimination, i.e. control, of all conditions which might affect his results. The use of control is essential in science; experimentation is preferred to casual observation because it makes control possible. When control is not used, the sources of variation cannot be identified with any degree of certainty, for
the uncontrolled variables will always be sources of possible explanation.

The psychologist is a scientist. He seeks to explain the causes and reasons underlying man's behavior in terms that are objective, factual, and empirical. Using scientific method to achieve control makes possible the elimination of some extraneous influences and increases the possibilities that his results may be attributable to the particular variable he is studying.

Method refers to the basic procedure a scientist uses. Control is the essence of this procedure. The psychologist-scientist may use different techniques to implement the general procedure. The techniques refer to particular ways or manners that he uses in conjunction with the general method. Thus, method and technique are two different things. Marx and Hillex (1963) believe that failure to recognize this or failure to distinguish between the two can account for much of the controversy that presently exists in psychology, particularly between experimentalists and clinicians.

The scientist begins with a problem which had originated in some commonsense or prescientific notion or observation. While it is often true that many current scientists may seem to begin with problems of purely scientific proportions, it remains that these problems had an origin that can be traced back to commonsense antecedents, even though the antecedents may have eventually become obscured. The scientist wishes to solve the problem by some means of empirical evidence, he has a number of hypotheses about the problem; he must set up some process for testing each hypothesis. The degree of control that is involved will become the crucial factor in his analysis and evaluation of the hypothesis.

A second characteristic of scientific method is what Bridgman called
"operationism," the kind of definition that follows from this concept is called an "operational definition." Bridgman (1927) stressed the essential need for scientific concepts to be given clarity and distinction. If an experimenter's results are to have any value, they must be clearly understood. There is no room for ambiguity in scientific method, although the scientist must be tolerant of ambiguity, for it will often lead to more definitive study. Bridgman urged that all concepts expressed in connection with the experiment be stripped of all connotations that would not be meaningful. Every concept must have an exact reference; the meaning must be expressed in terms of operations; only in this way will their meaning persist for the person who has performed the experiment and another person who tries to comprehend the experiment.

A third characteristic of scientific method is analysis. The scientist must formulate his hypothesis in such a way that it can be studied by means of scientific method and by using scientific method and by using scientific techniques. The scientist's questions must lend themselves to empirical answers. Thus, the hypothesis must be testable and it must be answerable. The hypothesis must be defined operationally, the operations must be performed, the results must be observed and finally analyzed. The analysis results in the answer to the question; it tells the scientist whether the hypothesis is tenable or whether certain revisions or modifications may be necessary. Hypotheses and theories are never final. When enough verifying evidence accumulates, then confidence in the validity of the hypothesis or theory may be increased. When confidence in a hypothesis is large, and generally accepted, it may become part of a theory. According to Bergmann (1957, p. 31) "A theory is a group of laws deductively connected." It must be noted that many psychological theories do not
consist of laws, and in some instances, their deductive connections are most tenuous. The amount of confidence which may reasonably be placed in such theories should be conditioned by this fact.

"Scientific study always involves reference to empirical systems and their relationship to symbolic systems" (Marx and Hillex, 1963, p. 18). The scientist tries to adhere to empirical systems. He tries to remain objective about his theories; he tries to be intellectually honest enough to analyze fairly, evaluate objectively, and to admit of errors when it becomes necessary. To the degree that a given science adheres to scientific criteria it may be called a science. To the degree that a scientist adheres to the same scientific criteria he may be accorded the title "scientist."

Theoretical systems for the interpretation of intelligence have grown up along with the study of intelligence. To understand one, it is necessary to understand the other. To comprehend the theoretical interpretation of a particular research study on intelligence, it is necessary to understand the researcher's operational definition; one must understand the relationship of this definition to the theory of intelligence as a part of an empirical system. It is important to understand the rationale of an experiment, to know the background to the problem, and to understand the purpose of the experiment. For it has been through research studies of intelligence that most theories of intelligence have evolved.

In appraising the degree of confidence that one may reasonably place on a theory, close, objective scrutiny is needed. In some cases of intellectual theory, the theoretical involvement has proceeded to such an extent that the original problems have become barely recognizable. In some other cases, the theory has preceded any empir-
ical research, later, when data are obtained from experimental situations they are molded to fit the theory. There are instances where a researcher has merely applied new names to old theories, or fresh subjects to old experiments. Recently, there have appeared a number of studies and theories expressed in terms of computer systems, ornate models and diagrammatic hierarchies. One suspects that some of these researchers have forgotten the problem because they have become immersed in the computer. When dealing with research on intelligence, it frequently becomes necessary to scrutinize the experiment. Often there are aspects of the experiment which seem artificial or trivial; sometimes these can be justified in the light that it may have been necessary for the experimenter to construct artificial situations in order to manipulate certain variables, while holding others constant. Such a situation is not ideal and may be justified only when there is evidence that the behavior he wishes to observe does not lend itself to observation in other, better ways. Sometimes a very detailed analysis of an experiment is necessary to evaluate the validity of research conclusions.

At present, there is an immense mass of accumulated data and literature pertaining to intelligence and its measurement. The work of more than sixty years of experimentation is available to today's psychologist. Many of the same problems that bothered Spearman are now bothering current researchers. We are still in the dark about the mechanics of thought. What motivates thought? Can it be studied empirically? Can it be described in objective, factual terms? We are still handicapped by having to deal with the unconscious processes and motivation, which appear to have important determining tendencies for the achievements and products of intelligence.
We have never been able to separate the covert processes, i.e., experience, from the overt activities, i.e., the behavior of the subject, when dealing with theory and research on intelligence.

The writer wishes to call attention to the fact that while some hypotheses may have been replaced, they have not been useless or insignificant. They had a value within their respective limits and within the historical era of their study. As the various evolving theories are discussed, an effort will be made to stress the elements which later theorists expanded, modified or subsumed.

19th Century Background to 20th Century Study of Intelligence

Over the past several decades many hypothetical concepts of intelligence have evolved. They show various degrees of difference among one another; some agree to certain extents, others are outright contradictions of another theory. In order to test a given hypothesis, the researcher must express his concept in terms of an operational definition; he must construct an observational situation that allows for scientific method, he must pose his question in such a way that it is testable and answerable. His answer must be viewed from the standpoint of its relation to the larger system of which it is a part. In the analyses of the selected theories of intelligence which follow, attention shall be directed to: first, the theorist's operational definition, secondly, to the experimental situations he has used for the observation, and lastly, to the analysis and relationship of the hypothesis to the theorist's larger system of intelligence.

Faculty theory

The turn of the century may be said to mark the beginning of scientific investigation of intelligence. The general consensus of the 18th and 19 Centuries
indicated the "faculty theory of intelligence" to be an acceptable explanation of mental functioning. It might be noted that there are two distinct interpretations of "Faculty theory," while they have a considerable number of concepts in common, they differ in one essential: philosophic basis. The faculty theory of scholasticism and neo-scholasticism is in the vein of the classical tradition of Aquinas, Augustine and Aristotle. Knowledge comes through the senses, there is nothing in the mind that was not, in some way, first in the senses. The mind has separated and distinct faculties: intellect, reason, emotion, will, memory, discrimination, concentration, perception. Faculties can be strengthened through the use of appropriate exercises; the appropriate exercises came to be known as "formal discipline". The influence of this theory is easily observed in the curriculum of the schools and in the training materials used in the schools of the period. This classical concept of faculty theory was to persist, in modified versions, in an educated setting through the first half of the 20th Century.

The other interpretation of faculty theory developed in Germany (Wolff and Kant); it opposed the association theory (Hobbes and Locke). It maintained, in common with the traditional faculty theorists, that knowledge came through the senses, that the mind was made up of a number of separate and distinct abilities of faculties: such as intellect, emotion, will, memory, discrimination, reasoning, concentration and perception, that these faculties could be strengthened through the use of appropriate exercises. Where this interpretation differed radically from the traditional faculty theorists was in attitude regarding the character of mind. The traditionalist maintained that mind was unity; it was the unifying principle through which meaning would be given to the various component parts, which though separate and distinct, worked in
conjunction with each other. The interpretation given by the Kantian version proposed that the faculties were not only separate and distinct, but independent of one another as well. This version of the theory went to an extreme under the phrenologists, who assembled, classified and related the separate, distinct and independent faculties to specific cranial locations. Many authors of tests in psychology, particularly educational psychology, neglect to distinguish between the two versions; as a result, considerable confusion has arisen.

The textbook writers generally state that faculty theory of intelligence was commonly accepted, go on to enumerate the salient points and then imply that all intellectual, scientific inquiry of the 20th Century has evolved in opposition to this theory. In point of fact, what Spearman objected to in faculty theory was the Kantian view that the different faculties were independent of each other; he believed them to be closely related - so close or unified in such manner that they could account for a general level of intelligence to be found across the board in different intellectual tasks performed by an individual. His two-factor theory of intelligence is based on the concept that there is a g (general) factor of intelligence that enters into all types of performance; he concluded that g was some type of mental energy - a concept not unlike the traditional faculty concept of a "unifying principle," in the sense of pulling together, assessing, reassessing and energizing. Thorndike, on the other hand objected to the traditional faculty concept of mind as a unifying principle. He denied a unifying principle, as did the Kantian version, Mind, or intelligence, to Thorndike was composed of innumerable stimulus-response bonds which were independent of each other. Thorndike differed sharply with Spearman on the concept of general
intelligence; a difference that was identical to the way in which Kantian faculty theory differed from traditional faculty theory. To miss this point is to miss much of the significance underlying the theories of intelligence proposed by both men.

The concept, common to both versions of faculty theory, was that the mind was like a big muscle; the more it was exercised, the better it became. Accordingly, the theories would explain variations in intelligence as differences in exercise. The concept was formulated more through theoretical than empirical means. It tended to be a general observation rather than to investigate the causes of individual variation. When Thorndike did perform an empirical investigation, he found that exercise in one area did not improve performance in another area.

During the period that the faculty theories held sway, little attention was given to the individual as such. Eventually, Darwin's theory of evolution would reemphasize the importance of the individual and Galton would initiate the study of individual differences in human behavior. Galton would study the senses as indicators of intelligence. Prior to the contributions of Darwin and Galton, there was little attention directed to the individual or to variations among individuals. Faculty theorists of both schools gave the impression that all people were born with the same amount of mental muscle; those who trained and exercised this muscle tended to achieve; those who did not achieve had apparently let the muscle become flaccid. Galton (1869) indicated, in no uncertain terms, the intellectual variability to be found among individuals. "In whatever way we may test ability, we arrive at equally enormous intellectual differences" and "...the range of mental power between...the greatest and least of English intellects, is enormous" (Galton, 1869,
Galton did not believe that all people started off with the same potential for achievement. "It is in the most unqualified manner that I object to pretensions of natural equality" (Galton, 1896, chapter 3). He believed that individuals had differing degrees and differing mental traits, and that the differences could be attributed to heredity. It was not the exercise that made the difference, it was what had been inherited.

**Galton's contributions**

Galton pioneered in the use of new techniques: the case history, influence of genetics on special traits, use of twins as a kind of control, the concept of a "test" as a measure of a special trait, correlational technique in the analysis of data. He viewed intelligence as a general ability (Burt, 1958). He believed that sensory acuity tests and reaction-time experiments could indicate the level of intelligence. The sharper and more discriminating the acuity, and the faster the reaction-time, the higher the level of intelligence. Galton proposed a method of classifying men according to their natural abilities. "I propose to range men according to their natural abilities, putting them into classes separated by equal degrees of merit, and show the relative number of individuals included in the several classes... The number of men included in the several classes will predictably be quite unequal... The method I shall employ for discussing all this, is an application of the very curious law of deviation from an average" (Galton, 1869, chapter 3). Thus we see the antecedent of the standard score, a concept considered to be basic in present psychometrics.

For some time prior to Galton, scientists had been unable to find an acceptable empirical method expressing the degree of relationship between two variables.
Galton discovered a single index that could perform this function (Galton, 1888). This index is correlation; it depends upon deviations from the mean. Later it would be expanded and refined by Pearson, but Galton expressed it in this way:

...the prominent characteristics of any two co-related variables, so far at least as I have tested them, are four in number. It is supposed that their respective measures have been first transmuted into others of which the unit is in each case equal to the probable error of a single measure in its own series. Let \( y \) = the deviation of the subject, which ever of the two variables may be taken in that capacity; and let \( x, y_2, x_3, \text{ & c.} \), be the corresponding deviations of the relative, and let the mean of these be \( X \). Then we find: (1) that \( y - rX \) for all values of \( y \); (2) that \( r \) is the same, whichever of the two variables is taken for the subject; (3) that \( r \) is always less than 1; (4) that \( r \) measures the closeness of the co-relation (Galton, 1888, p. 145).

Galton was not concerned with spelling out the nature or structure of intelligence; he was concerned with showing that it was an inherited ability. The task of taking philosophic concepts and definitions of intelligence and making them more operational and investigating them more scientifically was to fall to Spearman.

Charles Spearman

Charles Spearman made the military his career until he was 34 years of age. At this point, he turned to psychology. He studied in Germany under Wundt, Klilpe and Müller. Spearman published his two-factor theory of intelligence in 1904. As frequently happens to men who are ahead of their time, Spearman's magnitude was not always appreciated. According to Anastasi (1965) "With this publication, Spearman opened up the field of research on trait relationships and paved the way for current factor analysis" (1965, p. 19).

Perhaps Spearman's military conditioning influenced his desire to bring order to a most chaotic branch of science. It surely must account for the characteristic approach he used to begin each of his general works.
Principles of Cognition (1923), The Abilities of Man (1927), and Human Abilities (1951) all commence with a rapid convocation of the foe (opposing or incomplete theories) followed by sharp and deadly thrusts to dispatch them. Spearman returned from Germany in 1907, he located at University College in London. His was a vigorous and earnest career, aimed at setting forth a scientific, comprehensive, systematic theory of intelligence. He attacked the unscientific, unsystematic theories of his age: sensationism, associationism; hedonism he viewed as an abomination; Pavlovian psychology he claimed was not psychology at all, rather it was "Pavlovian reflexology". He found structuralism, as proposed by Titchener, to be distorted and Gestalt psychology, as proposed by Wertheimer, to be romantic mysticism. Behaviorism, a la Watson, he wrote off as "a South Sea Bubble".

Spearman explained that his theory of intelligence originated from casual attempts to verify Galton's belief that differences in sensory discrimination could predict differences in higher mental functionings. This was the hypothesis. His experiment was conducted on subjects from English grammar schools. By use of the correlational techniques he had earlier developed, Spearman related the subject's grades in school with performance on tests of relative sensory discrimination. The tests were similar to those used by Galton. His analyses indicated a rather high relationship both among the grades of the individual subject and between the grades and the sensory tests. He concluded that an assortment of tests could yield indications of intelligence and that the indications would remain fairly consistent, regardless of the tasks. He was aware that not all abilities would be measured by the tests, but he believed that a series of tests would indicate some average concepts. He felt
that tests could be used to measure, not intelligence in general, but rather general intelligence.

In all of Spearman's published works, there can be identified a consistent, systematic approach. Underlying all his expositions was the sincere plea for psychologists to be more scientific and less speculative or emotional, to adhere to scientific method, to resist making unwarranted assumptions or conclusions. He began with an historical and critical review of the problems; he indicated the sources of error; he explained the success or failure of an individual researcher's experiment. The next step involved his solutions to the ways in which specific errors could be overcome. He suggested different uses of statistics, or a way to redesign the experiment. He then discussed the problem in terms of his experimental findings; he detailed his analyses with reference to mistakes other researchers had made. He showed the way in which his suggested solutions had been applied; he directed attention to the way in which the previously identified sources of error were overcome by his new techniques. The last step concerned the elaboration of principles which were formulated as based on his work. He expressed the conclusions he had drawn from his observations and analyses. This characteristic procedure was exemplified in Proof and Measurement of Association Between Two Things (1904) and "General Intelligence, " Objectively Determined and Measured (1904).

Proof and Measurement of Association Between Two Things

The article opened with accusations that many otherwise learned psychologists have a total lack of understanding of correlational techniques. Spearman identified the studies which were conducted and published with the purpose of in-
dicating some connection between two events in which the psychologist betrayed his limitations in proving and measuring correspondence. Spearman claimed that they ended up with an experiment that could not possibly be significant, for in truth, they hadn't proved anything. Spearman then pointed out the sources of error in the interpretation of correlation: attenuation by errors, limits of associative problems, constriction and dilation, distortion, number of necessary cases. He stressed the need for information regarding reliability of mental measurements; he discussed the use of a statistic for probable error.

The next part of the paper presented Spearman's views on elementary correlation and accidental deviation. He stated four requirements for a good method of correlation: quantitative expression, significance of the quantity, accuracy, ease of application. He then gave his techniques, which he believed to have overcome the errors previously identified. The quantitative expression had to be precise; the most fundamental requisite was to be able to measure the observed correspondence by means of a plain numerical symbol. The significance of the quantity could be extended to afford a measure of the hidden underlying causes of the variations. For this, he proposed the formula: \( 1 - \frac{1}{x^2} \), this was the square of Galton's correlation; it indicated the relative influence of factors in one variable toward any observed correspondence as compared with the remaining components of that variable tending in other directions. Accuracy was achieved by using a method that gave the least amount of probable error; Spearman identified the number of cases used and the mathematical method of correlation as determining the size of the probable error. Ease of application could be obtained by utilizing some auxiliary methods to meet certain varied
conditions, in addition to standard methods used for the finally established principle.

Spearman then detailed the product moment correlation, rank difference method, cross-
multiple method and several auxiliary types, he also mentioned conditions where cer-
tain types would be preferred.

"General Intelligence," Objectively Determined and Measured

This milestone paper was the original work from which factor analysis would
develop. It provoked a furious controversy, it set the stage for the long, and some-
times violent, debate of general versus specific traits of intelligence. Spearman began
by identifying the current weaknesses in experimental psychology. He then reviewed the
literature of previous attempts to measure intelligence. He recognized the work of
Ebbinghaus with regard to the completion type item. He indicated that Binet and Henri
had quite successfully managed to bridge the gap between the basics of laboratory work
and the complexity of practical activities. Thirty-two investigators' works were
summarized by Spearman. He concluded that the findings failed to show any kind of
consistency or to reveal any clear patterns of relationship. Spearman criticized pre-
vious work methods. Only one study, that of Wissler, met the first fundamental re-
quirement of correlation: the expression of precise quantification. Not one of the
cited studies had bothered to calculate the degree of probable error; Spearman con-
cluded that there was no way of knowing how much of any given study of relationship was
due to accidental coincidence. Spearman noted that in no case had any clear explicit
definition of the problem to be solved been given. In not one of the studies had the in-
vestigator ventured to consider errors of observation, which Spearman felt to be a large
source of error and present in every investigation. He described some incredibly hur-
ried and inadequate methods of testing used by certain investigators. Spearman stated
that in all the previous work, the only thing to be clearly demonstrated was that the
means used by investigators had been entirely inadequate.

Spearman next presented his endeavor; he believed that he had elaborated a
new and reasonably complete methodological procedure which might bring some light to
important regions that had previously been unexplored. Spearman then detailed
methods which would obviate the errors he had identified; he introduced the correlation
coefficient, estimates of probable error, and formulas for computing reliability. He
urged greater concern with experimental procedures and techniques.

Spearman described his experiment; he stated his rationale of selection (a
rationale to be repeated and for the same purpose some sixty years later):

...the guiding principle has been the opposite to that of Binet and Ebbinghaus. The
practical advantages proffered by their complex mental operations have been
unreservedly rejected in favor of the theoretical gain promised by utmost simplicity
and unequivocality; there has been no search after condensed psychological extracts
to be on occasion conveniently substituted for regular examinations; regardless of
all useful application, that form of psychical activity has been chosen which intrinsically appeared to me as the simplest and yet pre-eminently intellective. This
is the act of distinguishing one sensation from another...(Spearman, 1904, p. 280).

The tests he used were described in detail. The population he used consisted
of five experimental groups from which two groups were retained for critical analyses.
The two groups that were ultimately retained were quite different from each other. One
consisted of 24 children from a village school; the other consisted of 33 children from
an upper class preparatory school. Intelligence estimates for each subject were
obtained from teacher and peer ratings for the village group and from examination
records for the preparatory group.
Spearman's analyses exemplified the methodological procedures he had urged. He corrected and recorrected the correlation coefficients for such factors as assumed reliability of the discrimination tests, the estimated reliability of teacher and peer ratings, the estimated reliability of examination grades, the effect of musical training on the subject's performance and so on. His corrected coefficients for theoretical relationship between general discrimination and general intelligence approximate ±1.00. This result led him to argue for "theoretical unity of intellectual functioning". (As an armchair quarterback, some 65 years later, it is easy to see that such corrections on such small samples can be very misleading, especially when the reliabilities of the tests are low.) Spearman indicated a positive relationship to be found in both groups. The work was important from the point of what it ultimately led to; also, it marked the first truly methodological treatment of the study of intelligence and its conscientious adherence to scientific principles.

Further analysis of the prep school group's data led Spearman to argue for the "hierarchy of intelligence":

The Theorem of Intellecutive Unity leads us to consider a corollary proceeding from it logically, testing it critically, and at once indicating some of its important practical uses. This corollary may be termed that of the Heirarchy of the Specific Intelligences.

For if we consider the correspondences between the four branches of school study, a very remarkable uniformity may be observed. English and French, for instance, agree with one another in having a higher correlation with Classics than with Mathematics. Quite similarly, French and Mathematics agree in both having a higher relation with Classics than with English. And the same will be found to be the case when any other pair is compared with the remainder. The whole thus forms a perfectly constant Hierarchy in the following order: Classics, French, English, and Mathematics. This unbroken regularity becomes especially astonishing when we regard the minuteness of the variations involved, for the four branches have correlations of 0.77, 0.72, 0.70, and 0.67 respectively (Spearman, 1904, p. 280).

Spearman's analysis of pitch discrimination and its correlation to school
studies, and the correlation of musical talent with school studies indicated a uniformity very nearly perfect. When these coefficients were corrected for possible error and remained strong, he determined that the relationship far surpassed the limits of chance coincidence. Spearman saw that the correlations in their raw form did not tell the true rank of each individual activity, or the full saturation of each activity with general intelligence. He felt that he must first eliminate observational errors and then square the result. He concluded that the degree of any observed correlation depends on two marked and different influences: (1) the extent to which the considered factor is functionally identified with general intelligence, and (2) the accuracy with which the factor has been estimated.

Spearman proposed that his study gave evidence that it was possible to determine the precise accuracy of the various means of measuring general intelligence - then in an equally objective manner determine the exact relative importance of this general intelligence to other characteristics described for particular predictions. He hoped that eventually pedagogical conclusions would be reached by adequately representative established facts.

The two-factor theory of intelligence should lead to more and better information regarding intellectual functioning.

...if the thesis be correct, its proof should be reproducible in all times, places, and manners - on the sole condition of adequate methodics... the observed facts indicated that all branches of intellectual activity have in common one fundamental function (or group of functions), whereas the remaining or specific elements of the activity seem in every case to be wholly different from that in all the others. The relative influence of the general to the specific function varies in the ten departments here investigated from 15:1 to 1:4. As an important practical consequence of this universal Unity of the Intellectual Function, the various actual forms of mental activity constitute a stably interconnected Hierarchy according to their different degrees of intellective saturation. Hence the value of any method of examination as
Methods have been given whereby they can be sufficiently ascertained (Spearman, 1904, p. 291-292).

The theory was presented and the means for its investigation had been defined. Later, in The Abilities of Man (1927), Spearman put the analysis on a more systematic basis; he introduced the tetrad equation whereby tests could be analysed in sets of four. The technique was very unwieldy, especially in the light of modern computers, but it was a breakthrough in its time.

Spearman maintained that all intellectual activities have g; in addition, each activity has s factors; the s factors are numerous, they are peculiar to a specific task. No two intellectual activities could share specific factors; only the general factor would be common to different tasks. Spearman argued that such a theory was consistent with correlation studies; the presence of s factors in every activity would account for the absence of perfect +1.00 correlation. No matter how dependent an activity might be upon g, it was never entirely lacking in s. Spearman’s observations usually indicated that abilities were positively related; this would be attributed to the presence of g. The difference in the proportions of g and s in different tasks would account for the range to be found among correlations.

Spearman believed that the proper aim of psychometrics must be the measurement of an individual’s g. He reasoned that if this factor ran through all intellectual activities, then it could legitimately be used as the basis for prediction. He felt that it would be ridiculous to try to measure s factors, for they pertained to single tasks and only operated in one activity. Spearman believed that a single test, highly saturated with g, would be the best method for appraising intelligence. He
suggested that tests dealing with abstract relations were probably the best indicators of g.

Spearman was able to give only tentative hypotheses to explain the nature of g. In his final work Human Abilities (1951) he explained g as general mental energy; energy that drives the engines through which intelligence operates. Even from the beginning, Spearman recognized that the two factor concept would have to be qualified. Even in the original presentation in 1904 he anticipated group factors. Ultimately, he would try to explain the group factors as being peculiar to intellectual activities which were very similar; some of the correlation which resulted would be caused by similarities over that which could be attributed to g. The group factors would be common to a specific group of activities, they would not be common to all intellectual activities.

In the later writings of Spearman the presence of three classes of factors was evident. Anastasi (1964) feels that the chief difference between Spearman's earlier and later modifications of the two-factor theory seems to be in the relative amount of emphasis attributed to g as producing the correlation. In the earlier versions the relationship occurred because of g; in the later versions, the correlation was the result of g supported by based group factors.

Anastasi (1964) comments on the difficulty involved in the interpretation of factors; this difficulty was experienced by Spearman, has been experienced by those who followed him, and is even now a source of confusion. The distinction among general, specific and group factors is not as fundamental as it might appear. Much of the distinction is caused by the instruments used and the statistical methods applied. If the battery of tests used is small, then a single "general" factor may account for the
correlation found. But when the same tests are included in a larger battery with a more
heterogenous collection of tasks, the original g factor may emerge as a group factor,
common to some, but not to all of the tests. Similarly, a certain factor may have
occurred in only one of the tests in the original battery, but may be shared by several
of the tests in the larger battery, such a factor would then be identified as specific in
the original findings, but would become a group factor in the second findings. Anastasi
suggests speaking of group factors of varying extent, rather than of sharply differenti-
ated general, specific, and group factors.

Many studies conducted during the 30's and 40's gave indications of intellectual
abilities becoming more differentiated with increasing age and experience. Large
members of studies, conducted by Spearman used school children as subjects; this
may account for some of his insistence for a g factor. Most of the studies which were
conducted in the United States and attempted to replicate his findings used college
students as subjects; this type of study yielded little or no evidence of g.

Spearman's definition of intelligence was presented operationally in many
studies. While not as empirical as demanded by present criteria, he was far more
empirical than anyone previously had been. His empirical definitions were adequately
connected and portrayed in his larger system. Unfortunately, Spearman did not have
the tools to measure and verify many necessary connections to the larger system.
Spearman never constructed and standardized a test battery designed to measure his
hypotheses and theory; ironically, Binet never fully formulated a theory of intelligence
but did construct and standardize a test battery that was to become the progenitor of
future mental tests. In practice, Spearman's theory came to be applied to Binet's
Alfred Binet

Binet's outstanding personality characteristics appear to be his curiosity and flexibility. He explored many areas of knowledge before turning to psychology. He took a degree in law, studied natural sciences, received a doctorate in science in 1894, and wrote widely in diverse areas. He published works on hypnotism (1886), the psychology of reason (1886), changes in personality (1892), the powers of suggestibility (1900). He wrote a textbook on the introduction to experimental study of psychology (1894). Probably his most famous work was L'Etude experimentale de L'Intelligence (1902).

In 1904, Binet was approached by the Minister of Public Instruction to develop a method of identifying subnormal children in the schools of Paris, in order to place them in special schools. This request led to the construction of the first scale of intelligence.

"Probably no psychological innovation has had more impact on the societies of the Western world" (Jenkins and Paterson, 1961, p. 81).

Binet and Spearman both led energetic professional lives. Where Spearman constantly sought scientific methods, Binet sought valid ways of testing for intelligence. Binet was not above experimenting with any technique which might indicate intelligence, including phrenology, palmistry and hypnotism. He experimented widely, both with groups and with individuals to identify the kind of test item which might conceivably measure intelligence. He disagreed with the Galtonian concept that sensory acuity tests or reaction-time tests would be measures of intelligence. He believed that intelligence tests should measure the higher mental functions, which he considered to be complex.
"I believe...that it is possible and useful to make an experimental investigation of the
higher processes with scientific precision..." (Binet, 1903, p. 3).

In 1895, Binet set out to determine the nature and extent of individual differences
in psychological processes and to try to discover the interrelationships of mental
processes within the individual. His subjects were primarily his two daughters, Mar-
guerite and Armande. One of the test items which he found to be a good measure of
span of attention was the memory of sentences. Results of the three-year observation
were published in L'Etude experimentale de L'Intelligence (1903). He concluded with
an expressed need for patience:

The main conclusion I can draw from this study...is the need for patience. A
serious study of the complex functions cannot be done in a hurry or by statistical
methods. What I call here statistical method is the illusion of great numbers of
observations done in a hurry with many Ss. American psychologists love to do their
studies with hundreds and thousands of Ss, and think thereby they are doing great and
outstanding research. This is an illusion. When we reproduce repeatedly similar
observations, little more is known than from few selected ones. In studies with
great numbers the quality of observation is inversely proportional to the quantity of
Ss. I much prefer to work intensely with few Ss I know well, like my daughters. I,
too, have made the mistake of great numbers, and I have regretted it. My investi-
gation with many Ss of grammar school was done in a few weeks, but it lacked
deepth... (Binet, 1903, p. 281; translated by the writer).

It becomes increasingly evident that Binet differs from Spearman in certain regard
toward the appropriate numbers for an investigation, and in the importance to be
 accorded statistical proof.

In 1904, Binet was appointed to a commission to study the problem of retar-
dation among children in the public school system of Paris. A year later, in assoc-
iation with Simon, he published the 1905 Scale for measuring intelligence. He had put
into practice the conclusions and theories derived from his earlier studies; the pur-
pose of the scale was an indication of over-all psychological functioning. The scale
appraised the more complex psychological functions in Binet's belief that these were better indicators of intelligence. His rationale and methods of operation can be identified in his writings which appeared from 1905 to 1908. (The writings appeared originally in volumes of L'Année Psychologique published during the period 1905 to 1908; they were later collected and translated by Elizabeth Kite and published as The Development of Intelligence in Children by the Training School at Vineland, New Jersey, in 1916.)

Upon the Necessity of Establishing a Scientific Diagnosis of Inferior States of Intelligence

This article, first in the series, appeared in 1905. In discussing the deplorable conditions caused by inexact terminology prevalent in diagnosis, Binet pointed to the lack of agreement in the use of technical terms; he pleaded for precision: "precision and exactness of science should be introduced into our practice whenever possible, and in the great majority of cases it is possible" (Binet, 1905, p. 163). Binet and Simon felt the confusion was caused by a fault in the method of examination. They proposed to supply a precise basis for differential diagnosis. They criticized the weaknesses of the current classification, particularly the lack of specific gradation. They proposed some minimal quantitative differences. They went on to indicate that such quantitative differences were of no value unless they were measured, even if measured somewhat crudely.

New Methods for the Diagnosis of Intellectual Level of Subnormals

Our purpose is to be able to measure the intellectual capacity of a child who is brought to us in order to know whether he is normal or retarded. We should therefore, study his condition at the time and that only. We have nothing to do either with his past history or with his future; consequently we shall neglect his etiology, and we shall make no attempt to distinguish between acquired and congenital idiocy; for
a stronger reason we shall set aside all considerations of pathological anatomy which might explain his intellectual deficiency... We do not attempt to establish or prepare a prognosis and we leave unanswered the question of whether this retardation is curable... We shall limit ourselves to ascertaining the truth in regard to his present mental state... (Binet and Simon, 1905, p.191).

Binet's expressed limitations of application of his method take on a significance when subsequent application of his methods were made by others who ignored the cautions.

Binet and Simon proposed to make the identification by using test items which would cause the subject to make an effort to give some evidence of his ability regarding comprehension, judgment, reasoning, and invention. The method proposed by Binet was based on a measuring scale of intelligence. "The scale is composed of a series of tests of increasing difficulty" (Binet and Simon, 1905, p.194). Binet explained that the scale began at the lowest level of intelligence that could be discovered and moved upward to what might be considered that of normal average intelligence. Each level of the test corresponded to what the investigators had found to be a different mental level. Binet made the observation that intelligence could not be measured directly because intellectual qualities were not "superposable"; he cautioned that intelligence could not be measured as a linear surface would be measured. He found the abilities to be in the nature of classifications; he recognized a hierarchy among diverse intelligences and suggested that his classification might be used as the equivalent to a linear measure.

The scale that Binet and Simon described is the result of many long investigations conducted with both normal and subnormal children. The items were chosen on the basis of the following criteria: simplicity, speed, convenience, precision, heterogeneity, the ability to keep the subject's attention, and particularly on the demand for judgment by the subject. Their expressed purpose was the evaluation of the level
of intelligence, disregarding as far as possible the degree of instruction the subject might possess. Binet explained that the subject was given nothing to read or to write, the subject was not called on for any performance where previous rote learning might give him an advantage. They said that they were seeking a level of natural, rather than acquired intelligence. They saw intelligence as:

"...a fundamental faculty, the alteration or lack of which is of utmost importance for practical life. This faculty is judgment, otherwise called good sense, practical sense, initiative, the faculty of adapting one's self to the circumstances. To judge well, to comprehend well, to reason well, these are the essential activities of intelligence" (Binet and Simon, 1905, p. 196).

Binet explained that they had measured memory and found it to be distinct from and independent of judgment: "One may have good sense and lack memory...the reverse is also common" (Binet and Simon, 1905, p. 197). Resultantly their scale placed judgment first. Because they felt that the first gleams of intelligence contained traces of coordination, attention and memory, they included such items at lower levels; these were also included for the purpose of inviting absurd replies, so that under the cover of a memory test might be glimpsed some appearance of intelligence.

General recommendations for the administration of the scale were made; they include the following needs; a quiet, isolated room; the child should be alone; the child should be reassured when he sees the examiner for the first time by the presence of someone he knows and trusts; this witness was instructed to remain passive, mute, and unobstructive; the need for rapport between examiner and subject was underscored. Binet explained than an examination of their type was based on the good will of the subject and if, after repeated attempts, the examiner could not establish rapport, the subject should be sent away. The examiner might try again, at a future time; but the
exam must never be administered in the absence of adequate rapport.

Binet felt that the techniques for good questioning could only be achieved by example and imitation. Binet urged any users of their methods to come to their clinic and observe. He pointed to two principal errors committed by inexperienced persons: (1) recording gross results without making psychological observations, the very psychological observations which give the gross results their true value, and (2) the error of making suggestions. Binet remarked that it was a most difficult and demanding art; the examiner must be able to encourage the subject, hold the subject's attention, try to make the subject want to do his best, and at the same time refrain from giving any aid or any form of unskillful suggestion.

Binet presented the 1905 scale. With each item, there was a description of the procedure for its administration and suggested interpretations for specific behaviors of the subject in his response. The scale contained thirty items which may be briefly identified as follows:

1. Follow a moving object with one's eyes.
2. Grasp a small object which is touched.
3. Grasp a small object which is seen.
4. Recognize the difference between a square of chocolate and a square of wood.
5. Find and eat a square of chocolate wrapped in paper.
6. Execute simple commands and imitate simple gestures.
7. Point to familiar named objects.
8. Point to objects represented in pictures.
9. Name objects represented in pictures.
10. Compare two lines of obviously unequal length.
11. Repeat three spoken digits.
12. Compare two weights.
13. Susceptibility to suggestion.
14. Define common words by function.
15. Repeat a sentence of fifteen words.
16. Tell how two common objects are different.
17. Memory for pictures
18. Drawing a design from memory.
19. Tell how two common objects are alike
20. Compare two lines of slightly different length.
21. Place five weights in order.
22. Discover which one of the five weights has been removed.
23. Make rhymes.
25. Use three given words in one sentence.
26. Answer an abstract question.
27. Tell what time it is when the hands of the clock have been reversed.
28. Cut paper according to given instructions.
29. Define given abstract terms.
30. Distinguish between pairs of abstract terms.

(Adapterd from Jenkins and Paterson, 1961, p.95-96.)

As can be seen, the tasks were considerably varied, called on the judgment of the
subject, increased with difficulty and were generally free from rote memory. Many of the items have been retained and appear in 1960 version of the Stanford-Binet. Of importance here, is the ingenious method of structuring the tasks, and the originality expressed by Binet.

The Development of Intelligence in the Child

The 1908 scale represented a great improvement over the previous scale. Binet added and revised earlier items. He called attention to the fact that the child's intelligence was different from an adult's intelligence, not only in degree and quantity, but also in form. Ironically, research studies are still coming up with the amazing conclusion that children's intelligence is structured differently from an adult's and that the structures are different at different ages. After the introductory comments, Binet and Simon described the intellectual development of the child, as revealed by the tests. Binet and Simon considered a task to be "normal" for an age level when 75 percent of the subjects within that age range were able to pass it. Binet found that he had used too many tests of memory and sensory acuity in the 1905 scale.

Binet expressed the need for a test designed for normal children, rather than one designed to separate the retarded children from normal children. The 1908 scale moved toward that direction; Binet expanded the number of items to 58 and, again, placed first priority on judgment.

Binet noticed the developmental quality of children's intelligence; he marked the pattern of improvement in performance with increasing age. He did not, however, believe that intelligence was genetically fixed.

...some recent philosophers appear to have given their moral support to the deplorable verdict that the intelligence of an individual is a fixed quantity...We
protest and must act against this brutal pessimism... A child's mind is like a field for which an expert farmer has advised a change in the method of cultivating, with the result that in place of desert land, we now have a harvest. It is in this particular sense, the one which is significant, that we say that the intelligence of children may be increased. One increases that which constitutes the intelligence of a school child, namely the capacity to learn, to improve with instruction (Binet, 1909, p. 54, 55).

Ironically, Binet's test were brought to the United States by people who believed in fixed intelligence; Goddard and Terman. When Terman applied the IQ concept to his revision of the Binet-Simon scale, he implied fixed intelligence, a concept quite in opposition to Binet's.

Binet urged the examiner to begin with tests that fix a child's age. He repeated the directions for administration. The tests which comprised the 1908 scale were then detailed; a new addition was the classification of the tests according to age. Binet called attention to the doubtful application of the classification at age three and at age thirteen. "A pupil who passes all the tests for the thirteenth year may have a mental capacity superior to that age. But how much? Our tests do not show us" (Binet and Simon, 1908, p. 64).

The 1911 revision contained further refinements. It introduced the concept of mental age. Binet used absolute differences between mental age and chronological age as the basis for estimating the amount of retardation or advancement. This revision was to be their final one. Binet died in 1911; the question usually arises as to whether further revision would have been undertaken. In view of Binet's personality characteristics, the answer would seem to be affirmative. Unfortunately, Binet never had the opportunity to defend his tests from others who used them and interpreted them differently than Binet intended. In some cases, claims were made for the scales which Binet never made; claims he had taken pains to caution against in his writings. The
lack of concern, on the part of others who used the scales, for Binet's expressed intentions is startling. When one considers this fact, as well as, the fact that Spearman's theory of intelligence was applied to them, it is no wonder confusion regarding the measurement of intelligence would ensue for some time.

The 1911 version of the scale contained an age range from three years to average adult level. At each age level, with the exception of the four year level, there were five test items. The number of items in the scale was increased to 81. For the first time, partial credit was given for some items.

The final chapter of Development of intelligence in the Child pertained to the use of the measuring scale. The explanations and cautions have a very timely application:

...when one wishes to be more precise, or to make a closer approximation, one may make many more tests; if the child is seven years old, he may attempt the tests of eight, nine, or ten years for example. One would also be able after an interval of several days to substitute analogous tests...Instruction (in school) should always be according to the natural evolution of the child, and not precede it by a year or two...The child should be taught only what he is sufficiently mature to understand; all precocious instruction is lost time, for it is not assimilated...We are of the opinion that the most valuable use of the scales will not be its application to the normal pupils, but rather to those of inferior grades of intelligence...

Retardation is a term relative to a number of circumstances which must be taken into account in order to judge each particular case...

All our work has shown that intelligence is measured by a synthesis of results...

(Regarding prediction)...it is understood that these diagnoses apply only to the present moment. One who is imbecile today, may by the progress of age become a moron, or on the contrary remain an imbecile all his life. One knows nothing of that; the prognosis is reserved...

...our test of intelligence will not suffice to show absolutely that a child is subnormal...one may be among the less brilliant in the test of intelligence and yet follow the course of study for his age at school; when one is able to follow the course of study for his age, he is saved from a suspicion of backwardness...
It is frequent, not to say constant rule that those backward in arithmetic to do the operations better than the problems, and do more easily the operations of addition and multiplication than those of subtraction and division. (This observation will appear in the factor analytic studies of the Thurstones, and will cause some problems for Guilford in the attempt to deal with number concept as an isolated factor.) (Binet and Simon, 1911, pp.85-90).

Evaluation of Binet's work according to other psychologists

Although Binet never fully expressed a theory of intelligence he exerted tremendous influence on intelligence and its measurement. Variations and translations of his scale became the model for measurements of intelligence. The influence of the scale on research studies cannot be adequately assessed, for several decades, it has been a major criterion in the majority of studies conducted on children.

Terman (1925) stated that the progress made by Binet in the field of mental measurement created an entirely new situation; for the first time, it was possible to determine some accurate approximation of the brightness of a given child, in comparison with other children of the same age.

The importance of Binet's work for later studies of intelligence can hardly be overestimated. It has not yet received and possibly never receive from psychologists the appreciation which it deserves. Critical ability, unfortunately, is far more common than the ability to create, and to the critical psychologist the imperfections and crudities of Binet's methods, both in their practical and in their theoretical aspects, have often been more evident than their remarkable originality. More than anyone else, it was Binet who taught us where to search among mental functions for significant intellectual differences. It was he who gave us our first successful intelligence scale and demonstrated the actuality of an age development through successive "hierarchies of intelligences". That the term "mental age" which resulted from the latter concept has often been misinterpreted and misused, does not detract from the importance of his contribution... (Terman, 1925, p.3-4).

Spearman (1927) remarked on the comment made by Binet in his explanation of the use of the scales; Binet had stated that the tests were always special in their scope, and were each appropriate to the analysis of a single faculty. To this statement
Spearman questioned: "Why did not he then, why do not his avowed followers, measure (for each year of age) each of these independent faculties, memory, judgment, etc., one by one? To have made no attempt in this direction seems inconceivably illogical" (Spearman, 1927, p. 77). In the same place, Spearman said:

...appeared the great work of Binet and Simon. Here the paradoxical recommendation to make a hotchpot was actually adopted in practice. (Spearman is discussing the merits of pooling items.) Nevertheless the elaborate correlation theory which had...generated the idea, and supplied the sole evidence for its validity, was now passed over. The said authors employed a popular substitute. "Intelligence" as measured by the pool, was depicted as a "general level" of ability. So far as doctrine is concerned, this is the only thing introduced by them that was novel. And most surprisingly Binet, although in actual testing he took account of this "general level" alone, still in all his theoretical psychology continued to rely although upon the old formal faculties, notwithstanding that these and the "general level" appear to involve doctrines quite incompatible with each other.

Spearman was not one to compliment others with any kind of frequency; he could never really forgive Binet for the lack of statistical procedures he felt to be so necessary to research. He felt that Binet was influenced by the old faculty psychology ideas, and that this was a limitation to his thinking. Spearman was direct in what he interpreted to be Binet's total neglect of genuine sampling procedures. Spearman frequently complained that Binet had borrowed the pooling of items from him: "When Binet borrowed the idea of ...pooling, he carried it into execution with a brilliancy that perhaps no other living man could have matched. But on the theoretical side, he tried to get away too cheaply. And this is the main cause of all the present trouble" (Spearman, 1927, p. 79).

Edward Thorndike

Thorndike did graduate work at Harvard under the direction of William James. His experiments in comparative psychology were American classics; the first of which,
using chickens, was conducted in James' cellar. Thorndike received his doctorate from Columbia University in 1898, at the age of 24. He was appointed instructor in genetic psychology at Teachers College of Columbia. He served there until 1940; as full professor from 1904 to 1922, as director of the division of psychology of the Institute of Educational Research from 1922 to 1940. Thorndike's influence on American education was considerable.

Many textbook authors identify Thorndike as "the father of educational psychology". He was to the American psychology of education what Dewey was to the American philosophy of education. He wrote one of the first textbooks on educational psychology; it was published in 1904 and became not only a classic but the standard reference for many years to come. The extent of his influence can be increased when one considers that an entire generation of teachers and teachers of teachers came under his influence. Many educators feel it is no exaggeration to assert that educational psychology, since Thorndike, has been to a very great extent the verification and modification of principles of learning which he developed. Although his influence has waned in recent years, he dominated the field of educational psychology through the first half of the 20th Century.

Thorndike, as did Spearman and Binet, urged the use of scientific method and precision in psychological studies. His chief concern was the importance of exact measurement in education:

Whatever exists at all exists in some amount. To know it thoroughly involves knowing its quantity as well as its quality. Education is concerned with changes in human beings; a change is a difference between two conditions; each of these conditions is known to us only by the products produced by it - things made, words spoken, acts performed, and the like. To measure any of these products means to define its amount in some way so that competent persons will know how large it is,
better than they would without measurement. To measure a product well means to define its amount so that competent persons will know how large it is, with some precision, and that this knowledge will be conveniently recorded and used... (Thorndike, 1918, p.16).

His experimental animal psychology studies involved chickens, dogs and cats. Thorndike experimented on the abilities of chickens to learn simple mazes and on the abilities of dogs and cats to learn how to open problem boxes. He recorded the time required in the case of dogs and cats to get to the reward and, in the case of the chickens, the number of errors in learning the maze. His analysis of the studies included graphing the results of successive trials. In the observed behavior of his subjects, Thorndike could see no evidence of inferential reasoning; he concluded that animals learn by trial and error. He interpreted initial successes as accidental; the responses which lead to accidental successes tended to become "stamped in". He asserted that animals and children learn in much the same way: by trial and error.

His studies of 1898 cited many experiments to verify his claim. Based on the observed behaviors, Thorndike believed that the responses that occurred were functions of the structure of the animal; thus learning was interpreted as the strengthening of the connections between the response that achieved the goal and the stimulus that evoked it. He proposed the Stimulus Response Theory of Learning.

Thorndike's theories on learning met with wide acclaim in some circles, and, as might be expected, with expressed disfavor in others, particularly the Gestaltists. Köhler's classic study, The Mentality of Apes (1917), was conducted, in part, to refute Thorndike's suggestion that animals are planless, generating merely random responses to problems.

Köhler criticized Thorndike's choice of phylogenetic level of subject and the
unwarranted assumptions in applying the results to humans. Köhler took great care, in the introduction to his work, to establish his rationale. He defended his choice of chimps as subjects because they are beings in many ways much closer to man than other ape species; and the ape species, as a whole, are much closer to man than animals of lower phylogenetic levels. He stressed the fact that his study was limited to observations and conclusions which pertain to chimps. Köhler structured his tasks in order of increasing difficulty. He carefully noted the subject's behavior and concluded that chimps show insightful behavior. By analyzing both the structured problems and the pattern of subject responses, Köhler could establish levels at which response became impossible for the subject. He pointed out that when Thorndike's subjects could not solve a puzzle box, Thorndike had no more indications as to why not than before he started. Köhler's study was so structured that when an animal failed, there were indications of the reason for such failure. Köhler deplored Thorndike's casual application of animal learning to human learning. Unfortunately some time passed before such cautions were heeded.

Thorndike's theory of intelligence was greatly influenced by his animal studies. He specifically and energetically set out to dethrone faculty psychology of the classical type. He denied the existence of general intelligence, or general mental ability; he denied any unifying characteristics of mind. According to Thorndike, there were only specific stimuli and specific mental responses. The term "intelligence" was merely a convenient label for a practically infinite number of actual or potential specific connections between stimulus and response. There were as many different "intelligences" as there were different tasks. The "mind is a multitude of particular capacities, all of
which may be highly independent of one another" (1902). He believed that every mental act involved a number of minute elements operating together. Certain constellations of these elements had enough in common to be grouped together; these were classed as:

1. abstract or verbal - the ability to deal with ideas and symbols,
2. concrete or mechanical - the ability to deal with objects,
3. social - the ability to deal with people.

He claimed that each one of these intelligences was composed of specific constellations.

Thorndike characterized intelligence as having four attributes:

1. altitude - the level of difficulty of problems in any given field that can be mastered by an individual,
2. range - the number of given fields in which an individual shows competence,
3. area - the product of level and range,
4. speed - the amount of time required to solve a given problem (Thorndike, 1920).

Intelligence was given meaning only by observing the consequences, which Thorndike called "products". Products may be defined as the tasks an individual could complete; the level of difficulty of the task indicated the level of intelligence (Thorndike, 1926). Thorndike believed that the "quality of intellect depends upon the quantity of connections of neural connectors" (Thorndike, 1921, p.43).

Thorndike composed a test designed to measure four constellations of intelligence. He admitted that the four constellations did not represent the totality of intelligence, rather they represented a significant sampling (Thorndike, 1926). The test was known as the CAVD; each letter stood for one of the selected factors; C - sentence completion, A - arithmetical reasoning, V - vocabulary, D - following directions,
Thorndike was opposed to combining the scores of the four different subtests; he claimed them to be highly specialized abilities; combining them would imply a unitary or general intelligence, a concept that he denied.

As Thorndike's theories on animal learning had been soundly trounced by Köhler, so his theory or intelligence was attacked by Spearman.

Thorndike does appear to continue to assert the existence of many different abilities; but now he carefully proceeds to note that these are more or less inter-correlated. By the aid of these safeguards, the doctrine may indeed be said to have been rendered absolutely irrefutable. Beyond all reasonable doubt, human ability does admit of being regarded as being made up of a very numerous particular abilities that are mutually correlated. But has not his security been purchased at the price of significance? The collapse of the earlier and crude view, that all different abilities are independent had come from establishing just this fact of their inter-correlations. Thereafter, the whole problem at issue was to discover some aspect from which the inter-correlations could be rendered intelligible. And toward solving this problem such statements...do not appear to make even a commencement; the bare proposition that the intellectual aptitudes stand in complex relations to one another says nothing wrong only because it says nothing at all (Spearman, 1927, chapter 5).

There were significant, positive correlations among the various subtests of the CAVD. Burt (1955) interpreted this to support the g theory. Terman criticized the CAVD tests:

Thorndike has tried to give them meaning by positing a theory of intelligence which explains intellectual differences as solely a function of the number of established neural bonds...but we are unable to accept his proof that area and altitude of intelligence are perfectly correlated. His view seems...an over simplification of the complex and in direct opposition to most of the trends of psychological theory (Terman and Merrill, 1937, p. 45).

According to Garrett (1946) Thorndike offered no proof whatsoever for the existence of the three kinds of intelligence. As regards Thorndike's theory of intelligence, Wechsler (1950) remarked that little had been done to verify or refute the hypothesis.

It would appear perhaps that Thorndike's influence outweighed his actual practical contributions; although he did devise word lists and dictionaries for children
that were widely used. Thorndike's laws of learning were important to educational psychology, but they have been replaced in present times. Of importance here is his opposition to a single IQ score. Thorndike advocated a profile score based on the results from the subtests of the CAVD. He believed the subtests to measure quite distinct mental abilities. The concept of measuring distinct mental abilities would be developed and extended by the Thurstones. Another concept, to be treated a little differently and considerably extended, was his concept of social intelligence. Guilford makes use of this concept as a category in his structure of intellect.

Factor Analysis

Crossroads in the Mind of Man was published by Truman Kelley in 1928, and with it factor analysis in America took a different direction from the factor analytic model proposed by Spearman. Kelley believed that the nature and scope of mental traits covered a range as broad as the entire field of psychology. He remarked on the prevalent situation, noticing that the psychological field was in a state of turmoil, induced, he felt, by exclusiveness. "Each separate school is generally willing to ignore the others with the fine tolerance of the wise toward the harmlessly demented" (Kelley, 1928). He believed that the situation could be improved by two things: (1) a technique that could be applied universally to different kinds of psychological study, and (2) the will to do it, along with the opportunity for applying it. Regardless of the particular sentiments, every psychologist has essentially the same desire: to test the independence of a given element from those related or similar to it. Before there can be testing, there must be defining; the particular psychological school could frame the definition according to its particular tenets; but should do so precisely and in terms that could be
observed. "If the designation of some trait or capacity, as a category of mental life, is to be given serious consideration, it must be such as to reveal itself as a measurable difference in conduct, i.e., as a measure differing in the same individual as different times, or in different individuals at the same time" ... "The demand that a concept be subjected to objective measurement before...serious consideration as an independent category of mental life...is not too sweeping if we limit objective measurement to such as are definable and verifiable" (Kelley, 1928, p.3). Even concepts that could only be defined roughly and verified in part could be included if: "(1) the degree of agreement of a measure in hand with a second equally trustworthy measure is known, (2) the technique adopted takes the unreliability of the measure into account and allows for it so that no systematic error is introduced, and (3) the technique adopted guards, by drawing tentative conclusions where necessary, against any chance error which may be introduced due to this unreliability of the measure" (Kelley, 1928, p.5).

Kelley based his technique on the tetrad difference of Spearman, but he modified and extended it. Kelley had found in his work, not the $g$ factor, but evidence of group factors. Kelley summarized and critically analyzed many of Spearman's studies. He concluded that Spearman's $g$ was of relatively little importance; it could generally be interpreted in light of the heterogeneity of his subjects compounded by the generally high verbal content of the measures he had employed. If a general factor were to remain after these influences had been ruled out, it would probably be quite small and not significant. The major relationships, to be found among various tasks, could be attributed to a comparatively small number of broad psychological factors. Using his technique, which was only slightly less unwieldy than Spearman's, Kelley found
evidence for the following broad group factors: manipulation of spatial relationships, number ability, verbal ability, memory, and mental speed.

Briefly, factor analysis is a statistical method used for the analysis of obtained data. It is an extension of the correlational technique; it is based on correlational theory. Where correlation tries to show the degree of relationship among variables, factor analysis tries to identify those factors which account for the relationship. For example, an experimenter finds Test A to be related to Test B to the degree of .78. By using one of the factor analytic techniques, he further determines that one factor accounts for .57 of the relationship. In his analysis of both tests, the experimenter hypothesizes that the factor may be a verbal factor. He tests both Test A and Test B against a known measure of verbal ability; when his results support his hypothesis, he concludes that the factor which accounts for .57 of the relationship is a verbal factor. He asserts that Test A and Test B have significant verbal loadings. Kelley's work in factor analysis determined to a large degree the direction that subsequent psychological theory and research took in America.

Louis Leon Thurstone

In flexibility, curiosity, inventiveness and insight, Thurstone resembled Binet. In adhering to precise and empirical methods of research, Thurstone resembled Spearman. He brought to psychological study his cross-discipline experiences. His interest and skill in music persisted throughout his life. Art, photography, engineering and education were interests which developed while he was in high school; these too, persisted. Thurstone had been published twice in Scientific American before he was 25 years old. He published 23 books, 165 articles, 24 Reports
on American Council on Education Psychological Examination, 46 standardized versions of tests and 95 Psychometric Laboratory Reports before the end of his career.

Thurstone entered Cornell University in 1908; he began as a civil engineer major but later changed to an electrical engineering major. He began work on a design for a motion picture camera which later resulted in a model that impressed Edison enough to offer him an assistantship in his laboratory. After receiving his degree in mechanical engineering, he joined Edison's staff. Thurstone was very impressed by Edison's tremendous fluency of ideas. Wood (1962) felt that this influence contributed to Thurstone's later interest in creativity and in his development of tests of ideational fluency.

Thurstone was a born teacher. His love of teaching was a vital part of his life. Intrigued as he was with the work in Edison's laboratory, the desire to teach prompted him to leave. He began his teaching career at the University of Minnesota in 1912. As time went on, he taught at the Carnegie Institute, the University of Chicago and the University of North Carolina. He married his co-worker, Thelma Gwinn, in 1924, the same year that he began teaching descriptive statistics at the University of Chicago. Thelma Gwinn had been prominent in the Bureau of Child Study of the Chicago Board of Education; her chief interest concerned the evaluation of children's intellectual abilities. Both Thurstones devoted a lifetime to the development of the Primary Mental Abilities theory of intelligence and the methods for its appraisal.

Spearman's work had consisted mainly of theory; he never developed an instrument to test his theory of intelligence. Binet's work had consisted mainly of his intelligence test; he never fully formulated a theory of intelligence to go with it. Tho...
dike had developed a theory and a test which measured some aspects of his theory, but his theory rested on an invalid assumption. It now appeared that mental measurement would, at last, have a tenable theory and an instrument to go with it.

Mental testing, particularly the measurement of intelligence, was being regarded quite critically during the mid to late 20's. Critics appeared both from within ranks and outside the ranks. From within, concern was generally at a theoretical level and involved the question of existence or non-existence of Spearman's $g$. Outside the ranks, concern was generally at a practical level; the charge being made that no one, least of all the psychologists, knew what their tests measured.

Psychologists have never agreed on a definition of intelligence... The psychologist proceeds to guess at the more abstract mental abilities which come into play again and again... he invents puzzles which can be employed quickly... the tester himself guesses at a large number of tests which he hopes and believes are measures of intelligence... these puzzles may test intelligence, and they may not. They may test an aspect of intelligence. Nobody knows... (Walter Lippmann, quoted in Spearman, 1927)

Thurstone was teaching a course in mental test theory at the University of Chicago in 1924. He was challenged by the lack of organization in the area and also, the lack of comprehensive references on the subject. He determined to get to the root of some of the basic problems in psychological measurement. His analysis of the various educational scales in use indicated the assumption that the distribution of scores for various age groups differed only with respect to the mean. Hoping to improve quantititative description of general intelligence, Thurstone developed a scaling method for psychological tests (Thurstone, 1925). A year later, he went after the mental age concept. He urged professionals to abandon the concept because it was "a failure in that it leads to ambiguities and inconsistencies" (Thurstone, 1926, p.268). He
suggested that IQ should be discarded also, as its value was obtained from the mental age concept. In place of these, he recommended either the percentile or sigma deviation of the appropriate group in relation to the individual subject. He felt that IQ made no sense when applied to adults, and further, all psychologists should be seeking the relative standing of the subject with his peers. "Binet may still be given credit for having introduced certain types of objectivity in mental measurement but his invention of the mental age concept was an awkward and unfortunate one" (Thurstone, 1926, p. 278).

The Theory of Multiple Factors appeared in 1932. In it, Thurstone set forth his theory of multiple factor analysis; he detailed the first techniques he had devised for calculating multiple factors. Thurstone was most impatient with the single overall index of intelligence; he claimed it to be a hodge-podge of who knows what combined at unknown weights. Rather typical of his ingenuity. Thurstone posed the question in a new form. Instead of debating whether a table of correlation coefficients supported a general factor, he re-posed the question to ask how many factors must be postulated to account for observed correlations. Using this approach enabled him to find whether a factor could be regarded as general for each study.

Thurstone wondered about the relation of his multiple-factor approach to Spearman's methods. He was writing out the tetrad difference equation, when he suddenly saw that it represented the expansion of a second-order minor. He concluded that "if all these vanish, the rank of the matrix is unity. If not all second-order minors vanish, but all third-order minors do so, the rank is two; and so on" (Thurstone, 1933, p.9). Again, he had recast an old problem in a new way that pointed to a solution.
Thurstone credited Kelley with the principal contribution to the development of his theory. He explained the tetrad difference method as being a special case of multiple factor methods. The introduction to the book gave a most lucid explanation to the distributions which must be made: (1) the distinction between Spearman's two-factor statistical or quantitative method and (2) the hypothesis about the presence of g in intelligence, and (3) the nature of uniqueness in factor analysis and scientific proof.

Thurstone changed the calculational methods for obtaining factors shortly after the publication of *Theory of Multiple Factors*, but the theory remained the same. During the 30's, Thurstone and his students conducted extensive researches using multiple factor methods: "The Isolation of Seven Primary Abilities" (1936), "The Factorial Isolation of Primary Abilities" (1936), "A New Concept of Intelligence and a New Method of Measuring Primary Mental Abilities" (1936), "Primary Mental Abilities" (1938), "Factorial Studies of Intelligence" (1941).

The experimental edition of Tests for Primary Mental Abilities was published by the American Council on Education in 1938. A standardized version, published jointly with his wife, came in 1942, followed by a single booklet edition in 1943. Various forms of the PMA tests were published by Science Research Associates from 1943 through current editions of the tests.

Were Thurstone's PMA's found by other researchers? Or to be more scientific, were the Thurstone studies reproducible? In general, yes. In actual practice, some of the variations in the results of other experimenters would be caused by the populations studied and the method of factorial analysis employed. Some studies identified sub-areas of one or more of the primaries. Some researchers (Corter, 1952) applied
factor analysis indiscriminately and produced results of little value, for they could identify no factors that could be interpreted according to previously identified factors; even using Thurstone's test of perceptual speed, which has generally stood up no matter what was done to it, Corter failed to identify the perceptual speed factor.

The primaries, which have been fairly consistently identified by Thurstone and his students, and such independent investigators as Christal, French, Guilford, Kettner, Michael, Zimmerman, and others are:

1. **S - spatial relations**: the ability to visualize two- or three-dimensional figures; some investigators have found two or three subfactors to be included.

2. **P - perceptual speed**: speed and accuracy in judging similarities or differences or in response to visual details.

3. **V - verbal comprehension**: reading comprehension, vocabulary, verbal analogies, verbal reasoning, and the like.

4. **W - word fluency**: speed in dealing with isolated words, anagrams, rhymes, categorical word naming, and so on.

5. **N - number facility**: speed and accuracy in arithmetic computations.

6. **M - associative memory**: rote memory for paired associates.

7. **I - induction**: ability to derive a rule or a principle.

The primary factor which Thurstone originally identified as inductive was modified as a result of subsequent experimentation. Thurstone had originally proposed inductive reasoning and deductive reasoning. Inductive reasoning was measured by tests which asked the subject to find a rule, particularly in number or symbol series items. Deductive reasoning was measured primarily by tests of syllogistic reasoning.
He found that college students' test data contained an R factor: the R factor he called arithmetic reasoning, it was much like the I factor that had been found in younger populations. The D (deductive reasoning) factor was common to college students but not to a younger population. Part of the explanation may rest in the evidence of differentiation of ability with age. Guilford (1963, Report No. 31) has found a similar situation.

In the more recent research, conducted by Guilford and his associates, not only have most of the primaries been identified, but some of them have been successfully broken into the component parts of distinct abilities that combine to make up factors which Thurstone had regarded as primary. Anastasi (1964) points out that differences among general, group and specific factors are not as clearcut, nor basic, as might appear at first. The number and kind of tests used in an experimental battery can cause varying results. When a small number of tests is used, a single general factor may cause all of the correlation to be found, particularly when the tests used are of similar construction. When the same small number of tests are included in a larger battery, containing tests of more heterogeneity, the original general factor may emerge as a group factor, indicating that it is common to some but not all of the tests. Sometimes a small group of tests will contain a factor that does not show relationship to others in the same small group; it would be identified as a specific factor. If this same small group of tests were included in a larger battery, the original specific factor might show relationship to others in the battery and would then be identified as a group factor.

Thurstone published The Vectors of Mind in 1935; he presented his theory of multiple factor analysis in terms of his approach to the problem, the methods used and
inferences drawn. The publication caused considerable ferment. Included in this work were several modifications and extensions of his earlier theories; he developed the theory and methods for obtaining communalities, he explained the rotation of reference frame, he described the use of oblique reference axes, he discussed the principles of factorial invariance and simple structure. There was considerable misinterpretation of his work, as well as misapplication of his method. Thurstone published Multiple Factor Analysis in 1947. In this work, he expanded, revised and explained material contained in *The Vectors of Mind*, particularly his concept of simple structure. He gave further support for the theorems previously introduced, he added a new theory on the influence of selection and secondary order domain. He expanded and explained simple structure, communality and oblique reference frame. He presented new factorial methods which made possible the working of rotational problems and factoring problems that had earlier been impossible.

Thurstone made a concentrated effort to identify the sources of misunderstanding:

The brevity of *The Vectors of Mind* was probably responsible for much of the controversy about multiple factor analysis. As far as I am aware, all the theorems in the first edition are as valid today as they were ten years ago. The theorems were stated, and, in general, they were proved; but I left them without the support of exposition as to their implications and interpretation in exploratory scientific work. Several concepts have been the subject of controversy. It has been a mystery to me why the fundamentally simple notion which I called "simple structure" has been twisted around by some critics into the most inconceivable nonsense. There has been misunderstanding about the communality concept by which multiple-factor analysis is limited to the common factors - just as it is in Spearman's single-factor case. Some students of this subject change their set in going to the multiple-factor case by insisting that they must include the total test space. There has also been confusion about the oblique reference frame which represents parameters or factors that are correlated in the general population as well as in the experimental population. (Thurstone, 1947, p. vi).
The test correlations define a configuration of test vectors without a reference frame. Since the factors are represented by the axes of this frame, it is necessary to locate a reference frame somehow in the test configuration. Here we have to recognize a distinction between an arbitrary orthogonal reference frame that is used for computing purposes and the reference frame that should be used for scientific interpretation of the factors. The arbitrary orthogonal frame is defined by the method of factoring that the computer happens to use. In order to locate a reference frame for interpretation... I favored a principle that I called "simple structure." This principle of simple structure has been the cause of much controversy... The fact that it very frequently gives a set of factors or parameters that can be interpreted as meaningful in scientific context would seem to be an argument in its favor, but even that has been the object of controversy...

In locating a meaningful frame of reference for a set of correlated variables, one may voluntarily impose the restriction that the reference frame shall be orthogonal, or one may allow it to become oblique according to the test configuration. If we impose the restriction that the reference frame shall be orthogonal, then we are imposing the condition that the factors or parameters shall be uncorrelated in the experimental population or in the general population. It is my own conviction that this restriction should not be imposed if we are looking for meaningful parameters. It seems just as unnecessary to require that mental traits shall be uncorrelated in the general population as to require that height and weight be uncorrelated in the general population (Thurstone, 1947, p. vii).

So far, one of the principal handicaps of the statistician in dealing with multiple-factor analysis has been his failure to appreciate the significance of the rotational problem. This is the problem of choosing the most fruitful set of parameters to describe the variation in a domain. These parameters represent scientific concepts. They are not merely numerical coefficients. (Thurstone, 1947, p. xi).

In factorial investigation of mentality we proceed on the assumption that the mind is structured somehow, that mind is not a patternless mosaic of an infinite number of elements without functional groupings. The extreme, opposite view would hold that the mind has no structure at all. In the interpretation of the mind we assume that mental phenomena can be identified in terms of distinguishable functions, which do not all participate equally in everything that mind does. It is these functional unities that we are looking for with the aid of factorial methods. It is our scientific faith that such distinguishable mental functions can be identified and that they will be verified in different types of experimental study. No assumption is made about the nature of these functions, whether they are native or acquired or whether they have a cortical locus (Thurstone, 1947, p. 57).

"Primary Mental Abilities of Children" by Thelma G. Thurstone appeared in 1941. It explained the Thurstone's efforts to extend PMA research to the level of
children. It was indicative of the beginning of a reconciliation between American and British factor analytic psychologists regarding the concept of general intelligence. The article first presented a plea, if one the basis of rational observation alone, for abandoning the single index of intelligence; mental age, intelligence quotient, percentile rank in general intelligence. "An average index of mental endowment should be useful for many educational purposes, but it should not be regarded as more than the average of several tests...the error that is frequently made is interpreting it as measuring some basic functional unity, when it is known to be nothing more than a composite of many functional unities" (Thurstone, Thelma; p. 105).

She explained the research studies on PMA which had been conducted over the past several years; they had had as first priority the identification and definition of the independent factors of mind. As these became more clearly indicated, the Thurstones became involved with a practical purpose; the preparation of a series of tests of psychological significance which could be easily adapted to educational testing. The article summarized the studies, gave the rationale behind the measures used for each factor, described the tests and some of the problems they had encountered, and the ways they had tried to overcome them.

"General intelligence" was explained as a second-order factor:

We have not been able to find in these data a general factor that is distinct from the primary factors, but the second-order general factor should be of as much psychological interest as the more frequently postulated, independent general factor of Spearman. It would be our judgment that the second-order factor found here is probably the general factor which Spearman has so long defended, but we cannot say whether he would accept the present findings as sustaining his contentions about the general factor. We have not found any occasion to debate the existence of a general intellective factor. The factorial methods we have been using are adequate for finding such a factor, either as a factor independent of the primaries or as a factor operating through correlated primaries (Thurstone, 1941, p. 110).
The primary factors which appeared to have enough stability over several age levels to justify their practical use were:

1. V - verbal comprehension
2. W - word fluency
3. N - number ability
4. S - space
5. M - rote memory
6. R - reasoning

It was their judgement that P - perceptual factor and D - deductive factor were not sufficiently clear for practical application. Important to note is the care and integrity observed in considering the difference between research and application - a characteristic many psychologists sometimes neglect to observe. The plea for a mental ability profile was repeated:

In presenting for general use a differential psychological examination which appraises the mental endowment of children, it should not be assumed that there is anything final about six primary factors. No one knows how many primary mental abilities there may be. It is hoped that future factorial studies will reveal other important primary abilities so that the mental profiles of students may eventually be adequate for appraising educational and vocational potentialities. In such a program the present studies are only a starting point in substituting for the description of mental endowment by a single intelligence index the description of mental endowment by a profile of fundamental traits...

We must recognize that the new test program has for its object the production of a profile for each child, as distinguished from the description of a child's mental endowment in terms of a single intelligence index (Thurstone, Thelma, 1941, p. 112).

Anastasi (1964) points out a most important fact. The original PMA battery, as described here, was the direct outgrowth of the Thurstones' careful research on the identity of PMA. The reliabilities and validities for each of the tests were of highest
order. When originally published by the American Council on Education in 1942, the battery entailed six sessions for its administration. The following year, publication rights were obtained by Science Research Associates. The number of tests for each factor were reduced; the series was compressed to a single booklet two-hour administration. Later in 1946 and 1947 and 1948, SRA made more modifications; the booklet was further condensed and the tests were extended downward to ages 5 - 7. Not all of the PMA's were included, normative data were inadequate, unsupported interpretations of scores were given, validity data were scant, improper procedures were given for computing reliability of speeded scores and there was low reliability of factor scores.

McNemar (1964) comments: "The real teaser is why Thurstone ever sanctioned, if he did, the summing of SRA PMA scores to obtain an IQ. One has the uncomfortable feeling that his publishers wished to garnish the factor cake to make it more palatable in the market place" (1964, p. 874). It appears to be quite obvious that a single index IQ, as presented by SRA, is totally against the basic concept of PMA, and in total disagreement with the plea made by Louis Thurstone in 1926 and reiterated by his wife in 1941. Both urged that the single index be abandoned on the grounds of it being misleading. It appears that much of the controversy regarding the worth of the PMA tests has been caused by an unprofessional attitude and a lack of integrity on the part of Science Research Associates - not by the Thurstones.

Garrett (1946) in an explanation of the developmental theory of intelligence, found that the differentiation hypothesis implied a rapprochement between the Spearman g theorists and the Thurstonian group theorists. He indicated the general trend to be found in numerous studies: at elementary school levels there appeared to be a functional
generality among tests at the symbol level; later on, in high school and college populations the general or g factor broke down into quasi-independent factors. He found that the g factor, which appeared to be fairly well marked at the elementary school level, seemed to be mostly verbal or linguistic in nature. Garrett also found that Thorndike's "quality hypothesis" could be included in the differentiation hypothesis. Thorndike claimed that the difference in intelligence between the very bright and the very stupid was one of quantitative (more of the same thing) rather than qualitative (new sorts of mental processes). The more intelligent a person was, the more access he had to numerous connections. According to the differentiation hypothesis, the common general ability that ran through elementary school intellectual performance became more differentiated with increasing age and experience. As individuals became increasingly more mature and shared a more common background of language facility, general ability dissolved into more specialized talents or group factors.

Hobson (1947) found a number of sex differences in the PMA. Using the 1941 edition of the tests of PMA, which consisted of 17 subtests, Hobson found girls to be higher than boys for the following factors: number, verbal, word fluency, reasoning, and memory. The boys were higher in the space factor. The study was conducted on a 9th grade population. A second study was conducted by Hobson, using the revised single booklet edition, again with a 9th grade population. The results indicated girls to be higher in number, word fluency and reasoning; boys were higher in space and verbal factors. Hobson felt that the lack of differentiation for sex in the norm tables indicated a limited use of the tests for individual guidance purposes.
Hierarchical Theories of Intelligence

Essentially, the hierarchical theories of intelligence, as proposed by several British psychologists, accept the factors of intelligence concept, but offer a hierarchical scheme for their organization. Two of the better known theories of this type are those of Vernon and Burt.

Vernon's scheme

Vernon placed Spearman's g factor at the head of the hierarchy; from g came two major group factors: v:ed and k:m. V:ed referred to verbal-educational abilities. The two major group factors could be split further; v:ed could give verbal and numerical subfactors. K:m referred to practical-mechanical abilities. When this was split, the subfactors: mechanical information, spatial, and manual were identified. At the base of the hierarchy were specific and apparently quite independent factors (Vernon, 1950).

Figure 1
Vernon's Hierarchical Theory
Burt's scheme

Burt conceived of mind as being divided into two major parts; \( g \), which represented Spearman's \( g \) concept, and practical, which represented behavioral characteristics. \( g \) split into two components as did practical, and so on (Burt, 1949).

Figure 2

Burt's Hierarchical Theory

Cattell's scheme

Cattell had worked with both Spearman and Thurstone. He thought he detected flaws in Spearman's monolithic structure; in 1940 he put forth a theory of two \( g \)'s: \( g_c \) and \( g_f \). \( g_c \) represented crystallized general ability which was verbal in nature; it represented those skills which had been acquired by cultural experience: vocabulary, synonyms, number skills, mechanical knowledge, memory and habits of reasoning. Crystallized \( g \) reached across the whole range of cultural acquisitions. \( g_f \) - fluid ability represented a general relation-perceiving capacity, independent of sensory area.
and was determined by cortical, neurological development. It included performance tasks, judgment and reasoning considered to be relatively culture free. Gf would be shown in problems that did not involve much educational acquisition to solve. Both gc and gf were further subdivided and interrelated.

**Figure 3**

*The Cattell's Hierarchical Theory*

Basicly, the hierarchical theories are extensions of Spearman's theory of intelligence arranged in hierarchical order to indicate logical interrelationship. They differ from the theories of Thurstone and Guilford in that they are multilevel; Thurstone and Guilford place group factors on a single level. Burt, Vernon, and Cattell put emphasis on a g factor; they account for inter-test relationships in terms of g. Thurstone found g to be a second-order factor; he used oblique rotation of axes to do this. Guilford does not agree with the use of oblique factor vectors as the basis for estimating factor intercorrelations. He reasons that there is not enough knowledge, as yet, to
construct the tests that would be needed to locate the axes exactly; thus, experimental control cannot be firmly established. He gives three reasons for choosing a morphological model rather than a hierarchical one:

(1) generally the research studies using factor analysis of intelligence tests in the United States have failed to find a g factor, the tendency has been for each factor to be limited to a small number of tests,

(2) there has been little or no tendency to find a few broader group factors and a large number of narrow group factors. "The extra loadings often come out in the analysis because tests are designed for one factor so often unintentionally show significant relationships to other factors. The absence of a g factor and the apparently comparable generality of all the factors does not give support to a hierarchical conception of their interrelationships" (Guilford, 1967, p. 61),

(3) many factors appear to have parallel properties: "...there seems to have been a belief that psychological operation is the same whether it is performed with verbal-meaningful information or with visual-figural information, and gestalt psychologists have contributed to this assumption. Extensive factor-analytical results have proved wrong the belief that the same ability is involved regardless of the kind of information with which we deal" (Guilford, 1967, p. 61).

**Developmental Theories of Intelligence**

Spearman, Binet, Thorndike, Thurstone, Burt, Vernon, Gattell, and Guilford have all been concerned with the structure of intelligence. They have tried to identify the factors which make up intelligence. Binet stressed such factors as judgment, common sense, initiative and adaptability. Spearman conceived of a g factor as 'a general
fund of mental energy” which worked in conjunction with specific and group factors. Thorndike opposed the general factor and offered the theory of specificity. Thurstone offered the primary mental abilities theory with g as a second-order factor. Guilford has not found g; he offers a theory formulated on the basis of the contents, operations, and products involved in intellectual acts. The developmental theories have been concerned with the changes in the composition of intelligence. How intelligence develops, what patterns emerge and what changes can be described are their chief areas of concentration. Where the trait theorists have observed the products of intelligence, the developmental theorists have observed the process of intelligence. They do not necessarily disagree with one another, they represent different ways of looking at the same thing.

"Piaget and his associates were the first to actually formulate a theory of mental development in which the nature of developmental change as such was primary concern" (Stott and Ball, 1965, p. 32). Piaget viewed intelligence as being a dynamic process of organization; "...an assimilatory activity whose functional laws are laid down as early as organic life and whose successive structures serving it as organs are elaborated by interaction between itself and the external environment" (Piaget, 1952, p. 359). Piaget’s theory of intelligence is approached from concerns that are totally different from those of the psychometrist or the experimental psychologist; ultimately, he hopes to arrive at the same destination. Both types of study have as their final objective the knowledge of what intelligence is. A problem can be solved in more than one way. At present, Piaget is to the developmental study of intelligence what Guilford is to the factor-analytic study of intelligence. There are wide areas of converging agreement to be found in the
hypotheses and observations of both men. In a very real sense, they compliment one another.

Such brevity, as is necessary here, does not do justice to Piaget's theory. The writer merely wishes to indicate the importance of Guilford’s broad concept of intelligence and to stress the areas of mutual agreement. Guilford (1967) notes that studies of mental growth by psychometric methods indicate very little by way of basic concepts; they do indicate the need for a multiple-aptitude view of intelligence. Piaget believes that understanding the way in which humans acquire and use knowledge is the key to understanding intelligence and the operations of the human mind. In general, Piaget's observations are informal and casual; he makes little use of experimental control, in the sense of Guilford's use of control. Piaget's data are usually in the form of written protocols; rarely does he employ empirical, statistical treatment. In many ways his techniques resemble those of Binet. This is not surprising as Piaget met Simon in 1921 and was invited to work in Binet's laboratory. Under the benevolent direction of Simon, Piaget assisted in the standardization of Burt's reasoning test for children for a French population. The work conducted at Binet's laboratory eventually lead to Piaget's lifelong field of research: the development of reason in children. Piaget became Director of Studies at the Institute J. J. Rousseau in Geneva. In 1925 he married one of his student-collaborators. Their children were born in 1927, 1929, and 1931. As had Binet, Piaget observed in minute detail the development of his own children; hypotheses were tested on them, the observations were published. Much of what he had observed in his own children was later observed and tested in larger populations of children. Piaget's entire professional life has been devoted to researching the way in which humans ac-
Piaget (1952) marks three aspects of intelligence: content, function and structure. By content, he means those aspects of intellectual behavior which may be observed. By function, he means broad principles of intellectual activity; these are consistent as they apply generally to all levels of development. They are the general concepts which have been inferred from observations. By structure, he means knowledge; structure is not consistent, it changes with age and experience and it develops with activity.

Although Piaget has devoted considerable time and analysis to sensorimotor activity, his main theory is cognitive development. He presents a theory of continuous transformations in the organized structure of intelligence. The series of organizations begins with assimilation and accommodation. At birth, these are largely sensorimotor in nature. Piaget marks six stages of development for the first 18 months to 2 years of life:

Stage 1 - congenital reflex
Stage 2 - primary circular reactions
Stage 3 - secondary circular reactions
Stage 4 - coordination of the secondary schemata and their application to new situations
Stage 5 - elaboration of the object and the search for something new: tertiary circular reactions
Stage 6 - transitional phase between the practical and the systematic of deductional levels of intelligence.

Piaget (1952) stresses that each new stage superimposes the new behavior patterns over the older ones; the older ones are never abolished, they are changed qualitatively. Assimilation and accommodation enable the individual to progress to the
next higher stage. By assimilation, he means taking the input from sensory experiences and incorporating new elements into the existing structures of knowledge. By accommodations, he means the process of self-adjustment as the individual modifies the existing structure to make it adapt to new situations.

Piaget (1952) marks two additional kinds of operations: concrete and formal. By concrete, he means those operations which are characteristic of a typical child under 8 years of age. Concrete operations are largely of sensorimotor origin; they are restricted to a certain natural time order. By formal operations, he means those which are characteristic of adolescents and adults. The formal operations are based more on the rules of formal logic, but they have derived from childhood schemes. It is in the area of concrete and formal operations that much conceptual agreement with Guilford's theory may be found. Many intellectual abilities found by Piaget, through questioning and observing individual children have also been found by Guilford, using factor-analytic techniques.

Piaget emphasizes three categories of abilities in intellectual development: semantic concepts (Guilford's units), classes and relations. In the developing stages, Piaget refers to systems, implications, and transformations, Piaget's definition of content is equivalent to Guilford's definition of products. Both men are concerned with an understanding of the knowledge in the possession of the individual at specific ages and its importance as the most feasible approach to the study of intelligence. Piaget has given considerable attention to the development of spatial orientation; this is Guilford's factor CFS-V. Other areas of cognition, production and evaluation find many mutual agreements. Binet's conclusions were criticized by Spearman as lacking statistical
procedures and proof. Binet's death made a joint endeavor impossible. Sixty years later, Piaget, using similar but more systematic techniques than Binet, has put forth a comprehensive theory of the development of intelligence. Sixty years after Spearman, Guilford, using similar but more sophisticated techniques than Spearman, has put forth a comprehensive theory of the structure of intelligence. The combination of Piaget and Guilford, interestingly foreshadowed by Binet and Spearman, may well provide some of the answers to the questions of intelligence.

Summary

Spearman appears to have been headed in the right direction in his attempt to understand intelligence. He was limited by the tools that he had to use; he was deterred by the criticisms he had to answer and the misinterpretations he had to clarify. While Thorndike made numerous contributions to the understanding of some aspects of intelligence, his theory was narrow and rested on a false premise. His well-known dicta: "If a thing exists, it exists in some amount, if it exists in some amount, it can be measured" implies that psychologists are concerned only with things and implies further that such "things" are distinct elements or traits which have a real existence. This is his false premise, a basic assumption found to be faulty by Cronbach (1960) and others.

Binet's observational insights and testing genius were limited by lack of statistical analyses, lack of expressed theory and an apparent adherence to certain tenets of faculty psychology. The Thurstones modified and extended Spearman's theories; factor analysis in America moved rapidly through their impetus. Guilford has further modified and extended the earlier works. Most important, he is the first to supply a framework and a psychological theory that has long been needed. Guilford is the first to
present a firm, comprehensive and systematic theory of the structure of intelligence; a theory concerned with its relation to the mainstream of contemporary psychology.
CHAPTER III

GUILFORD'S STRUCTURE OF INTELLECT THEORY

Human nature is exceedingly complex... The rapidly moving events of the world in which we live have forced upon us the need for knowing human intelligence thoroughly. Humanity's peaceful pursuit of happiness depends upon our control of nature and of our own behavior; and this, in turn, depends upon understanding ourselves, including our intellectual resources.

- Guilford (1959)

J. P. Guilford, Professor of Psychology at the University of Southern California, directs the Aptitudes Research Project. The project is devoted to empirical research; it is designed as an intense investigation of human abilities. Guilford's professional life has been dedicated to research in human abilities. His scholarship and creative approach have made both valuable and influential contributions to behavioral science, particularly to the area of human intelligence and its appraisal. His unique talents have been recognized by professional groups as well as educational institutions. He is a Fellow and Past President of the American Psychological Association; he is a Diplomate in Psychology. In 1964 he received the award for Distinguished Science Contribution. He has been given numerous honorary degrees, among them an LLD from the University of Nebraska and an ScD from the University of Southern California. He has made significant contributions to government research projects and has served as consultant for testing organization such as Educational Testing Service. His textbooks in psychology and statistics are classics. He is a constant contributor to professional journals in both education and psychology. The publication of The Nature of Human Intelligence in 1967
may be regarded as a landmark contribution to behavioral science. The work has been acclaimed as "monumental" and "in the great tradition established by Spearman's Abilities of Man" (Carroll, 1968).

Guilford received his doctorate from Cornell University in 1927. He was subsequently appointed director of the Bureau of Institutional Research at the University of Nebraska. He initiated a research study on the aptitudes of college freshmen. His study of intellectual aptitudes has, with the passage of time, grown to include all age levels and educational levels. During World War II, Guilford was asked by John C. Flanagan to join his research group, The Army Air Forces Aviation Psychology Research Project. Guilford was assigned to the research unit that specialized in intellectual aptitudes. The other researchers assigned to the unit agreed with Guilford that factor-analytic techniques seemed to be the most promising method of dealing with their data.

Shortly after the war, Guilford collaborated with Fruchter, Michael and Zimmerman in further analytic studies. Since 1949, Guilford has continued his research on intellectual abilities at the University of Southern California as Director of the Aptitudes Research Project. This project has been supported continuously by the Office of Naval Research; it has been a frequent recipient of grants from the U.S. Office of Education and the National Science Foundation. In the period since 1949, many graduate students at USC have worked with Guilford; some of them have gone on to be recognized in their own right, such as Christensen, Merrifield and Hoepfner.

**Development of Theory and the Structural Form**

*SI theory*
The Structure of Intellect (SI) theory has grown out of experimental applications of the multivariate method of factor-analysis of psychological test data. For the past 25 years, Guilford has worked with insight and deliberation in the attempt to discover and identify the factors which comprise intelligence. For the past 12 years, Guilford has directed his energies toward the construction and verification of a psychological model which would integrate the study of intelligence within the framework of contemporary psychological theory. Guilford (1967) admits:

Although it might seem premature to write this book when the theory has not been tested in all its aspects, enough appears to be known to lend support to the expectation that in large part the theory is sound and that research in the future will continue to provide empirical support for it. Implications from the theory and its concepts have led to many new interpretations of already-known facts of general significance in psychology. Thus it appears timely to let the linkages between a psychometrically based theory and general psychological theory be brought out for more general consideration... (Guilford, 1967, p. vii).

Guilford's theory of intelligence is based on the belief that intelligence is composed of many different factors. He rejects the theory of general intelligence; instead he offers a general theory of intelligence. The emphasis is on information. He views man as an agent designed to deal with information. By nature, man seeks information, he processes information, he retains information; from given information man can produce new information. Was it not Aristotle who said: "All men by nature desire to know"? Guilford believes that many of the factors of intelligence can be identified. He proposes factor-analysis as an acceptable method for studying the obtained information about these psychological factors, but he explains certain limitations:

Any subjectivity in decisions on where to rotate is undesirable, but the facts of life in factor-analytic procedures are such that it is often necessary; otherwise strict adherence to the rules of best simple structure may lead one astray psychologically... Since it is psychological information that the psychological factor analyst presumably wants to achieve and not exercise in completely objective
following of rules of a method by which he may be misled, the exploration of abilities under relaxed rules seems defensible. The investigator can always test the hypotheses about psychological factors derived from an analysis by planning a better test battery and applying the procedures of analysis in a completely objective way in a later analysis. The writer often feels that the chief virtue of factor analysis is that it enables us to turn complex data around, in simpler views, so as to achieve better looks at the data, from which new insights may arise (Guilford, 1967, p.55).

Factor-analytic theory uses a dimensional type model; each factor is represented by a unique dimension in common-factor space (Guilford, 1967, p.67). The factor-analytic model provides a reference frame for describing individuals with regard to trait dimensions, and also for describing tests in terms of underlying variables that have much claim to invariance and to psychological significance. According to Guilford, the individuals are represented as points in the common-factor space and the tests are represented as vectors. There are several ways of representing intellectual factors, two of the more common are the hierarchial and the geometrically orthogonal. In general, the hierarchial models (cf. Burt, Vernon) are based on the acceptance of a g factor. Because Guilford rejects the concept of a g factor, it follows that he would not use a hierarchial model to represent his theory of intelligence; thus, he uses a geometrically orthogonal model.

Guilford's research has persistently dealt with the nature of human intelligence. He has been concerned by the lack of integration in earlier studies. Underlying all his research has been the desire to supply a systematic and comprehensive basis for understanding the nature of human intelligence. Guilford insists that the basis must be formulated in such a manner that it will provide a means for testing empirically hypotheses derived from the theory. His method is scientific; his subject is man's intellectual behavior; his work is characterized by control. Every concept has an exact
reference, its meaning is expressed in terms of operations. His experimental questions lead to empirical answers.

Frame of reference

Guilford's first concern as a scientist is with an adequate frame of reference: one that is comprehensive, systematic, and empirically based. According to him (1967) the frame of reference provides the goal and direction of research; it serves to generate problems and hypotheses, it helps to interpret and evaluate results of investigation. A frame of reference that is comprehensive keeps the larger view in mind. A frame of reference that is systematic can take advantage of all possible logical connections. A frame of reference that is empirically based will yield communicable concepts. Guilford's frame of reference is his structure of intellect (SI) model.

Morphological model

The comprehensive, systematic, empirically based model formulated by Guilford is a morphological model of three parameters: contents, operations, and products. Guilford borrowed the term "morphological" from the astronomer, Zwicky. The concept denotes a cross-classification of intersecting categories. Guilford has attempted to organize intellectual abilities within a unitary system in which each parameter consists of a set of generally mutually exclusive categories. By contents, Guilford means the types of information or stimulus material that is discriminated by the organism. By operations, he means the different kinds of intellectual activities that are necessary to process the information which is being discriminated. By products, he means the forms that information assumes after the organism has processed it.
The categories in the content dimension consist of: figural, symbolic, semantic, and behavioral. Another way of understanding this concept would be to visualize four distinct types of inputs of initial information. The categories of the product dimension consist of: units, classes, relations, systems, transformations, and implications. These can be viewed as six distinct outputs of information in a different form as a result of being processed. The categories of the operation dimension consist of: cognition, memory, divergent production, convergent production, and evaluation. They are five distinct intellectual processes which the organism can use to process information.

Geometric representation

The SI model is represented as a three-dimensional solid composed of 120 different cells (5x4x6). One dimension consists of the five operations, a second dimension consists of the four kinds of contents, the third dimension consists of the six types of products. Each cell in the model represents a specific intellectual factor, a factor which is theoretically independent of other intellectual factors. Each factor has its own trigraph which stands for its unique combination of operation, content and product. Each factor stands for a psychological construct which Guilford believes has, or potentially can be, shown to exist. The existence of each factor can be demonstrated through extremely carefully designed factor-analytic studies. The factor-analytic studies consist of rather large batteries of experimental tests for hypothesized factors and of a body of reference tests for the established factors. Figure 4 represents the model graphically. This representation is adapted from the 1968 model; it allows for whatever necessary changes future research shall dictate. It is basically the same model that Guilford presented in 1956.
Progress and change

Guilford conscientiously and consistently places his theory in scientific perspective. He presents the SI theory as a scientific theory; he gives exact clarification to his understanding of scientific theory:

A scientific theory is a source of significant problems, each problem a question to which an answer is sought. Progress depends very much on being able to ask questions, furthermore, to ask significant questions. Theory generates questions and also provides a basis for determining whether questions, however generated, are significant ones. Obtaining answers to questions by way of empirical testing or research should be expected either to support the theory or not to support it. In the latter case, a change in theory may be called for. The need to change a theory is no disgrace. In research, one cannot afford to be afraid of making mistakes in theory. Such fears put a damper on creative production. Correction of mistakes at least eliminates blind alleys and holds the prospect of progress in other directions. Finding out what is not true is often as informative as finding out what is true. There is no need for expecting that any theory will stand for all time. It is often said that the history of science is strewn with discarded theories; they are means to
ends, not ends. In all probability the theoretical models favored (by Guilford) will sometimes be replaced with better one. For the time being, they seem very fruitful. Fruitfulness is an important criterion by which a theory should be judged (Guilford, 1967, p. 46).

In adhering to the scientific concepts of theory, Guilford is following the requisites set forth by Marx and Hillex and others. In ingenuity, flexibility and practicality, he reminds one of Thurstone and Boring.

Guilford is careful to point out that the SI model is designed as a frame of reference for understanding intellectual abilities. He frequently underscores its heuristic function in generating new hypotheses for new factors of intelligence. He has found it to be a flexible frame of reference for it can be readily expanded to include additional factors. At present, Guilford and his associates have found evidence for 81 unique intellectual abilities. Because some cells contain more than one factor, only 77 of the hypothesized 120 cells in the model are occupied. He believes that further research can verify the remaining cells. This concept is similar to that of Mendelejeff, who developed the periodic law for the classification of elements. At the time that Mendelejeff proposed the classification only some of the elements were known, but based on the periodic law, he was able to predict the properties of elements which were subsequently confirmed. The table has consistently been expanded to include new discoveries and the periodic law has remained virtually unchanged. The SI model affords much the same expansion. The heuristic value of the SI model is a remarkable contribution to psychological theory and ongoing research. When further research suggests expansion or consolidation of factors, Guilford is most anxious to modify the model.

"Thus whether SI theory is the last word (and it probably is not), it has served well its purpose of guiding research...Its concepts can add considerable new meaning and
significance to old and new psychological findings by other methods" (Guilford, 1967, p.65).

**Intellectual Factors Identified**

In 1959, Guilford was asked to give the Walter V. Bingham Memorial Lecture at Stanford University. The lecture consisted of a simplified version of his work on human intelligence. The lecture appeared in American Psychologist, 14, as "Three Faces of Intellect." It became one of the most discussed and influential articles of recent time. More scientific and detailed reports of the results of his research have appeared in professional journals continuously to the present time. The carefully contrived factor-analytic studies on the SI factors have appeared in reports from the Psychological Laboratory of the University of Southern California. The latest, the 39th report, appeared in August 1966. The publication of The Nature of Human Intelligence in 1967 represented the integration and expansion of Guilford's developing theory and research.

The writer's presentation of each factor in the SI model is, of necessity, an abbreviated version of Guilford's monumental and amply documented research. The writer's intention is to establish a conceptual understanding of the factors of intelligence, as they are understood and empirically tested by Guilford; for they shall be applied to selected measures of intelligence. The short-cuts and shortcomings are the writer's; a resume of this type can scarcely do justice to a theory as comprehensive as Guilford's.

In brief, Guilford has developed a unified theory of human intellect; he organizes the unique intellectual abilities into a single system which he calls the "structure of intellect." These factors are sufficiently distinct to be identified through factor analysis. The factors themselves, while being distinct in certain aspects, resemble one another in
other ways. Thus, they can be classified according to broad categories. These broad categories can become the dimensions or parameters of the morphological model used to unify the theory.

One way of classifying them is according to the kind of process or operation performed by the organism in dealing with the raw materials of information. This kind of classification recognizes five major groups of abilities: factors of cognition, memory, convergent thinking, divergent thinking and evaluation. Cognition means the immediate discovery of information in various forms: awareness, rediscovery, comprehension or understanding. Memory refers to the retention or storage, with some degree of availability, of information in the same form it was committed to storage and in response to cues (the same) in connection with which it was learned. Divergent production means the generation of information from given information; emphasis is on the variety and quantity of output from the same source. What has traditionally been called "transfer" is likely to be involved. Divergent production is typically involved in creative aptitudes. Convergent production means the generation of information from given information; emphasis is on achieving unique or conventionally accepted best outcomes. Usually, the given information (in the sense of "cue") will fully determine the response. Evaluation means reaching decisions of making judgments about the criterion satisfaction (correctness, suitability, adequacy, or desirability) of information.

Another way of classifying the factors is on the basis of what resulted from the application of a certain operation to a certain kind of content. This kind of classification recognizes six possible forms that information can take through the processing by the organism: units, classes, relations, systems, transformations, and implications.
Units mean relatively segregated or circumscribed items of information having "thing" character. Guilford suggests that a unit may be close to Gestalt psychology's "figure on a ground" concept. Classes refer to the conceptions underlying sets of items of information grouped by virtue of their common properties. Relations mean the connections between items of information based on variables or points of contact that apply to them. Relational connections are more meaningful and easier to define than implications. Systems mean the organized or structured aggregates of items of information; they refer to the complexes of interrelated or interacting parts.

Transformations mean the various kinds of change (redefinition, shift, modification) in the given information or in its function. Implications refer to extrapolations of information, in some form of expectancies, predictions, known or suspected antecedents, concomitants, or consequences. The connection between the given information and that extrapolated is more general and less definable than a relational connection.

Another way of classifying the factors is on the basis of contents or the kind of material processed by the organism. This kind of classification recognizes four broad types of discriminable information: figural, symbolic, semantic, and behavioral. Figural means information in its concrete form as perceived, or as recalled possibly in the form of images. Guilford suggests that the term "figural" minimally implies figure-ground relationship (perceptual organization). For example, visual spatial information is figural; different sense modalities may also be involved. Symbolic refers to information in the form of denotative signs, having no significance in and of themselves; for example, letters, numbers, musical notations, codes, and words.
when meanings and form are not considered. Semantic means information in the form of meanings to which words commonly become attached. Semantic information is most notable in verbal thinking and in verbal communication but it is not identical with words; the emphasis is on meaning. Meaningful pictures can frequently convey semantic information. Behavioral means information, essentially non-verbal, involved in human interactions where the attitudes, needs, desires, moods, intentions, perceptions, and thoughts of self and others are involved.

When mental abilities are classified according to content, Guilford notices four major kinds of intelligence. The abilities which involve figural content can be regarded as concrete intelligence. Those abilities which involve symbolic material may be regarded as a type of abstract intelligence which is used to deal with symbols such as letters, numbers, and other signs by which coding may be done. Abilities which involve semantic content can be regarded as another type of abstract thinking such as is used in learning facts and understanding ideas. Those abilities which involve behavioral content, Guilford tentatively calls social intelligence. Thorndike recognized three major types of intelligence: concrete, abstract and social. Wechsler (1950) recognized three types: cognitive, conative and non-intellective. Guilford’s elaboration accepts concrete intelligence much as Thorndike described it. He presents a refinement of the concept of abstract intelligence; abstract verbal intelligence and abstract nonverbal intelligence. Guilford’s behavioral intelligence is comparable to Thorndike’s social intelligence. Wechsler’s trimarcation is not as definitive; he views them as aspects of the personality. While the recognition of distinct kinds of intelligence would indicate an influence by others, the SI theory is basically an extension and refinement of Thur-
The SI model is a three-way classification of intellectual abilities. The three dimensions of the model specify the content, operation and product of a given kind of intellectual act. Each factor hypothesized by the model is uniquely located and defined by specifying a category on each of the three dimensions. The three categories that specify each factor are coded in terms of a trigram symbol which identifies the operation, content and product for that factor. The coding is the notational system used by Guilford and his associates. It is the notational system that shall be employed in the analysis of selected psychological measures in this paper.

Organization of factors

Guilford explains that the order of categories along each dimension of the model has some logical reasons behind it, but without any great degree of compulsion. With regard to operation, he feels that cognition is basic to all other kinds:

If no cognition, no memory; if no memory, no production, for the things produced come largely from memory storage. If neither cognition nor production, then no evaluation. From front to back of the model, there is increasing dependency of one kind of operation upon others...Placing the symbolic category between figural and semantic depends upon the relation of symbols to both those two kinds of information; symbols are basically figural but take on symbolic functions when they are conventionally made to represent something in the semantic category...They also represent information in the other categories...Of the products, units are basic; hence they appear at the top. Units enter into classes, relations, systems, transformations and implications...The unique character of transformations would be a reason for putting them last, since a transformation involves one item of information (possibly any other kind of product) becoming something else (Guilford, 1967, p. 63).

The factors shall be presented in the systematic order suggested by Guilford. The sequence used proceeds from the order of the operations category. Preceding the identification and explanation of each factor in the operations parameter is a table portraying the matrix for the factors in that category. The red cells indicate an SI
factor that has been found numerous times by Guilford and also by other researchers. Guilford defines numerous as "more than ten". The blue cells indicate an SI factor that has been found several times by Guilford and other researchers. Guilford defines several as "more than twice and less than ten". The green cells indicate an SI factor that has been found only once or twice, in some cases by Guilford or his associates, in others by independent researchers. The white cells indicate an SI factor that has not been isolated; in some cases the attempt has been unsuccessful, in others, the attempt has not yet been made. Guilford requires a minimum of three different tests to support evidence of a given factor. Each of the three must give evidence of significant loading on that factor; Guilford uses "significantly" to mean a minimum of .30. In most cases, the loading is higher than .30; Guilford is careful to point out those cases where the range is between .30 and .40.

Each factor will be identified by its unique trigram and followed by its operational definition; in cases where possible, the common name is given to a factor also. Some examples of tests which have been used to show evidence of a factor are cited; descriptions and sources of the less well-known tests will be found in the Appendix under the trigraph used for the particular factor identification.

The identification and explanation of each factor is adapted from Psychological Laboratory Reports, augmented by adapted from The Nature of Human Intelligence.
### TABLE 2
**COGNITION FACTORS MATRIX**

**Operation:**

Cognition (c)

<table>
<thead>
<tr>
<th>Operation</th>
<th>Cognition (c)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Content:</th>
<th>Figural (F)</th>
<th>Symbolic (S)</th>
<th>Semantic (M)</th>
<th>Behavioral (B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CFU-V</td>
<td>CSU-V</td>
<td>CMU</td>
<td>CBU</td>
<td></td>
</tr>
<tr>
<td>CFU-A</td>
<td>CSU-A</td>
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<td>CSC</td>
<td>CMC</td>
<td>CBC</td>
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</tr>
<tr>
<td>CFR</td>
<td>CSR</td>
<td>CMR</td>
<td>CBR</td>
<td></td>
</tr>
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<td>CBS</td>
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<td>CFS-A</td>
<td>CFT</td>
<td>CBT</td>
<td></td>
</tr>
<tr>
<td>CFI</td>
<td>CSI</td>
<td>CMI</td>
<td>CBI</td>
<td></td>
</tr>
</tbody>
</table>

**Products:**

- **Units (U)**
- **Classes (C)**
- **Relations (R)**
- **Systems (S)**
- **Transformations (T)**
- **Implications (I)**

**Key:**

- **Numerous**
- **Several**
- **One or two**
Cognition factors

Guilford defines cognition as "awareness, immediate discovery, or rediscovery, or the recognition of information in various forms; comprehension or understanding" (Guilford, 1967, p. 71). Most of the current standardized "intelligence" tests measure one or more of the factors that Guilford calls cognition; they give an indication of what a person already knows, they involve recognition. Some of the tasks on some of the standard instruments call upon the S to relate what he already knows to some new information, thus there is some room for learning in such tasks. The cognitive factors are more familiar to most people because they have been dealt with in various ways in both traditional tests and in earlier psychological theory. The label "cognitive abilities" has previously been used to describe all intellectual abilities; Guilford restricts the term to a particular area; he uses "intellectual" to cover the whole range of human abilities. Cognition is probably the best understood of all the operations categories, it has been studied more extensively and intensively than the others; thus, more is known about cognitive abilities. It represents the only operations matrix in the SI model where all 24 factors have been accounted for, theoretically and empirically.

Cognition of units refers to the awareness, discovery or recognition of information in terms of understanding or comprehension of units. Units are fairly circumscribed items of information; the gestalt concept of "closure" is descriptive of the process by which units are set off from other types of information.

CFU - cognition of figural units - the ability to "close" figural information to perceive a complete figural form. Figural information has sensory character, hence will differ along lines of various senses. CFU-V refers to the ability to "close" figural
information to perceive a complete visual form; this was interpreted by Thurstone (1944) as "speed of perception"; it is commonly called visual cognition. Tests of CSU-V include the Gestalt Completion Test, Concealed Words Test, Peripheral Span Test. CFU-A refers to the ability to perceive auditory figural units by organizing groups of successive inputs. Commonly called auditory cognition, it concerns the recognition of code-like signals. Tests of CFU-A include Copying Behind, Army Radio Code Test and Dot Perception Test.

**CSU** - cognition of symbolic units - the ability to recognize signs that can be used to stand for something else. CSU-V refers to the ability to recognize graphic symbolic units, such as words. Tests of CSU-V include Word Combinations, Disem-voweled Words, Omelet Test and Correct Spelling. CSU-A refers to the ability to decode auditory information in the form of language symbols. Commonly called symbol cognition, tests of CSU-A include Haphazard Speech, Illogical Grouping and Singing. In each case, the S must derive word structure in auditory terms from given stimulation.

**CMU** - cognition of semantic units - the ability to comprehend the meanings of words or ideas. Commonly called verbal comprehension, this factor is the best-known and most widely tested of all intellectual factors. The best measure of CMU is some form of vocabulary test. The emphasis is on the meaning attached to the word label, not on the label itself. Measures of CMU are frequently in the form of completion type, multiple choice vocabulary items, and reading comprehension tests. Word Completion, General Information (as in the Wechsler tests) also load significantly on CMU.

**CBU** - cognition of behavioral units - the ability to understand units of expression, such as a facial expression. Tests of CBU include Faces (subject is asked to indicate
which man's face expresses the same feeling or intention as a given woman's face),

Expressions (subject is asked to identify a gesture or posture that expresses the same

though as a given gesture or posture).

Cognition of classes refers to recognized sets of items of information which
can be grouped according to their common properties. The emphasis is placed on the
attributes or properties which may be observed.

CFC - cognition of figural classes - the ability to recognize classes of figural
items of information. This is commonly called figural classification. Tests of CFC
include Figure Class, Picture Classification, Figural Class Inclusion.

CSC - cognition of symbolic classes - the ability to recognize common properties
in sets of symbolic information. Guilford has had difficulty constructing tests to meas-
ure CSC that don't load significantly on other factors. Number Classification has been
one of the more successful. Others include Number-Group Naming, Best Number
Pairs, Thurstone's Letter Group Naming.

CMC - cognition of semantic classes - the ability to recognize common pro-
perties of words, ideas and objects. Commonly called conceptual classification, it has
been measured by Verbal Classifications (adapted from Thurstone), Word Classification,
Sentence Classification.

CBC - cognition of behavioral units - the ability to see similarity of behavioral
information in different expressional modes. Examples of CBC tests include Expression
Grouping and Picture Exclusion.

Cognition of relations refers to the recognized connection between 2 items of
information based on variables or points of contact that apply to them. The best kind of
relation-cognition test is the traditional analogies type.

CFR - cognition of figure relations - the ability to recognize figural relations between forms. It is commonly called figural analogies. One of the most consistent tests of CFR is the figure-analogies test; examples include Figure Analogies, Figure Matrix, Abstract Reasoning of the DAT, Cattell’s Series Test.

CSR - cognition of symbolic relations - the ability to see relations between items of symbolic information; commonly called symbol relations. Measures of CSR include Seeing Trends II, Word Relations.

CMR - cognition of semantic relations - the ability to see relations between ideas or meanings of words. CMR is commonly called semantic relations. Verbal analogies type is one of the best measures of CMR; however, the vocabulary level should be kept low to avoid a dominant CMU loading. The Miller Analogies Test was used by Guilford in some studies, it loaded on CMU rather than the expected CMR indicating that the definitions of the words were of utmost concern instead of the relationships between them. Tests used in Guilford’s research include: Verbal Analogies I, Word Matrix Test, Word Linkage Test, Sensitivity to Order Test.

CBR - cognition of behavioral relations - the ability to understand social relationships. Measures include: Social Relations, Silhouette Relations.

Cognition of systems is defined as an organized or structured aggregate of items of information; the emphasis is on recognition of organization.

CFS - cognition of figural systems - the ability to comprehend arrangements and positions of information. CFS is commonly called spatial orientation; it can be organized and distinguished along sensory-input lines: visual, auditory and kinesthetic.
The cell contains three distinct abilities. CFS-V refers to the cognition of visual-figural systems; it is the ability to apprehend visually the spatial arrangement of things in one’s psychological field. Guilford has found numerous good tests of CFS-V; these include Thurstone’s Figures, Cards, and Flag Tests, Complex Coordination Test, Discrimination Reaction Time Test, Aerial Orientation, Guilford-Zimmerman Spatial Orientation, Block Counting, Thurstone’s Cube Comparisons Test. CFS-K represents a kinesthetic space factor. Thurstone’s Hands Test has been a consistent measure, as has his Bolts Test. The factor appears to involve a right-left discrimination. Compass Orientation and Following Oral Directions appear to be a measure of this factor. CFS-A involves the cognition of rhythms and melodies; measures such as Seashore’s Rhythm Discrimination Test and Hidden Tunes are suitable tests of CFS-A.

CSS - cognition of symbolic systems - the ability to understand the systematic interrelatedness of symbols within an organized set. CSS is commonly called symbolic patterning. Several studies have shown links between Thurstone’s induction factor and Guilford’s CSS factor. Measures of CSS include: Circle Reasoning, Letter Triangle, Number Series, Letter Series (based on Thurstone’s Letter Series).

CMS - cognition of semantic systems - the ability to comprehend relatively complex ideas. The emphasis is on understanding a system semantically conceived; it is commonly called general reasoning. Measures of CMS include: Guilford-Zimmerman General Reasoning Test, Ship Destination, Necessary Arithmetical Operations, Necessary Facts, Problem Solving, Math Aptitude.

CBS - cognition of behavioral units - the ability to comprehend a social situation or sequence of social events. Though still being investigated, CBS has been identified
by the Missing Pictures Test and the Missing Cartoons Test, also, Facial Situations, Odd Strip Out.

Cognition of transformations refers to the recognition or understanding of various kinds of changes in known or existing information with regard to its attributes, meaning or use. The most common transformations in figural information concern changes in sensory qualities, quantities, location (movement) or arrangement. In symbolic information, the obvious examples are found in math, such as factoring or solving equations. In semantic information, the changes will be found in meaning, significance or use. In behavioral information, the changes involve changes in interpretation, mood or attitude.

CFT - cognition of figural transformations - the ability to visualize how a given figure or object will appear after given changes, such as folding or rotation. The emphasis is on visual information; it is commonly called spatial visualization. Measures of CFT include: Spatial Visualization I, Spatial Visualization II, Thurstone's Punched Holes Test, Surface Development Tests, Bennett's Mechanical Principles Test, Paper Folding Test, Form Board Tests.

CST - cognition of symbolic transformations - the ability to recognize the needed changes in given unmeaningful information which will transform it into meaningful information. Guilford refers to a factor reported by Mooney (1954) as qualifying for the cell. The tests which have been used to measure this factor are Disjointed Sentences and Spoonerisms. In both cases, the S is presented with nonsense or partial nonsense which he can restructure to produce a sensible idea. The tests which have been used experimentally are quite similar to those used to identify NST; Guilford has
some reservations about the positive identification of CST.

CMT - cognition of semantic transformations - the ability to see potential changes of interpretations of objects and situations. CMT is commonly called penetration. The most consistent marker tests for CMT have been Similarities (like the Wechsler subtests) and Social Institutions Test. Guilford expresses a need for more research on CMT and suitable measures for it.

CBT - cognition of behavioral transformations - the ability to reinterpret either a gesture, a facial expression, a statement, or a whole social situation so that its behavioral significance is changed. The Picture Exchange Test and the Social Translations Test have identified CBI in one study; Cartoon Exchange was used in another study.

Cognition of Implications refers to the recognition or understanding or expectancies, anticipations, predictions. The implication, as a product, must be the connection, but not a relation. Guilford explains this as coming close to the type of relation that is described as cause and effect; it is not an iron-clad connection, it can include probability.

CFI - cognition of figural implications - the ability to foresee the consequences involved in figural problems. It is commonly called perceptual foresight and has been identified by the following tests: Competitive Planning, Route Planning, Planning a Circuit, Maze Tracing Tests.

CSI - cognition of symbolic implications - the ability to foresee or be sensitive to consequences in a symbolic problem. The Aptitudes Research Project has produced the only evidence for this factor; they used the following tests in their study: Word
Patterns, Symbol Grouping, S-Test.

CMI - cognition of semantic implications - the ability to anticipate or be sensitive to the needs of or the consequences of a given situation in meaningful terms. Commonly called conceptual foresight, CMI has been identified by: Pertinent Questions, Alternate Methods, Seeing Problems, Apparatus Test, Seeing Deficiencies, Effects, Contingencies. The tests call for connections which the S has experienced either in person or vicariously, otherwise loading will go in a different direction.

CBI - cognition of behavioral implications - the ability to draw implications or make predictions about what will happen following a given social situation. This factor is the least well-supported of the behavioral-cognition factors. Of the three tests designed to measure CBI, only one, the Cartoons Prediction Test was univocal and strong.
TABLE 3
MEMORY FACTORS MATRIX

**Operation:**
Memory (M)

<table>
<thead>
<tr>
<th>Content:</th>
<th>Figural (F)</th>
<th>Symbolic (S)</th>
<th>Semantic (M)</th>
<th>Behavioral (B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MFU</td>
<td>MSU</td>
<td>MMU</td>
<td>MBU</td>
<td></td>
</tr>
<tr>
<td>MFC</td>
<td>MSC</td>
<td>MMC</td>
<td>MBC</td>
<td></td>
</tr>
<tr>
<td>MFR</td>
<td>MSR</td>
<td>MMR</td>
<td>MBR</td>
<td></td>
</tr>
<tr>
<td>MFS-V</td>
<td>MSS</td>
<td>MMS</td>
<td>MBS</td>
<td></td>
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<tr>
<td>MFS-A</td>
<td>MFT</td>
<td>MST</td>
<td>MBT</td>
<td></td>
</tr>
<tr>
<td>MFI</td>
<td>MSI</td>
<td>MMI</td>
<td>MBI</td>
<td></td>
</tr>
</tbody>
</table>

**Products:**

- **Units (U):**
  - MFU
  - MSU
  - MMU
  - MBU
  - MFC
  - MSC
  - MMC
  - MBC
  - MFR
  - MSR
  - MMR
  - MBR
  - MFS-V
  - MSS
  - MMS
  - MBS
  - MFS-A
  - MFT
  - MST
  - MMT
  - MBT
  - MFI
  - MSI
  - MMI
  - MBI

**Key:**
- Several
- One or two
- Not presently isolated
The memory category has posed several problems. When testing for memory, Guilford has tried to maintain scientific control. Testing for memory involves a two-stage process: first, memorizing certain information, and second, testing to find out how much has been retained. In the other operations categories only the testing is necessary. In order to separate memory from cognition, the Ss must all be given the same material and the same amount of time to memorize it. Guilford defines memory as "retention or storage, with some degree of availability, of information in the same form in which it was committed to storage and in connection with the same cues with which it was learned" (Guilford, 1967, p. 211).

Memory abilities are distinguished from cognitive abilities by means of the tests and the testing procedures; the Ss are exposed to certain kinds of information and are later tested for retention of that information. Cognitive abilities are functions of the quantities of information possessed by the S regardless of how or when obtained. "There is memory if, and only if, there has been cognition" (Guilford, 1967, 211).

Another difference pertaining to the memory abilities refers to the fact that meaningful material (semantic) is memorized and retained much more effectively than is symbolic or figural material; thus, the S will tend to translate symbolic and figural material into semantic terms. Confusion between units and systems is common; although difficult to control, Guilford has found it to be not impossible. On the other hand, retention in unit form may become a feature of tests designed for other products;
for example, a relation may be verbalized or named by the S in the process of memorizing and will be remembered as a semantic unit. Despite this predicament, Guilford has found sufficient evidence that information is retained in forms other than units.

In distinguishing between relations and implications, Guilford cautions that both are connections between pairs of items of information, but relations have meaningful character and their connections have qualitative differences, whereas, implications tend to be simpler, their connections are more incidental and less definitive.

Memory for units refers to the ability to remember or recall given units of information or to recall given information as units.

MFU - memory for figural units - the ability to remember given figural objects. MFU is commonly called visual memory. Tests which have been used to identify MFU include: Memory for Designs and Map Memory.

MSU - memory for symbolic units - the ability to remember isolated items of symbolic information, such as syllables and words. Guilford's experiments have indicated that when the S must recall the symbolic elements, either letters or digits, as in certain memory span items, in a prescribed order, the factor MSS is involved rather than MSU. These item types demand a memory for symbolic systems, either temporal or spatial; having to give a short list in backward order would tend to increase the need for system even more (as in the Wechsler subtests and some of the Stanford-Binet items). Tests for MSU include: Memory for Nonsense Words-Free Recall, Memory for Listed Nonsense Words, Memory for Digital Units.

MMU - memory for semantic units - the ability to remember isolated ideas or word meanings. MMU's common name would be memory for ideas. Tests of MMU
include: Picture Memory, Recalled Words, Word Recognition, Test Name Recall, Recalled Words.

**MBU** - memory for behavioral units. Not presently isolated.

**MFC** - memory for figural classes. Not presently isolated.

**MSC** - memory for symbolic classes - the ability to remember symbolic class properties. As symbolic classes are formed on the basis of common attributes in literal or number items of information, tests for MSC stress similar sets of syllables, words or numbers. Such tests include: Memory for Number Glasses-Recall, Memory for nonsense Word Classes, Memory for Name Classes, Memory for Word Classes.

**MMC** - memory for semantic classes - the ability to remember verbal or ideational class properties. Tests for MMC include: Classified Information, Picture Class Memory.

**MBC** - memory for behavioral classes. Not presently isolated.

**Memory for relations.** In testing for memory for relations, Guilford found that paired associate tests with arbitrary pairings of units tended to go with the implications factors MSI and MMI, unless fairly recognizable relations were possible. His tests have controlled the distinctions.

**MFR** - memory for figural relations. Not presently isolated.

**MSR** - memory for symbolic relations - the ability to remember definitive connections between units of symbolic information. This factor is commonly called rote memory. Measures of MSR include: Memory for Word-Number Relations,
Memory for Name Relations, Memory for Letter Series, Memory for Picture-Number Relation.

**MMR** - memory for semantic relations - the ability to remember meaningful connections between items of verbal information. MMR is commonly called meaningful memory. Tests of MMR include: Remembered Relations, Recalled Analogies.

**MBR** - memory for behavioral relations. Not presently isolated.

Memory for systems refers to the information which has been cognized or constructed as a system and is retained as such structurally in memory storage.

**MFS** - memory for figural systems - can be auditory or visual. **MFS-V** refers to the ability to remember spatial order or placement of given visual information. Tests of MFS-V include: Spatial Memory and Position Memory. **MFS-A** refers to the ability to remember auditory complexes of rhythm or melody. It has been identified by such tests as Musical Memory and Rhythm.

**MSS** - memory for symbolic systems - the ability to remember the order of symbolic information. Characteristics of MSS have been mentioned earlier regarding the tests of digit span. Other tests of MSS include: Memory for Order of Listed Numbers, Memory for Nonsense Word Order, Memory for Transpositions, Consonant Span, Digit Span, Nonsense Word Span.

**MMS** - memory for semantic systems - the ability to remember meaningfully ordered verbal material. MMS is commonly called memory for temporal order. Measures of MMS include: Learned Information, Memory for Test Order, Sequence Memory.

**MBS** - memory of behavioral systems. Not presently isolated.
Memory for transformations refers to the information-process which makes the S experience certain given transformations. The S is tested for the retention of such transformations.

MFT - memory for figural transformations. Not presently isolated.

MST - memory for symbolic transformations - the ability to remember changes in symbolic information. One measure for MST was Memory for Word Transformations, although it had a significant loading for MST, it had an even higher loading for CSU. Memory for Hidden Transformations has been successfully used to identify MST.

MMT - memory for semantic transformations - the ability to remember changes in meaning or redefinitions. Successful MMT tests include: Double Meanings, Homonyms.

MBT - memory for behavioral transformations. Not presently isolated.

Memory for implications refers to recalling the simplest and most general way in which informational units would be connected.

MFI - memory for figural implications. Not presently isolated.

MSI - memory for symbolic implications - the ability to remember arbitrary connections between symbols. Guilford's most recent research has indicated that the familiar concept "numerical facility" is actually a memory ability; it refers to a memory for the manipulation of symbols according to practiced connections. For most subjects the practice has occurred much earlier than the memory test. Although number-operations tests violate one important feature of good memory tests, ie, the condition that all Ss have an equal amount of practice, a number-operations test can be regarded as a measure for symbolic implications. Guilford's extensive factor-analytic studies of
such number tests indicate rather large specific components and lower loadings on MSI:

From studies of the relation of practice to factor content, it is commonly found that there is a specific component in the variance of scores from a task and that this component grows in importance with the practice. Number-operations skills are overlearned habits; hence tests that measure them should be expected to have a strong specific component. The same is somewhat true of activities like the span tests, for which acts like memorizing phone numbers and the like should yield individual differences in that kind of skill (Guilford, 1967, p. 134).

Thus, what has traditionally been viewed as a unitary and quite easily identifiable factor: the number factor, is in reality a complex factor. Tests which have been used to identify MSI include: Guilford-Zimmerman Numerical Operations, Number-Letter Associations, Addition Test, Division Test, Subtraction and Multiplication Test.

**MMI** - memory for semantic implications - the ability to remember arbitrary connections between pairs of meaningful concepts or elements of information. To keep MMI tests clear of factor MMR, it is necessary to use connections that are obviously on the arbitrary side. Successful measures of MMI include: Paired Associate Recall, Related Alternatives, Books and Authors.

**MBI** - memory for behavioral implications. Not presently isolated.

Two important facts have been brought to light by Guilford's most recent factorial analyses of memory abilities. Two well-known and popular kinds of tests: memory-span tests and numerical-operations tests appear to be factorially complex. Neither of them seems to be factorially strong and both appear to have substantial specific components. In the case of number-operations tests, the condition is probably due to the fact that they are overlearned special habits.
### Table 4
**Divergent Production Factors Matrix**

**Operation:**
- Divergent Production (D)

**Content:**
- Figural (F)
- Symbolic (S)
- Semantic (M)
- Behavioral (B)

<table>
<thead>
<tr>
<th>Figural (F)</th>
<th>Symbolic (S)</th>
<th>Semantic (M)</th>
<th>Behavioral (B)</th>
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</tr>
</tbody>
</table>

**Products:**
- Units (U)
- Classes (C)
- Relations (R)
- Systems (S)
- Transformations (T)
- Implications (I)

**Key:**
- Numerous
- Several
- One or two
- Not presently isolated
With items of information cognized and put into memory storage, they are more or less available for retrieval when occasions call for them. Reviving items of information from memory storage in order to meet certain objectives is the basis for psychological production, either divergent or convergent. Divergent production is a concept defined in accordance with a set of factors of intellectual ability that pertain primarily to information retrieval and with their tests, which call for a number of varied responses to each test item. Certain hypotheses about abilities that should be of special relevance for creative thinking led to the search for abilities having to do with fluency of thinking and flexibility of thinking, abilities concerned with the ready flow of ideas and with readiness to change direction or to modify information (Guilford, 1967, p.138).

The intensive factor-analytic studies conducted by Guilford which aimed at the investigation of these hypotheses indicated three fluency factors, two flexibility factors and also a factor termed "originality". The three fluency factors were probably those which had been found by others in earlier research: word fluency (Thurstone, 1938), ideational fluency (Taylor, 1947), and associational fluency (Fruchter, 1948). Subsequently, other researchers have added to the list of divergent production factors.

The main difference between cognition and both divergent production and convergent production is that cognition means having information and understanding it; while the production abilities involve using the information in a given way. Divergent production calls for production of information in quantity, variety, and often in altered forms. Convergent production calls for the production of information in forms which are of a logic-tight, deductive nature; production of information in forms that are essentially uniquely determined by the given information. The difference between cognitive and production abilities may be understood as the difference between a spectator and a participant.

Tests which measure the divergent production abilities require the S to produce
his own answers. This basic characteristic of divergent production eliminates the use of multiple choice items; it also makes the use of machine scoring impossible. Thus, divergent production tasks are not to be found in current group tests of intelligence, and rarely found in current individual psychological appraisals. Traditionally, the divergent production abilities have remained beyond the area measured by tests, and generally have not been included in conceptions of intelligence.

**Divergent production of units** refers to products generated by specified classes. The specifications must be neither too broad nor too narrow. When the specifications are too narrow, the result is convergent production. The emphasis is on fluency of response.

**DFU** - divergent production of figural units - the ability to produce many figures that conform to simple specifications. DFU is commonly called figural fluency. Measures of DFU include: Make a Figure Test, Sketches, Make a Mark, Dot Systems.

**DSU** - divergent production of symbolic units - the ability to produce many symbolic units, like words, that conform to simple specifications not involving meanings. DSU is commonly called word fluency. There is a general tendency for CMU variance in DSU tests where the specification is more restrictive. DSU measures include: Word Fluency, Suffixes, Prefixes, Word Beginnings and Endings Test, Rhymes.

**DMU** - divergent production of semantic units - the ability to produce many elementary ideas appropriate to given requirements. DMU is commonly called ideational fluency; measures include: Topics Test, Theme Test, Consequences (obvious), Utility Test (fluency), Plot Titles (non-clever), Responses to Inkbolts.

**DBU** - divergent production of behavioral units. Not presently isolated.
Divergent production of classes concerns the flexibility characteristic. Where the fluency characteristic is marked by the total number of relevant responses, the flexibility characteristic is marked by the total number of different categories, or shifts in categories of the responses.

**DFC** - divergent production of figural classes - the ability to group figural information in different ways: figural spontaneous flexibility. Measures include: Alternate Letter Groups, Figural Similarities, Multiple Grouping of Figures.

**DSC** - Divergent production of symbolic classes - the ability to group items of symbolic information in different ways. DSC is commonly called symbolic spontaneous flexibility. Measures of DSC include: Multiple Letter Similarities (Varied Symbols), Name Grouping, Multiple Groupings of Nonsense Words.

**DMC** - divergent production of semantic classes - the ability to produce many categories of ideas appropriate in meaning to a given idea. This is also known as semantic spontaneous flexibility. Consistent markers for DMC include: Utility Test (flexibility), Alternate Uses (Unusual Uses Test), Object Naming, Multiple Grouping Test.

**DBC** - divergent production of behavioral classes. Not presently isolated.

Divergent production involving relations has stressed tasks that require the production of either relations or correlates. Where the cognition-relation tests pertain to seeing or recognizing a relation, given two correlates (Spearman's concept of "eduction"), the production-relation tests have generally presented one correlate and a relation and required the S to produce the other correlate to complete the relationship. What Guilford calls "divergent production of relations," Spearman called "eduction of
DFR - divergent production of figural relationships. Not presently isolated.

DSR - divergent production of symbolic relations - the ability to relate letters or number in many different ways. Some successful tests of DSR include: Alternate Additions, Number Rules.

DMR - divergent production of semantic relations - the ability to produce many relationships appropriate in meaning to a given idea. This factor is commonly called associational fluency. Consistent markers for DMR include: Controlled Associations, Inventive Opposites, Simile Insertions, Associational Fluency.

DBR - divergent production of behavioral relations. Not presently isolated.

Divergent production of systems involves rational sequences of meaningful steps; the stress is on system-producing abilities.

DFS - divergent production of figural systems - the ability to produce composites of figural information in many ways. The emphasis in DFS tasks is on the organization of visual-figural elements into wholes. Tests of DFS include: Making Objects, Monograms (only at grade 9), Designs (DFU variance). Guilford's experiments indicate that age and experience may contribute to different variance at different ages.

DSS - divergent production of symbolic systems - the ability to organize sets of symbolic information into different systematic arrangements. Although poorly supported, DSS has been measured by Make a Code Test.

DMS - divergent production of semantic systems - the ability to organize words in various meaningful complex ideas. DMS is commonly known as expressional fluency. Sentence-construction tests have been good markers; other tests include: Expressional
Fluency, Simile Interpretations, Word Arrangement, Carroll's Letter-Star Test (1941), Taylor's Sentence Fluency (1947), Roger's Unfinished Stories (1953).

**DBS** - divergent production of behavioral systems. Not presently isolated.

Divergent production of transformations involves the characteristic of adaptive flexibility; the term "adaptive" is distinguished from "spontaneous" because the flexibility is essential to solving the problems and doing so rapidly.

**DFT** - divergent production of figural transformations - the ability to process figural transformations - the ability to process figural information in revised ways, DFT is also known as figural adaptive flexibility. Successful tests of DFT include: Match Problems II, III, IV, and V; Planning Air Maneuvers, Insight Problems, Squares, Dot Systems. DFT tasks contain problems which require shifts of tactics as the S uses trial and error technique.

**DST** - divergent production of symbolic transformations. Not presently isolated.

**DMT** - divergent production of semantic transformations - the ability to produce unusual, remote, or clever responses involving reinterpretations or new emphasis on some aspect of an object or situation. DMT is commonly called the originality factor. Measures of DMT include: Plot Titles (clever), Consequences (remote), Symbol Production, Riddles (clever), Puns.

**DBT** - divergent production of behavioral transformations. Not presently isolated.

Divergent production of implications refers to the elaboration abilities, the emphasis is on the amount of detail that is added to given information.
DFI - divergent production of figural implications - the ability to elaborate upon given figural information. DFI is commonly known as figural elaboration. Consistent measures of DFI include: Figure Production, Production of Figural Effects, Decorations.

DSI - divergent production of symbolic implications - the ability to produce varied implications from given symbolic information. Commonly known as symbolic elaboration, this factor has been poorly demonstrated. The test Symbol Elaboration has been the only consistent test of DSI; Limited Words has not been as consistent.

DMI - divergent production of semantic implications - the ability to produce many antecedents, concurrents, or consequents of given information. DMI is commonly called semantic elaboration. Tests of DMI include: Planning Elaboration, Planning Skills II (adapted from Lorge), Possible Jobs.

DBI - divergent production of behavioral implications. Not presently isolated.

Relations between divergent production scores and IQs are generally quite low, there is indication that while a high IQ is not necessarily sufficient for scoring well in divergent production tasks, being above average in IQ is almost necessary.
TABLE 5
CONVERGENT PRODUCTION FACTORS MATRIX

**Operation:**
Convergent Production (N)

<table>
<thead>
<tr>
<th>Operation</th>
<th>Convergent Production (N)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Content:</th>
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<th>Semantic (M)</th>
<th>Behavioral (B)</th>
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<td>NMU</td>
<td>NBU</td>
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</tr>
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<td>NSC</td>
<td>NMC</td>
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</tr>
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<td>NMT</td>
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<tr>
<th>Units (U)</th>
<th>Classes (C)</th>
<th>Relations (R)</th>
<th>Systems (S)</th>
<th>Transformations (T)</th>
<th>Implications (I)</th>
</tr>
</thead>
</table>

**Key:**
- Several
- One or two
- Not presently isolated
Convergent production factors

Convergent production refers to the area of logical deductions or compelling inferences. When the input information is sufficient to determine a unique answer, the resultant operation is convergent production. Tests of convergent production abilities stress the drawing of conclusions from given information; the deductions are logic-tight, in the respect that they are essentially uniquely determined by the given information.

In the divergent production abilities, there is considerable freedom in producing responses to serve a purpose. In convergent production, there is no freedom. If the S's processes are working normally and if he has the information available, or can readily reconstruct it, there is only one direction that his response may take.

The convergent production abilities represent one of the less studied areas of intelligence. They have been relatively neglected in factor-analytic studies and practically ignored in traditional intelligence tests. The convergent production abilities appear to be important in all areas of intelligence where rigorous thinking is called for: mathematics, logic, science, engineering, law and other similar fields.

Some of the more recent research in psychology and education seems to have confused the concepts of cognition and convergent production. Cognition means having information and comprehending it, while convergent production means using the information to meet definite requirements and produce a response.

Convergent production of units refers to the logical, deductive properties in the production of units.

NFU - convergent production of figural units. Not presently isolated.
NSU - convergent production of symbolic units. Not presently isolated.

NMU - convergent production of semantic units - the ability to converge on an appropriate name or summarizing word for any given information. NMU represents a naming factor; it is commonly known as concept naming and concerns the naming of abstractions. In the course of his research, Guilford found that several tests which had been developed for certain cognitive abilities loaded on another factor. The tests involved all called for the naming of the class or relation. The tests which have been strongest for NMU include: Picture Group Naming, Word Group Naming, Verbal-Relations Naming, Number Group Naming. Many of the tests for NMU have secondary loadings.

NBU - convergent production of behavioral units. Not presently isolated.

Convergent production of classes refers to the ability to classify items of information in a conventional manner.

NFC - convergent production of figural classes - the ability to classify uniquely items of figural information. This factor has not been investigated by Guilford; he refers to a factor-analytic study of Silverstein and Mohan (1965) that identified a factor which might qualify for NFC.

NSC - convergent production of symbolic classes - the ability to classify uniquely items of symbolic information. NSC has only been identified in one study and the identification was not very strong.

NMC - convergent production of semantic classes - the ability to produce verbally meaningful classes under tight restrictions for class production. NMC has been found, but only in one study (Merrifield et al., 1962). The experimental tests used in-
Convergent production refers to the ability to produce.

**NBC** - convergent production of behavioral classes. Not presently isolated.

Convergent production of relations refers to the ability to produce a connecting link between items of information in a conventional manner.

**NFR** - convergent production of figural relations. Not presently isolated.

**NSR** - convergent production of symbolic relations - the ability to complete a specified symbolic relationship. NSR is known as symbolic correlates; the most consistent test for it has been Correlate Completions II, it is the "eduction of correlates" using symbolic information only. Canisio (1962) identified a factor which fits NSR.

**NMR** - convergent production of semantic relations - the ability to produce a word or idea that conforms to specific relational requirement. NMR is commonly known as semantic correlates. To avoid loadings on CMR, tests for NMR must keep cognition of relations low; Guilford has done this by stating the relationship in the first part of the stem of the item. Thurstone's Inventive Opposites is a successful test for NMR; the Guilford test Associations III has been moderately successful.

**NBR** - convergent production of behavioral relations. Not presently isolated.

Convergent production of systems refers to the ability to produce an orderly sequence for given information in a conventional manner.

**NFS** - convergent production of figural systems. Not presently isolated.

**NSS** - convergent production of symbolic systems - the ability to produce a fully determined order or sequence of symbols. NSS tests include: Word Changes, Operations Sequence, Right Order.

**NMS** - convergent production of semantic systems - the ability to order infor-
mation into verbally meaningful sequences. This factor is commonly known as semantic ordering. The most successful NMS tests concern temporal ordering; these include; Picture Arrangement (like those found on the Wechsler Scales), Sentence Order, Temporal Order.

**NBS** - convergent production of behavioral systems. Not presently isolated.

Convergent production of transformations concerns the ability to produce some kind of change in given information in order to reach a goal; conditions are restricted so that only one particular change can serve the purpose.

**NFT** - convergent production of figural transformations - the ability to break down given figural units to form new ones. NFT is commonly called figural redefinition. Thurstone's Hidden Pictures Test and variations of the Gottschaldt-figures Tests have identified NFT; Thurstone referred to the factor as "gestalt-flexibility". Measures of NFT include: Hidden Figures, Hidden Pictures, Hidden Patterns, Penetration of Camouflage.

**NST** - convergent production of symbolic transformations - the ability to produce new symbolic items of information by revising given items. NST is commonly called symbolic redefinition. NST tests include: Camouflaged Words, Word Transformations.

**NMT** - convergent production of semantic transformations - the ability to produce new uses for objects by tearing them out of their given context and redefining them. Commonly called semantic redefinition, NMT has been identified by the following tests: Gestalt Transformations, Object Synthesis, Picture Gestalt.

**NBT** - convergent production of behavioral transformations. Not presently
Convergent production of implications refers to the ability to produce logic-tight deductions from given information.

NFI - convergent production of figural implications. Not presently isolated.

NSI - convergent production of symbolic implications - the ability to produce a completely determined symbolic deduction from given symbolic information, where such an implication has not been practiced, as such. NSI is commonly called symbol substitution. NSI measures include: Form Reasoning (based on Blakey's tests), Sign Changes. Numerical operations tests (MSI) have fairly heavy loadings on NSI, as well as a strong specific component. The specific component is regarded by Guilford as an overlearned ability, acquired through education.

NMI - convergent production of semantic implications - the ability to deduce meaningful information that is implicit in the given information. NMI appears to be very close to the popular concept of "deduction" or "logical deduction". Syllogistic-reasoning tests are characteristic of the tests which have been successful in identifying NMI; these include: Sequential Associations, Attribute Listing II. It is important to note that in tests of NMI the S must produce the answer; if the S must choose among several expressed answers, the process involves evaluation abilities.

NBI - convergent production of behavioral implications. Not presently isolated.
TABLE 6

EVALUATION FACTORS MATRIX

**Operation:**
Evaluation (E)

<table>
<thead>
<tr>
<th>Content:</th>
<th>Figural (F)</th>
<th>Symbolic (S)</th>
<th>Semantic (M)</th>
<th>Behavioral (B)</th>
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<td>Emi</td>
<td></td>
<td>Implications (I)</td>
</tr>
</tbody>
</table>

**Key:**
- Numerous
- Several
- One or two
- Not presently isolated
Evaluation factors

Evaluation involves reaching decisions or making judgments about the correctness, suitability, adequacy or desirability of information in terms of criteria of identity, consistency, and goal satisfaction. Guilford defines evaluation as "a process of comparing a product of information with known information according to logical criteria, making a decision concerning criterion satisfaction" (Guilford, 1967, p. 185).

Evaluation is another aspect of intelligence that is neglected both in studies of intelligence and in traditional measures of intelligence. Binet recognized "autocriticism" as a final step in problem solving abilities; by this he meant self-evaluation. In a more general concept of intellectual abilities, Binet emphasized common sense, or judgment as a characteristic. Spearman (1927) regarded intelligence as the operation of thinking in universal terms; he theorized that such thinking would generally be manifested in specific ways: conception, judgment and reasoning. Although aware of certain concepts of evaluation, Binet's scales did not reflect this concern to any great extent. Spearman did not construct any intelligence tests. Thurstone and a few other researchers identified some factors which may be interpreted as evaluation factors; some of them are readily identified with some of Guilford's evaluation factors. Guilford has found that "the more nearly tests emphasize criteria of identity, similarity, and consistency, the more likely they are to measure evaluation abilities" (Guilford, 1967, p. 186).

Evaluation of units involves the ability to judge quickly and accurately units of information in meeting specific criteria.

EFU - evaluation of figural units - the ability to judge quickly and accurately
units of figural information as being similar or different based on minor aspects of the information. Thurstone identified a factor which came to be known as "perceptual speed". Guilford identifies this factor as EFU. The typical EFU test is highly speeded both comparison and decision are involved. In CFU-V (visual cognition of figural units) only recognition is involved; in EFU both comprehension and evaluation are involved. Successful tests of EFU include: Identical Pictures Test, Thurstone's Identical Forms Test, Guilford-Zimmerman Perceptual Speed Test, Spatial Orientation Tests I and II.

**ESU** - evaluation of symbolic units - the ability to make rapid decisions regarding the symbolic identification of accuracy of words, letter sets, and number sets. ESU is commonly known as symbolic identification; measures of ESU include: Symbol Identities, Thurstone's Letter A Test, First Digit Cancellation, Letter U Test.

**EMU** - evaluation of semantic units - the ability to judge the suitability or adequacy of ideas and objects in terms meeting certain criteria. Measures of EMU include: Double Descriptions, Word Checking Lists Tests I and II, Thurstone's Concrete Associations Test, Thurstone's Abstract Classifications Test.

**EBU** - evaluation of behavioral units. Not presently isolated.

Evaluation of classes essentially appears to involve judging the adequacy of a particular class in meeting certain criterional requirements. Guilford places the emphasis on "class idea" rather than on collections of particulars. He places emphasis on denotative rather than connotative aspects.

**EFC** - evaluation of figural classes. Not presently isolated.

**ESC** - evaluation of symbolic classes - the ability to judge applicability of class properties to symbolic information. Tests of ESC include: Best Number Class,
Sign Changes II.

**EMC** - evaluation of semantic classes - the ability to judge the applicability of class properties to semantic information. EMC has been identified by the following tests: Best Word Class, Class Name Selection.

**EBC** - evaluation of behavioral classes. Not presently isolated.

**Evaluation of relations** requires that two criteria be met: the criteria of identity and the criteria of consistency.

**EFR** - evaluation of figural relations. Not presently isolated.

**ESR** - evaluation of symbolic relations - the ability to make choices among symbolic relationships on the basis of similarity and consistency. ESR is commonly called symbol manipulation. Successful tests for ESR include: Related Words I, Similar Paris, Symbol Manipulation.

**EMR** - evaluation of semantic relations - the ability to make choices among semantic relationships on the basis of similarity and consistency of meanings. Successful measures of EMR include: Matched Verbal Relations, Verbal Analogies III, Best Trend Name.

**EBR** - evaluation of behavioral relations. Not presently isolated.

**Evaluation of systems** involves the ability to judge the consistency of information in adhering to a system.

**EFS** - evaluation of figural systems. Not presently isolated.

**ESS** - evaluation of symbolic systems - the ability to estimate the appropriateness of aspects of a symbolic system. ESS tests include: Series Relations Test, Way-Out Numbers Test.
EMS - evaluation of semantic systems - the ability to judge internal consistency of complex, meaningful information. EMS concerns experiential evaluation; measures include: Unusual Details (What's Wrong With This Picture?), Word Systems, Unlikely Things.

EBS - evaluation of behavioral systems. Not presently isolated.

Evaluation of transformations involves the ability to judge the appropriateness of changes in meeting specified criteria.

EFT - evaluation of figural transformations. Not presently isolated.

EST - evaluation of symbolic transformations - the ability to judge adequacies of symbolic substitutes or reorderings. EST measures include: Jumbled Words, Decoding, Typing Errors.

EMT - evaluation of semantic transformations - the ability to judge which objects or ideas could best be transformed or redefined in order to meet some new requirement. EMT is not well supported, although the test Useful Changes has been fairly consistent in identifying EMT.

EBT - evaluation of behavioral transformations. Not presently isolated.

Evaluation of implications involves judging the soundness of conclusions, inferences, or expected consequences. It answers the questions: Are the conclusions in all probability correct; Do the conclusions follow from given information?

EFI - evaluation of figural implications. Not presently isolated.

ESI - evaluation of symbolic implications - the ability to judge the consistency or probability of inferences from symbolic information. ESI has been identified by the following tests: Best Letter Set, Abbreviations, Symbol Reasoning, Letter Problems.
EMI - evaluation of semantic implications - the ability to judge adequacy of a meaningful deduction. Thurstone identified such a factor with certain tests of syllogistic reasoning, False Premises Tests. The following tests have been successful for Guilford: Nonsense Syllogisms, Logical Reasoning, Inference Test, Sentence Selection.

EBI - evaluation of behavioral implications. Not presently isolated.

Present Status of the SI Theory

At present, 81 unique intellectual abilities have been identified; they fill 77 cells of the SI model. The discrepancy in the numbers occurs because some of the cells contain subdivisions of an ability. Cognitive abilities have been studied extensively, undoubtedly because traditional intelligence tests emphasize cognition. All 24 cells in the cognition matrix have been identified. The next most explored abilities are in the divergent production category; 16 cells are filled. In the memory matrix, 14 cells are occupied. The convergent production abilities and the evaluation abilities are the least explored regions; in the evaluation category, 13 cells are filled; in the convergent production category, 10 cells are filled. The present SI model has 43 cells which represent theorized abilities that have not been successfully isolated.

Is SI theory tenable? Does it conform to Guilford's claims of sound basis? Is it both comprehensive and systematic? Does it subsume and extend traditional concepts about the nature of intelligence? Is it rooted in the mainstream of general psychological theory? Does it clarify some of the traditional psychological problems about intelligence and its measurement? Can it be accepted as a basis for mental measurement that will provide more accurate and meaningful information? The next chapter shall explore the answers to these questions.
CHAPTER IV

RELATIONSHIP OF SI THEORY TO EVOLVING CONCEPTS AND CURRENT PSYCHOLOGICAL THOUGHT

I find the great thing in this world is, not so much where we stand, as in what direction we are moving.

- Goethe

Evolving Concepts

In the evolutionary process of its emergence as a branch of science, psychology has suffered many growing pains. Some of the pains have been caused by inherited problems; others have been caused by the conditions of the time. Some of the pains have been caused by restrictions and limitations which prevented growth; others have been caused by lack of integration. Some of the pains have been caused by narrow conceptions; others have been caused by lack of direction and the need for sound foundation.

For hundreds of years, the subject of intelligence was the concern of philosophy. As psychology moved away from philosophy, philosophic generalizations gave way to empirical testing. Psychology came to be regarded as that branch of science whose chief concern was human behavior; thus, the subject of intelligence became the concern of psychology. To become regarded as an empirical science, it was necessary to establish restrictions in terms of definitions and methods. While the topic concerned human behavior in general, the practice had to be limited to observable behavior. While psychology attempted to adhere to scientific principles, its pattern of development differed from the typical developmental curve of other sciences. The study of
intelligence became more and more disassociated from the larger psychological field of which it was an important part.

As psychology has developed, investigation of man's intellectual behavior has become a prime concern. Psychologists have gradually come to recognize the complexity of mental processes. Unfortunately, the recognition has been little evidenced in the psychologists' methods of measuring intelligence. Psychologists have gradually come to recognize the variations in human intellectual behavior. Unfortunately, they have generally concentrated their scientific efforts on the commonalities. Because mental measurement has developed without an accepted systematic, theoretical foundation, the observations, relationships, and insights garnered by individual researchers have not been expressed within a framework that would foster coalescence. The fragmentations caused by lack of framework have perpetuated obsolete concepts, absence of synthesis and resistance to change. Operating without a conceptual framework has increased the ever-widening distance between mental measurement and other areas of behavioral research. Too much emphasis on the technology of testing and too little emphasis on psychology has tended to isolate mental measurement from the mainstream of contemporary psychology.

Presently, the most urgent need in that branch of psychology that deals with man's intellectual behavior is a systematic, theoretical foundation. Only within such framework is consolidation and synthesis of past research possible. Only within such framework is direction and meaning of present research possible. Only within such framework can necessary distinctions be made: between the inherited philosophical problems of metaphysics and epistemology and the proper concerns of an empirical
science, between the relationship of heredity and genetics to present intellectual performance, between empirical requirements and practical realities, between motor tasks and mental tasks, between complex mental tasks and simple mental tasks.

Guilford offers the SI theory as a possible theoretic foundation. He asserts that it is systematic, comprehensive, and sound. He claims that it can serve as a conceptual framework affording synthesis of past, present, and future research. He says that it can untangle vague notions and present them in more clear-cut, objective statements. He suggests that it affords new ways to attack old problems. He states that it is rooted in contemporary psychological theory.

Conformation of SI to Guilford's Claims

Guilford uses the term "intelligence" as a general concept; it embraces the many different components of intellectual behavior. Guilford views the nature of intellectual abilities as being informational-operational. He proposes a general theory of intelligence that is expressed in terms of a comprehensive, systematic, empirically based frame of reference: the SI model. Intellectual abilities may be organized along the lines of the nature of the material (information), the process the organism uses to deal with information (operation), and the end-product or the use to which he has put the information (product). Due to the complexities involved, Guilford has chosen a morphological (cross-classification) model as his frame of reference. The model has three parameters which are determined by the kind of information: Content; the process used to deal with information: Operations; and the end-result: Products. The Contents parameter contains four categories; the Operations parameter contains five categories; the Products parameter contains six categories. The SI is represented as
a rectilinear, multi-dimensional model containing 120 cells. Each cell represents a unique factor of intelligence. Each cell may be identified and empirically tested by means of its unique combination of content, operation and product. Factor-analytic, multi-variate methods provide suitable technique for empirical testing.

SI theory is comprehensive because it has space for all aspects of intelligence. It is systematic because it embraces numerous phenomena within a logically-ordered structure. It has a firm foundation because it is empirically based.

Heuristic value of the SI model

The heuristic value of the model must be stressed. Guilford's theory is expressed in such a way that modifications and extensions may be made without destroying any fundamental concepts. As future research uncovers information about the nature of human intelligence, the SI model is designed to incorporate such information within its basic structure. The theory is suggestive of new approaches to the solution of old problems. Of considerable importance, the theory generates new problems; the morphological model indicates many obvious parallels that occur between series of factors, subsequent research is given a direction and a framework with which to conduct the investigation.

It has been noted, in the historical development of research on intelligence, that scientific controls and empirical procedures have been notoriously inadequate in too many instances. Scientific investigation demands control, if it would be deemed "scientific." Experimental conditions must be so ordered that controls are carefully maintained in the population being tested, in the test variables being analyzed together, and in the contents of the test items. The purpose of factor-analytic technique is to
separate and identify one factor from others. Guilford advocates the use of simple, rather than complex test items. If each test is unique in its own way, it tends to be more factorially pure; thus it lends itself to better empirical study. It has been noted, in the historical development of concepts of intelligence, that although many theorists recognized the complex nature of intelligence, they mistakenly believed that complex tasks should be used to appraise intelligence. Complex tasks defeat the purpose of factor analysis. Guilford suggests that when the occasion requires a factorially complex criterion to be predicted, it is sufficient to combine measures of relevant abilities in a weighted, summative equation (Guilford, 1967, p. 469). In this manner, the criticism that no one knows what intelligence tests really measure may be avoided.

Traditional Concepts Subsumed and Extended

An operational-informational type of psychology (to which SI theory leads) can clarify previous vague concepts and restructure traditional phenomena so that significant relationships become both ordered and obvious. Most of the traditional concepts regarding intelligence have been subsumed and expanded in SI theory. What have been vague generalities proposed by earlier theorists become empirically identified factors, or can be shown to be factorially complex factors. What have been isolated areas of study can become redefined and given a relationship to the total structure. What have been historically recognized factors can be given improved interpretations. Of crucial importance is the opportunity for organization afforded to a research area that has been persistently handicapped by inadequate perspective and unrooted discoveries.

Casual reference to standard textbooks in psychology and educational psychology indicates the current deplorable state. Some authors make a feeble attempt to
classify intellectual functions; such classifications tend to list abilities and ignore relationships. Other authors make no attempt to classify unique abilities; they discuss complex intellectual behaviors as if they were unitary traits. Other authors evade the issue of definition by equating intellectual abilities with learning.

Royce (1961) gives this philosophic psychological definition: "Intellect is the power or ability to think and simply refers to the fact that man is able to do so... Man knows by means of his intellect. Thinking or intellection is the act of this power and includes ideas, judgments, and reasoning. These are the operations for which the intellect is the basic natural potency. Intelligence is the degree to which intellect is operative. It differs from intellect because it refers to the amount of measurable operation we can expect from this potency" (Royce, 1961, p.109). Intelligence is a quantitative term to Royce. To Guilford, intelligence is characterized by quality as well as quantity. Royce enumerates the operations of the intellect as consisting of apprehension, judgment and reasoning. Guilford enumerates the operations of the mind as cognitive, memory, divergent production, convergent production, and evaluation.

Coleman (1960) views intelligence as consisting of learning, reasoning, and imagination; he distinguishes between associative learning and cognitive learning; both, however, he calls intelligence. Greene, Jorgensen and Gerberich (1951) state that the exact nature of the combination of abilities regarded as intelligence is not understood; they present 12 common, but different, definitions and suggest that "the ability of the individual to adapt himself to his environment and situation" is the best. Stephens (1965) avoids the definition issue by enumerating specific examples of intellectual
behavior characteristic of a child at age six. The implication is that at some unspecified time earlier, certain sense experiences enabled the child to form concepts. A later chapter in Stephens' text, concerned with the "Higher Uses of Intellect," discusses problem-solving, critical thinking, and creative thinking. Distinctions between learning and thinking are vague; no relationship between thinking and intelligence is given; no conceptual framework is provided to indicate other higher uses or mention what the lower uses might be. Sorenson (1954) mentions that various concepts of intelligence have mentioned perception, memory, reasoning, and imagination; "but in the field of educational psychology, the definition of intelligence as the capacity to learn is as satisfactory as any" (Sorenson, 1954, p. 279).

The majority of authors fail to distinguish between the philosophical definitions and the psychological definitions concerning the nature of human intelligence. Many fail to specify which abilities may be considered to be intellectual. Many writers imply that intelligence consists of the ability to learn, while others imply that intelligence consists of the ability to solve problems or think critically. Traditionally, then, and currently, intelligence appears to involve such things as perception, imagination, memory, cognition, varieties of reasoning (deductive, inductive), varieties of thinking (problem-solving, critical, creative), evaluation and learning. Is there any way to organize this conglomeration? Is there any way to indicate relationships, if they exist? Yes! One way involves the reinterpretation of these concepts within a uniform frame of reference.

Traditional concepts reinterpreted

Reformulated in the light of SI theory, both perception and cognition involve
input information from sensory sources. Perception is concerned with the sensory properties and is the more immediate; it includes precognitive operations, but overlaps with cognition of figural units. Input information involves filtering operations; Guilford's concept of filtering operations is what traditionally was called "attention."

Perceptual learning develops through constant processing of units of figural information; the processing involves differentiation, recognition, and organization. The units are stockpiled in memory storage. Reinforcement occurs through feedback information. Reinforcement plays an important part in the development of perceptual learning, as well as in the other types of learning. Perceptual learning leads through further practice and reinforcement to concept formation.

Cognition is distinguished from memory. In SI theory, cognition means awareness; emphasis is placed on present possession of information, whereas memory refers to latent information held over a long term. Cognition is very dependent upon information in memory storage. Cognition includes quick learning in the form of immediate extensions and transformations of acquired information; previously this has been called "discovery" and in some instances "insight."

The SI cognition factors account for all of the traditional induction phenomena. Induction has traditionally implied abstraction. Induction is redefined as the cognition of different kinds of products. Guilford proposes four kinds of induction: classificatory, relational, systematic, and implicational. Once the products are derived, they are transposable. These are the kinds of information to be had by going beyond the given; the class idea applies not only to the particular units that gave rise to the class idea, but also, to any other units that share the same pertinent class properties;
relations may be perceived, inferences may be made. This extension explains the
generalizing aspect of induction. Every experienced product has general, as well as
specific aspects. The general aspect is transferable, the specific is not. In SI
terminology, concrete can be regarded as figural information; abstract can be regarded
as other kinds, especially symbolic and semantic.

SI theory defines memory as storage of information only; it is identified
empirically by means of memory tests with specific controls; the emphasis is on the
requirement that all Ss be given the same amount of time, or opportunity, to memorize.
SI theory has been unable, thus far, to determine whether there are different memory
abilities for immediate and long-term memory, and incidental and intentional memory.
Images are memory phenomena; to the extent that they are revivals of perceived ex­
periences, SI theory places them in the category of figural information.

"Recall" or retrieval of information from memory storage is essential to both
divergent production abilities and convergent production abilities. The outstanding
characteristic of divergent production is the phenomena of transfer recall. Guilford
explains transfer recall as the revival of information in response to new cues, which
are in the nature of search models. The search models, in turn, provide cues for
recall and enable recall to be selective. Divergent production generates logical possi­
bilities.

The traditional concept "deduction" is accounted for in SI theory in terms of
convergent production of relations and implications. Convergent production generates
logical necessities.

Evaluation is a process of comparing and matching items of information accord­
Guilford's definition of evaluation includes the term "decision." After comparing and matching, a decision is made with respect to satisfaction of meeting the specified criteria.

It is Guilford's belief that the many similarities between what is generally called "problem-solving" and "creative thinking" make it possible to deal with them as essentially one topic. The similarities are indicated both by the traditional steps involved and by the intellectual ability concerned. Guilford delineates an operational model for problem-solving based on SI theory (Guilford, 1967, p. 315). He accounts for the relationship between problem-solving and creative production in terms of similar motivation, information, incubation, intuition, flexibility, implications, and evaluation. He distinguishes between pseudo problem-solving and genuine problem-solving. Genuine problem-solving requires some element of novelty; novelty is the essence of creative production; genuine problem-solving therefore involves creativity. The divergent production abilities are essentially creative abilities. Genuine problem-solving and creativity are accounted for by the divergent production operations. Thus, the SI model gives an empirical foundation to the traditional concept of "creativity"; in so doing, it averts the vagueness that has typically confounded studies of creative behavior.

SI theory can account for perception, concept-formation, memory, imagination, cognition, specific methods of reasoning and specific methods of thinking. SI theory separates purely motor tasks from intellectual tasks. Guilford (1958) has classified and developed a system of psychomotor abilities. In earlier works he presented a workable model for psychomotor abilities; in *The Nature of Human Intelligence* he
presented a model for perception. Both are consistent with, and conform to, SI theory. Thus, most of the traditional concepts have not only been accounted for, but clarified.

Can SI theory explain the relationship between learning and intelligence?

**SI theory and learning**

Guilford takes pain to show that intelligence can not be identified with any general learning ability (Guilford, 1967, p. 20). No factor has been identified as “learning ability” in the numerous factor-analytic studies of intelligence. It is not identified as a kind of operation or a kind of information or any unique combination of information and operation. Ironically, learning is rather universally recognized as belonging to the intellectual domain. Where does it really belong?

Traditionally, the assumption has been made that all learning phenomena represent one particular type of psychological operation. This false assumption has led to the attempt to discover some single principle or some simple set of principles to explain learning. As a result, there are presently several conflicting theories of learning: theories centering around contiguities, theories centering around reinforcement, theories centering around cognition. Within the respective categories, there are considerable areas of dispute.

SI theory suggests a revolutionary way of understanding learning. Learning is defined as a change in behavior induced by experience; learning refers to the change, rather than the behavior. When experience is interpreted as informational-operational, different kinds of learning result from different kinds of experience. The different kinds of learning are determined by the different operations involved and the different things produced. Guilford suggests that learning means developing new
products of information or revising old products of information. For example, the traditional concept of perceptual learning is reinterpreted as the cognition of figural units. Guilford proposes that the traditional concept of association to explain learning be largely replaced and extended in the form of the six products of information. The term "association" has been superseded; everything that can be accounted for by association can be accounted for by SI; but SI theory can go beyond the limits of association. Several contemporary learning theories involve "structures" to explain learning; these structures are readily translated into products of information.

The traditional studies in conditioning and other learning based on the associative principle may be reinterpreted in SI theory as the acquisition of implications. Serial learning involves learning units of information, learning the implications involving relations and systems. Paired associate learning involves the learning of units of information, learning the connections between the pairs, and the formulation of implications. Concept formation pertains to learning to form classes. The learning of motor skills can be understood as the acquisition of behavioral systems of the self-knowledge type; other skills can be given informational interpretations. Strategies in learning can be interpreted as behavioral systems.

When Guilford's concept of transformation is applied to learning many traditional concepts may be included: the reorganizations of gestalt psychology, Piaget's concept of accommodation. The traditional concept of reinforcement can be understood as evaluation, using feedback information: such concepts as drive reduction, pleasure-pain, reward and punishment, confirming reaction, and knowledge of results can be included. Guilford suggests that parallels between SI categories and the area
of executive functions might furnish a natural link between cognition and action in behavior. "A situation cognized in a certain way calls for organized actions of a certain kind, because of some degree of isomorphism that exists between input and output events" (Guilford, 1967, p. 294).

Guilford distinguishes between learning and intelligence; while sharing many components, the terms are not synonymous. He identifies the specific abilities involved in both; he identifies the components that are shared and indicates the aspects that are not shared. At all times he is careful to distinguish between the nature of the learning task and the nature of the test. SI theory, when applied to learning, has untold implications for learning theorists and experimental studies.

Relation to Other Theorists

In the preface to The Nature of Human Intelligence, Guilford acknowledges his assistance from numerous sources. He admits that without the initiation and development of factor-analytic methods, the book could not have been written at all. "To Charles Spearman, Cyril Burt, L. L. Thurstone, and others, we all owe great debts" (Guilford, 1967, p. viii).

Spearman maintained that intelligence consisted of a g factor and numerous s factors. Guilford denies the g factor; he attributes its existence to the combination of factor-analytic methods used in certain studies and the historical belief that a psychological operation is the same whether it is performed with verbal-meaningful information or visual-figural information.

Spearman found his best tests of g to be those tests which involved relations or connections between things. He used the term "fundaments" to mean the things be-
tween which a relation occurs. If the S were given two fundamentals and asked to find their relation, Spearman used the term "eduction of a relation" to describe the process. If the S were given one fundament and one relation and asked to find the other fundament, Spearman used the term "eduction of correlates" (or eduction of a fundament) to describe the process. Guilford states that Spearman's concepts about fundamentals and relations are very sound; but they are most limited and need to be extended.

Interpreting Spearman in SI theory means that fundamentals are equal to SI units; relations are equal to SI relations; the eduction of a relation is equal to SI's cognition of relations; the eduction of a correlate is equal to SI's convergent production of a relation. Spearman believed that the two major intellectual operations that were characteristic of g were eduction of relations and eduction of correlates or fundamentals. When Spearman's concepts about relations and fundamentals are extended by means of SI theory, the following things happen. The major intellectual operations expand to include cognition, memory, divergent production, convergent production, and evaluation. For the eduction of a relation, four distinct abilities can emerge, one for each kind of task content: cognition of figural relations, cognition of symbolic relations, cognition of semantic relations, cognition of behavioral relations. For the eduction of correlates, four distinct abilities can emerge, one for each kind of task content: convergent production of figural relations, convergent production of symbolic relations, convergent production of semantic relations, convergent production of behavioral relations. Spearman (1926) recognized several different kinds of relations based on the kind of material used; in SI theory this would be the different kinds of information. Spearman's "psychological relation" is equal to SI's behavioral relations.
Even when extended through SI theory, Spearman's psychological concept of g is very narrow. "If eduction of relations and correlates taken together are accepted as the *sine qua non* of g, then g embraces only 8 of the 120 intellectual abilities represented in the SI model" (Guilford, 1967, p. 65).

Binet was openly concerned with the needs for a theoretic psychological basis for testing. He was a respected experimental psychologist of his time; he believed findings from the psychological laboratory to be a proper source of test material and a proper basis for the selection of tests to be used generally. The parallel with Guilford's beliefs is obvious.

Binet (1896) criticized Galton's tests as being too sensory and too simple. He found Galton's tests did not discriminate among the different kinds of memory; he believed different kinds of memory were produced by different types of information, e.g. letters, colors, paired associates. The SI parallel can be seen in memory for figural information, memory for symbolic information, memory for semantic information, etc.

Binet believed intelligence to be complex; much more complex than previously expected as it appeared to be composed of many different abilities. He urged the use of complex tests as a proper measure of intelligence. Guilford would agree that intelligence is complex; he would also agree that intelligence is composed of many different abilities. Guilford would not agree that a complex test is a proper measure of intelligence. SI theory is based on the unique intellectual abilities that combine to mean a global concept of intelligence. To Guilford, the complex test defeats the purpose of factor analysis.
Binet proposed ten functions of intelligence that could be measured by tests: memory, imagery, imagination, attention, comprehension, suggestibility, aesthetic appreciation, moral sentiment, muscular force and force of will and motor skill, judgment of visual space. It does not appear that he regarded these as unitary traits because he recommended a variety of tasks for each function. He does not imply that this is "all" of intelligence, he indicates that these are functions that can be measured. Obviously Binet's view of intelligence was a comprehensive one. As Spearman (1927) was quick to point out, Binet's introduction of the single score for measuring intelligence was a direct contradiction of all his convictions.

When Binet is interpreted in SI theory, memory, imagery and imagination (to the extent of their being revivals of perceived experience) are equal to SI's memory operations; attention is equal to SI's filtering of input information and applicable to all SI operations; comprehension is equal to SI's cognitive operations, suggestibility is equal to SI's product: implications; aesthetic appreciation and moral sentiment are equal to SI's unique combination of evaluation operations and behavioral information; muscular force and force of will and motor skill are partially equal to Guilford's psychomotor taxonomy and partially equal to SI's production operations; judgment of visual space appears to be equal to SI's CFS-V and possibly an evaluation factor, depending on the form of the item.

Binet's 1905 scale (cf. p. 55) contained many varieties of test items; many of them will be considered in connection with the Stanford-Binet test in the next chapter. The test, as a whole, stressed judgment, common sense, initiative and the ability to adapt. Items 1, 2 and 3 involve motor tasks. Items 11, 15, 17 and 18 involve the
operation of memory with different kinds of information. Items 23, 24 and 25 involve divergent production of semantic information. Eighteen of the items involve cognitive abilities. Binet's desire to include varieties of items to measure varieties of intellectual abilities is obviously extended in SI theory.

Binet's investigations on problem-solving, as a unique method of thinking, led to his conclusion that four distinct steps were involved: direction (mental set), adaption (invention, choice), autocriticism (self-evaluation), and comprehension. The four steps are remarkable for their similarity to contemporary analyses of problem-solving abilities and for their relationship to SI's divergent production abilities. Binet did not believe that intelligence and scholastic ability (learning) were exactly the same thing. He admitted to numerous similarities, but contended that scholastic ability was dependent upon many other traits and influenced by many other conditions. Guilford's distinction between learning and intelligence reaffirm and extend this concept.

Terman adapted Binet's scales and produced the Stanford-Binet Scale of Intelligence. He established national norms, but his use of the IQ concept and single score perpetuated narrow and misleading concepts of intelligence. This is contrary to Guilford's convictions (as well as Binet's). Terman showed little concern for psychological theory. He defined intelligence as "the ability to do abstract thinking" yet he never really defined abstract thinking. His implied conviction that intelligence was a single trait would, of course, obviate concern for the uneven item-task composition of the Stanford-Binet.

Thorndike's concern with the importance of exact measurement is echoed by Guilford. Thorndike's theories of learning and their derivations are very different
from Guilford's. While Guilford would reject Thorndike's definition of intelligence, he would agree with and extend his concept of "kinds" of intelligence. Guilford would tend to agree with some aspects of Thorndike's "products"; he would agree with his opposition to a single score indicator.

Guilford's debt to Thurstone and his compatibility with Thurstone's major concepts have been acknowledged frequently. Essentially, SI theory is an extension and elaboration of Thurstone's theories. His concept of primary mental abilities is subsumed and extended considerably to serve a taxonomic purpose in SI theory.

Garrett's developmental theory and its differentiation hypothesis has not been supported by numerous factor-analytic studies. Guilford offers an alternative hypothesis based on SI theory; each intellectual ability has its own unique origin, but all intellectual abilities develop through interaction of hereditary dispositions and environmental sources of information. Guilford suggests that heredity provides the basis for the five kinds of SI operations and that environment provides the sources of information along the lines of interaction of content with product; i.e. the 24 categories represented on each operations matrix.

The hierarchical theories of intelligence accept the factors of intelligence concept, but organize the factors around the concept of g. Guilford denies the concept of g, but the interpretation of many of the factors in the different hierarchical theories are similar to Guilford's interpretations of SI factors. Vernon's v:ed may be interpreted as SI's semantic information; his k:m may be interpreted as SI's figural information, although Vernon's concept is broader than the SI concept because it includes spatial, mechanical, and psychomotor abilities. When Vernon divides v:ed into group
factors, the verbal group is roughly equal to some SI semantic concepts, and the numerical group is roughly equal to SI's symbolic information. Burt's g is really verbal education and his "practical" is really behavioral and psychomotor education. Many of Burt's factors are readily identified with SI factors, but the arrangement is very different and the relationships are difficult to observe.

Guilford (1966) presents a table of equivalent SI factors and Cattell's Universal Index factors. An abbreviation and adaption is found in Table 7.

**TABLE 7**

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<thead>
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<th>SI FACTORS AND EQUIVALENT UI FACTORS</th>
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<td>UI T12</td>
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(Adapted from Report From the Psychological Laboratory of the University of Southern California, Number 36, June 1966)

Piaget's developmental theory of knowledge has many parallels with SI theory. As these have been discussed in Chapter II, it appears sufficient to mention the con-
siderable complementary characteristics of both theories, numerous links between them and suggest the important roles of SI's information and operation concepts in Piaget's theory. There is no basic conflict between the two theoretical approaches; as Piaget has not, as yet, developed a comprehensive and unified presentation of his theory, SI theory provides a framework wherein Piaget's findings and concepts may be organized and related.

Relation to Current Psychological Theory

SI theory is based on the concept of information-processing. Guilford distinguishes the psychological concept from the philosopher's concept of knowledge. Thus, one of the persistent problem areas concerning the relationship between psychology and philosophy is ameliorated. His distinction provides a systematic basis for what he terms "psychoepistemology." Based on an interpretation of the products of information, Guilford is able to provide a basis for what he terms a "psychologic," a construct that closely parallels current formal logic concepts. The SI definition of information embraces the broad area of all things which an organism discriminates; the current concept "psychological field" is appropriate.

The evolving admission that the intellectual processes are complex is amply demonstrated in the SI model. Despite the fact that numerous theorists have urged the abandoning of the single score indicator as being misleading and logically incorrect, the majority of standardized psychological tests continue to use it. Application of SI theory should be instrumental in hastening its disuse. Guilford has been unquestionably successful in providing empirical evidence for recognition that intelligence is composed of a large number of different abilities rather than one general ability.
While many contemporary theorists admit that intelligence may be composed of multiple aptitudes, they maintain that some of them cannot be measured and theoretically are not investigational concerns. Guilford has been undeniably successful in demonstrating, particularly with the creative abilities, that factors other than the traditional scholastic type are amenable to empirical investigation. SI theory expands both concepts about intelligence and empirical means to investigate them. The traditional meaning attributed to the concept "cognition" is revised in SI theory to distinguish among cognitive, evaluative, divergent production and convergent production abilities.

As has been indicated, SI theory can account for most of the traditional concepts centering on perception, learning, recall, problem-solving and creative thinking. Its unique value is its ability to organize seemingly disparate concepts around a common structure; and further, it has the ability to extend many limited ideas in an orderly and meaningful fashion.

It has been shown that almost every psychological construct maintained by earlier theorists (whose concepts have withstood the test of time) may be logically reinterpreted and extended in the SI framework. Essentially, psychology, as a general field, is concerned with data of a behavioral nature. Guilford considers each SI factor to represent a unique psychological function. The SI framework affords a technique whereby the factors of intellectual behavior may be classified and related. Its breadth and structure permit a synthesis previously impossible.

There is a general trend in current psychological thought to present a theory in terms which are broad enough to guide subsequent research, to generate diverse hypotheses leading to investigation, and to provide means of giving research results
some form of systematic significance. Commonly found in such presentations is the theorist's use of a model, particularly a model which is founded on mathematical or logical properties. In general, such models express theoretic concepts in a more extensive framework and in a more interrelated complexity than the traditional simple diagrams. The morphological representation of SI theory conforms to the characteristics of contemporary models.

Another current trend in general psychology concerns the application of computer technology to psychology. The numerous similarities between SI theory and cybernetics, computer bits, and input-output functions are easily seen. Closely related to this general trend is the general trend to be observed regarding both learning behaviors and the nature of intelligence. Guilford has explained the difference between learning and intelligence and given substantial evidence that "intelligence" cannot be identified with any general learning ability. His explanations put considerable light on previous vague connections between the two; his argument serves to contradict the historical concept that intelligence is the ability to learn. More importantly, perhaps, his clarification leads to better understanding of current concerns in these areas. There has been a general trend away from S-R psychology and its application to learning theory and also to theories of intelligence. The current indications appear to favor some form of cognitive psychology. SI theory is a cognitive model of intelligence; information represents the input, operations represents the organism's reaction or intervening operations, and product represents the output. The SI theory may be extended, with Guilford's cautions, and become analogous to general cognitive models of human learning.
The writer's purpose has been to indicate the ways in which SI theory reflects and exemplifies general trends in contemporary psychological thought. The second half of The Nature of Human Intelligence constitutes "a work of enormous scholarship" (Carroll, 1968, p. 255). Although the purposes of this paper would not be served by further detailed delineation of SI factors and specific equivalents; Guilford's magnificent contribution to psychology must be acknowledged. A theory of intelligence that revolves around the processing of information leads to an operational-informational type of general psychology. As a general structure, it can logically be related to nearly every phase of current psychological research. In the last nine chapters of The Nature of Human Intelligence, Guilford summarizes the recent and significant research in such broad areas as: perception, learning, memory, problem-solving, creativity, child development, gerontology, brain psychology, animal psychology, psychomotor behavior, social-environmental psychology, heredity and genetics. In this arduous undertaking, Guilford has used the SI theory as an organizational scheme to explain and evaluate relevant studies. The applicability of SI theory to experimental studies is most significant; Guilford has indicated the operations of the particular SI factors involved in the various experimental settings. Guilford stresses those problem areas of differential psychology that may be reconsidered in SI concepts and contribute significantly to general psychology. He stresses the important implications in the SI model that pertain to transfer-of-training; these implications are basic to all forms of learning and problem-solving activities in education, as well as in social settings apart from school. Comprehensiveness, synthesis, and insight characterize Guilford's incredible scholarship.
Implications for Psychological Measurement

SI's implications for psychological measurement are both manifold and significant. The use of any psychological measure involves three rather obvious but too frequently overlooked conditions: a basic understanding of the nature of intelligence, a basic understanding of the nature of measurement, a basic understanding of the utilization of test results. As specific implications for selected instruments shall be the topic of the next chapter, it appears sufficient to mention general implications here and illustrate them later.

If one purports to measure intelligence, one must have a basic understanding of the nature of intelligence. Intelligence cannot exist apart from man's other behaviors; therefore, a systematic, psychological theory is needed to account for the nature of intelligence and its relation to other psychological concerns. The psychological theory provides the rationale for validity, selection of tasks, and empirical techniques.

Traditional associationism implied that intelligence consisted of what we knew through the senses. The common agreement expressed the conviction that good senses indicated good intellect. The earliest investigations of intelligence involved the measurement of sensory functions, with emphasis on motor abilities. The tendency to measure intelligence by motor abilities was partially checked by subsequent research which failed to show the assumed correspondence between motor abilities and performance in subject matter areas.

The unitary trait and g theories of intelligence were measured by tests predominantly cognitive-semantic in nature, the results, indicated by a single score,
were supposedly characteristic of the intellectual capacity of the S. When subsequent research indicated frequent examples of disparity between test performance and life-situation performance, the charge was made that no one knew what the so-called intelligence tests measured. When SI theory can be used to identify, item by item, those abilities that are actually being measured, it is possible to determine, with a high degree of accuracy, those intellectual factors which are being measured.

If one defines what is being measured (a minimum requirement for credibility), the definition should not contain undefined concepts or imply undefined concepts. The definition must contain referents to reality, or at least, point to reality. Terman defined intelligence as the ability to do abstract thinking; he never presented a satisfactory definition of abstract thinking. Wechsler defined intelligence as "operationally defined, intelligence is the aggregate or global capacity of the individual to act purposefully, to think rationally, and to deal effectively with his environment" (Wechsler, 1958, p. 7). This definition appears to be an improvement; it is superficial, for Wechsler supplies no empirical referents.

If intelligence is viewed in a multi-aptitude concept, multivariate methods are required for investigation; the different abilities must have test representation. Traditional psychometric studies of mental growth have imparted little information about basic intellectual concepts; however, they have persistently pointed to the need for a multi-aptitude view to understand intelligence. If the multi-aptitude concept of intelligence is adopted, logical consistency demands profile or multi-aptitude scores.

When a psychological test is defined as essentially an objective and standardized measure of a sample of intellectual behavior, there are implications for
measurement, as well as for the nature of intelligence; there must be a sufficient
number of items to represent an adequate sampling of the totality implied by the con-
cept "intelligence." The items must be characterized by both breadth and depth if
they would provide the necessary range implied by the concept "measurement."
There must be some empirical evidence concerning the relationship of the items to
the behavior they purport to assess, if they would be considered valid.

If one purports to measure intelligence, one must have a basic understanding
of the nature of measurement. Essentially, measurement implies a constant process.
Measurement, when applied to psychological tests, involves understanding such con-
cepts as descriptive statistics, sampling statistics, standardization, correlation,
factor analysis, variability, reliability, validity, test bias, distribution curve, pre-
diction, item analysis. The empirical requirements of control, quantification,
objectivity, and simplicity are essential to psychological measurement.

Frequent references have been made to the plea for more sophisticated
techniques in dealing with psychological data. Surveys conducted on large groups of
test-users (Goslin, 1967, Stanley, 1964) indicate vital areas of ignorance of common
techniques; the vague assumption that correlation indicates a cause and effect
relationship is common. Also common, although more excusable, is the belief that
measures of general achievement and measures of aptitude for achievement are
measuring two different things, despite the fact that numerous published factor-
analytic studies have found them to be two different measures of the same ability.

If one purports to measure intelligence, one must have some reason for doing
so. Provision must be made or at least specifically implied for the utilization of
test-results. The psychological test is but one of several standard methods for collecting data. Certainly the mere collection of data is pointless, unless there is a purpose or direction to be indicated by the results. Testing should be the starting point in evaluation. All too frequently, especially in the educational setting, it is the end. Even worse is the custom of simply filing the results and making no interpretive or evaluative use of them. Some administrators go so far as to prevent the classroom teachers from having access to them for fear it might "prejudice" their concept of their pupils' abilities. This unfortunate custom makes as much sense as destroying the laboratory analyses of organic matter from diseased patients so that the doctor will not get "upset." If the doctor is incapable of understanding the implications of the laboratory report, the fault would appear to lie with the doctor, not the laboratory; the cure would appear to involve enlightening the doctor, not in hiding the report.

When applying SI theory to psychological testing, several specific implications emerge. Of prime importance is the need for change in the nature of intelligence tests. This change involves expansion of the factorial composition of intelligence tests, multivariate scoring procedures, variety of item types, and the uses made of the test-score information. This change involves appropriate varieties of age norms, different group and culture norms, profile scores, explanation of the meaning of specific abilities and their relation to specified activities, uncomplicated and descriptive indications of the quantitative and qualitative intellectual resources of a given S. If the test-results are to be fully utilized to facilitate intellectual growth and to guide the direction of functions of education, there are serious implications for change in teaching methods, curricula concerns and social demands.
CHAPTER V

APPLICATION OF SI THEORY TO SELECTED PSYCHOLOGICAL MEASURES

Man's capacities have never been measured; nor are we to judge of what he can do by any precedents, so little has been tried.
- Thoreau

In general usage, the intelligence test is defined as an objective device designed to yield quantitative information about an individual's intellectual abilities. The administration involves the use of standard operating procedures. The interpretation involves comparison with the performance of other individuals. From the comparative, quantitative information a description of the individual's abilities can be made, and predictions about the individual's performance in intellectual tasks can be made. Theoretically, the obtained data may be used to describe and predict. The intelligence test, in theory at least, has been developed through a scientific process; the process begins with a theory of intelligence, tasks are designed in accordance with the theory, experiments are conducted so that scientific observations may be made, empirical techniques are applied to test the hypothesis, revision and retesting are based on the empirical techniques; finally, standardization and publication conclude the process. The difference between theory and practice is a major source of the confusion that characterizes psychological testing.

Ever since Binet, mental testers have tried to ride in two directions at once. They try to predict school success and therefore include measures of educational skill in their tests. But they also ask the same tests to measure a psychological attribute which is thought of as distinct from educational attainment. Most present tests are a muddled combination of predictive
measures which rest upon past achievement, of measures unrelated to either past or future achievement, and of measures which predict future performance but do not depend on past schooling (Cronbach, 1960, p. 241).

Psychological testing begins with experimental psychology. Application of experimental tasks to general populations calls for revision and modification based on clear communication between experimenters and testers. There is little evidence that such revision or modification has occurred. There has been practically no change in test-tasks for the past 50 years! The use of psychological tests to obtain valid descriptive and predictive information demands cooperative understanding between the theoretic-experimenter and the practical-tester. There is little evidence that such understanding has existed. Strange ironies have occurred in the development of psychological testing; such situations have contributed to the present lack of confidence in psychological testing.

The evaluation and interpretation of information derived from psychological tests is commonly used to make some decision about an individual. The person who makes use of test information in this way incurs a serious responsibility. This responsibility includes a realistic evaluation of the derived information in terms of theoretic and practical application; it includes the need to evaluate the instrument in order to evaluate the performance of the individual. A uniform frame of reference or a common measuring stick is needed for such evaluation. SI theory can be regarded as a uniform frame of reference. Application of SI theory to selected psychological tests will provide a framework for evaluation, and hopefully, the means for more effective use of test information.

Intelligence testing had its origins in the experimental laboratories of the
early psychologists. Ever since Ebbinghaus, the most popular device of the experi-
mental psychologist has been some kind of test to measure the S's performance.
Whenever the experimental psychologist measures performance, he is using a psycho-
logical test. The earliest test items were developed in experimental laboratories in
Germany, France and England. Much of the muddle indicated by Cronbach can be
attributed to the application of test-tasks to situations which differ from laboratory
situations, and by demanding more from the test than was originally intended. The
communication between experimenters and testers has never been adequate. In the
material which follows, background to the development of traditional item types is
given. The degree of inadequate communication between experimenter and tester
becomes marked. The development and use of traditional item types is given to show
the lack of change or implementation in items over a period of 50 years.

As intelligence testing has developed over the past years, strange ironies have
occurred. Binet's original purpose for his scales was the identification and classifi-
cation of mental defectives; yet the best known longitudinal study of intellectual
superiority used the Stanford-Binet scale for a selective criterion (Terman's studies
of the gifted). With the exception of the Wechsler scales, there has been practically
no change in the nature of intelligence tests, despite the fact that research, as well
as social discernment, indicates considerable change in the meaning of intelligence.
Wechsler had two purposes for the construction of his scale; first, to develop intelli-
gence tests designed to measure adult intelligence; and secondly, to provide a clinical
diagnosis by means of analysis of subtest patterns. He subsequently extended the
adult scale downward. At the present time, the Wechsler children's scale is as
popular as the adult scale on which it was modeled. The clinical value of the Wechsler subtest pattern analysis is highly questionable because empirical studies have indicated little validity (Rabin and Guertin, 1951; Guertin, Frank and Rabin, 1956; Anastasi, 1961).

Experimental tests designed to be applied to the measurement of illiterates have come to be applied to general populations. Even the early items developed in the experimental laboratories have been little changed and comprise a considerable portion of current standard tests. Is there any wonder that a muddle has emerged from such a development?

Traditional Item Types

Developmental background

Wundt established the first laboratory for experimental psychology at Leipzig, Germany in 1879. Wundt used objective measuring devices to assess the physiology of sensory processes. The tests included reaction time and word association items. The influence of sensory tasks on intelligence test items has been discussed. Item types gradually became less sensory, but continued to stress reaction time and motor speed.

As item types became less sensory they tended to make more demands on memory and rote learning abilities. Some of the notable "Firsts" are presented in Table 8.
<table>
<thead>
<tr>
<th>Year</th>
<th>Person</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1890</td>
<td>Cattell</td>
<td>First used the term &quot;mental test&quot;</td>
</tr>
<tr>
<td>1897</td>
<td>Ebbinghaus</td>
<td>First used the completion type test</td>
</tr>
<tr>
<td>1905</td>
<td>Binet</td>
<td>Developed the first intelligence scale</td>
</tr>
<tr>
<td>1908</td>
<td>Binet</td>
<td>First use of the mental age concept and the development of a mental age scale</td>
</tr>
<tr>
<td>1912</td>
<td>Stern</td>
<td>First use of the term &quot;IQ&quot;</td>
</tr>
<tr>
<td>1916</td>
<td>Terman</td>
<td>First use of the IQ ratio on the 1916 Stanford-Binet scale</td>
</tr>
<tr>
<td>1917</td>
<td>Otis</td>
<td>First group intelligence test</td>
</tr>
</tbody>
</table>

In 1895, a student of Kraepelin, Oehrn, developed and used the following items in experimental studies:

- **Letter Counting:** count the number of letters on a printed page; count the number of times a given letter occurs on a printed page.

- **Letter Cancellation:** draw a line through or around a given letter on a printed page.

- **Proofreading:** mark all typographical errors on a page; mark all spelling errors on a printed page; find all errors (any type) on a printed page.

- **Association:** the free-association type item: the S is asked to respond to a stimulus word by giving the first word that comes to mind. (Galton described the technique in 1879.)

- **Addition:** add given numbers, presented in both oral forms as well as in printed forms.
Dictation: S is required to write sentences, passages based on dictated material, S must write from memory.

Rapid Writing: S is required to copy printed material as fast as possible.

Motor Functions: S is required to perform selected motor tasks.

In 1897 Ebbinghaus devised the first sentence completion item. Ebbinghaus was one of the earliest experimenters in the study of learning and memory. He used the Memory for Nonsense Syllable item to measure whole vs. part learning. He studied re-learning and reaction time involved as a measure of the amount of retention. He used arithmetic computation items, memory span items, and sentence completion items on a large population of school children. He found that the sentence completion items were the only parts of the test that correlated with school grades.

Interpretation of pictured material was first used by Ferrari in 1896 (Anastasi, 1964). His population consisted predominantly of pathological Ss; but as an item type, interpretation of pictures has been widely applied to normal populations as well. Binet’s 1905 scale contained the first true variety of items. He did include sensory and perception tests, but there was a greater proportion of verbal material than other tests of the same time. In 1907, Sequin introduced a nonverbal measure of intelligence: the form board. Generally, the tests developed during this period contained items which were believed to measure memory, imagination, comprehension and evaluation. Claims were made for the common sense characteristics of many tests, indicating an interest in measuring aspects of intelligence that were not educationally biased.

Tests of memory contained items of the following types:
memory span: rote and serial; long term and short term abilities,

memory for associations: paired associate memory,

logical memory: memory for ideas from paragraphs, stories and pictures,

visual memory: memory for designs, visual forms.

Tests of imagination called for visual-semantic imagery. They typically required the S to imagine a previously experienced setting. Questions were asked pertaining to the sharpness of objects and details recalled.

Tests of comprehension included both cognition and understanding. Typical cognition tests included the following item types:

cognition of figures, objects, colors, words;

cognition of likenesses and differences, rhymes.

Tests of comprehension included:

verbal associations: relations and classes, sentence completions, synonym, antonym, definitions;

reading comprehension: reading and explaining what a passage meant, listening to a reading and answering specific questions based on the material;

number abilities: performing number operations, solving verbally expressed number problems;

spatial comprehension: space perception, distance, orientation, formboard, mazes.

Tests of evaluation included items like the following:

matching: identifying like and unlike things;

incongruities: finding something logically wrong;

interpretations: judging given conclusions in the light of previously given information;

syllogisms: both formal and informal types used.
Common sense was thought to be measured by certain problem solving tasks. Given certain information, the task was to obtain a specified result. Theoretically, problems of this type were supposed to involve aspects of insight. The early tests were highly verbal, individual assessments of intelligence.

The Otis group test introduced new variations of items. Revisions of earlier types were adapted for group administration. The format of testing was re-ordered so the results could be quickly scored. Two forms were devised: one verbal and one nonverbal. The verbal form, Group Examination Alpha, Test 1, form 5, contained the following tests:

**Test 1:** 12 items to be solved by following oral directions; time: items 1 and 2 - five seconds, items 3 through 12 - ten seconds. The examiner read directions of the type: "Look at the circles at the line marked 1; make a cross in the first circle and a figure 1 in the third circle."; "Look at the square and the triangle at the line marked 3; make a cross in the space which is in the triangle but not in the square, also make a figure one in the space which is in the triangle and in the square."

![Diagram](image)

**Test 2:** arithmetic problems; time: five minutes. 20 items of increasing difficulty:

"How many are 5 men and 4 men?"
If you walk 4 miles an hour for 3 hours, how far do you walk? 

Ans. ( )

If 3 1/2 tons of coal cost $21, what will 5 1/2 tons cost?" 

Ans. ( )

Test 3: practical judgment; time: one and a half minutes. Of the type:

"Why do we use stoves? Because

_____ they look well; _____ they keep us warm; _____ they are black

If the earth were nearer to the sun

_____ the stars would disappear
_____ our months would be longer
_____ the earth would be warmer 

Test 4: synonym-antonym; time: one and a half minutes. 40 items of increasing difficulty of the type:

"good-bad
little-small
encomium-eulogy

_____ same _____ opposite
_____ same _____ opposite

Test 5: disarranged sentences; time: two minutes. 24 items of increasing difficulty; S was instructed to unscramble the sentences, then mark true or false for the statement idea, all of the type:

"a eats cow grass
horses feathers have all
envy bad malice traits are and

_____ true _____ false
_____ true _____ false
_____ true _____ false "

Test 6: number series completion; time: three minutes. 20 series of numbers, S must supply the next two in the series:

" 2 4 6 8 10 12 _____ _____
9 8 7 6 5 4 _____ _____
2 2 3 3 4 4 _____ _____
1 7 2 7 3 7 _____ _____ "
Test 7: verbal analogies; time: three minutes. 40 items of increasing difficulty, all of the type:

"sky - blue as grass - _____ table, green, warm, big
fish - swims as man - _____ paper, time, walks, girl"

Test 8: information; time: four minutes. 40 items of increasing difficulty, all of the type:

"People hear with the eyes ears nose mouth
Bombay is a city in China Egypt India Japan
The stanchion is used in fishing hunting farming motoring"

The S was instructed to underline the correct word.

The total working time was twenty-two minutes. The test contained a total of 212 items.

The nonverbal form, Group Examination Beta, form O, contained the following tests:

Test 1: mazes; time: two minutes. 5 mazes of increasing difficulty, all of the type:
Test 2: cube analysis; time: two and a half minutes. 16 items of increasing difficulty, all of the type:

![Cube](image)

Test 3: X-O series; time: one and three quarter minutes. 12 series of increasingly more complex X-O patterns. The S was instructed to finish each row. Adequate explanation and demonstration of the problem preceded the S's attempts. The items were of the type:

```
5. xo xo xc xo
```

Test 4: digit symbol; time: two minutes. The S is given the number-symbol chart which is in front of him while he is taking the test; he is asked to write the proper symbol in the blank space under each number:

![Digit Symbols](image)

Test 5: number checking; time: three minutes. 50 items of increasing difficulty; the S was asked to mark with an X the pairs that are identical:

```
650   650
041   044
76568100398030  76568100298030
```

Test 6: picture completion; time: three minutes. 20 items of increasing difficulty; the S is asked to draw in the thing that is missing in each picture, all of the type:
Test 7: geometrical construction; time: two and a half minutes. The S is asked to draw lines in the right hand picture to indicate how the pieces on the left are put together to form the figure on the right, all of the type:

![Diagram](image1)

The total working time was sixteen and three-quarters minutes. The total number of items in the test came to 203. The materials cited have been adapted from the original tests; for the most part, they are identical to the Otis items.

Monroe (1945) marks the year 1920 as "beginning the widespread use of objective tests in American schools." According to the *Encyclopedia of Educational Research* (1952), by 1930 there were 1300 tests available for educators and researchers. For the past 50 years, scores from group tests of intelligence have been largely determined by three types of abilities: number, verbal, and reasoning. These abilities are most dependent upon past learning experiences. The high verbal-educational content of most intelligence tests has frequently been noticed.

**Shortcomings**

Some of the limitations of traditional intelligence tests are caused by the design of the format, or presentation. In order to meet the requirements for machine scoring, it becomes a necessity to employ some form of multiple choice item. Rarely is the S asked to "produce" an answer; he is asked to recognize the correct answer from several given answers. The operation involved is usually cognition. If the S is asked to decide which of several choices is the best, some evaluation factors may be
involved. Items dealing with semantic material are most popular; these include definitions, synonyms, class inclusion, class exclusion, antonyms, verbal analogies, and word naming items. General information items and reading comprehension items are also quite popular.

The number ability is usually measured by solution to verbally expressed number problems, number operations items and number series items.

The so-called "general reasoning" items may be constructed of figural, symbolic or semantic information. Usually the S is asked to choose the answer which completes a series, or relation. Matrix type items and analogy items are also popular. Some of the syllogistic items involve evaluation or recognition of implications.

The nonverbal abilities are measured by mazes, form boards, figure rotations, mechanical principles, cube counting, geometric construction items. By and large, the common test items involve cognitive operations. Of these, the SI factor: CMU and SI factor: CMR are predominant. It is a rare test item in current measures that does not involve either verbal comprehension or semantic relationships.

Intelligence tests of one variety or another are used by the hundreds upon thousands in the United States; they are used in educational, clinical and personnel settings. Decisions are made daily on the basis of information derived from such instruments; some of the decisions can have implications that will extend for a lifetime. Any person, who makes use of test information in making a decision, has a serious ethical responsibility to attempt to find out just what it is such instruments measure.

In all of the thousands of factor-analytic studies, no one single factor can be
identified as "general learning ability," "learning ability," or "problem solving ability." It is most important than an intelligence test author's understanding of intelligence, or his definition for intelligence, be identified. If a test is supposed to measure something, then the items which are chosen should be representative of the thing that is being measured. The author's understanding of intelligence is the rationale for the construction of the test; it should be revealed by the kinds of items used, by the content of the items used, and by the extent to which test information may be applied.

The following psychological tests have been selected for analysis and application of SI theory:

- The Wechsler Adult Intelligence Scale
- The Wechsler Intelligence Scale for Children
- The Stanford-Binet Intelligence Scale - Form L-M
- SRA Primary Mental Abilities Tests (1962 Revision)
- Lorge-Thorndike Intelligence Tests - Form A (Levels 1-5)
- California Test of Mental Maturity - Long Form 1963 Revision (Level 5)
- Otis-Lennon Mental Ability Tests - Elementary II Level, Intermediate Level, and Advanced Level

The measures have been selected for several specific reasons. Some of them have been used almost consistently and exclusively in mental research for the past seventy years; detailed understanding of what they measure imparts more significant comprehension to various research studies. It should serve to throw new light on old problems. The measures selected have been chosen on the basis of extent of usage in both clinical and educational situations. This decision was based on estimates from
standard texts in tests and measurement by Anastasi, Cronbach, Kendler, Stanley, and Stephens, as well as data from publishing houses and reviews from professional journals. The selected instruments are based on specific theories of intelligence; one of the aims of the writer is to show the manner in which a respective theory influenced the choice of items to be included in the instrument and can be held to account for the limited aspects of intelligence to be measured by the respective test. The instruments selected cover both individual and group tests; the age range includes children, adolescents, and adults. They have all had a significant influence on the changing concepts of intelligence and its measurement.

The analysis of the selected tests which follows is an attempt to place information derived from them in a more meaningful frame of reference. It is an attempt to discourage blind faith in a particular instrument by showing what it does and does not do. The SI theory appears to be a tenable one; it affords a common measuring stick by which the selected measures may be evaluated. It is hoped that such evaluation will serve to specify, modify and amplify the kinds of information that may be derived from using such appraisals. After general relevant information about each test, each item on the test has been transformed into the SI factor that it is understood to measure.

Techniques for Transforming Standard Test Items into SI Factors

There are three possible ways to transform a given item from a standard test into an SI factor:

1) use the interpretation based on empirical evidence offered by Guilford and other researchers who have used Guilford's notational system to identify items which
measure SI factors,

2) compare a selected item with items that have been used by Guilford and others for similarity and base the interpretation on the degree of similarity,

3) theorize the SI factor measured by a given item by subjecting the item to an analysis based on the content, operation, and product involved in the item.

Of the three possible techniques, the first is the most objective and considered the most valid, the second involves a minimum of subjectivity, the third is the least certain, but it does have some validity.

**Empirical studies**

Since 1950, there have been 39 reports issued from Guilford's Psychometric Laboratory. There are numerous descriptions of the various item content factors from standard measures used in Guilford's experiments. Guilford has given numerous identifications in articles published during the period 1950 to 1969. The Nature of Human Intelligence is a rich source of detailed descriptions and empirical identifications. Wherever possible, this is the method that has been employed by the writer in making the identification of a factor measured by a given item from one of these selected measures.

During the past few years, several notable studies have been conducted by independent researchers using Guilford's notational system (Bonsall and Meeker, 1964; Osborne, 1964; Meeker, 1965; Osborne, 1965; Smart, 1965; Stott and Ball, 1965, McCartin and Meyers, 1966; Merrifield, 1966; Cattell, 1967). Generally, each of these studies was designed with the help of Guilford's advice or corroboration. The ETS kit for cognitive factors (Revised Edition, 1963) edited by French, Ekstrom and
Price is another fruitful source of reference. The kit is based on factor-analytic re-
search studies conducted by Guilford, French and others.

The second method involves the comparison of a given item from a selected
measure with an item from a standard measure that has been used in an empirical
investigation. When such comparison indicates identical or very close to identical
characteristics, the writer has determined the SI factor involved as being measured
in the same way by both items. For example, Test 10 of the California Test of Mental
Maturity contains 40 items of this type:

"Mark the number of the word that means the same or about the same
as the first word.

Blossom;
  1. tree  2. vine  3. flower  4. garden"

Guilford (1967) states that "the most dependable and univocal measure of CMU
is a vocabulary test...the completion type, in which the S provides definitions or
other kinds of responses indicating that he has speaking acquaintance with the concept
for which the word stands, is usually, quite successful; so is a multiple choice form
of this test" (Guilford, 1967, p. 75). The factor identified as V in the ETS kit is
measured by five tests, all of which are composed on the same order:

"One of the four numbered words has the same meaning or nearly the
same meaning as the word at the left; mark the number of this word
in the answer column:

Attempt: 1. run  2. hole  3. try  4. stop"

The ETS Manual states: "This factor has been found in at least 70 published
studies. Identification: Cattell's UI T13; Guilford's CMU" (French, Ekstrom and
on the original reference and verifying cross-references, the writer assumes the 40 items on Test 10 of the California Test of Mental Maturity to be measures of CMU.

Theorized factor technique

The third method involves the analysis of a given item on the grounds of the content, operation, and product involved. Due to the degree of subjectivity involved in making such decisions, it is the least desirable method. There are no empirical references to substantiate the writer's hypothesized interpretation. The greatest pitfall in hypothesizing concerns the problem expressed by Guilford: "Since each SI ability is clearly and uniquely defined, the task of hypothesizing factors for tests is fairly easy, but experience with analyses shows that one can sometimes go wrong in making such predictions" (Guilford, 1967, p. 472). Guilford and other researchers have found, through factor-analytic techniques, that sometimes the same item will measure different things at different ages; this is another source of possible error in hypothesizing. The complex nature of many items on standard measures necessitates hypothesizing more than one factor. The writer has used the third technique only as a last resort; such hypothesizing is offered after considerable mental wrangling and with the earnest, but questioned, conclusion. The writer has stated the references involved for all identified factors; in the interest of economy, they are cited only with the first identification. Any factors which have been hypothesized have been clearly indicated as such. In hypothesizing factors, the writer conscientiously followed a standardized technique developed by Bonsall and Meeker (1964), and refined by Meeker (1965).

A group of psychologists, employed by the Los Angeles County schools, work-
ing with the Division of Research and Guidance in developing programs for the gifted, wished to find a way of relating a child's performance on the S-B with pertinent SI factors. Mary Meeker and Marcella Bonsall developed a way (1963). They were considerably assisted and guided by Dr. Philip Merrifield and Dr. J. P. Guilford (Newland and Meeker, 1964). The initial presentation appeared as Research Report Number 8 from the Office of Los Angeles County Superintendent of Schools, Division of Research. It was co-authored by Bonsall and Meeker. The method was refined and presented in detail by Meeker (1965). Although exemplified with the Stanford-Binet scale, the writer believes that the method is applicable to any given test item, and has applied it.

Because hypothesizing factors is the one aspect of this paper that lacks empirical referents, the method is given in detail. The purpose is to make very clear the grounds on which any hypothesizing was based.

Meeker offers the technique as a practical tool, which, if used in the context of the Binet, would allow much more precise information to be gained. "...the Guilford tests, designed specifically to measure factors in the structure, would be 'cleaner' tests of the specific factors; the time involved in such testing would usually preclude their use. By contrast, the present method is a means of gaining some insight into these same factors by classifying the Binet items, thereby gaining the desired differentiation at a very small cost" (Meeker, 1965, p. 27).

Meeker's rationale for placing S-B items in the appropriate SI cell is identical to the writer's rationale for placing items from other selected measures in the appropriate SI cell:
The relative "impurity" of the Binet items presented another series of problems. Certain of the items involve only one of Guilford's 120 factors. Others involve primarily one factor and secondarily one or more other factors. Still others, especially at the upper levels, seem to involve equally two or more factors. It looked as though many items required not one run through the screening, but several in order to ascertain which type or types of abilities were being tested. Consequently, multiple cells were needed for many test items, if they were to be judged exactly. On the other hand, certain limitations on multiple classification seemed appropriate. Although every item involves visual or auditory cognition, items were not classified as such unless this factor represented the major facet for a given item. And, similarly, since audio-memory is also involved in almost every item, it is classified as a memory item only if the required response is primarily an assessment of recall ability. In all, the classification reflects the primary as opposed to the necessary but peripheral abilities required for correct response.

The technique is based on a logical analysis; it consists of a tree of questions which, by the direction of "yes" or "no" answers, automatically leads to the first, second, and third letters of the trigraph which best fits the test item (Meeker, 1965, p. 27).

Based on Meeker, the technique involves the use of three tables: Part I - Operations is found in Table 9, Part II - Contents is found in Table 10, Part III - Products is found in Table 11.

The validity of the method is presently being investigated by empirical means:

A necessary consequence of the attempt to analyze the Binet in this fashion is the conducting of validity studies to see whether children who score highly on the factors thus identified also would score proportionately high on those same factors in Guilford's own tests. A preliminary investigation of this type was reported at the 1964 Convention of the American Psychological Association by Dr. Philip R. Merrifield. Based upon data taken from the Binet tests of children in the two-pilot study of gifted children in California, the reported findings indicated essential substantiation.

Inter-judge reliability presents a two-fold problem: Those people who have a working knowledge of the Binet do not necessarily know the structure. Conversely, those who know the structure best, do not necessarily have a working knowledge of the Binet and what the items are requiring the examinee to do. This factor identification procedure permits the latter group to make a conceptual contribution and the former group to make a judgmental contribution. Inter-judge reliability studies, led by Calvin Dyer at Indiana University, are in progress (Meeker, 1965, pp. 34-35).
TABLE 10

PART II - CONTENTS
TABLE 11

PART III - PRODUCTS

- Does item present a process (as actually performed or by serial presentation)?
  - Yes
    - Does item present just one element?
      - Yes
        - Is examinee to produce an equivalent?
          - Yes
          - In the order presented?
            - Yes
            - Classes
              - Yes
              - Relation
                - Systems
                  - Implications
                    - Transformations
                      - Yes
    - No
      - Does item are examinee to produce more than one element?
        - Yes
          - Is examinee asked to recount or enumerate only?
            - Yes
            - In the order presented?
              - Yes
              - Classes
                - Yes
                - Relation
                  - Systems
                    - Implications
                      - Transformations
                        - Yes
        - No
          - Is examinee asked to identify likenesses and differences?
            - Yes
            - Classes
              - Yes
              - Relation
                - Systems
                  - Implications
                    - Transformations
                      - Yes
            - No
              - Is examinee asked to identify connections between elements (causal, spatial)?
                - Yes
                - Are connections merely enumerated or recounted?
                  - Yes
                  - Are the relations those that any item age; child would know?
                    - Yes
                    - Classes
                      - Yes
                      - Relation
                        - Systems
                          - Implications
                            - Transformations
                              - Yes
                  - No
                    - Classes
                      - Yes
                      - Relation
                        - Systems
                          - Implications
                            - Transformations
                              - Yes
                - No
                  - Classes
                    - Yes
                    - Relation
                      - Systems
                        - Implications
                          - Transformations
                            - Yes
            - No
              - Is examinee asked to judge material as to expectations, consequences, etc?
                - Yes
                - Classes
                  - Yes
                  - Relation
                    - Systems
                      - Implications
                        - Transformations
                          - Yes
                - No
                  - Classes
                    - Yes
                    - Relation
                      - Systems
                        - Implications
                          - Transformations
                            - Yes
            - No
              - Is examinee expected to convert material into any other form or order?
                - Yes
                - Classes
                  - Yes
                  - Relation
                    - Systems
                      - Implications
                        - Transformations
                          - Yes
                - No
                  - Classes
                    - Yes
                    - Relation
                      - Systems
                        - Implications
                          - Transformations
                            - Yes
    - No
      - Is examinee asked to produce an equivalent?
        - Yes
        - In the order presented?
          - Yes
          - Classes
            - Yes
            - Relation
              - Systems
                - Implications
                  - Transformations
                    - Yes
        - No
          - Classes
            - Yes
            - Relation
              - Systems
                - Implications
                  - Transformations
                    - Yes
    - No
      - Classes
        - Yes
        - Relation
          - Systems
            - Implications
              - Transformations
                - Yes
      - No
        - Classes
          - Yes
          - Relation
            - Systems
              - Implications
                - Transformations
                  - Yes
Application of SI Theory to the Stanford-Binet

The Stanford-Binet Intelligence Scale is the most widely used and imitated individual test of children's intelligence; its only competition has been the Wechsler Scale for Children (WISC). "The Stanford-Binet IQ has become almost synonymous with intelligence" (Anastasi, 1961, p. 207). "If there is a standard for American intelligence tests, it is most certainly the Stanford version of the Binet test" (Jenkins and Paterson, 1961, p. 449). Details and notable studies using the Stanford-Binet Scale are given in the Appendix.

Author's definition of intelligence

Binet's conception of intelligence included the following characteristics: ability to reason and judge well, to take and maintain a definite direction of thought, to adapt thinking to the attainment of a desired end, and to be autocrical. The tasks that he chose to measure intelligence stress his conception. He believed intelligence to be complex, therefore, he devised a good variety of tasks. Terman's first revision of the Binet scale was published in 1916.

Terman's conception of intelligence revolved around the ability to do abstract thinking; it has been mentioned that he never defined what he meant by abstract thinking. Terman implied that intelligence was a single trait:

The assumption that it is easier to measure a part, or one aspect, of intelligence than all of it, is fallacious in that the parts are not separate parts and can not be separated by any refinement of experiment. They are interwoven and intertwined... Memory, for example, cannot be tested separately from attention, or sense discrimination separately from the associative processes. After vainly trying to disentangle the various intellectual functions Binet decided to test their combined functional capacity without any pretense of measuring the exact contribution of each to the total product (Terman, 1916, p. 151).
Terman's 1916 revision of the scale introduced the first standardization on an American sample composed of 1000 children and 400 adults. He increased the original 54 items to 90 items, he revised many of the older items, he re-allocated some of the old items to different age levels and discarded some. The Terman revision became known as the Stanford-Binet (S-B); it became the standard clinical method for the evaluation of intelligence, as mentioned, it became a popular tool of research with a wide range of Ss. Scarcely was there an important investigation of intelligence that did not involve the S-B.

The 1916 S-B incorporated the chief characteristics of the Binet scales: age standards, types of mental functions, concept of measurement of a "general intelligence." To this, Terman added an American standardization. According to the belief at the time, the ceiling on mental ability was reached at age 16; the tests appropriate for adult levels were in this range. The tests were arranged in order of increasing difficulty by age level. The mental ability of a given S was determined by a comparison of his performance on the scale with the standards of performance for normal children at different ages. The intelligence ratings were expressed as mental age scores. The single IQ score was derived by computing the ratio of mental age to chronological age.

During the 1920s and 1930s the 1916 scale was most widely used; certain limitations slowly came to light. The ability below age 4 and above age 16 had been inadequately sampled. There developed a question of validity for these age ranges. Certain items on the scale were found to have low validity. There was no alternate form of the scale. The manual of directions lacked a certain degree of precision.
regarding administration and scoring, thus objectivity and comparability of results could not be insured.

To overcome these flaws and to incorporate a more adequate sampling of Ss and abilities, Terman revised the scale. The second edition appeared in 1937. Measuring Intelligence by Terman and Merrill detailed the results of their 10-year research and standardization project. The 1937 scale contained two forms: Form L and Form M. The sampling was considerably extended at both the upper and lower levels. The procedures for administration and scoring were meticulously defined. Each form of the revision was increased to 129 items. The missing half-year intervals below age 5 and at ages 11 and 13 were filled. Two superior adult levels were added. In general, the 1937 revision retained the content, item-type and rationale of the 1916 version. Age standards of performance were continued in the belief that general intelligence is a trait that develops with increasing age. Despite the fact that the 1937 revision incorporated a wider sampling of abilities in the form of pictorial and manipulative items, it was heavily loaded with verbal ability.

The third revision was published in 1960. Form L and Form M were incorporated into a single form, the best items from both forms were used. No new content was introduced; the obsolete items were discarded. Some of the retained items were relocated based on statistical evidence amassed during the 23-year period which indicated an altered level of difficulty. The revision avoided the duplication of items and made possible an alternate subtest at each age level. Terman had died in 1956, but at the time the revisions were well under way and his plans had been well formulated. Merrill carried on the work. Both of them agreed to the one form test for the
revision; they felt there was less need in 1960 for an alternate form than there had been in 1937. In 1937, no other well constructed test for individual appraisal was available. (The Wechsler Intelligence Scale for Children had been published in 1949.) By combining the best items on both forms, more discriminating selection of items was possible.

As in the earlier forms, the items of the 1960 S-B are arranged in order of increasing difficulty by age level. The age levels range from Year II to Year V in half-year intervals. From Year V to Year XIV the age levels correspond to yearly intervals. The last four levels are titled: Average Adult, Superior Adult levels I, II, and III. With the exception of Average Adult level which contains eight items, each age level contains six items and an alternate item. The alternate items are approximately the same level of difficulty as the other items at the given age level, they may be substituted if one of the other items has been spoiled during the administration.

The S-B should only be administered by an experienced examiner who has been trained in its administration, scoring, use, and interpretation. Terman suggests that the minimal training requirements include a general course in mental-test theory, a practicum course wherein the student administers the test to at least 25 Ss for practice and clinical experience involving the application of the test to diverse Ss. This should be followed by the supervised administration of the test to about 100 Ss. The materials needed for the administration of the S-B include test booklets, the detailed manual for administration and scoring procedures, a box of standard toy items, a set of printed cards. The items call for tasks which range from simple manipulation of objects to abstract thinking. The item content at each age is different; there
is an uneven distribution of tasks. Each S is tested on the range of age levels appropriate for his ability. Generally, the testing begins at a level slightly below the expected mental age level of the S; basal age is the level where all tasks are successfully passed; the testing continues to the age level where all tasks are failed. This level is referred to as the ceiling age level. The manual specifies the minimal performance which can be considered "passing"; the individual items are scored on an all or nothing system. Certain items appear in the same form at different age levels, they are scored by different standards of performance. These items are administered only once, they are credited at the level of S performance according to the original administration level. The S's mental age is found by granting credit for the basal age level and adding to that age all further months of credit for each item passed beyond the basal level. The month-task credits are indicated in the manual. The ceiling for mental age theoretically attained on the S-B is 22 years and 10 months; it is not a true mental age, rather it is a numerical score used to indicate a degree of superiority above Average Adult level. The 1960 revision instituted the use of deviation IQ scores in the place of ratio IQ scores.

In general, the data indicate the S-B is a highly reliable test; most of the reported reliability coefficients for the various ages and mental levels are over .90. The 1960 S-B has a standard deviation of 16; the standard error of measurement is 5 points. This indicates that the chances are 2 to 1 that a S's true S-B IQ differs by 5 points or less from the obtained S-B IQ and that the chances are 99 to 1 that it varies no more than 13 points.
The validity of the S-B is high, if one accepts the author's definition of general intelligence. Despite the variety of items, the scale is predominantly composed of verbal material. As might be expected, the S-B correlates very highly with academic performance. The interpretation of S-B scores must be guided by certain conditions: the S-B is a measure of present ability; it does not measure innate capacity. The S-B is heavily weighted with verbal abilities. Research studies using the S-B have given evidence that the S-B measures different abilities at different ages. The S-B does not pretend to measure separate aspects or factors of intelligence:

Grouping tests together according to some logical classification scheme on the basis of some special ability which they seem to have in common has little psychological justification. Too, such classifications as have been proposed have little in common, varying from one test user to another, and have often been proposed with no attempt at validation (Terman and Merrill, 1960, p. 13).

Reasonable men may differ!

The S-B has a cultural bias; in order to do well, it is necessary to have experiences which are common to United States urban culture. Numerous research studies indicate the influence on performance by the S's personality and emotional disposition. The 1960 S-B places greater emphasis on vocabulary than any of the older forms. If the S-B is understood and interpreted properly it can be used as one measure of present performance in a limited area of intellectual development.

Description of the items

The common item types, that appear with frequency in the test will be discussed first. The levels at which items appear are indicated by references in parentheses. The numbering order is the same as is used in the test. After discussion of common item types, the items for each age level will be presented as they
occur in the test. When an item is repeated at a later level, the reference will be made to its initial appearance; the interpretive comment will not be repeated, unless there is a change in factor hypothesis at that later age level.

The SI factor theorized by Meeker will be given. There are several cases where the writer's interpretation differs from Meeker's. These instances have occurred where factor-analytic research has become available since Meeker theorized the factor. At all times, care will be taken to explain any apparent disparity. The writer has had the advantage of results from research for a five-year period since Meeker theorized the factor assignments; the writer has also had the advantage of references to Guilford's works that were not available to Meeker.

The Vocabulary Test consists of a list of 45 words; they range in difficulty from "orange" to "homunculus." The scoring and passing number of items differs at each age level where the test occurs. It is administered at the following levels:

<table>
<thead>
<tr>
<th>Age Level</th>
<th>Score</th>
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<tbody>
<tr>
<td></td>
<td>(minimum number of correct responses to pass at the given age level)</td>
</tr>
<tr>
<td>VI</td>
<td>6</td>
</tr>
<tr>
<td>VIII</td>
<td>8</td>
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<td>X</td>
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<td>XIV</td>
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<td>AA</td>
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<td>SAI</td>
<td>23</td>
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<tr>
<td>SAI1</td>
<td>26</td>
</tr>
<tr>
<td>SAI11</td>
<td>30</td>
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</table>

The test is administered only once to each S; his score is based on the age level at which he took the test. If an S took the test at Year X and scored 13, and then passed every item until he came to Year XII, he would be given the score of 13 at the XII
level where the score must be 15 to pass the test, meaning that he would not be able to pass that demand for Year XII, but would be allowed to go on to other items and be credited if he passed them.

Guilford and others have found the vocabulary test to be a generally univocal measure of CMU. In the S-B, the S must produce his answers. At the lower levels in age, there is evidence from Stott and Ball (1965) and McCartin and Meyers (1966) that the process is evidently more than one of mere recognition. Factors NMU and NMS load on this, as well as CMU; NMU appears at the 3 to 6 age and NMS appears at the 6 to 10 age. As the S gets older, the task appears to be essentially CMU, although whenever the S must produce an answer, rather than recognize it, some NMS variance can be expected.

Definitions appear at several levels; at lower age levels they concern concrete concepts, at the middle and higher levels they concern abstract concepts (V, 3; X, 3; repeated XII, 5; XI, 3: repeated XIII, 2; AA, 8). The vocabulary type and the definition type are essentially the same. They are both measures of CMU; the variance that could be expected for Vocabulary can also be expected for these items.

Comprehension items appear in several variations. At the lower level, they ask: "What should you do if you are thirsty?" Stott and Ball, working with pre-school age children found these items to load on CMU and NMU (.41). The older levels are tested by items like: "What should you do if you found a baby that was lost while you were in the city?" Guilford (1967, p. 445) has found these item types to load on CMU and CMS with children of early teens and adults. In both instances, CMU is involved, but at earlier ages, the production of an entire idea is involved; at older ages, it ap-
pears that the grasping of the whole situation, as in recognizing what's going on, is involved. CMS is typical of the "general reasoning" factor.

Reasoning items are found throughout the test of the type making change, figuring out what has occurred by understanding the aftermath, and the water jar problems (IX, 5: XIV, 3; XIV, 4; XIV Alt. repeated AA, 2; SAII, 4; AA, 4; SAI, 2; SAIII, 5; XIV, A). They will be discussed in turn, in the test; in general such items are measures of CMS; the crux to the problem rests in understanding the organization or structure of the problem.

Analogies appear frequently (IV, 3: repeated IV-6, 2; VI, 5: VII, 5; SAIII, 3; SAIII, Alt.). Guilford has found the analogy item to be essentially a measure of CMR (1967, p. 208). If the relationship is difficult, some NMR variance may be expected as the S has to deal with the first pair and produce a relationship, rather than just recognize it. Both Stott and Ball, and McCartin and Meyers have found strong CMR loadings for this item, and some NMR variance at times.

Copying a figure appears four times in the test; at III, 5 it is a circle, at III, 6 it is a vertical line, at V, 4 it is a square, at VII, 3 it is a diamond. Meeker hypothesized NFU at III, 5 and III, 6; and she hypothesized NFU and EFS for the other two levels. Stott and Ball found the circle task to load at .97 on CFU; possibly the reason that NFU is apparently not involved concerns the idea of copying, as in all cases the S has the item in front of him as he works; the square and the diamond probably involve more than CFU because the S must do some evaluation as he compares his sample for its faithfulness to the given item. The writer has used CFU for lower levels and CFU/EFS for older Ss.
Memory is measured at several levels in different ways with figural, symbolic and semantic information. In Memory for Designs the S looks at a given design for a specified period of time, the design is removed and the S draws the design from memory; the factory involved is MFU.

Digit span memory involves repeating digits in the same order or reverse order as the presentation. This item has been popular through the entire development of testing. It appears in the S-B at II-6, 5; III, Alt.; VII, 6; XII, 4 (reverse); SAI, 4 (reverse). Originally theorized for MSU, the digit span item has given evidence from research of being a two factor task; it has shown high loadings on MSS as well as MSU. The test is another case that has been found to involve more than was first expected. The S must process the information in some manner for systematic memory to occur; it is fairly obvious that this is very necessary for repeating digits in reverse order. Although much more needs to be learned about memory factors, the factors which have been identified with digit span items are MSS and MSU. Guilford feels that the item has more affinity for MSS (Guilford, 1967, p. 450).

The Memory for Sentences item requires the S to repeat the exact order of words given in a meaningful sentence. MMR has been identified by Guilford (1967, p. 128 and p. 132) as the factor involved, but he has been surprised at the high loading in CMU that is involved on this item; his research dealt with teenage and older Ss. Stott and Ball found an MMU loading of .60 for this item; their population consisted of Ss below age six. It is apparent that MMR is involved with both groups; what is CMU involvement in the adult populations must be a parallel involvement of MMU with younger subjects.
Memory for ideas is tested by reading a paragraph to the S and asking him to tell what it was about. The S does not have to repeat the same words, he does have to repeat the same idea. Guilford was surprised to find that systems were not involved; his research indicated MMU as the factor most involved (1967, p. 128). Possibly the information is processed as a system and then produced as a unit.

Another popular item deals with absurdities; at lower levels pictorial information is used and at older levels the information is semantic. In both cases, something is illogical and the S must tell what it is. Guilford has found EMS to be the factor most involved.

There are several Problem Situation items on the S-B (VIII, Alt.; XI, 5 and XIII, 4). In all cases, the S must figure out what has happened by understanding the information presented to him; he is called on to give a logical reason to explain the situation. CMI is involved in understanding the situation and figuring out what happened; NMI is involved in producing the logical explanation based on the given information.

Similarities and differences appear several times in the S-B. Guilford has found similarities for words to be measures of CMT (1967, p. 404). This item occurs at VII, 2; XI, 6; XIV, 6 and repeated at SAI, Alt.; SAI, 6. Essentially the item is one of CMT, but based on the recent research with children, some other variance may creep in; CMU is involved in any item of semantic nature, when the S has to produce rather than recognize the answer some NMT can creep in.

The item type that asks the S to tell in what ways things are alike and also in what ways they are different is essentially CMT, but depending on the age of the
subject and the format of the item, some variance with NMT or NMC can become involved.

The items from the S-B will be presented as they occur; the discussions concerning general item types will not be repeated, although references are made in several places to the general item discussions as the source for the factor identification. The term "trial" as used in the S-B refers to the parts of the item; it does not mean the number of chances a § has on the same part, rather the number of chances he has on different parts of the same item. In most cases, the § does not have to pass all the trials; he must show the general ability to deal with such items; the trials are given to obviate a chance correct guess.

Year II

1. Three-Hole Form Board - the § is asked to replace 3 insets in the form board; the insets are in the shapes of a circle, a square and a triangle. The same item is given as a task, but the board is rotated away from the § at II-6, Alt. Meeker lists NFR and CFT; the task appears to be primarily one of producing a figural relationship, spatial visualization is very minimal. This task appears to be essentially a measure of NFR.

2. Delayed Response - the E hides a toy cat under one of three boxes; the § is asked to watch carefully. The three boxes are then screened, after a delay of 10 seconds, the § is asked to find the cat; three trials are given. Meeker hypothesizes MFS; the task appears to involve no more than the memory for the location of the cat.

3. Identify Parts of the Body - E shows § a large paper doll and asks § to point to specific parts of the doll; seven parts are names as: "Show me the dolly's nose." Meeker identifies CMC. This item is extremely similar to the picture vocabulary items which are known to be measures of CMU; experience with children at this level with this item has indicated to the writer a good deal of the problem involves recognizing the word. The writer hypothesizes CMU with an allowance for CMC variance.

4. Block Building: Tower - E makes a tower out of four blocks; the tower is left in view and § is asked to make one just like it with four more blocks. Stott and Ball found this to load at .78 with CFR; Meeker hypothesized CFS, BFS, NFR. The
task appears to be essentially CFR.

5. **Picture Vocabulary** - E shows S a card (of 18) with a line drawn picture of a common object; E asks S to tell what it is. The same item is given at II-6, IV, 1. Meeker gives CMU as the predominant factor; research studies indicate the picture vocabulary item to be a measure of CMU.

6. **Word Combinations** - E notes the child’s spontaneous word combinations at any time during the interview. Meeker’s identification of NMR appears to be all that is involved.

7. **Identifying Objects by Name - Alternate Test** - E shows S a card with six small toys attached to it; S is asked to point to each named object. Meeker identified CFU; it would appear that the task involves no more than the recognition of the object that each toy represents.

Year II-6

1. **Identifying Objects by Use** - E shows S a card with six small toys attached; S is asked to point to the object which is used for a stated purpose. Meeker hypothesized NMR; however, Stott and Ball found this to load .68 on CFU. The child does not name the object; he recognizes the toy as a unit rather than a system or relation. This test is very similar to the previous item. Test 1 appears to be a measure of CFU.

2. **Same as II, 3. CMU with a possibility of some CMC.**

3. **Naming Objects** - E presents common toy objects one at a time; S is asked to tell what it is. CFU appears to be the leading factor; Meeker felt that because the child had to produce the answer some NMU might be involved; the item is very similar to II, A which Stott and Ball found to measure CFU, the name to fit a prescription (NMU) does not appear to be involved; recognition of what the toy represents appears to be the crux.

4. **Picture Vocabulary** - Same as II, 5 - CMU.

5. **Repeat 2 Digits** - Ask S to repeat two given numbers; the digit span items have been identified as measures of MSS/MSU. Meeker had hypothesized it for MSS/MSU; Stott and Ball found it to load at .73 for MSS at this age level.

6. **Obeying Simple Commands** - E uses five small objects placed in a row on the table to ask S to perform a given simple task; as "Put the button in the box." Three trials are given. Meeker had hypothesized CMS as the leading factor for this item; however, in 1967, Guilford stated that his analyses of the S-B gave no indication of CMS before age VII (p. 472). Guilford is referring to logical
analyses. Stott found it to load at .46 on CMS. It is hypothesized by the writer that the task involves seeing the relationships between the items, e.g., "in the box," "beside the kitty"; the writer hypothesizes CMR.

Alternate - Three-Hole Form Board: Rotated - E uses the same board as in II, 1. With the board in position, E removes the pieces; as S watches E replaces the pieces to form a row in front of the board; E leaves the pieces as they are and rotates the board a full 180 degrees; E asks S to place the pieces in their proper places in the board. Meeker hypothesized NFR/CFT; this appears to be what is involved.

Year III

1. Stringing Beads - E asks S to watch while E strings some beads; after four beads, E hands S a string and passes over the box of beads; E asks S to work on own chain while E continues. The only requirement for passing involves getting beads on the string; any order or color will do. Meeker hypothesized CFS as primary and NFU as secondary; this seems to identify the task.

2. Picture Vocabulary - Same as II, 5 - CMU.

3. Block Building: Bridge - E builds a bridge with three blocks, then asks S to build one just like it. Meeker hypothesized CFS, NFS, and NFU; Stott and Ball found it to load .78 at CFR; CFR shall be used to identify test 3.

4. Picture Memories - E presents a card with pictures of animals and points to each one; E asks S if he knows what it is; if S does not know, E tells the name of the animal. The card is then removed and a second card is presented with several pictures of animals on it. E asks S to find the one that he saw on the original card; several of the original animals are represented; after S has found one, E asks him to find another, etc. Four trials are given. Meeker theorized EFU and MFU; these seem to be the factors involved; S must evaluate the animals on the second card for their likeness to the remembered animals on the first card.

5. Copying a Circle - E shows S a circle printed in the test booklet and asks S to make one just like it in the space beside it. Meeker hypothesized NFU; Stott found this to load at .97 on CFU; apparently all that is involved is recognition.

6. Drawing a Vertical Line - E draws a vertical line in the test booklet and hands the book and pencil to S asking S to make one just like it next to E's. Meeker had hypothesized NFU on the same basis as test 5; Stott and Ball's finding for that item can reasonably be applied to this one; the tasks are alike in the kind of response they elicit. Test 6 should also be a measure of CFU.

Alternate - Repeat 3 Digits - E asks S to repeat three given numbers; three trials are given. As previously discussed this item has been identified as the factor Meeker
hypothesized: MSS/MSU, a complex factor.

Year III-6

1. Comparison of Balls - E shows S a card with one large and one small sphere. E asks S to show which ball is bigger, the card is rotated, and each time the S must tell which ball is bigger. Meeker hypothesized CFR and BFR for this task; Stott and Ball found this to load .75 at CMR; apparently the crux of the task to the child involves the understanding of bigger. CMR shall be used to identify test 1.

2. Patience: Pictures - E presents cards (two halves of a picture). The S is asked to put them together to make a specified object; two trials are given. Meeker has hypothesized the leading factor as CFT; Guilford's research on the object assembly item (to which this is very similar) indicates CFT is the factor involved.

3. Discrimination of Animal Pictures - Using two cards, E places a frame on Card A so that only one animal picture shows, and asks S to find one just like it among the animal pictures on Card B; 12 trials are given. This is a matching item, the S must find the animal that is exactly like the given animal, both pictures are exposed to the S while he makes the match. Meeker hypothesized CFC and BFU; Guilford's research on perceptual speed indicated the Thurstone test of Identical Forms to be a consistent marker for the factor BFU. In the S-B items speed is not a factor, but the exact matching is; the crux of the task rests in the evaluation of which of the choices is exactly like the given animal, although the animals are not represented in similar forms, the task involves finding one that matches; there does not appear to be very much CFC involved, and due to the item's close resemblance to the Identical Forms item, the writer hypothesizes this as measuring BFU.

4. Response to Pictures: Level I - E presents three pictures of different scenes, one at a time, and asks S to tell about the pictures; the pictures deal with such things as a birthday party, wash day and a visit to Grandmother's house. The same item is given at VI, Alt., but scored differently. Meeker identified factors CMC and EMR being involved; the writer agrees.

5. Sorting Buttons - E empties a box of 20 buttons (10 black and 10 white) and places one black button in a box and one white button in a second box; S is asked to place all black buttons in the proper box (E points to the proper box), and all white buttons in their proper box (points to it). Meeker hypothesized NFC; it would appear that only NFC is involved.

6. Comprehension I - E asks two common sense questions of the type: "What should you do when you are thirsty?" Although Meeker hypothesized CMI and EMT, Guilford's research has found items of this type to load on CMU and CMS. S must
recognize the meaning of the word "thirsty" and then recognize the organization of what the question wants to know; the item appears to involve more of the system and less of the implication; at the time that Meeker was writing, it was thought that implications were involved, but Guilford's subsequent study led to the finding that understanding the organization was crucial in such items.

Alternate - Comparison of 2 Sticks - E places two small wooden sticks on the table and asks S to point to the longer stick; the sticks are rotated and each time the question is the same; three trials are given. This item is very much like the comparison of balls item (CMR). Although Meeker hypothesized EFR, the research indicates that understanding "longer" is the crux; for this reason, the writer feels that this item measures CMR.

Year IV

1. Picture Vocabulary - Same as II, 5 - CMU.

2. Naming Objects from Memory - E places three small toy objects in a row on the table before S; as they are put down, E asks S to tell what it is; if S does not know, E supplies the answer. E tells S to close eyes, E screens the objects and removes one; S is asked to tell which one has been removed; three trials are given each time with three different sets of toys. Meeker's hypothesis of MFU appears to be correct.

3. Opposite Analogies I - S is asked to complete analogies of the type: "Brother is a boy, sister is a _____." Five trials are given. Meeker hypothesized CMR and NMR; Guilford has found items of this type to measure CMR and NMR; Stott and Ball found this item to load at .80 on CMR. At this age level, it would seem to be essentially a test of CMR, with the possibility of a little NMR variance.

4. Pictorial Identification - E shows S a card with line drawings of common objects; in each of six trials, S is asked to show the one that meets specific requirements of the type: "Show me the one that we use to cook on." Guilford has found these items to load on NMU with some CMU involved; Stott and Ball found this item to load .91 on NMU at this age level. Although Meeker hypothesized CMI and NMR, subsequent research indicates this item to be a measure of NMU with a little CMU variance.

5. Discrimination of Forms - E uses a card with 10 forms (figural) and 10 separate cards, each matching one of the forms on the larger card. E asks S to find another just like the designated form. Guilford has found the form matching item to measure CFC. Meeker hypothesized CFC as the leading factor with some EFU variance; at this age level, it appears that some BFU is involved; the factor of primary importance is CFC.
6. Comprehension II - S is asked to answer common sense questions, two trials are given. Stott and Ball found this item to load .40 on NMU; Guilford has found this type to involve CMU and CMS at other age levels; the item appears to be a measure of CMU and NMU at this age level. Meeker's CMI/EMR hypothesis does not seem to apply to this item.

Alternate - Memory for Sentences - S is asked to repeat sentences in order of oral presentation. Guilford's work with this item discussed earlier indicated MMR and high CMU variance; Stott and Ball found this item to load .60 on MMU; at this age level the item appears to measure MMU and MMR.

Year IV-6

1. Aesthetic Comparison - E shows S three cards, one at a time. Each card has two line drawings of faces, one of them is distorted; S is asked to tell which one is prettier. Although Meeker hypothesized EMR and EFS, Stott and Ball found this item to load at .80 on CMR.

2. Opposite Analogies - Same as IV, 3 - CMR.

3. Pictorial Similarities and Differences I - E presents six cards, one at a time, each card contains four figures, one of which is different. This is the figure class exclusion type which Guilford has found to measure CFC at older age levels. Meeker hypothesized CFC and CMC. Stott and Ball found the item to load at .56 on CMR. At this level, the test appears to involve CFC and CMR.

4. Materials - S is asked to respond to common sense items of the type: "What is a house made of?" Three trials are given. Meeker hypothesized the leading factor to be CMI; Stott and Ball found this item to load .69 at CMR. At this age level, the item seems to involve CMR with some CMI variance.

5. Three Commissions - E asks S to perform three tasks; all are given orally and at the same time: "Here is a pencil. Put it on the chair; then open the door; then bring me that box." S may not start until all the directions are given. Meeker's hypothesis that this measured MMS was borne out in the Stott and Ball study, which found the item to load at .82 on MMS.

6. Comprehension III - common sense questions - Meeker hypothesized CMS and CMI; Guilford has found CMS and CMU with older groups, the NMS factor has been found by Stott and Ball; at this age the item appears to measure CMU and NMS. The items are slightly different at this age level, asking: "What do we do with our eyes?" which may explain the NMS variance.

Alternate - Same as IV, 4 - NMU - CMU.
1. Picture Completion: Man - S is shown an incomplete figure drawing of a man in the test booklet and is asked to finish the drawing. Guilford has found the picture completion item to measure CFT with some CFI variance at older ages. Stott and Ball found the item to load at .54 on CFT; Meeker hypothesized the leading factor to be CFL. At this age, the item appears to measure CFT and CFI.

2. Paper Folding: Triangle - E folds a six-inch square of paper once along a diagonal, making a triangle; then E folds this once through the middle; E hands S a six-inch square piece of paper and asks him to make one just like it. E's folded paper is left on the table. Guilford has found items of this type to measure CFT; Meeker hypothesized CFT as the leading factor; Stott and Ball found this item to load at .74 on EMT. At this age the item appears to measure EMT with some CFT variance.

3. Definitions - Three items of the type: "What is a ball?" Items of this type have been shown to measure CMU.

4. Copying a Square - E shows S a printed square in the test booklet and asks S to make one just like it in the space next to it. Meeker hypothesized EFS and NFU; more recent research has shown that recognition rather than production is involved; the S apparently recognizes the figure and then evaluates the way in which his reproduction resembles the original; the item seems to measure CFU and EFS.

5. Pictorial Similarities and Differences - S is shown 12 cards, one at a time, each card has two line drawn pictures; S is asked to tell if the pictures are the same or different. The pictures are very obvious; the task appears to be one of classifying. Guilford has found items of this type to measure CFC and Meeker hypothesized this as the leading factor. Stott and Ball found the item to load at .56 on CMR at this age. The S apparently is concerned with the relationships between the objects and "same" and "different"; it appears that the item at this age is a measure of CFC and CMR.

6. Patience: Rectangles - E places a cardboard rectangle on the table, then places two halves of a divided rectangle beside it. E asks S to put the halves together to form a whole one. Guilford has found CFT to be measured by items of this type; he has found some CFU variance to occur at times. Meeker hypothesized CFT as the leading factor; the test is probably primarily CFT, as the completed object is in view of the S; in similar tests, as in the WISC, the S must figure out what the object is. The item is identified as measuring CFT with the allowance made for some CFU variance, as no research has indicated that it is not involved at this age, with this item.

Alternate - E takes string and ties a single know around a pencil, then gives S a string
and asks S to tie a know around E's finger. Meeker hypothesized NFR and CFT; the writer agrees.

Year VI

1. Vocabulary (see previous discussion concerning the general item type) - CMU.

2. Differences - S answers questions of the type: "What is the difference between a bird and a dog?" Three trials are given. Guilford has found items of this type, in multiple choice format, to measure CMT; Meeker hypothesized CMT as the leading factor; the variance with NMT occurs when the item is not given as multiple choice, and the S must produce the answer. It seems that this item is a measure of CMT and NMT.

3. Mutilated Pictures - E asks S to look at the given picture and tell what is missing; this is like the Picture Completion type found on the Wechsler scales which Guilford has found to measure CFT with some CMI variance. Meeker hypothesized CFU and MSI; Stott and Ball found this item to load on CFT, thus Meeker's hypothesis is not supported. The item appears to measure CFT and have some CMI variance.

4. Number Concepts - E places 12 blocks on the table in front of S and asks S to give him a specified number of them; five trials are given. Meeker hypothesized MSI and NMR; Stott and Ball found the item to load .58 at CMR. The writer had occasion to test a child who failed the item at every trial, indicating that the spoken "five" or "three" had no meaning to the child. Later in the day, the same child gave evidence, not only of being able to "count," but also of being able to manipulate number concepts. The child had hidden a bag of candy; when told to share it with four other children, the child asked if it would all right to get a piece for each child as the child did not wish to bring in the bag and possibly be forced to part with more than was required. The child brought in the exact number when told to get one for each child, or to get two for the girls and none for the boys, etc. The child was able to determine the amount each time by using the names of the children in the room. The Stott and Ball study would indicate that the task involves the recognition of a semantic relation; this appears to be the same technique used by the writer's S. It would appear that the item is a measure of CMR at this level, some MSI variance can be expected if the child has reached that level in the development of numbers as symbols.

5. Opposite Analogies II - on same order as Opposite Analogies I; CMR and NMR.

6. Maze Tracing - three trials on the traditional maze item. Meeker hypothesized CFI; numerous studies have identified CFI as the factor measured by the maze item.

Alternate - Response to Pictures Level II - Same as II-6, 4 - CMC and EMR.
**Year VII**

1. Picture Absurdities - E shows S five pictures, one at a time and asks S to tell what is funny about the picture. Meeker hypothesized EMS; this has been borne out in several studies (Guilford, 1967, p. 196).

2. Similarities - Two things - CMT (see Similarities as general item types).

3. Copying a Diamond - Same as Copying a Square - NFU and EFS.

4. Comprehension IV - Same as VIII, 5 - common sense information type: "What makes a sailboat move?" Meeker hypothesized EMT as the leading factor; Guilford has found similar items on older groups to load on CMU and CMS; McCartin and Meyers (1966) found the item type to load 0.56 on NMS. At this age, the item to involve CMU and NMS variance caused by the need to produce the answer rather than recognize it.

5. Opposite Analogies III - Same type as I and II - four trials are given - CMR and NMR.

6. Repeat Five Digits - traditional digit span item - MSS, some MSU.
Alternate - Repeat Three Digits Reversed - traditional digit span item - MSS and MSU.

**Year VIII**

1. Vocabulary - CMU.

2. Memory for Stories: The Wet Fall - E reads a short paragraph to S; S is asked to answer specific questions based on the story. Guilford has found items of this type to measure MMU and have some CMU variance; Stott and Ball found the item to load on MMU. Meeker hypothesized the leading factor to be MMU; the item appears to measure MMU and have some CMU variance.

3. Verbal Absurdities I - E reads a statement to S and asks S to tell what is foolish about it. Each sentence contains a logical impossibility. Guilford's research indicates EMS to be measured by items of this type; Meeker has hypothesized EMS as the factor involved.

4. Similarities and Differences - E asks questions of the type: "In what way are a ball and an orange alike and how are they different?" Guilford has found items of this type to measure CMT which was the leading factor identified by Meeker; research on children below the age of ten (McCartin and Meyers, Stott and Ball) indicates some NMT or NMS variance occurs.
5. Comprehension IV - Same as VII, 4 - CMU and NMS.

6. Name the Days of the Week - E asks S to name the days of the week; three checks are given as: "What day comes after Sunday?" Guilford has identified the temporal ordering item as a measure of MMS; Meeker hypothesized MMS and MMR; the MMR probably is involved through the question check part of the item.

Alternate - Problem Situation I - E reads three problems to S of the type: "About two o'clock in the afternoon a number of boys and girls dressed in their best clothes rang the bell at Alice's house. What do you think was happening?" The item is of the verbal contingency type where the S must produce a logical response. Meeker theorized EMR and NML. On the basis of later research, the writer feels that this item measures CMI and NMI. The S seems to recognize the situation, rather than evaluate it.

Year IX

1. Paper Cutting - repeated at XIII, Alt. - the item is of the traditional paper cutting type; E folds a paper and cuts a notch; S is asked to draw what it would look like if it were opened up; two trials given. Guilford (1967, p. 101) describes this item as being a measure of CFT.

2. Verbal Absurdities II - five trials - repeated at XII, 2 - EMS.

3. Memory for Designs - E shows S a card with two line drawn designs; S is told to study the card for 10 seconds after which it will be removed and S must draw the design from memory. Meeker hypothesized MFU; Guilford has found MFU to be the factor involved, as has Kelley (1964).

4. Rhymes: New Form - E asks S to supply a word to fit specifics of the type: "Tell me the name of a color that rhymes with head." Four trials are given. Meeker hypothesized MFU and DMR. The DMR factor does not seem to be involved as the S has no flexibility at all, only one color will do. As the word must fit very definitive needs, the task appears to be word naming ability described by Guilford (1967) as NMU.

5. Making Change - traditional arithmetic reasoning problem - Guilford has identified this as being a measure of CMS with some MSI (probably caused by the computation involved). See the discussion on "general reasoning" items.

6. Repeating Four Digits Reversed - MSS and MSU (traditional digit span item).

Alternate - Rhymes: Old Form - Of the type: "How many words can you name that rhyme with red?" Meeker hypothesized DSU; the item is typical of the word fluency items identified by Guilford as measures of DSU.
Year X

1. Vocabulary - CMU.

2. Block Counting - traditional type where S must determine the number of blocks contained in a pictured pile; S must include in the count the unseen as well as the seen blocks; 14 trials are given. Guilford has found this item to measure CFS-V (Guilford, 1967, p. 92).

3. Abstract Words - repeated at XII, 5 - four trials given on the traditional vocabulary definition type item: "What does pity mean?" This is a measure of CMU; at this level it makes little difference if the word is concrete or abstract; the crux is whether the S recognizes the word; due to the fact that the S must produce the answer, there is the possibility that some NMS variance may be involved; the task is essentially CMU.

4. Finding Reasons I - repeated in similar form at XI, Alt. Two trials of the type: "Give two reasons why children should not talk in school." Meeker hypothesized MMR, CMI, EMR, DMI. Guilford discusses a situation regarding this item type (Effects and Pertinent Questions; 1967, p. 106). He found it to be a measure of CMI in multiple choice items. The fact that the S must produce a reason that fits the implication would lead to the assumption that production is involved, but the fact that the S is not completely circumscribed by limitations regarding the response would indicate a degree of flexibility applies to the response. The writer hypothesizes this item to be a measure of CMI and DMS.

5. Word Naming - E asks S to name as many words as he can in one minute. The item is typical of the items used to measure DSU.

6. Repeat Six Digits - MSS and MSU.

Alternate - Verbal Absurdities III - EMS.

Year XI

1. Memory for Designs - Same as IX, 3 - MFU.

2. Verbal Absurdities IV - EMS.

3. Abstract Words II - five trials - CMU.

4. Memory for Sentences II - MMU and MMR.

5. Problem Situation II - of same type as Problem Situation I - CMI and NMI.
6. Similarities: Three Things - CMT.
Alternate - Finding Reasons II - like Finding Reasons I - CMI and DMS.

Year XII

1. Vocabulary - CMU.
2. Verbal Absurdities II - Same as IX, 2 - EMS.
3. Picture Absurdities II - one trial - EMS.
4. Repeat Five Digits Reversed - MSS and MSU.
5. Abstract Words - Same as X, 3 - CMU.
6. Minkus Completion I - E shows S a sentence in the test booklet and asks S to fill in the missing word in the blank space; four trials of the type: "We like to pop corn _____ to roast chestnuts over the fire." The task involves the word finding ability discussed by Guilford as NMU (1967, p. 76 and pp. 172-3). Because there is nothing to suggest the answer, production must become involved. The writer hypothesizes this as measuring NMU with the allowance for some NSU. Items of the same type are given at SAI, 3.

Alternate - Memory for Designs II - MFU.

Year XIII

1. Plan of Search - S must indicate a plan in this paper and pencil item to show where he would look in his search for a lost object within a given diagram. Guilford (1967, p. 104) has found items of this type measure CFL.
2. Abstract Words II - Same as XI, 3 - CMU.
3. Memory for Sentences III - two trials - MMU and MMR.
4. Problems of Fact - three trials - items are like those in Problem Situations I and II - CMI and NMI.
5. Dissected Sentences - three trials - S is presented with a card on which disarranged words are printed; he is asked to show how the sentence should read. Guilford refers to the ordering factor (1967, p. 209) which appears to apply here. Meeker had hypothesized NMS (the ordering factor) as being primary, but DMS was also listed. The writer feels that the task is too prescribed to include DMS, for only one correct arrangement is possible.
6. Copying a Bead Chain from Memory - E strings nine beads on a string telling S to watch carefully because the chain will be removed and then S must make one just like it. Meeker hypothesized MFS and NFS; the writer concurs.

Alternate - Paper Cutting - Same as IX, 1 - CFT.

Year XIV

1. Vocabulary - CMU.

2. Induction - Paper folding and cutting - E folds a paper and cuts according to directions; with each cut, E asks S how many holes will be in the paper, unfolds and shows to S. After E has demonstrated several times, he asks S what the rule is. The rule is that each time the paper is folded one more time the number of holes is doubled. Finding the rule or the basic structure of the problem is the essence of what Guilford has identified as CSS.

3. Reasoning I - the problem is presented to S on a printed card; the problem involves using given information (semantic) to arrive at a logical conclusion; Guilford has identified items of this type as measuring CMS; because the answer must be produced rather than recognized, NMI is also involved.

4. Ingenuity I - the Luchins Water Jar Problem - given also at AA, 2 and SAIL, 4.
Guilford's study on this item indicated a loading of .45 on BMI and .42 on CMS (1967, p. 158).

5. Orientation: Direction I - E describes a situation of the type: "What way would you have to face so that your left hand would be toward the east?" Five trials are given. This item is almost identical to a type mentioned by Guilford as measuring CFS-K (1967, p. 95).

6. Reconciliation of Opposites - Five trials of the type: "In what way are summer and winter alike?" Meeker hypothesized NMT, but the task does not fit the description of NMT as given by Guilford; it does fit the description of CMT; it appears that the recognition of the transformation is the crux.

Alternate - Ingenuity II - one trial - Same type as Ingenuity I - BMI and CMS.

Average Adult

1. Vocabulary - CMU.

2. Ingenuity I - three trials - Same as XIV, 4 - BMI and CMS.

3. Differences between Abstract Words - three trials of the type: "What is the dif-
ference between laziness and idleness?" Guilford has found the word difference item to be a measure of CMT.

4. Arithmetical Reasoning - traditional item of the type: "If a man's salary is $40.00 a week and he spends $28,000 a week, how long will it take him to save $300.00?" Guilford has found the arithmetic reasoning item to load consistently on CMS, the general reasoning factor; the MSI variance is explained by the computation involved; as mentioned before, the crux of the problem rests in understanding the structure expressed semantically.

5. Proverbs I - three trials of the type: "Tell what this proverb means: Large oaks from little acorns grow." Based on Guilford's research (1967, p. 72, p. 445) this item should measure CMU and NMT.

6. Orientation: Direction II - five trials of the same type as XIV, 4 - CFS-K.

7. Essential Differences - repeated at SAIL, 5 - three items of the type: "What is the essential difference between labor and leisure?" Guilford has found items of this type to measure CMT.

8. Abstract Words III - five trials of same type as Abstract Words I and II - CMU.

Alternate - Binet Paper Cutting - Same as IX, 1 - CFT.

Superior Adult I

1. Vocabulary - CMU.

2. Enclosed Box Problem - four trials of the type: E shows S a box and says: "Suppose that this box had three smaller boxes inside and each of the smaller boxes had one box inside. How many boxes would there be in all?" This is typical of the arithmetic reasoning problems that Guilford has found to measure CMS with some MSI variance.

3. Minkus Completion II - four trials of the same type as XII, 6 - NMU.

4. Repeating Six Digits Reversed - MSS and MSU.

5. Sentence Building - three trials of the type: "Make up a sentence that has in it these three words: ceremonial, cunning, pursuit." This item fits the description of items that Guilford has found to measure DMS (1967, p. 150).

6. Essential Similarities - three trials of the type: "What is the principal way in which an egg and a seed are alike?" Guilford has found items of this type to be measures of CMT.
Alternate - Reconciliation of Opposites - Same as XIV, 6 - CMT.

Superior Adult II

1. Vocabulary - CMU
2. Finding Reasons III - two trials of same type as Finding Reasons I and II - CMI and DMS (understanding implications and supplying a possible solution).
3. Proverbs II - two trials of same type as Proverbs I at AA, 5 - CMU and NMT.
4. Ingenuity I - Same as XIV, 4 - EMI and CMS.
5. Essential Differences - Same as AA, 7 - CMT.
6. Repeat thought of Passage I - E tells S he will read a short paragraph and when he is through he wants S to repeat as much of it as he can remember; he will not need the exact words, only the ideas. This item is almost identical to the type used by Guilford to measure memory for ideas (1967, p. 128), which he found to measure MMU.

Alternate - two trials - E shows S a message and a code printed in the test booklet; he explains that each letter in the code stands for a letter in the message; S is asked to figure out how the code goes and write a given word in the code. The crux of the problem involves seeing the organization of the symbolic system; this is the description Guilford gives for factor CSS.

Superior Adult III

1. Vocabulary - CMU.
2. Proverbs III - three trials on items like Proverbs I and II - CMU and NMT.
3. Opposite Analogies IV - three trials of same type as Opposite Analogies I, II, and III - CMR and NMR.
4. Orientation: Direction III - a two-part item; the first part is like Orientation I and II - CFS-K. The second part asks S how many miles he is from his starting point; this should involve CMS.
5. Reasoning II - one item of the induction type which involves seeing a rule (CSS) and making an arithmetical reasoning computation (CMS).
6. Repeating Thought of Passage II - Same as SAILI, 6 but uses a different passage - MMU.
Alternate - Opposite Analogies V - Same type as previous Opposite Analogies - CMR and NMR.

The S-B scales have dominated the testing world; until the debut of the Wechsler Intelligence Scale for Children, the S-B was the most generally used individual test of children's intelligence. The S-B scales became the model on which group tests were based and they became the criterion against which all other tests of children's intelligence were evaluated. Guilford (1967) has hypothesized the apparent leading factor for each test, although this is not available in any printed matter (at present), he concludes that "... the cognitive abilities are decidedly over-represented, while divergent production abilities are seriously under-represented. ... more than half the tests fall in the semantic area, with very few having symbolic content and none whatever having behavioral content. In terms of products, the most heavily represented are units, with relations not very far behind, but classes and transformations are under-represented, classes seriously so... Considering only one strong factor per test in the S-B scale L-M, 28 of the SI abilities are represented at some place in the scale but with uneven frequencies (Guilford, 1967, p. 472). According to Guilford's count, CMU appears 30 times and CMS appears 14 times. The following factors appear from six to nine times each: CFT, CMI, CFS, CMT, and NMI. Guilford cautions strongly that the changes in test content at different age levels should be considered when mental age and IQ assessments are used. He particularly marks this caution with regard to research.
Application of SI Theory to the Wechsler Adult Intelligence Scale (WAIS)

Details concerning commercial aspects of the WAIS are given in the Appendix.

Extent of general usage

"The Wechsler scale, combining as it does a good performance measure with a good verbal measure, has almost entirely replaced earlier performance batteries. Among general-purpose predictors, the Wechsler and the Stanford-Binet are equally prominent, with no other serious competitor" (Cronbach, 1960, p. 206). "The amount of interest aroused by the publication of the Wechsler-Bellevue, as well as the extent of its use in clinical testing and in research, can be seen in the bibliography of 625 references listed in the Fifth Mental Measurements Yearbook for this test alone, exclusive of the WISC and WAIS" (Anastasi, 1961, p. 304).

Empirical usage

The Wechsler scales (WBIS and WAIS) are unquestionably the most widely studied scales of adult intelligence. Rabin and Guertin (1951) summarized research with the WBIS from 1945 to 1950. Guertin, Rabin and Frank (1956) summarized and highlighted important empirical studies on the WBIS from 1950 to 1955. Guertin, Rabin, Frank and Clayton (1962) researched a similar project using the WAIS from 1955 to 1960.

The Wechsler scales have been investigated very widely as a possible aid in psychiatric diagnosis. Numerous studies have been conducted regarding the factor composition of the scales (French, 1951; Birren, 1952; Davis, 1956; Cohen, 1957; Saunders, 1959, 1960; Burt, 1960; Jackson, 1960; Maxwell, 1960; Green and Berkowitz, 1964). Although there are many areas of uncertainty and disagreement to be found
among such studies, certain concepts have been found to be generally true. These concepts shall be utilized as far as general agreement is possible.

**Author's definition of intelligence**

"Intelligence, operationally defined, is the aggregate or global capacity of the individual to act purposefully, to think rationally and to deal effectively with his environment" (Wechsler, 1958, p. 7). "General intelligence cannot be equated with intellectual ability, but must be regarded as a manifestation of the personality as a whole" (Wechsler, 1950, p. 82). Wechsler believes that general intelligence can be social and practical, as well as abstract; he proposes cognitive, conative, and non-intellective factors of intelligence. Wechsler's global concept is based on his belief that intelligence is composed of elements, not entirely independent, but qualitatively differentiable. He warns that intelligence is not a mere sum of intellectual abilities although it is possible to evaluate it quantitatively by measuring various aspects of abilities. He views intelligence as being complex. He feels that an intelligence scale should measure sufficient aspects of intelligence in order to use it as a fairly reliable index of the Ss' global abilities. That which is produced by the intelligence

... depends upon the interaction of a theoretically infinite but practically limited number of qualitatively different but additive components or factors. These factors manifest themselves objectively in different forms of behavior. A factorially defined segment of behavior constitutes an ability. Such segments of behavior may be descriptively grouped into such broad classifications as verbal, spatial, numerical and other kinds of abilities, in the sense that they describe overlapping or similar modes of function.

A test is a device for evaluating a fragment of behavior; an intelligence test is one which seeks to appraise this bit of behavior insofar as it may be called intelligent (Wechsler, 1958, p. 15).
human abilities are utilizable for measuring intelligence because when applied to goal directed activity they depend for their effectiveness on certain concomitant attributes or factors which constitute the basic components of intelligent behavior. These basic attributes are what contemporary psychologists, in searching for the "vectors of the mind," have described as general factors. The thing we seek to measure when we measure intelligence is the net result of the complex interaction between the various factors entering into intelligent behavior. In practice we measure this resultant fact by means of tests of ability. An intelligence scale is an assembled battery of such tests; the intelligence rating obtained from them is a numerical expression of their combined contribution. Although the amounts contributed by each test may be, and usually are, expressed as a simple sum, the factors which determine the scores ought not, strictly speaking, to be so combined, since the result is not a linear function of these factors. More likely it is what mathematicians call a complex functional, but the exact form of this function is yet to be determined... (Wechsler, 1958, p. 16).

In order to completely measure intelligence, it is insufficient to extend the range of abilities measured, though this is needed too; we must also find tests which manifest both greater coupling potential and greater resonance characteristics (Wechsler, 1958, p. 23).

Wechsler objected to several conditions inherent in the S-B scales: the uneven content of intellectual aspects appraised at different age levels, the school-biased content of the items, the lack of discrimination and applicability for adult populations. He hoped to produce an intelligence scale that was designed for adults and standardized on an adult population. Wechsler believed that certain item-types had enough specificity that they could be used to profile different types of performance. He objected to the speed factor in most adult measures as handicapping older Ss. He objected to the high verbal content of most adult measures as being over-represented. The publication of the WBIS in 1939 marked his attempt to overcome some of these objections. The WBIS was very similar to the WAIS which later replaced it.

The most outstanding weakness of the WBIS concerned the narrowness of the normative sample; the population was drawn for the most part from New York City.
and it numbered only 1081 including both sexes. The WAIS was produced to provide more efficient measurement of adult intelligence based on a larger, more representative sampling of adults.

Compared with the S-B, the major difference in the format of the WAIS (later to be employed in the WISC and WPPSI, also) is the arrangement of items into subtests. Where Terman and Binet mixed item content and grouped items according to age level of difficulty, Wechsler arranged items according to type into subtests; the order within the subtest was structured according to increasing difficulty by age. Raw scores are converted to scaled scores with a mean of 10 and a standard deviation of three. He introduced the concept of standard-score IQs with a mean of 100 and a standard deviation of 15. Wechsler's objection to the assumption that mental ability remains constant during adulthood caused him to develop separate standard-score conversions of specific adult age groups. He also provided separate standard score tables for verbal and performance raw scores.

Various research studies have indicated that S-B and Wechsler scores are not interchangeable (Bayley, 1949; Krugman, 1951; Bradway, 1958). The separate IQs for verbal and performance subtests indicate that they are measures of different abilities; indications are based on correlational studies with the S-B, with other subtests, and among different age groups. The validity concerning the interpretation of subtests and profiles for psychiatric purposes is presently being disputed, due to lack of objectivity and unrepresentative or limited samples. Cronbach summarizes the value of the Wechsler scale as:

It is efficiently designed, interesting to most subjects, and at least as valid
for predictive purposes as the Stanford-Binet. It covers a broader range of tasks and affords exceptionally good opportunities for qualitative observation of behavior and thought processes. The norms for the test, once a point of serious criticism, have been greatly improved. As a practical individual test, the WAIS falls short in only one particular: the scale has insufficient range to measure very high and very low abilities dependably. It is a useful sample of complex behavior in which both emotional and intellectual factors are entwined. But it is based on no clear theory of intelligence and makes no serious effort to separate mental ability from other aspects of adaptation. The tasks are chosen from techniques invented thirty years or more ago, and there is no adequate rationale for interpreting subtest scores. It is reasonable to hope that some future worker will start from a theory of mental processes, choose or design tests to measure those particular processes, and so arrive at a superior diagnostic device. The total score on such a test would almost certainly correlate substantially with Wechsler's (Cronbach, 1960, p. 202).

The writer wishes to call particular attention to the last four sentences in Cronbach's critique.

The performance tests are far less culture-free than Wechsler had theorized them to be. Skills involved in performance tests are developed through learning experiences of one sort or another. The emphasis placed on word games, puzzles, educational toys and games in the United States is quite obvious.

There is an important incongruity to be considered before studying the item composition of the subtests. Wechsler claims to measure factors of intelligence that are distinct, but not entirely separate from one another. In practice, his stand appears to be most ambivalent; he chose only those items and subtests which had high correlational coefficients with the total test. Essential to any concept of measuring factors is the realization that the lower the intertest relationships, the more sure one can be that the subtests are measuring different things. In this concept, a zero correlation would be most desirable. Further, "the author of the WAIS has attempted an impossible task; the construction of a scale to measure general (global) intelligence
which at the same time will provide differences among subtests which are of diagnostic value" (McNemar, 1956, p. 127).

**Description of the items**

The Verbal section of the WAIS consists of six subtests: Information, Comprehension, Arithmetic, Similarities, Digit Span and Vocabulary.

**Information:** According to Wechsler, the range of a man's knowledge is generally a good indication of his intellectual capacity. The information item should "call for the sort of knowledge than an average individual with average opportunity may be able to acquire for himself" (Wechsler, 1958, p. 65). Wechsler has tried to avoid specialized and academic information, dates, names, and other discrete bits of information. Wechsler feels that the Information Test is one of the most satisfactory in the battery; it declines negatively with age and correlates second highest with total test score on the WBIS and WAIS. It does not correlate highly with rote memory, as measured by Digit Span. Information correlates .84 with the full scale score; Vocabulary correlates .83 with the full scale score. Information correlates generally in the low .80s with Vocabulary. Although variations are found among the different age levels used, the range is in the .80s. As might be expected, Information and Vocabulary are measuring much of the same ability.

The Information Test contains 29 items of the type:

"What is the population of the United States?"
"What does rubber come from?"
"How many weeks are there in a year?"

The Davis (1956) factor analysis of the WAIS and Guilford's research (1960, 1966, 1967) indicate the Information Test to be primarily a measure of CMU: the ability to
understand the meanings of words or ideas. Guilford has found the Information Test of the WAIS to be univocal for CMU.

Comprehension: Wechsler refers to the popularity of general comprehension items in most scales of intelligence; they can be found on the original Binet scales and in all the revisions, they are found in group exams such as the Army Alpha and the National Intelligence Tests. In group tests, the S is asked to select the answer from given answers; the Binet and the Wechsler tests pose the questions in an open-ended format; the S must produce the answer. Comprehension correlates .72 to .77 with full scale scores. According to Wechsler, the Comprehension score is highly dependent upon verbal comprehension. It correlates best with Information and Vocabulary; it correlates least with Digit Span and Object Assembly. The Comprehension Test holds up well with age; when it does drop off, it drops less than most of the other subtests.

The test contains 14 items of three main types: those involving common sense judgment, those involving a breadth of information and its application, and three proverbs. Typical items are:

"Why should we keep away from bad company?"
"Why does land in the city cost more than land in the country?"
"What does this saying mean: Shallow brooks are noisy?"

The Davis factor analysis found the Comprehension Test to be loaded on factors equivalent to SI factors CMU and CMS. Guilford has found the Comprehension Test to be a measure of CMU with some CMS variance.

Arithmetic: Wechsler (1958) mentions that even before the introduction of psychometrics, the arithmetic test was a commonly used indicator of intelligence. Wechsler feels the advantages of the Arithmetic Test rest in its high correlation with global
measures of intelligence, indicating its ability as a general intellectual measure, it is easy to devise and easy to standardize. He warns that it is influenced by education and occupation. Wechsler chose problems appropriate to adult populations and which involved common situations and practical calculations. They are expressed in a manner designed to avoid verbalization or reading difficulties. The correlations between Arithmetic and full scale scores vary considerably according to the age at which they are calculated; generally they are higher at upper age levels. The Arithmetic Test correlates from .66 to .77 with full scale scores. Wechsler was surprised when frequent factor-analytic studies indicated loadings on memory factors (Wechsler, 1958, p. 130). Davis' analysis of the Arithmetic Test indicated high loadings on general reasoning and also, what was understood as numerical fluency.

There are 14 items which fall into three general groups: easy, intermediate and difficult. Typical examples are:

"If three cans of soup cost 35¢, how much will one dozen cans cost?"
"How many oranges can you buy for 36¢, if one orange costs six cents?"

Guilford (1967), in extensive studies of items of this type, found them to be primarily measures of CMS, with some MSI or NSI variance.

Similarities: Wechsler believed the similarities type item called on the S to perceive common elements of terms in comparison and the ability to express them as a single concept. He admits that verbal comprehension is necessary for even minimal performance. The answers are scored according to two levels; at the superficial discrimination level, and for higher point value, at the essential discrimination level. Wechsler believes that the qualitative difference in response is valuable because it
affords a more discriminating scoring method, as well as being suggestive of the evenness and level of the S's intellectual function. The Similarities Test correlates from .66 to .80 with full scale scores. The higher correlations appear at the lower age levels. The Similarities Test is loaded on the verbal comprehension factor; it appears to involve a generalizing ability. Wechsler was aware that the Similarities Test shared some elements with the Picture Completion Test in numerous factor-analytic studies.

The Similarities Test contains 13 items of the type:

"In what way are an orange and a banana alike?"
"In what way are air and water alike?"
"In what way are poem and statue alike?"

The Davis factor analysis indicated a high loading on verbal comprehension. The Guilford studies have refined this conclusion to indicate the Similarities Test as a strong measure of CMT (Guilford, 1967, p. 404).

Digit Span: "Memory span for digits correlates rather well with (global measures) intelligence, roughly up to the ability to repeat six or seven digits forward, but beyond this point it becomes more and more a test of sheer rote memory" (Wechsler, 1958, p. 72). Memory span for digits has been a traditionally popular item; it is easy to administer and easy to score. Until recently, the digit span item was thought to measure a specific ability. Wechsler found the Digit Span among the poorest as a test of general ability. He retained the Digit Span because of its clinical value. "Except in cases of special defects or organic disease, adults who cannot retain five digits forward and three backward will be found, in nine cases out of ten, to be feeble-minded or mentally disturbed" (Wechsler, 1958, p. 71). The Digit Span Test corre-
lates least with full scale scores, the range goes from .53 to .61; it correlates least with other tests of the scale. Research indicates that the Digit Span Test shows greater decline with age than most of the other tests.

The Digit Span Test contains two trials at each level for numbers spanning three to nine forward and two to eight backward. If the \( S \) passes the first trial at a given level, the \( E \) does not give the second trial, but moves on to the next level.

Guilford's research indicates that memory span tests of this type have a substantial specific component, in factor-analytic studies they can go in the direction of MSU and MSS, although they appear to have more of an affinity for MSS. Guilford feels that MSS is a better representative of digit span than MSU, although both are involved, as well as a specific component (Guilford, 1967, p. 118).

**Vocabulary:** According to Wechsler, "Contrary to lay opinion, the size of a man's vocabulary is not only an index of his schooling, but also an excellent measure of his general intelligence. Its excellence as a test of intelligence may stem from the fact that the number of words a man knows is at once a measure of his learning ability, his fund of verbal information and the general range of his ideas" (Wechsler, 1958, p. 84). Wechsler admits that a man's vocabulary is influenced by his education and cultural background. Wechsler thinks that the quality of an \( S \)'s definition can indicate something of his cultural milieu; the word on which an \( S \) passes or fails is always of some significance. He believes that the semantic character of a definition can give the clinician insight into an \( S \)'s thought processes. The Vocabulary Test is scored quantitatively as well as qualitatively. As might be expected, the Vocabulary Test correlates most highly with full scale scores, ranging from .73 at age 75 to over .83 at
most other age levels. The Vocabulary Test holds up better with age than any other
test in the scale. The Vocabulary Test involves verbal comprehension; it is loaded
higher on this factor than any other test in the scale.

The Vocabulary Test contains 40 items of increasing difficulty. The S is asked
to explain or define such words as: "fabric," "conceal," and "tirade." According to
Guilford's research, such tests are essentially, and generally univocally, measures
of CMU (Guilford, 1967, p. 445).

The Performance section of the WAIS contains five subtests: Digit Symbol,
Picture Completion, Block Design, Picture Arrangement, and Object Assembly.

Digit Symbol: The Digit Symbol Test requires the S to fill in the proper code symbol
under each given number, doing as many as he can in a minute and a half. The code
remains on view as the S works; the S is free to refer back to the code, or depend
upon his memory. Speed of writing is unintentionally involved. According to Wech-
sler, the Digit Symbol Test is one of the oldest and best established of all psychologi-
cal tests. He admits, however, that the use of the Digit Symbol Test for measuring
adult intelligence does involve visual accuracy, motor coordination and speed. The
Digit Symbol Test scores decline earlier and drop off more rapidly than other tests of
intelligence. The Digit Symbol Test was taken from the Army Beta; for better dis-
crementation, the time limit was reduced. The Digit Symbol Test correlates from .53
to .62 with full scale scores. In the Cohen (1952, 1956) factor-analytic studies, the
Digit Symbol Tests appeared uniquely under an unidentified factor. In the Davis (1956)
study, Digit Symbol coupled with numerical facility and perceptual speed. Guilford's
research indicates that "the Wechsler Digit Symbol Test is a two factor test and it
should be expected to measure factors MSI and ESU about equally well... Evidently in doing a digit symbol type of test, the S does considerable checking back and forth between his answers and the code" (Guilford, 1967, p. 135).

**Picture Completion:** The Picture Completion Test uses 21 items presented on individual cards, given one at a time. On each card is a line drawing of a common subject from which something is missing. The S is asked to tell or point to the part that is missing. The Picture Completion Test is similar to other earlier types (Healy Picture Completion, Army Beta, Pintner Non-Language). According to Wechsler, the test is very much like the Mutilated Pictures item of the S-B. Wechsler claims that the Picture Completion Test generally correlates higher with Performance than Verbal tests and usually shows highest loading under the visual motor factor. The Picture Completion Test correlates from .59 to .76 with full scale scores. The test holds up with age better than any of the performance tests. Cohen (1956) found the Picture Completion Test to have a specificity of its own, extractable as a separate factor. Davis (1956) found the Picture Completion Test to load on the SI-equivalent factor CFT. Guilford's research indicates a loading on CFT and also some variability involving CMI. The cognitive-semantic aspects of the test undoubtedly explain some of the "hold" characteristics.

**Block Design:** The Block Design Test was originated by Kohs as a comprehensive measure of "non-verbal intelligence" in 1923. It was included in several subsequent test batteries (Grace Arthur, Pintner and Paterson). The Block Design Test is a nonverbal measure of analytic and synthetic reasoning with a fairly wide range of difficulty. The WAIS adaption makes use of nine 1-inch square colored blocks. The
blocks are all alike having two sides in solid red, two sides in solid white, and two sides in diagonal red and white. The E arranges four blocks slowly into a given design; he asks the S to make one just like it and leaving the model intact, he gives four more blocks to the S. If the S completes the task successfully, the E explains that subsequent designs will be made according to the design presented on separate cards. E illustrates by making a design from a given card, then asks the S to do the same thing, this time E does not leave his model on view. Items three to ten are presented in this manner. After item six, the E gives the S the remaining five blocks; items seven to ten involve using all nine blocks to make the given designs. The Block Design Test involves visual motor coordination. The performance on the test is imitative rather than productive; the patterns are kept before the S and the S must put the parts together to form a whole; the design must always be differentiated into parts by the S prior to reproducing the design.

According to Wechsler, "The Block Design is not only an excellent test of general intelligence, but one that lends itself admirably to qualitative analysis... One can learn much about the S by watching 'how' he takes to the task set him" (Wechsler, 1958, p. 79). Block Design correlates from .56 to .77 with full scale scores. Block Design performance falls off consistently with increasing age. Wechsler's research, as well as Cohen's research, indicate the Block Design Test loads consistently on a nonverbal organization factor. Wechsler believed the test to have valuable clinical potentials. The Davis study found the Block Design Test to load heavily on visualization. Guilford (1967, p. 447) has found the Block Design Test to be essentially univocal for CFT (spatial visualization). Some EFU may be present.
Picture Arrangement: The Picture Arrangement Test consists of eight items; each item has a set of cards containing pictures to be rearranged in the proper sequence so that they tell a story. The cards in each of the items are presented to the S in prescribed random order; the S must piece them together in the correct sequence. As in the Block Design Test, the S must identify a complex whole from disorganized parts. Wechsler admits that the items represent essentially American situations and sense of humor and that their appreciation may be expected to be influenced by cultural background. Wechsler feels that the Picture Arrangement Test effectively measures an S's ability to comprehend and size up a total situation. The subject matter of the test items almost always involves some human or practical situation. Wechsler interprets this not as "social intelligence," but as general intelligence applied to social situations. The Picture Arrangement Test correlates unevenly and sometimes unpredictably with other subtests of the scale; generally Wechsler has found the correlations to be higher with performance than other verbal tests of the scale. The Picture Arrangement Test correlates from .46 to .74 with full scale scores. The Picture Arrangement Test did not emerge clearly in either Cohen's, Davis', or other studies. Guilford's research indicates the Picture Arrangement Test to measure NMS consistently (Guilford, 1967, p. 176; p. 368; p. 444). The Picture Arrangement Test is virtually a semantic production test: the convergent production of semantic systems; it is small wonder that it correlates unevenly and unpredictably with other measures on the scale, particularly the Performance subtests.

Object Assembly: The Object Assembly Test is modeled after the Pintner-Paterson Manikin Test and Feature Profile Test. The S is given puzzle parts presented in pre-
scribed random order; he is asked to put them together to form an object. There are four different objects to be assembled; each is presented separately. Scoring procedures include bonus points for rapid performance. Wechsler admits their similarity to form boards and the fact that such items show great practice effects. The Object Assembly Test correlates poorly with most of the subtests and correlates from .55 to .65 with full scale scores. Cohen's study indicates a high loading on a perceptual organization factor, the Davis study supports this finding. Davis found the Object Assembly Test to be significantly loaded on visualization and perceptual speed. Guilford's research indicates agreement with this. The Object Assembly Test appears to be primarily a measure of CFT with some EFU variance.

Guilford feels that the WAIS tests are poor material for factor analysis if they are analyzed alone. The fact that Wechsler chose the tests on the basis of their correlation to the full scale score and the fact that many of them are factorially complex explain part of the problem. When the WAIS has been factor analyzed, there generally emerges a verbal comprehension factor (large weights in Vocabulary, Information, Comprehension and Similarities subtests); a perceptual organization factor (large weights in Block Design and Object Assembly); a memory factor (large weights in Arithmetic and Digit Symbol). Guilford (1967, p. 444) indicates the verbal and performance factors as being composites, roughly representing the differences between certain combinations of semantic and figural abilities. He calls attention to the fact that the Verbal IQ and Performance IQ cannot be accepted as purely semantic and figural. Picture Arrangement, included among the Performance tests, is a semantic ability test. Two symbolic tests, Memory Span and Digit Symbol, are both memory
tests, but represent symbolic memory abilities; the Digit Span is included in the Verbal tests, the Digit Symbol is included in the Performance tests. Guilford notes that factor-analytic studies that have dealt with factors of the Wechsler scales at all testable age levels generally indicate fewer interpretable factors at oldest age levels. "The trend suggests some simplification of the factor structure for the oldest tested groups, usually above 70, in a possible retreat from earlier differentiations" (Guilford, 1967, p. 444).

Application of SI Theory to the Wechsler Intelligence Scale for Children (WISC)

Commercial and other details are given in the Appendix.

Extent of usage

The WISC has been very widely used since its inception, part of its popularity is due to the supposed useful clinical features not found in the S-B; analysis of subtest patterns are supposed to differentiate between performance and verbal abilities. As has previously been indicated, the WISC is the only strong competitor for the S-B. "The most important performance tests today are those included in Wechsler's intelligence scales" (Cronbach, 1960, p. 191). Littell (1960) produced a review of 10 years of research with the WISC, despite the fact that the Wechsler scales dominate research literature, Littell concluded that the test is useful but lacks validity. Numerous factor-analytic studies have been conducted with the WISC (Cohen, 1959; Baumeister and Bartlett, 1962; Osborne, 1963, 1964, 1965; Orpet and Meyers, 1966; McCartin and Meyers, 1966; Osborne, Anderson and Bashaw, 1967). The stability of the Wechsler factor structures is very high. Age levels from $7\frac{1}{2}$ to 60 years have been been researched and found to be consistently stable (Balinsky, 1941; Davis, 1956;
Cohen, 1959; Saunders, 1959). Green and Berkowitz (1964) have concluded that the factor structure of the Wechsler scales does not change with age.

The WISC was prepared as a downward extension of the WBIS and WAIS batteries; standardized for ages 5 to 15. The WISC is modeled on the other Wechsler Scales, many items were taken from the adult scales and easier items of the same types were added. Although much of the material overlaps with the adult scales, the WISC is independently standardized. The size and representation of the normative sample and the careful procedures followed in determining reliability are of highest calibre. The rationale for the WISC is the same as that for the WAIS. Research has indicated some consistent discrepancies between WISC and S-B IQs at different age levels and different intelligence levels (Anastasi, 1961, p. 320). According to Anastasi: "There seems to be something of a paradox in the underlying rationale of the WISC. It will be recalled that a major reason for the development of the original WBIS was the need for an adult intelligence test that would not be a mere upward extension of available children's scales. Having ably achieved this objective, the author then proceeded to prepare a children's scale that was simply a downward extension of the adult scale. Is this a case of "Heads I win and Tails you lose?" (Anastasi, 1961, p. 320).

Correlations between WISC and S-B range from .60s to .90s depending on age, intellectual level and heterogeneity of the samples. In general, the Verbal score correlates higher with the S-B than does the Performance score. According to Cronbach (1960), the WISC, taken as a whole, measures about the same abilities as the S-B. The fact that some studies have indicated that the Verbal scale is generally
significantly higher correlated with the S-B than the Full Scale score poses a problem:

There is, then, a real psychological difference between the Stanford-Binet and the broader Wechsler. In any composite score, however, elements present in only part of the test have far less influence on the total than do elements running all through the test. Abilities to comprehend directions, to concentrate, to criticize and correct one's responses, and to understand words and pictures referring to familiar experiences run through both the Verbal and the Performance scales. These general abilities therefore largely determine the total score on both the Wechsler and Binet tests; specific abilities found only in arithmetic items or performance items have some influence, but not very much (Cronbach, 1960, p. 197).

Thus, what might have been identified as a specific factor has been lost through statistical procedures and the summing of the scores.

Questions concerning differentiation with age

Numerous research studies have indicated that intelligence tests measure different things at different age levels, sometimes with the same items. Generally, trends indicate increasing differentiation with age; what may be understood as a system by younger children may, through experience and age, become recognized as a unit by older children. Meyers and Dingman, Stott and Ball, McCartin and Meyers, and Osborne have all conducted research studies with very young children to determine the evidence of a structure in intelligence at early ages.

The researchers all sought the answer to the same basic question: Is there a factor structure involved in the intelligence of preschool children? Can it be identified? If it can, then "general mental energy" is not sufficient to describe preschool intelligence. The general consensus of the researchers was that a differentiated structure could be found. Psychometric tasks of sufficiently broad spectrum do reveal more than "general intelligence"; they do show some structuring of abilities in groups as young as two to four years old; this has been supported by groups of six years old, in
both normals and retards.

Is the factor structure for children the same as the factor structure for adults? This part of the question has not been fully explored, at present. What has emerged from the studies is the fact that no systematic change in factor presence has yet been evidenced. Development, as measured empirically, appears to consist of integrations and consolidations, as well as differentiations. Learning a verbal system might consolidate other habit systems. Evidence indicates that mental ability is structured at two years, if not before. Yes, Virginia, there is a factor structure in the intelligence of very young children!

Description of the items

Verbal Section:

Information: 30 items designed to measure the range of knowledge.

Information Test Intercorrelations

<table>
<thead>
<tr>
<th>Age</th>
<th>Verbal</th>
<th>Performance</th>
<th>Full Scale Score (FSS)</th>
<th>Vocabulary</th>
</tr>
</thead>
<tbody>
<tr>
<td>$7\frac{1}{2}$</td>
<td>.64</td>
<td>.44</td>
<td>.59</td>
<td>.55</td>
</tr>
<tr>
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<td>$13\frac{1}{2}$</td>
<td>.80</td>
<td>.51</td>
<td>.73</td>
<td>.74</td>
</tr>
</tbody>
</table>

Guilford has found the Information Test to be a measure of CMU in adolescent and adult populations. Factor-analytic studies have consistently found the Information Test to be significantly loaded on a verbal comprehension factor. McCartin and Meyers (1966) found the Information Test to load .49 with CMS and .31 with NMU at age six. It appears that the task demanded becomes more integrated with age and thus more of a measure of CMU from 10 years old and up. It must be remembered that the
McCartin and Meyers study used "systems" to mean any meaningful statement of words as in a sentence or an idiom; they used "units" to mean essentially single word utterances. It appears safe to assume that the Information Test is essentially a measure of CMU, but at younger age levels, some variance with CMS or NMU can be expected. It appears that the effort to produce an answer which meets specifications is more demanding for younger Ss; as the S's experience increases, the task becomes essentially one of recognition rather than production.

**Comprehension:** 14 items designed to measure practical judgment or common sense. There are no proverbs involved in the WISC as there are in the WAIS.

<table>
<thead>
<tr>
<th>Age</th>
<th>Verbal</th>
<th>Performance</th>
<th>FSS</th>
<th>Vocabulary</th>
<th>Arithmetic</th>
</tr>
</thead>
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<tr>
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<td>.49</td>
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<tr>
<td>13½</td>
<td>.68</td>
<td>.37</td>
<td>.58</td>
<td>.60</td>
<td>.46</td>
</tr>
</tbody>
</table>

Guilford has found the Comprehension Test to be a measure of CMU with some CMS variance. The general factor-analytic studies have found the Comprehension Test to load significantly on a verbal comprehension factor. McCartin and Meyers found the Comprehension Test to load .56 on NMS for a first grade population, but warned that the problem of distinguishing between cognitive and convergent production was a serious concern for them, they have reservations about some of the results. It would appear fairly safe to assume that the Comprehension Test is a measure of CMU and CMS at all age levels.

**Arithmetic:** 16 items designed to measure numerical problem-solving ability.
Guilford has found the number problem-solving items of this type to be measures of CMS and MSI; understanding the semantic structure of the problem is of primary importance. The general factor-analytic studies indicate the Arithmetic Test loads significantly on a memory factor. It appears that the Arithmetic Test measures CMS and MSI. In the absence of specific factor-analytic studies of the Arithmetic Test with younger age groups, and in consideration of the Piaget and Bruner concepts regarding the development of number concepts in children, there is probably more memory involved at lower age levels.

Similarities: 16 items designed to measure the ability to perceive the common element between pairs of words.

Guilford has found the Similarities Test to be a measure of CMT. The general factor-analytic studies have found the Similarities Test to load significantly on a verbal comprehension factor. McCartin and Meyers found the Similarities Test to load .38 on
CMS and .34 on NMS with a first grade sample; but they did not have a CMT factor among those analyzed. In view of the Stott and Ball (1965) study with younger age levels and Meeker's (1965) work, it appears fairly safe to conclude that the Similarities Test is a measure of CMT. There is the possibility of variance at the younger age levels where the integration level is lower and the task calls for more than simple recognition.

**Vocabulary:** 40 words designed to measure the size and range of vocabulary.

<table>
<thead>
<tr>
<th>Age</th>
<th>Verbal</th>
<th>Performance</th>
<th>FSS</th>
<th>Information</th>
<th>Comprehension</th>
</tr>
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<tr>
<td>7½</td>
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</table>

Guilford has found the Vocabulary Test of this type to be a measure of CMU. The general factor-analytic studies indicate the Vocabulary Test loads significantly on a verbal comprehension factor. McCartin and Meyers found the Vocabulary Test to load .39 on CMU and .49 on NMS for a first grade population. Stott and Ball found vocabulary items on the S-B to load .40 on MMU at age five. It would appear that the Vocabulary Test is essentially a measure of CMU at all age levels; at the lower levels one can expect some variance with memory. The high loading on NMS in the McCartin and Meyers study may be caused by the memory factor necessary for convergent production, as they did not include memory factors in their analyses.

**Digit Span:** Offered as an alternate test. Wechsler used the two subtests which gave lowest intercorrelations with the rest of the scale as alternate tests. The Digit Span
is offered with the Verbal section, and the Mazes is offered with the Performance section. Ironically, in the case of Mazes, what Wechsler viewed as a weakness is really a strength for factor analysis of the test. Mazes has been a univocal measure of CFL. The Digit Span Test has been found, by Guilford, to be a complex test which appears to measure MSS and MSU with some specific component. The WISC Digit Span Test has seven series of two trial sets of numbers containing three numbers and increasing to nine numbers forward. The digits backward have seven series of two trial sets of numbers containing two numbers and increasing to eight numbers. 

Digit Span Test Intercorrelations

<table>
<thead>
<tr>
<th>Age</th>
<th>Verbal</th>
<th>Performance</th>
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<th>Mazes</th>
<th>Block Design</th>
<th>Arithmetic</th>
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<td>.44</td>
<td>.29</td>
<td>.42</td>
<td>.25</td>
<td>.29</td>
<td>.40</td>
</tr>
</tbody>
</table>

General factor-analytic studies indicate a high memory factor loading for the Digit Span Test.

Performance Section:

Picture Completion: 20 items designed to measure perceptual and conceptual abilities involved in visual recognition of figural information.

Picture Completion Intercorrelations

<table>
<thead>
<tr>
<th>Age</th>
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<th>Performance</th>
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<th>Block Design</th>
<th>Object Assembly</th>
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<td>.55</td>
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</tbody>
</table>
Guilford has found the Picture Completion item to be a measure of CFT with some CMI variance. The intercorrelation of the Picture Completion Test with Block Design and Object Assembly, both of which are presumed to be measures of CFT indicate increasing relationship with age. The general factor-analytic studies have found Block Design and Object Assembly load significantly on a perceptual organization factor. The fact that Picture Completion does not become identified with the perceptual organization factor in the general studies may be due to the CMI variance, as the S tends to verbalize the picture content.

Picture Arrangement: 7 sets of items designed to measure the ability to reorganize disconnected material into a meaningful sequence; the ability to understand the "whole" from disorganized parts.

<table>
<thead>
<tr>
<th>Age</th>
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<th>Performance</th>
<th>FSS</th>
<th>Object Assembly</th>
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<td>.31</td>
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</table>

Guilford has found the Picture Arrangement Test to be a measure of NMS, based on his finding that this item has usually led in the identification of factor NMS, it appears fairly safe to assume that Picture Arrangement measures NMS at all age levels. At present, there is no research on younger populations to support or refute such an assumption.

Block Design: 7 sets of designs to be made from wooden blocks; the test is intended as a measure of visual motor coordination and perception. It requires analysis of
complex whole, breaking a pattern into elements.

<table>
<thead>
<tr>
<th>Age</th>
<th>Verbal</th>
<th>Performance</th>
<th>FSS</th>
<th>Picture Arrangement</th>
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<td>.45</td>
</tr>
</tbody>
</table>

Guilford has found Block Design to be a measure of CFT. As has previously been mentioned, some variance with EFU can be expected, especially with younger Ss. The general factor-analytic studies have indicated a significant loading on a perceptual organization factor. The intercorrelation of Block Design with Object Assembly (at $7\frac{1}{2}$ - .53; at $10\frac{1}{2}$ - .59; at $13\frac{1}{2}$ - .63) appears to bear this out. Block Design appears to be a measure of CFT at all age levels.

Object Assembly: 4 sets of parts to be assembled to form a whole; the test is designed to measure visual organization, and pattern coherence.

<table>
<thead>
<tr>
<th>Age</th>
<th>Verbal</th>
<th>Performance</th>
<th>FSS</th>
<th>Comprehension</th>
<th>Similarities</th>
</tr>
</thead>
<tbody>
<tr>
<td>$7\frac{1}{2}$</td>
<td>.38</td>
<td>.59</td>
<td>.52</td>
<td>.25</td>
<td>.29</td>
</tr>
<tr>
<td>$10\frac{1}{2}$</td>
<td>.55</td>
<td>.66</td>
<td>.64</td>
<td>.35</td>
<td>.25</td>
</tr>
<tr>
<td>$13\frac{1}{2}$</td>
<td>.31</td>
<td>.68</td>
<td>.52</td>
<td>.13</td>
<td>.31</td>
</tr>
</tbody>
</table>

Guilford has found the Object Assembly Test to be a measure of CFT. General factor analytic studies have found the Object Assembly Test to load significantly on a perceptual organization factor. While some EFU may be involved, it appears that the Object Assembly Test is essentially a measure of CFT.
Coding: Two forms of items that are similar to the WAIS Digit Symbol Test; Coding A, which is a simplified version, is administered to Ss below the age of eight; it consists of 45 forms to be marked according to the key:

\[ \star \quad \bullet \quad \square \quad \star \quad \square \]

Coding B, which is similar to the adult test, is administered to Ss of eight years and older; it consists of 93 spaces to be marked according to the key:

\[ \begin{array}{c} 4 \\ 1 \\ 5 \\ 7 \end{array} \]

The time limit for both trials is two minutes.

### Coding Test Intercorrelations

<table>
<thead>
<tr>
<th>Age</th>
<th>Verbal</th>
<th>Performance</th>
<th>FSS</th>
<th>Digit Span</th>
<th>Arithmetic</th>
<th>Block Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>7(\frac{1}{2}) (A)</td>
<td>.31</td>
<td>.32</td>
<td>.35</td>
<td>.27</td>
<td>.32</td>
<td>.26</td>
</tr>
<tr>
<td>10(\frac{1}{2}) (B)</td>
<td>.42</td>
<td>.35</td>
<td>.43</td>
<td>.30</td>
<td>.38</td>
<td>.27</td>
</tr>
<tr>
<td>13(\frac{1}{2}) (B)</td>
<td>.42</td>
<td>.42</td>
<td>.48</td>
<td>.24</td>
<td>.34</td>
<td>.35</td>
</tr>
</tbody>
</table>

Guilford has found the symbol substitution or digit span item to be a two factor test, measuring MSI and ESU about equally well.

Maze Test: Offered as an alternate for the Performance section. There are eight mazes offered of increasing difficulty. There are specific allowances made for errors and different time limits. The Mazes are all of the type:
Guilford has found items of the Maze type to be measures of CFI. All intercorrelation pertaining to the individual subtests and Verbal, Performance, Full Scale Score and other subtests has been obtained from informational data provided by Wechsler (1949). In each of the age level samples, the population included 100 boys and 100 girls. No differentiation for sex is provided; research has indicated fairly consistent sex differences at all age levels; some of the significance of the variations may have been lost by summing.

Application of SI Theory to the SRA Primary Mental Abilities Tests (SRA-PMA)

Commercial and other details are given in the Appendix. The SRA Primary Mental Abilities Tests have previously been mentioned in Chapter II with regard to the discrepancies between Thurstone's concepts and testing theories and Science Research Associates marketing practices. The differences become quite obvious in the detailed presentation which follows.

The current PMA batteries have been widely criticized because of technical faults. The early forms were based on extensive research and represented an important breakthrough in test construction. Rather than providing the needed refinement and empirical validation, however, the subsequent evolution of these tests has proceeded chiefly in the direction of abridgment and simplification. Inadequacies of normative data, questionable types of scores (such as ratio IQs), unsupported interpretations of scores, meager validity data, improper procedures for computing reliability of speeded tests, excessive dependence of scores on speed, and low reliabilities of factor scores are

Maze Test Intercorrelations

<table>
<thead>
<tr>
<th>Age</th>
<th>Verbal</th>
<th>Performance</th>
<th>FSS</th>
<th>Block Design</th>
<th>Vocabulary</th>
</tr>
</thead>
<tbody>
<tr>
<td>7½</td>
<td>.31</td>
<td>.51</td>
<td>.46</td>
<td>.49</td>
<td>.22</td>
</tr>
<tr>
<td>10½</td>
<td>.43</td>
<td>.55</td>
<td>.53</td>
<td>.53</td>
<td>.44</td>
</tr>
<tr>
<td>13½</td>
<td>.40</td>
<td>.39</td>
<td>.44</td>
<td>.28</td>
<td>.32</td>
</tr>
</tbody>
</table>

Guilford has found items of the Maze type to be measures of CFI. All intercorrelation pertaining to the individual subtests and Verbal, Performance, Full Scale Score and other subtests has been obtained from informational data provided by Wechsler (1949). In each of the age level samples, the population included 100 boys and 100 girls. No differentiation for sex is provided; research has indicated fairly consistent sex differences at all age levels; some of the significance of the variations may have been lost by summing.
among the chief weaknesses of these tests. In their present form, they are of interest primarily to illustrate the nature of the factors identified in the original research (Anastasi, 1961, p. 349).

The Primary Mental Abilities Tests for Ages 11 to 17 are given with short time limits, yet the manual reports only split-half reliabilities. Anastasi and Drake (1954) administered the half-tests with separate time limits in order to get a proper estimate of reliability, and compared these with reliabilities computed by the spurious single-administration method. The results are as follows for the four PMA tests:

<table>
<thead>
<tr>
<th></th>
<th>Separately Timed Halves</th>
<th>Single Administration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Verbal:</td>
<td>.90</td>
<td>.94</td>
</tr>
<tr>
<td>Reasoning:</td>
<td>.87</td>
<td>.92</td>
</tr>
<tr>
<td>Space:</td>
<td>.75</td>
<td>.90</td>
</tr>
<tr>
<td>Number:</td>
<td>.83</td>
<td>.92</td>
</tr>
</tbody>
</table>

It is obvious that the split-half estimates from the single administration are inflated and give too favorable an impression of the test (Cronbach, 1960, p. 142).

Description of the items

SRA-PMA Grades 2-4:

Verbal Meaning: consists of 60 items:

Items 1 - 30 consist of a set of four line drawings; the S is asked to mark the picture of the word given orally by the E; items are of the type:

"Find the picture of the ornament, mark it."

Items 31 - 60 consist of a set of four line drawings; the S is asked to mark the picture of the word that finishes the story; items are of the type:

"Mark the picture that finishes the story: It was the first of September. The children had enjoyed the long vacation, but were glad to go back to ...."
ences, it would appear that items 1 - 30 measure CMU. As the item is one of multiple choice format, a little variance with EMU might be possible, but the item seems to be essentially CMU. Items 31 - 60 appear to involve more than recognition; understanding the situation that leads up to making the completion is involved. In the McCartin and Meyers (1966) study, three parts of the 1953 SRA-PMA 5 - 7 year test were used; the three parts were based on items similar to items 31 - 60. The three parts involved sentence completion, sentence comprehension and paragraph comprehension. McCartin and Meyers added items from Avaldan to increase the range of paragraph comprehension. In their analyses, sentence comprehension loaded at .45 on CMS and .22 on CMU; sentence completion loaded at .47 on CMS. Paragraph comprehension was hypothesized for CMS, but it appeared as a singlet where rotation permitted; it was forced into CMS by the Procrustes solution. The test may involve more complexity than anticipated at first grade level, or the addition of the Avaldan items may be to blame. In any case, it would appear that items 31 - 60, under consideration here, are measures of CMS with CMU variance.

Spatial Relations: 27 items designed to measure the ability to deal with visual form relationships; time limit: six minutes. This is a measure of CFS-V. All items are of the type:

"Look at the first figure in the row. It is part of a square. Look at the drawings in the rest of the row to find the other part of the square. Put an X on the drawing that shows the other part of the square;
Number Facility: Measured by four different types of items; the responses are summed to obtain a number facility score. The confoundings surrounding the number facility factor have been mentioned in Chapter III, in regard to Guilford's continuing research with the so-called "number facility" factor. Part I contains 15 items of the type:

"Jack had 16¢. He spent half of it for candy. How much money did he have left?"

Guilford has found this item type to be primarily a measure of CMS (Guilford, 1967, p. 404). Part II contains 10 items of the number series type:

"Write the number that is missing:

1 1 2 2 ___ 3."

Guilford has found this item type to be a measure of CSS (Guilford, 1967, p. 96).

Part III contains five items similar to those in Part I, but presented in multiple choice format. They are essentially measures of CMS. Part IV contains 30 items of the addition type:

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>38</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>21</td>
<td>97</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>42</td>
<td></td>
</tr>
</tbody>
</table>

Time: 5 minutes

Guilford has found the number operations items to be factorially complex: they have weak MSI and NSI loadings, as well as strong specific components.

Perceptual Speed: 50 items designed to measure the ability to recognize likenesses and differences between objects or symbols quickly and accurately; time limit: five minutes. All items are of the type:

"Mark the two pictures in each row that are exactly alike."
Guilford has found items of this type to be a univocal measure of EFU.

**SRA-PMA Grades 4 - 6:**

**Verbal Meaning:** Consists of two parts: Part I Words, Part II Picture Test. Part I consists of 30 items of the multiple choice synonym type:

"Which one of these words means the same as BIG?
   a. fair   b. windy   c. soft   d. large."

Time limit: seven minutes. This is a measure of CMU.

Part II consists of 30 items of the multiple choice picture vocabulary type. E reads instructions as:

"Find the insect; mark the letter on your answer sheet."

Time limit: six minutes. This is a measure of CMU.

**Number Facility:** Consists of two parts: Part I Number Sense, Part II Addition.

Part I consists of 20 items all in multiple choice format; time limit: ten minutes.

Items 1 through 10 are number series items; they are measures of CSS. Items 11 through 20 are multiple choice arithmetic reasoning items; they are essentially measures of CMS, some MSI variance is to be expected.

Part II consists of 30 items of multiple choice addition problems; time limit: four minutes. The number operations items have been found to be factorially complex; in this format, the traditional form of presentation is given first, followed by four possible answers; the S must work the problem, then find his answer among the choices given. Guilford has found such items to measure MSI/NSI and have a large specific component.
Spatial Relations: Consists of 25 items in multiple choice format; the S is asked to choose the figure that represents the rest of the given incomplete figure; time limit: six minutes. This item is a measure of CFS-V.

Reasoning: Consists of two parts: Part I Figure Grouping Test, Part II Word Grouping Test. Part I consists of 25 items of the figure class exclusion type:

"Mark the letter of the figure that does not belong with the other figures in each row:

\[ A \quad B \quad C \quad D \]

Time limit: eight minutes.

Items of this type are measures of CFC (Guilford, 1967, p. 80). Part II consists of 25 items of the word class exclusion type:

"Mark the letter of the word that is different in each row:
   a. red    b. blue    c. heavy    d. green."

Time limit: six minutes. Guilford has found items of this type to be essentially measures of CMC (1967, p. 83). CMR variance may be involved.

Perceptual Speed: Consists of 40 items; the S is asked to mark the letter combinations on the answer sheet that agree with the letters of the two figures in each row that are exactly alike. Time limit: five minutes. Items of this type are measures of EFU.

SRA-PMA Grades 6 - 9:

Verbal Meaning: Consists of 60 items of the multiple choice format dealing with synonyms; time limit: four minutes. Items of this type are measures of CMU.

Number Facility: Consists of 30 items in multiple choice format; time limit: ten minutes. The number facility items are of several types presented in random order.
It is a jumbled mess. The following items are numerical operations items and can be expected to have slight loadings on MSI and NSI and large specific components; the specific components can be expected to differ according to the kind of operation called for. (Numbers refer to the test item numbers):

Addition: 3, 4, 10, 14 (fractions), 20 (decimals); 1 (coins expressed verbally), 2 and 16 (coins expressed as a mixture of number and word); 5 (Roman numerals), 21 (time), 13 feet and inches expressed in fractional parts).

Subtraction: 30 (fractions); 8, 17, 24, 28 (combinations of number and word); 16, 11 (money expressed in verbal and number combinations).

Multiplication: 18, 26 (percentage of dollar combinations), 22 (fractions); 27.


Express as a number a verbal expression: 7, 9.

**Reasoning:** Consists of three parts: Part I Letter Series, Part II Word Grouping, Part III Number Series. Part I Letter Series consists of 20 letter series with multiple choices for the next letter in the series; time limit: four minutes. Guilford has found the letter series item to be a measure of CSS (1967, p. 96). Part II consists of 30 items of the multiple choice class exclusion type; time limit: six minutes. This is essentially a measure of CMC, but some CMR variance can be expected. Part III consists of 20 number series items with multiple choices for the next number in the series; time limit: four minutes. This item type measures CSS. It is important to notice that the number series items in Test 2 - 4 and Test 4 - 6 were included in the Number Facility factor, not in the Reasoning factor as they are in Test 6 - 9.
Spatial Relations: Consists of 30 items of the figure rotation type; time limit: seven minutes. The S is asked to find the figure in the series that represents the first figure in the row:

This item type measures CFS-V, or spatial orientation (Guilford, 1967, p. 92).

SRA-PMA 9 - 12:

Verbal Meaning: Consists of 60 items of the multiple choice synonym type; time limit: four minutes. Such items measure CMU.

Number Facility: Consists of 30 items in the same form of disarray and jumble as the Number Facility section of Test 6 - 9. The result is probably a low measure of NSI and MSI and a high specific component according to the different operations called for. (Numbers refer to test item number):

Addition: 1, 9 (money combinations expressed by words and numbers); 2, 13 (decimals); 20, 21, 23, 24 (fractions); 25 (fractions); 3 (feet and inches in fractional parts).

Subtraction: 7 (time in hour and minutes); 11, 15, 19 (involves large numbers in verbal expressions); 27, 29 (fractional parts).

Multiplication: 6, 18 (percentage of money expressed in dollars); 8, 17; 16 (whole number and fractions).

Division: 12, 14; 26, 30 (mixed numbers divided by a larger number).

Combined operations: Addition and Subtraction: 4, 10 (decimals).

Other: Write in numbers a verbally expressed amount: 5. Selection of largest or smallest amount expressed in group combinations of mixed numbers, decimals, and fractions: 22, 28.

Reasoning: Consists of three parts: Part I Letter Series, Part II Word Grouping, Part III Number Series. Part I Letter Series consists of 20 series with multiple
choices for the next letter in the series; time limit: four minutes. Items of this type measure CSS. Part II Word Groupings consists of 30 items of multiple choice class exclusion type; time limit: five minutes. This is a measure of CMC with some CMR variance. Part III Number Series consists of 20 series with multiple choices for the next number in the series; time limit: four minutes. This is a measure of CSS. As in the Test 6-9 form, Number Series has been included as part of the Reasoning factor, rather than the Numerical factor as in Test 2-4 and Test 4-6. It rightfully is a reasoning factor.

Spatial Relations: Consists of 30 items of the rotation type; time limit: seven minutes. Such items are measures of CFS-V.

The Primary Mental Abilities tests as conceived by Thurstone had much promise. They originated from experimental factorial analysis. The two-way connection between experimenter and tester appeared to be well-established and opportune, until the PMA tests had the misfortune of falling into the hands of SRA. Thurstone had devised numerous kinds of tests and items; only until his research established the merit of using them on general populations, did he employ some of them commercially. Many of them remained, for him, experimental tests. Some of these have subsequently been used or modified by French (1951, 1963) and by Guilford. Several of Thurstone's experimental tests have become consistent markers in the factor-analytic studies of Guilford, and other researchers. It is most unfortunate that the concern, control and responsibility evidenced by Thurstone in managing the PMA tests was not to be continued by SRA.

The primary factors, with well-established support from research, that were
used in the 1941 Thurstone PMA tests were:

<table>
<thead>
<tr>
<th>PMA Factor</th>
<th>SI Equivalent Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>S - Space</td>
<td>CFS-V</td>
</tr>
<tr>
<td>R - Reasoning</td>
<td>CSS</td>
</tr>
<tr>
<td>M - Memory</td>
<td>Not certain</td>
</tr>
<tr>
<td>N - Numerical Facility</td>
<td>Factorially complex</td>
</tr>
<tr>
<td>V - Verbal Comprehension</td>
<td>CMU</td>
</tr>
<tr>
<td>W - Word Fluency</td>
<td>DSU</td>
</tr>
</tbody>
</table>

(Adapted from Guilford, 1967, p. 420.)

In the 1941 version, Thurstone did not believe that the factor P - Perceptual Speed (BFU) was sufficiently clear for general application (Thurstone, Thelma; 1941). As may be recalled, there were three tests for each primary factor, arranged in a booklet so that the three tests for any one factor could be administered within a 40 minute class period. The sweeping changes in test content, timing, length, and item content, engineered by SRA, are quite obvious and quite inconsistent with Thurstone's ideas. His repeated emphasis on differential abilities and their comparison in profile form is in direct opposition to the score summing procedures involved in the SRA interpretation. Thurstone persistently urged that mental age concepts, along with the ratio IQ concepts from which they were derived, be abandoned because they were misleading. He expressed this idea as early as 1926. The 1962 SRA-PMA K - 1 Test and 2 - 4 Test scores are obtained from mental age and ratio IQ tables. The 1962 SRA-PMA Tests 4 - 6, 6 - 9, and 9 - 12 scores are obtained from deviation IQ tables. The concept of intelligence and its measurement maintained by Thurstone has not been
maintained by SRA in their use of the PMA tests; indeed SRA avoids defining either intelligence or primary mental abilities. The best use that can be made of the SRA-PMA tests is a general indication of the ability being measured by each separate subtest.

If the subtests are used in this manner, it might be wise to establish norms based on the particular population being tested. They would probably be more reliable than the normative data offered by SRA.

Application of SI Theory to the Lorge-Thorndike Intelligence Tests (L-T)

Commercial and other details are given in the Appendix.

Extent of usage

One of the more popular group tests of intelligence; the various levels and alternate forms appeal to many school systems using a continual testing program. According to Cronbach, it is a "well constructed test... nonverbal and verbal sections can be separately administered. The nonverbal items call mostly for general ability, independent of vocabulary and reading. Since the verbal and nonverbal scores correlate about .70, differences between the scores will not be significant for the majority of pupils" (Cronbach, 1960, p. 230). Cronbach states:

It is apparent that our knowledge of what these tests measure and how their scores are to be interpreted would benefit from further empirical validation. The chief strengths of the tests stem from the sound theoretical rationale underlying choice of content, the size and representativeness of the standardization sample, the high reliability of the IQs, and the generally superior quality of test-construction procedures followed in developing the tests (Anastasi, 1961, p. 220).
Authors' definition of intelligence

The authors have been more concerned with what can be said about the activities called for in the tests than they have with any formal definition of intelligence. They believe that the tests can be characterized by the following statements and that these characteristics apply to behavior which they would describe as intelligent:

1. The tasks deal with abstract and general concepts.
2. In most cases, the tasks require the interpretation and use of symbols.
3. In large part, it is the relationships among concepts and symbols with which the examinee must deal.
4. The tasks require the examinees to be flexible in their basis for organizing concepts and symbols.
5. Experience must be used in new patterns.
6. Power in working with abstract materials is emphasized, rather than speed.

Clearly, there are types of ability which are not represented in the above. "Mechanical intelligence," "social intelligence," and "practical intelligence" are concepts which the Lorge-Thorndike tests do not well correspond. The tests are avowedly measures of abstract intelligence - expressed in verbal symbols in the one case and in pictorial, diagrammatic, and numerical symbols in the other (Lorge and Thorndike, 1957, p. 14).

Description of items

Level 1 - Form A:

Three subtests which consist entirely of pictorial items to measure abstract thinking.

Test 1: 25 items of the multiple choice picture vocabulary type. E reads the instructions for each item:

"Draw a ring around the picture that shows a boy diving."

12 of the items concern the identification of single objects such as "a workbench" or "a cot." These can be expected to measure CMU. 6 of the items concern the identification of a subject doing something such as "a girl eating" or "someone hoisting."

While such items are basically measures of CMU, some CMS variance may be involved; this is theorized on the basis of results of factor analysis with similar items
and at comparable age levels (Stott and Ball, McCartin and Meyers). Six of the items concern the identification of qualified ideas such as "that it must be very cold" or "the one that is habitable." Again, and for the same reasons as above, one can expect CMS variance for these items.

Test 2: 20 items of the multiple choice class exclusion type: E reads the instructions for each item:

"Draw a ring around the one that does not belong."

Nine of the items are geometric type figures; they may be expected to measure CFC, 11 of the items are pictured objects or scenes; they may be expected to measure CMC, as the tendency with the pictured material of this type is verbalization by the S.

Test 3: 20 items of five multiple choice line-picture pairs in series; E reads the instructions for each series:

"Draw rings around the two pictures in each row that go together."

The items call for somewhat varied associations; in some cases by class and in others by relation. One series shows pictures of a chair, a magazine, a pair of shoes, a violin, and a newspaper. The magazine and the newspaper go together because they are both paper, or because they are both kinds of reading materials. Another series shows pictures of a hammer, a screw, large shears, a wooden ruler, and a screwdriver. The keyed response is the screw and the screwdriver. It is theorized that the test is primarily a measure of CMC, it is anticipated that there may be some CMR and EMU variance.

Level 2 - Form A:

Three subtests which consist entirely of pictorial items designed to measure abstract
Test 1: 25 items of the multiple choice picture vocabulary type; \( E \) reads the instructions for each item:

"Put a ring around the picture that shows a boy running."

An examiner's manual was not included for this section of the research kit; according to the technical manual, the test is the same type, but more difficult than Test 1 of Level 1. 13 of the items of the pictured series are identical to items in Test 1, Level 1; it is assumed that (providing the directions to the \( S \) are essentially the same) Test 1 Level 2 is basically a measure of CMU with some CMS variance.

Test 2: 25 items of the multiple choice class exclusion type; \( E \) reads the instructions for each item:

"Draw a ring around the one that does not belong."

11 of the items are geometric type figures; they may be expected to measure CFC.

14 of the items are pictured objects or scenes; they may be expected to measure CMC.

Test 3: 25 items of multiple choice line drawn picture series; \( E \) reads the instructions for each item:

"Draw a ring around the two things in each line that go together."

Eight of the series are identical to item series in Test 3 Level 1; seven of the items are of the figure class exclusion type; they may be expected to measure CFC. The remaining 18 items involve pictured objects and scenes; some are paired by class, others by relation. These can be expected to measure CMC with some CMR and EMU variance.
Level 3 - Form A

Verbal Battery: consists of four tests designed to measure the ability to deal with abstractions presented in verbal form.

Test 1: 25 items of the multiple choice sentence completion type:

"Choose the word that makes the most sensible complete sentence:

Hot weather comes in the

a. fall b. night c. summer d. winter e. snow."

Five of the items are of this type and can be expected to measure CMU; 20 of the items are of this type:

"It is _______ to be generous with other people's property.

a. desirable b. necessary c. good d. important
e. easy."

Guilford has found that items of this type tend to go in the direction of NMU (1967, p. 76). This item is similar to the S-B item called Minkus Completion. It is expected that CMU is also involved.

Test 2: 25 items of the multiple choice class word inclusion type. Items of this type are measures of CMC.

Test 3: 15 multiple choice arithmetic reasoning items of the type:

"A pad of paper costs 5 cents. How much will 4 pads cost?

a. 9¢ b. 16¢ c. 18¢ d. 25¢ e. none of these."

Items of this type are essentially measures of CMS, some MSI variance can be expected.

Test 4: 25 multiple choice synonym items of the type:

"Choose the word that has the same, or most nearly the same, meaning as the first word:
land  a. ground  b. town  c. roof  d. river  e. grass."

Items of this type measure CMU.

Nonverbal Battery: consists of three nonverbal tests designed to measure abstract intelligence.

Test 1: 25 items of the multiple choice figure class inclusion type. The first part of each item consists of three geometric figures; the S is asked to choose among five other figures the one that belongs with the first group; 18 are of this type, and can be expected to measure CFC. Six of the items are figure series of the one-dimensional trend. Guilford theorizes items of this type to be measures of CFR (1967, p. 86).

Test 2: 24 items of the multiple choice number series type (four of the items use letter series, but they are measures of the same factor). Items of this type measure CSS.

Test 3: 30 items of the multiple choice picture analogy type. 24 of the items use geometric type figures; items of this type measure CFR. Six of the items are pictured material; items of this type are measures of CMR.

Level 4 - Form A

Verbal Battery: consists of five tests designed to measure the ability to deal with abstractions presented in verbal form.

Test 1: 25 items of the multiple choice synonym type. Items of this type measure CMU.

Test 2: 15 items of the multiple choice sentence completion type. They are all of the "word-finding" kind (finding a meaningful word to fit described information); they can be expected to measure NMU with some CMU variance.
Test 3: 15 items of the multiple choice arithmetic reasoning type. Items of this type are essentially measures of CMS with some anticipated MSI variance.

Test 4: 25 items of the multiple choice word class exclusion type. Items of this type measure CMC.

Test 5: 15 items of the multiple choice verbal analogy type. Items of this type are essentially measures of CMR.

Nonverbal Battery: consists of three tests of nonverbal material designed to measure abstract intelligence.

Test 1: 25 items of multiple choice inclusion type. 12 of the items are of the class inclusion type and may be expected to measure CFC. 12 items are of the figure series one-dimensional trend type. They are theorized to measure CFR. The last item is complex; it involves block counting which measures CFS-V and number series which measures CSS.

Test 2: 28 items of the multiple choice number series type. Items of this type measure CSS.

Test 3: 30 items of the multiple choice figure analogy type. Items of this type measure CFR.

Level 5 - Form A

Verbal Battery: consists of five tests designed to measure the ability to deal with abstractions presented in verbal form.

Test 1: 25 items of the multiple choice synonym type; such items are measures of CMU.

Test 2: 12 items of the multiple choice sentence completion type; all items concern
supplying a meaningful word to fit prescribed information; items of this type measure NMU.

**Test 3:** 15 items of the multiple choice arithmetic reasoning type. Items of this type are essentially measures of CMS with some MSI variance.

**Test 4:** 25 items of the multiple choice class word exclusion type; items of this type are essentially measures of CMC.

**Test 5:** 18 items of the multiple choice verbal analogy type; items of this type are essentially measures of CMR (as the words become more difficult, CMU becomes involved more).

**Nonverbal Battery:** consists of three tests designed to measure abstract thinking with nonverbal material.

**Test 1:** 25 items of the multiple choice inclusion type. 10 items measure CFC; 12 items are theorized to measure CFR; 2 items involve CFU-V and CFC; 1 item involves CFU-V and CSS.

**Test 2:** 28 items of the multiple choice number series type; items of this type are measures of CSS.

**Test 3:** 30 items of the multiple choice figure analogy type; items of this type measure CFR.

The special research kit did not provide examiner's manuals for each of the levels; manuals were provided for each of the Primary Batteries, but only two upper level manuals were provided. It is assumed that the time allowances will be essentially the same as the Technical Manual indicates the following:

Levels 3, 4, 5 - Verbal Battery - 34 minutes
Nonverbal Battery - 27 minutes
From the Examiner's Manual for Level 3 the following is indicated:

<table>
<thead>
<tr>
<th>Verbal Battery</th>
<th>Nonverbal Battery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test 1 - 9 minutes</td>
<td>Test 1 - 9 minutes</td>
</tr>
<tr>
<td>Test 2 - 8 minutes</td>
<td>Test 2 - 9 minutes</td>
</tr>
<tr>
<td>Test 3 - 10 minutes</td>
<td>Test 3 - 9 minutes</td>
</tr>
<tr>
<td>Test 4 - 7 minutes</td>
<td></td>
</tr>
</tbody>
</table>

From the Examiner's Manual for Level 4 the following is indicated:

<table>
<thead>
<tr>
<th>Verbal Battery</th>
<th>Nonverbal Battery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test 1 - 7 minutes</td>
<td>Test 1 - 9 minutes</td>
</tr>
<tr>
<td>Test 2 - 5 minutes</td>
<td>Test 2 - 9 minutes</td>
</tr>
<tr>
<td>Test 3 - 10 minutes</td>
<td>Test 3 - 9 minutes</td>
</tr>
<tr>
<td>Test 4 - 7 minutes</td>
<td></td>
</tr>
<tr>
<td>Test 5 - 5 minutes</td>
<td></td>
</tr>
</tbody>
</table>

It is assumed that the time limits for Level 5 will be the same as those given for Level 4 as the composition of both tests is the same.

Application of SI Theory to the California Test of Mental Maturity (Long Form) 1963 Revision (CTMM)

Commercial and other details are given in the Appendix.

Extent of usage

"One of the most widely accepted current tests, with an unusual variety of items, good format and standardization, and a continuous series of levels... Separate Language and Non-Language IQs are offered, but there is little evidence to indicate the practical significance of difference between the two IQs" (Cronbach, 1960, p. 229). Cronbach criticizes the validity of the subscores which are provided for a profile of
abilities, he feels that due to their dubious validity, they should be given little attention. The authors of the CTM standardized the test along with the California Achievement Tests, thus providing a comparison for a pupil's scores with the expectancy for his IQ level.

**Authors' definition of intelligence**

A test of intelligence obviously must be built on premises or hypotheses which are appropriate to the purpose for which the test is intended. In the same way, it must be interpreted according to standards that represent a realistic sampling of the population and reflect the educational and intellectual environment in which mental abilities are developing. These considerations guided the extensive research in preparation for the 1963 revisions of the California Test of Mental Maturity Series.

At each level, the rate and scope of mental development are measured in terms of five statistically-derived factors: Logical Reasoning, Spatial Relationships, Numerical Reasoning, Verbal Concepts, and Memory. Within these factors, the twelve test units are grouped into two sections, Language and Non-Language, that differentiate in general responses to stimuli that are primarily verbal in nature and responses to stimuli that are essentially nonverbal or pictorial (Sullivan, Clark, and Tlegs; 1964, p. 5).

The authors state that the test has been constructed to provide a "comprehensive measurement of the functional capacities that are basic to learning, problem-solving, and responding to new situations." While the authors do not specifically spell out whether or not they feel there are other functional capacities, the use of the definite article would imply that they have included all of them. One is left to infer that the five factors that are being measured are essentially what the authors mean by intelligence. The factors were chosen by means of:

Factor analysis by the Thurstone centroid method which produced the five discrete factors that form the major interpretive units of the CTMM-LF. These factors and the test units representing them are as follows: Factor I, Logical Reasoning (Opposites, Similarities, and Analogies); Factor II,
Spatial Relationships (Rights and Lefts, Manipulation of Areas); Factor III, Numerical Reasoning (Number Series, Numerical Values, and Number Problems); Factor IV, Verbal Concepts (Inferences and Verbal Comprehension); and Factor V, Memory (Immediate Recall and Delayed Recall).

The only major change resulting from the 1963 factor analysis is the transfer of the Inferences test from the Logical Reasoning factor to the Verbal Concepts factor (Sullivan, Clark, and Tiegs; 1964, p. 9).

It is important to note that the CTMM concept of "factors" is quite different from Guilford's concept of factors. The CTMM "factor" is basically far more general and includes more than one SI factor in its composition.

Description of items

Each level of the CTMM consists of 12 tests divided into Language and Non-Language sections. The Language section is composed of tests of number problems, inferences, verbal comprehension, and memory (delayed). The Non-Language section includes pictorial material for opposites, similarities, and analogies, discrimination of left and right, spatial visualization, number series, numerical values, and memory (immediate). As the levels are essentially the same, only one level shall be considered in this paper: Level 5, which is appropriate to Grade 12, college and adult populations.

Part A - Non-Language

Test 1: 15 items of the multiple choice picture type; time limit: four minutes. The S is asked to find the picture in each row that shows something that is the opposite of the first picture. This is the pictorial antonym type; it should be a measure of CMR. As happens in the case of pictured material, the S verbalizes the content. Test 1 is really a semantic test of pictured information. The concept of "Non-Language" as used in the CTMM is really the concept of pictorial or figural information; pictorial
is essentially semantic information, and therefore verbal; whereas the figural information is nonverbal. It would be expected that some confusion or misunderstanding could result regarding the interpretation of factors, if the distinction were not clearly understood.

**Test 2:** 15 items: one is figural, the other 14 are pictorial; the items are arranged in series with multiple choice answers. The first three pictures represent a class; the S is asked to find the one of four alternates that is most like the first three; time limit: four minutes. This is the picture class inclusion type; it can be expected to measure CMC. As with Test 1, this is basically a semantic understanding test.

**Test 3:** 15 items: two contain figural information, the rest contain pictorial information. The items are pictorial analogy with four choice answers; time limit: four minutes. Items of this type are essentially measures of CMR; items 32 and 44 (figural content) should be measures of CFR.

**Test 4:** 20 items; time limit: three minutes. Line drawings of objects and parts of the body are presented; the S is instructed to mark L for each picture that shows a left, and R for each picture that shows a right. Items of this type should be measures of CFS-K (Guilford, 1967, p. 94).

**Test 5:** 15 items; time limit: seven minutes. The items are multiple choice spatial visualization of figural information. The S is asked to find the drawing among the choices that is another view of the given figure. Items of this type measure CFT.

**Test 6:** 15 items; time limit: ten minutes. The items are multiple choice number series exclusion. The S is instructed to find the one number in each series that does not belong. Items of this type measure CSS.
Test 7: 15 items; time limit: five minutes. The items are multiple choice coin problems where the subject is given a certain number of coins to add up to a given amount of money:

"6 coins to add up to 10 cents -"

The possible coin combinations are presented in a table below the problems:

<table>
<thead>
<tr>
<th>&quot;Cents&quot;</th>
<th>Nickels</th>
<th>Dimes</th>
<th>Quarters</th>
<th>Half Dollars</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. 5</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>b. 5</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>c. 5</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

This item appears to be essentially of the arithmetic reasoning variety; it is theorized that it will be a measure of CMS with MSI variance, and some specific component. In all cases, the numerical operation called for is addition, the specific component that is expected to appear would concern the operation of addition. The answer table consists of 23 possible combinations. The answer choices given with each item are limited to four specified alternates from the table; for example, Item 100 has as alternates e, f, g, and h. There are several instances where the question part of the item calls for a total amount that is smaller than one of the coins represented in the answer choice combination; for example, the item;

"6 coins to add up to 10 cents"

where one of the choices reads:

<table>
<thead>
<tr>
<th>&quot;Cents&quot;</th>
<th>Nickels</th>
<th>Dimes</th>
<th>Quarters</th>
<th>Half Dollars</th>
</tr>
</thead>
<tbody>
<tr>
<td>d. 5</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
</tbody>
</table>

If the subject eliminates answers in this way, it is assumed that more of the CMS factor will
be involved.

**Test 11:** 33 items; time limit: approximately ten minutes. This is a test of immediate recall; it stresses associative memory. According to the authors, it is designed to measure retention, rather than comprehension of the orally presented stimuli.

Several sequences of paired words are read aloud by the E. After each set has been read, the S is instructed to turn up the covered picture series in his test booklet. The E reads the first word of each pair; the S is to identify the second word of the pair from the set of three pictures presented for each item. The capacity for direct recall is progressively extended from the first set of five pairs, to the final set of twelve pairs of words. The test is a rather unique type of paired associate recall, designed for group testing. The test fulfills Guilford's requirement for memory tests; all Ss have the same amount of time to memorize the information. According to Guilford (1967, p. 135), items of this type should measure MMI, memory for semantic implications, in which the first member of the pair implies the second.

**Part B - Language Section**

**Test 8:** 15 items; time limit: ten minutes. The items are multiple choice arithmetic reasoning problems. Items of this type measure CMS with some MSI variance expected.

**Test 9:** 15 items; time limit: six minutes. The items are all composed of a major premise and one or more minor premises. The S is asked to choose, among three possible responses, the best logical conclusion. Guilford’s recent research indicates that items of this type are measures of EMI (1967, p. 201); although a trace of EMR has been found, in some analyses, Guilford feels that the item type is essentially a
measure of EMI.

Test 10: 40 items; time limit: eight minutes. The items are multiple choice vocabulary type: the S is asked to choose the word that means the same, or about the same, as the given word. Items of this type measure CMU.

Test 12: 20 items; time limit: six minutes. This is a memory test of the delayed recall type. The items are in the form of 20 statements with multiple choice answers. The items deal with information stated or implied in a story which was read by the E at the beginning of the Language Section of the test. The intervention of three tests between the reading and the presentation of the questions provides a standardized condition to measure delayed recall. Based on Guilford's recent studies, it is theorized that this test should measure MMU, memory for ideas (Guilford, 1967, p. 118).

The subtests used to estimate Non-Language Ability are:

Test 1 - Pictorial Opposites
Test 2 - Pictorial Similarities
Test 3 - Pictorial Analogies
Test 4 - Left-Right Discrimination
Test 5 - Spatial Visualization
Test 6 - Number Series
Test 7 - Arithmetic Reasoning and Numerical Values (coin problems)
Test 11 - Immediate Recall (Paired Associate Pictures)

The subtests used to estimate Language Ability are:

Test 8 - Arithmetical Reasoning
Test 9 - Inferences

Test 10 - Verbal Comprehension - Vocabulary

Test 12 - Memory for Ideas - Delayed Recall

Cronbach's comment regarding little evidence to indicate the practical significance of differences between the Language and Non-Language IQs may be more clearly understood by observing the subtests used to measure Non-Language IQ. Tests 1, 2, 3, and 7 all involve semantic material; they can be expected to go in the direction of language abilities. His comment regarding the dubiousness of subscore validity can be viewed in a more positive manner, if one considers the SI factor measured by each subtest. The subtests were defined through factor analysis, thus they are, for the most part, factorially pure. Their validity increases when they are considered as measures of one distinct factor, rather than a complex, categorical function. If a division of mental abilities is desired, the subtests could be grouped differently. Possibilities for regrouping include organization along the lines of process: Cognition or Memory or Evaluation; or along the lines of the nature of the information: Concrete (figural) and Abstract (symbolic, semantic). On the basis of Concrete and Abstract, only Tests 4 and 5 would qualify as Concrete material, according to SI theory.

The authors' stated rationale for selection of items to measure mental maturity rests on the ability of the item to elicit the recognition or logical analysis of abstract relationships; if "abstract" is regarded according to SI "abstract" meaning, then ten of the subtests meet the criterion. The test is essentially a measure of abstract thinking ability.
As mentioned, the authors' concept of "factor," is a little different than the SI concept of "factor." This is perhaps more easily seen by the following exposition:

<table>
<thead>
<tr>
<th>Factor I - Logical Reasoning:</th>
<th>SI Equivalent Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test 1</td>
<td>CMR</td>
</tr>
<tr>
<td>Test 2</td>
<td>CMC</td>
</tr>
<tr>
<td>Test 3</td>
<td>CMR</td>
</tr>
</tbody>
</table>

**Factor II - Spatial Relationships**

| Test 4 | CFS-K   |
| Test 5 | CFT     |

**Factor III - Numerical Reasoning**

| Test 6 | CSS      |
| Test 7 | CMS (MSI-Variance) |
| Test 8 | CMS (MSI-Variance) |

**Factor IV - Verbal Concepts**

| Test 9 | BMI      |
| Test 10| CMU      |

**Factor V - Memory**

| Test 11| MMI      |
| Test 12| MMU      |

Other rearrangements are possible along the lines of:

1. Semantic recognition: Test 10
2. Semantic memory: Test 11, Test 12
3. Semantic classification: Test 2
4. Semantic relationships: Test 1, Test 3
5. Reasoning, as understanding systems:
   - Figural-kinesthetic (space): Test 4
   - Symbolic: Test 6
   - Semantic: Test 7, Test 8
6. Spatial visualization: Test 5
7. Semantic evaluation: Test 9

A factor-analytic study (Anderson and Leton, 1966) of the CTMM-LF consistently identified the authors' five factors at all levels; as the items were selected on the basis of factor analysis, it would be surprising if they were not identified; it is, however, reassuring to know that they have been independently identified, and that it holds true at all levels. It is felt that the use of the five factors, as they are represented, in interpretive or diagnostic analysis could be vague or misleading. A redefinition of the factors in more specific kinds of test-result information could be of greater assistance to the test-user.

**Application of SI Theory to the Otis-Lennon Mental Ability Tests (O-L)**

Commercial and other details are given in the Appendix.

**Extent of usage**

The present edition is the fourth major revision of the Otis series. The Otis Group Intelligence Scale grew out of Arthur Otis' Army Alpha Examination, which was the first group test of mental ability. The Otis Self-Administering Tests of Mental Ability were published from 1922 to 1929 in various forms. During the 1930s, the Otis Quick-Score Mental Abilities Tests were developed. These were published, with
several new forms added, through the 1950s. Because of the ease of administration, scoring and variety of available forms, the Otis tests have been extremely popular over the years, as a quick measure of general ability. Otis IQs have tended to be lower than IQs derived from other popular measures. The Otis Self-Administering Tests of Mental Ability: Higher Examination has been widely used in personnel screening. The Wonderlic Personnel Test is an adaptation and abridgment of the Otis; it is a 12-minute test, yet yields correlations of .81 to .87 with the longer Otis test.

Otis died in 1963. The present Otis-Lennon test is a revision of earlier editions with several changes and additions, directed by Roger Lennon.

Authors' definition of intelligence

There is an interesting paradox to be observed in the difference in concept which exists between Otis' earlier definition and Lennon's later explanation. Otis defines intelligence as "the term which refers to that innate mental quality which increases with age... mental ability is measured by the individual's score in the test... the measure of (the individual's) brightness is obtained by comparing his score with that of others of his own age" (Otis, 1950). Lennon states:

... the Otis-Lennon Mental Ability Test series have been designed to provide comprehensive, carefully articulated assessment of the general mental ability or scholastic aptitude, of pupils in American schools. Emphasis is placed upon measuring the pupil's facility in reasoning and dealing abstractly with verbal, symbolic, and figural test content sampling a broad range of cognitive abilities. The new Otis-Lennon tests, like the previous editions in the Otis series, were constructed to yield dependable measurement of the "g" or general intellective factor. Thus, the single total score obtained at a given level summarizes the pupil's performance on a wide variety of test materials selected for their contribution to the assessment of this general ability factor.

It should be clearly understood that the Otis-Lennon tests do not measure
the innate mental capacity of the pupil... the tests in the Otis-Lennon series measure broad reasoning abilities.

It must be emphasized again that these ability tests do not measure native endowment, nor should the notion of constancy, or fixity, of ability level be associated with the test results (Lennon, 1967, p. 4).

The Otis-Lennon tests to be considered in this paper are: Elementary II, Intermediate, and Advanced, Form J. The test at each of these levels is comprised of 80 items arranged in spiral omnibus form. A single score summarizes the S's performance on what Lennon calls "abstract reasoning ability."

Due to the omnibus format of the test construction, the writer has analyzed the items according to type, they shall be presented in that order, rather than the order in which they occur in the individual tests.

1) Multiple choice vocabulary items of the type:

"Injure means -
   a. suffer  b. bandage  c. question  d. hurt  e. inform."

Items of this type measure CMU. Elementary II has five, Intermediate has four, Advanced has four items of this type.

2) Multiple choice word class inclusion items of the type:

"Which thing below best belongs with: ship, bicycle, truck?
   a. sail  b. wheel  c. highway  d. train  e. tire."

Items of this type measure CMC. Elementary II has three, Intermediate has two items like these.

3) Multiple choice class exclusion of the type:

"Which thing below is most unlike the other four?
   a. taxi  b. automobile  c. bus  d. motorcycle  e bicycle."

Items of this type measure CMC. Elementary II and Intermediate have one each, Ad-
advanced has two items of this kind.

4) Multiple choice figure analogy of the type:

\[
\begin{array}{ccc}
\square & \square & \square \\
\square & \square & \square \\
\end{array}
\]

is to \[ \begin{array}{ccc}
\square & \square & \square \\
\square & \square & \square \\
\end{array} \]

as \[ \begin{array}{ccc}
\square & \square & \square \\
\square & \square & \square \\
\end{array} \]

is to \[ \begin{array}{ccc}
f & g & h \\
j & k & l \\
\end{array} \]

Items of this type measure CFR. Elementary II contains seven, Intermediate contains seven, Advanced contains five.

5) Figure matrix of the type:

"The drawings in the box go together in a certain way. Find the drawing that belongs where you see the question mark (\?) in the box.

\[
\begin{array}{ccc}
\circ & \circ & \circ \\
\square & \square & \square \\
\end{array}
\]

a b c d e

Items of this type measure CFR. Elementary II and Intermediate contain four each; Advanced contains five.

6) Figure relations of the one-dimensional trend type:

"The drawings in the first part of the row go together to form a series. In the last part of the row, find the drawing that belongs where you see the question mark (\?) in the series.

\[
\begin{array}{ccc}
\uparrow & \uparrow & \uparrow \\
\uparrow & \uparrow & \uparrow \\
\end{array}
\]

f g h j k

Based on Guilford's recent work, it is theorized that such items will be measures of CFR. Each of the test levels contains four of such items.

7) Number matrix of the type:

"The numbers in the box go together in a certain way. Find the number that belongs where you see the question mark (\?) in the box.

\[
\begin{array}{ccc}
7 & 5 & 3 \\
6 & 4 & ?
\end{array}
\]

\[
a. 1 \ b. 2 \ c. 3 \ d. 4 \ e. 5.\]
It is theorized that items of this type will measure CSR. There is one item of this sort on each of the three levels.

8) Letter matrix of the type:

"The sets of letters in the box go together in a certain way. Find the set of letters that belongs where you see the question mark (?) in the box.

\[
\begin{array}{ccc}
\text{strap} & \text{trap} & \text{rap} \\
\text{par} & \text{part} & ?
\end{array}
\]

a. pars  b. tap  c. parts  d. tar  e. prats."

Items of this type measure CSR. Elementary II and Intermediate contain one each of this type; another item, that is set up in the same kind of format is included once on each of the three levels. The second item type is not a matrix; it is a letter series on a one-dimensional trend, for this reason it is included in the letter series category.

9) Number analogy of the type:

"4 is to 1-1/3 as 24 is to -

a. 6  b. 8  c. 12  d. 22  e. 32."

This item appears once in the Intermediate and Advanced levels; it is theorized to measure CSR.

Letter analogy of the type:

"BDF is to GEC as JLN is to -

a. KMN  b. KMO  c. MKI  d. OKI  e. OMK."

This item appears once on the Advanced; it should measure CSR.

10) Antonym recognition of the type:

"The opposite of weak is -

a. poor  b. sick  c. tall  d. young  e. strong."

Items of this type measure CMR. Elementary II and Intermediate contain six such
11) Multiple choice verbal analogy of the type:

"Driver is to car as cowboy is to -
  a. horse  b. gun  c. cow  d. steer  e. range."

Items of this type measure CMR. Elementary II contains fifteen of these, Intermediate contains fourteen, and Advanced has eleven.

12) Verbal analogy of the type:

"A zoo without animals is like a library without -
  a. chairs  b. librarians  c. books  d. readers  e. windows."

Elementary II and Intermediate have one each of these, they should measure CMR.

13) Word matrix of the type:

"The words in the box go together in a certain way. Find the word that belongs where you see the question mark (?) in the box.

  grandmother  mother  daughter
  grandfather  father  ?

  a. boy  b. man  c. son  d. husband  e. relative."

One example of this item appears on each of the three levels; they should measure CMR.

14) Compass orientation problem: the same problem is given once on the Elementary II and repeated on the Intermediate; the answers are given in multiple choice format; the item is a measure of CFS-K.

15) Multiple choice number series of the type:

"Which number is missing in this series?
3  5  7  -  11  13
a. 8  b. 9  c. 10  d. 14  e. 15."

Items of this type measure CSS. Examples appear seven times each on all three
levels. The Advanced level contains one item that is a variation, letter series in combinations of five: \[ L \times \frac{X}{C}T \quad M \] Each unit is a separate matrix type, the item should be a measure of CSS (Guilford, 1967, p. 96).

16) One multiple choice problem of arithmetic reasoning of the verbally necessary operations type appears on the Elementary II level only.

17) Arithmetic reasoning items in multiple choice format of the type:

"If one piece of candy costs 5¢, how many pieces can John buy for 20¢?
   a. 4   b. 5   c. 6   d. 3   e. 10."

Items of this type measure CMS with some MSI variance expected, as well as specific components. Elementary II has four items of this type; Intermediate has three of this type; Advanced has seven of this type. In addition, Intermediate has two items of similar format, but which do not involve any math; they are essentially measures of CMS; Advanced has one of these. Intermediate and Advanced both have the same item of artificial language type; this should measure CMS also.

18) Multiple choice vocabulary evocation of the type:

"When a new machine is created, it is called _________.
   a. an adoption   b. an invention   c. a fabrication
   d. a fabrication   e. a discovery."

Items of this type measure NMU; one can expect some CMU to be involved. Elementary II has three, Intermediate has four, Advanced has five of such items.

19) Multiple choice sentence-ordering of the type:

"If the words below were arranged to make the best sentence, with which letter would the first word of the sentence begin?
   ever you Paris to been have
   a. b   b. e   c. h   d. p   e. y."

"
Items of this type should measure NMS; they are found three times each on Elementary II and Intermediate and once on Advanced.

20) Multiple choice of the Minkus completion type appear three times each on each of the three levels. In the multiple choice format, some evaluation becomes necessary, therefore they are theorized to measure EMU.

21) Multiple choice of the syllogistic reasoning type, both formal and informal, appear six times on Elementary II, five times on Intermediate, and two times on Advanced. Items of this type measure EMI.

22) Multiple choice sentence completion of the type:

"In order to live, all men must -
a. read  b. marry  c. exercise  d. study  e. eat."

It is theorized that such an item would call for evaluation of semantic implications and be a measure of EMI. Items of this type appear twice on Elementary II and Advanced, and once on Intermediate.

23) Two items of the type:

"Which of the following best tells what a horse is?"
appear on the Intermediate level. It is theorized that such items, apparently involving relations and implications, expressed in the multiple choice format, would call for evaluation. It is theorized that both items would be measures of EMR/EMI.

24) Two items of the evaluation of symbol substitute in syllogistic reasoning format appear on Advanced. Based on Guilford's description (1967, p. 245), it is theorized that they would measure EMI, as the understanding of the syllogistic implication is the crux of the problem.

Although the previous editions of the Otis tests contained the same number of
items (80), the format and content of the Otis-Lennon is considerably different. In the older editions, as in the new one, all items are presented in multiple choice format. In earlier tests, vocabulary was measured by approximately 27 to 30 items of the word meaning and analogy type. About 15 items involved verbal discrimination presented as "different from" or "most like." There were generally four or five each of: proverb meaning, number series, following directions, general information. Usually there was one arithmetic reasoning item. The remaining 10 or so items were of the verbal reasoning type; these included the artificial language item and symbol substitute syllogism item. A few of the same items have been retained in the new edition; about 80 percent of the items are new. Comparative analysis of the old and new forms reveals that the popular item types of the old form are also the popular item types of the new; the content has been changed. The new edition has significantly more nonverbal items; there were very few in the older editions, particularly at the upper levels.

The most serious drawback about the new edition is the lack of validity data. According to one critic, "correlational evidence interpreted by the author to support construct validity of the test is inconclusive... it may be concluded that the predictability of scholastic success is due to the fact that the Otis-Lennon is a direct measure of scholastic success" (Grotelueschen, 1969).

Final remarks

Each test will be treated separately in the next chapter. The interpretive aids have been developed from the application of SI theory to each test treated in this chapter. Chapter VI illustrates suggested interpretations based on the details of research described in this chapter.
CHAPTER VI
TECHNIQUES FOR MORE MEANINGFUL INTERPRETATION OF TEST DATA

The truth is something you get on toward and never to, and the way is filled with ingenuities and excitements. Don't take the straight and narrow path of stodgy positivists; be gay and optimistic, like Galton, and you will find yourself more toward than you expected.

- E. G. Boring

It is in such spirit of ingenuity and optimism that the interpretive schemata are offered - in the hope of getting more toward.

General Implications

It becomes increasingly apparent that even the more widely used psychological measures of intellectual behavior are limited to appraising a very small number of abilities. With the exception of a few memory tasks, an even fewer number of evaluation tasks, and a rare demand for production tasks, current appraisals involve primarily, the operation of cognition. Cognitive operations represent one fifth of the possible operations in SI theory. By far, the most dominant factor involved in current measures is verbal comprehension (French, 1951; Guilford, 1967). Measures of supposedly "general" abilities load at .69 to .79 and higher on one SI factor: CMU (Guilford, 1967, p. 77). CMU represents only one out of 120 possible SI factors.

One of the expressed purposes of this dissertation concerns the provision of an interpretive technique that will encourage better utilization of test data. Marland (1968) describes the situation in this way:
I emphasize the need for inventing a new way of providing a profile of the child's ability and performance against the environment in which he is living and working. This new device should be so constructed that it can be easily communicated to counselors and teachers, allowing for varying degrees of expertise. It must be so designed that it can be fully comprehended by them and, in turn, readily translated to parents and children (1968, p. 106).

Credit for the invention of a new way to provide a profile belongs to Guilford. The application of SI theory and the use of Guilford's notational system was undertaken by the writer to supply a uniform analysis to standard psychological tests, and thereby identify specific intellectual behaviors. The techniques for more meaningful interpretation of test data are all based on the redefinition of obtained information according to Guilford's inventions.

The rationale for the interpretive redefinitions is a simple one. Information obtained from sampling is basically a statistic. A statistic may be used to describe or predict. All too frequently, testing statistics have been used primarily for prediction. The descriptive qualities have been overlooked. Ironically, with a valid instrument, the descriptive qualities are generally more dependable than the predictive qualities; for prediction moves into the realm of probability and generality. Even accepting the ability of a measure to predict, what is implied, and rarely given attention, is the true meaning of the concept: this is what will probably happen if nothing is changed. When learning is understood to mean a change in behavior resulting from experience, the importance of change is obvious. The use of prediction with regard to learning should be directed more toward increasing the learning and less toward predicting what will probably happen. If we can determine, with a certain degree of accuracy, the kind of behaviors the S has now, then we can try to provide the kinds of experience that will lead to desired changes in the S's behavior.
The interpretive redefinitions of information derived from a selected test are designed to be easily communicated to test users having varying degrees of expertise. Once grasped by the test user, the information can be readily translated to other interested persons. Although each selected test is treated separately, a fairly uniform presentation is used:

(1) A **pie-shaped diagram** is used to show the proportion of intellectual behaviors measured by the selected test, in comparison with the intellectual behaviors theorized by Guilford's invention. The circle represents the 120 SI factors; the shaded areas represent the specific behaviors measured by the selected test. The different diagrams are provided to indicate the limitations of specific tests in assessing what has come to be understood as a global measure of intelligence. The interpretation of test information can be more accurate when the interpreter knows that the test sampled only a certain percentage of the possible behaviors, and that a certain percentage of this amount was derived from one factor. For example, a diagram might indicate that only 10 percent of the possible behaviors were tested; and of this amount, 70 percent involved tests of CMU.

(2) A **summary table** of the SI behaviors identified by each item contained in a selected test is given. Each summary table is based on the research described in Chapter V. Reference to the table permits the test user to redefine the test information as specific intellectual behaviors that have been identified. The reference tables for each test serve as the source material for the various test data sheets constructed for each selected test.

(3) A **Test Pattern Blank** is designed for use with any of the selected instru-
ments. It is constructed to illustrate the pattern, if any, of an individual's successes and failures on identified abilities. Emphasis can be directed toward areas of failure for diagnostic or remedial purposes. The Test Pattern Blank provides for analysis of pass-fail patterns.

(4) Test Summary Sheets vary slightly for each selected test; variations are caused by differences in content, breadth, and format peculiar to the selected test. In the construction of each Test Summary Sheet the objective was specific description; description of what the S can do now, what the S cannot do now, what specific intellectual behaviors appear to need further investigation. Hopefully, such descriptive information will suggest the kind of learning experiences that are appropriate for the S.
Table 12

Test Pattern Blank

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Test Pattern Blanks may be used with any of the selected instruments; reference to the appropriate table of SI factors measured by the specific items allows E to assign trigraphs to the small blocks; performance may then be recorded as plus or minus signs.
Interpretive Aids for the Stanford-Binet

According to Guilford's count, if one strong factor is hypothesized for each item of the S-B scale, 28 SI abilities are represented at some place (1967, p. 472). If one considers the area of the circle to represent the SI concept of intelligence, then what is measured in the TOTAL S-B scale would appear as:

Fig. 5
S-B Diagram 1

Guilford has found that if one strong factor is theorized for each of the 28 SI abilities measured in the S-B scale, that out of the 140 items, CMU appears 30 times; CMS appears 14 times; CFT, CMI, CFS, CMT, and NMI appear from 6 to 9 times each:

Fig. 6
S-B Diagram 2
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TABLE 13
SI FACTOR COMPOSITION OF S-B SCALE
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<td></td>
</tr>
<tr>
<td>5. CMU</td>
<td></td>
<td>CMI/DMS</td>
<td></td>
</tr>
<tr>
<td>6. Alt.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Superior Adult II</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. CMU</td>
<td></td>
<td></td>
<td>CMI/DMS</td>
</tr>
<tr>
<td>2. CMT</td>
<td></td>
<td>CMU/NMT</td>
<td></td>
</tr>
<tr>
<td>3. CMU</td>
<td></td>
<td>EMI/CMS</td>
<td></td>
</tr>
<tr>
<td>4. MMU</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Alt.</td>
<td></td>
<td>CSS</td>
<td></td>
</tr>
</tbody>
</table>
When the test-user knows, from reference to the table, which SI factors are being appraised by S-B items, the information may be recorded right on the test booklet. For each S the exam would probably not involve more than three or four age levels; E would use only that information from the table which pertained to the individual S.

If a diagnostic or pattern analysis were wanted, the E could make use of the Test Pattern Blank—the information could be recorded, according to the kinds of operations and specific factors involved. The smaller block, within each larger block is for the SI factor trigraph; the remaining space can be used for plus or minus signs to indicate the S's performance. Utilization of such a device forces the test-user to study the pattern of failures as well as the pattern of successes. It is assumed that such study will lead to more specific understanding of the S's performance than a single score total affords.
<table>
<thead>
<tr>
<th>Year</th>
<th>Test 1.</th>
<th>2.</th>
<th>3.</th>
<th>4.</th>
<th>5.</th>
<th>6.</th>
<th>Alt.</th>
<th>Year -</th>
<th>1.</th>
<th>2.</th>
<th>3.</th>
<th>4.</th>
<th>5.</th>
<th>6.</th>
<th>Alt.</th>
<th>Behaviors S has now:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Behaviors in need of further investigation:
TABLE 15
STANFORD-BINET SUMMARY - II

The Stanford-Binet at age level:

<table>
<thead>
<tr>
<th>alternate measures</th>
<th>SI Factors</th>
<th>Subject's Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test 6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alternate</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>alternate measures</th>
<th>SI Factors</th>
<th>Subject's Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test 6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alternate</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>alternate measures</th>
<th>SI Factors</th>
<th>Subject's Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test 6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alternate</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Interpretive Aids for the Wechsler Scales

According to Guilford (1967, p. 472), for each of the tests in the WAIS, one can easily hypothesize as many SI factors. If one includes 11 SI factors, the WAIS measures this amount of what SI theory conceives of as "intelligence:" (About 9% of the total).

Figure 7
WAIS Diagram 1

Of the 11 factors, 8 are in the cognitive category; 2 are in the memory category, and 1 is in the divergent production category. The proportion of operations involved may be seen as:

Figure 8
WAIS Diagram 2

Of the 9% of SI measured by the WAIS, 73% involves cognition, 18% involves Memory and 9% involves Divergent Production.
**TABLE 16**  
SI FACTOR COMPOSITION OF WAIS SUBTESTS

<table>
<thead>
<tr>
<th>Subtest:</th>
<th>Essentially One Factor</th>
<th>Two Factor</th>
<th>One Primary &amp; Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information</td>
<td>CMU</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Comprehension</td>
<td></td>
<td>CMU</td>
<td>CMS</td>
</tr>
<tr>
<td>Arithmetic</td>
<td></td>
<td>CMS</td>
<td>MSI/NSI</td>
</tr>
<tr>
<td>Similarities</td>
<td>CMT</td>
<td>MSS/MSU</td>
<td></td>
</tr>
<tr>
<td>Digit Span</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vocabulary</td>
<td>CMU</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Digit Symbol</td>
<td></td>
<td>MSI/ESU</td>
<td>CFT EFU</td>
</tr>
<tr>
<td>Block Design</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Picture Completion</td>
<td></td>
<td>CFT</td>
<td>CMI</td>
</tr>
<tr>
<td>Picture Arrangement</td>
<td>NMS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Object Assembly</td>
<td></td>
<td>CFT</td>
<td>EFU</td>
</tr>
</tbody>
</table>

Suggestions for interpretive use of the table include transcribing the SI factors on to the test booklet; in this way, the consecutive failures, which mark the S's ceiling need not be evaluated in the same manner as failures within the rest of the subtest, although they would be considered from the point of "ceiling." Another use is to transcribe the factors on the Test Pattern Blank; in this way a pattern of strengths and weaknesses could emerge.
### TABLE 17
**WAIS SUMMARY**

<table>
<thead>
<tr>
<th>SI FACTORS MEASURED</th>
<th>One factor tests</th>
<th>Two factor tests</th>
<th>Multifactor tests</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cognition</td>
<td>Memory</td>
<td>Primary</td>
</tr>
<tr>
<td></td>
<td>CMU CMT NMS</td>
<td>MSS MSI MSU ESU</td>
<td>Cognition</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Variance MSI NSI EFU</td>
</tr>
<tr>
<td>Information</td>
<td>29</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Comprehension</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arithmetic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Similarities</td>
<td>13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Digit Span</td>
<td></td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>Vocabulary</td>
<td>40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Digit Symbol</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Block Design</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Picture Completion</td>
<td></td>
<td>21</td>
<td>21</td>
</tr>
<tr>
<td>Picture Arrangement</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Object Assembly</td>
<td></td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

Numbers refer to number of times the factor is measured; blanks are to be filled in with the number of times S was successful for comparative purposes.

Behaviors S has now:  

Behavioral areas in need of further investigation:
### TABLE 18
**SI FACTOR COMPOSITION OF WISC SUBTESTS**

<table>
<thead>
<tr>
<th>Subtest:</th>
<th>Essentially One Factor</th>
<th>Two Factor</th>
<th>One Primary &amp; Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information</td>
<td>CMU</td>
<td></td>
<td>(with younger Ss) CMS or NMU</td>
</tr>
<tr>
<td>Comprehension</td>
<td></td>
<td>CMU</td>
<td>CMS/NMS</td>
</tr>
<tr>
<td>Arithmetic</td>
<td></td>
<td>CMS</td>
<td>MSI/NSI</td>
</tr>
<tr>
<td>Similarities</td>
<td>CMT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vocabulary</td>
<td>CMU</td>
<td></td>
<td>(with younger Ss) NMS or MMS</td>
</tr>
<tr>
<td>Digit Span</td>
<td></td>
<td>MSS/MSU</td>
<td></td>
</tr>
<tr>
<td>Picture Completion</td>
<td></td>
<td>CFT</td>
<td>CMI</td>
</tr>
<tr>
<td>Picture Arrangement</td>
<td></td>
<td>NMS</td>
<td></td>
</tr>
<tr>
<td>Block Design</td>
<td></td>
<td>CFT</td>
<td>EFU</td>
</tr>
<tr>
<td>Object Assembly</td>
<td></td>
<td>CFT</td>
<td>EFU</td>
</tr>
<tr>
<td>Coding</td>
<td></td>
<td>MSI/ESU</td>
<td></td>
</tr>
<tr>
<td>Maze</td>
<td>CFI</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The inclusion of the Maze test on the WISC increases the number of SI factors, measured by the WAIS, to 12. The WISC measures about the same factors as the WAIS; for younger ages different variance will be involved.
### WISC SUMMARY
#### SI FACTORS MEASURED

|                      | One factor tests | Two factor tests | Multifactor tests |  
|----------------------|------------------|------------------|-------------------|---
|                      | Cognition        | Conv. Prod.      | Cognition         |  
|                      | CFI CMU CMT NMS  | Memory M3S/MSU   | CMU CMS CFT CMS   |  
| Information          | 30               | 14               | 14                |  
| Comprehension        | -                | 16               |                   |  
| Arithmetic           | 16               | 16               |                   |  
| Similarities         | 40               |                   |                   |  
| Vocabulary           | 14               |                   |                   |  
| Digit Span           | 45               |                   |                   |  
| Picture Completion   | 7                | 20               |                   |  
| Picture Arrangement  | 7                |                   |                   |  
| Block Design         | 4                |                   |                   |  
| Object Assembly      | 4                |                   |                   |  
| Coding B             | 93               |                   |                   |  
| Coding A             | 45               |                   |                   |  
| Mazes                | 5                |                   |                   |  

Numbers refer to number of times the factor is measured; blanks are to be filled with the number of times S was successful for comparison.
Interpretive Aids for the SRA-PMA Test

SRA - PMA Grades 2 - 4

The SRA-PMA at this level measures 7 SI factors; not quite 6 percent of what SI theory implies to be intelligence:

Figure 9
SRA-PMA Diagram 1

TABLE 19
SI FACTOR COMPOSITION OF SRA -PMA 2-4

<table>
<thead>
<tr>
<th>Test</th>
<th>Essentially One Factor</th>
<th>Two Factor</th>
<th>One Primary &amp; Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Verbal</td>
<td>CMU</td>
<td></td>
<td>CMS/CMU</td>
</tr>
<tr>
<td>1 - 30</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>31 to 60</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spatial</td>
<td>CFS-V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 to 27</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number</td>
<td>CMS</td>
<td></td>
<td>MSI/NSI and specific component</td>
</tr>
<tr>
<td>Problems 1 - 15</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Series 1 - 10</td>
<td>CSS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Addition 1 - 30</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Problems 1 - 5</td>
<td>CMS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perceptual Speed</td>
<td>EFU</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SI Factors Measured:

<table>
<thead>
<tr>
<th>Cognition</th>
<th>Memory</th>
<th>Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>CFS-V</td>
<td>MSI/NSI</td>
<td>EFU</td>
</tr>
<tr>
<td>CSS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CMU</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CMS</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## TABLE 20
SRA-PMA 2-4 SUMMARY

The SRA-PMA test at this level measures 7 SI factors.

<table>
<thead>
<tr>
<th>TEST</th>
<th>NUMBER OF ITEMS</th>
<th>SI FACTORS</th>
<th>S's PERFORMANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Verbal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Items:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 - 30</td>
<td>30</td>
<td>CMU</td>
<td></td>
</tr>
<tr>
<td>31 - 60</td>
<td>60</td>
<td>CMS (CMU var.)</td>
<td></td>
</tr>
<tr>
<td>Spatial</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Items:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 - 15</td>
<td>15</td>
<td>CMS</td>
<td></td>
</tr>
<tr>
<td>1 - 10</td>
<td>10</td>
<td>CSS</td>
<td></td>
</tr>
<tr>
<td>1 - 30</td>
<td>30</td>
<td>MSI/NSI</td>
<td></td>
</tr>
<tr>
<td>1 - 5</td>
<td>5</td>
<td>CMS</td>
<td></td>
</tr>
<tr>
<td>Perceptual</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Speed</td>
<td>50</td>
<td>EFU</td>
<td></td>
</tr>
</tbody>
</table>

Subject's Cognitive Behaviors now: Subject's Behavioral Areas in need of further investigation:

Subject's Evaluative Behaviors now:

Other Behaviors now:
The SRA - PMA at this level measures 9 of the possible 120 SI factors:

**TABLE 21**
**SI FACTOR COMPOSITION OF SRA - PMA 4 - 6**

<table>
<thead>
<tr>
<th>Test:</th>
<th>Essentially One Factor</th>
<th>Two Factor</th>
<th>Other Primary &amp; Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Verbal</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Part 1 (1 - 30)</td>
<td>CMU</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Part 2 (1-30)</td>
<td>CMU</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Number</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Part 1 Number Sense</td>
<td>CSS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 - 10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11 - 20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Part 2 Addition</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 - 30</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Spatial</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 - 25</td>
<td>CFS-V</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Reasoning</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Part 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 - 25</td>
<td>CFC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Part 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 - 25</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Perceptual Speed</strong></td>
<td>EFU</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SI Factors Measured:
- Cognition: CFS-V, CFC, CSS, CMU, CMC, CMS
- Memory: MSI/NSI
- Evaluation: EFU
<table>
<thead>
<tr>
<th>TEST</th>
<th>NUMBER OF ITEMS</th>
<th>SI FACTORS</th>
<th>S's PERFORMANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Verbal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Part 1</td>
<td>30</td>
<td>CMU</td>
<td></td>
</tr>
<tr>
<td>Part 2</td>
<td>30</td>
<td>CMU</td>
<td></td>
</tr>
<tr>
<td>Number</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Items 1-10</td>
<td>10</td>
<td>CSS</td>
<td></td>
</tr>
<tr>
<td>Items 11-20</td>
<td>10</td>
<td>CMS (MSI var.)</td>
<td></td>
</tr>
<tr>
<td>Addition</td>
<td>30</td>
<td>MSI/NSI</td>
<td></td>
</tr>
<tr>
<td>Spatial</td>
<td>25</td>
<td>CFS-V</td>
<td></td>
</tr>
<tr>
<td>Reasoning</td>
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<tr>
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<td>25</td>
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</tr>
<tr>
<td>Part 2</td>
<td>25</td>
<td>CMC (CMR var.)</td>
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</tr>
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<td>Perceptual</td>
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</tr>
<tr>
<td>Speed</td>
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Subject's Cognitive Behaviors now:

Other Behaviors Now:

Subject's Behavioral Areas in need of further investigation:
The SRA-PMA at this level measures 7 of the possible 120 SI factors:

Figure 11
SRA-PMA Diagram 3

<table>
<thead>
<tr>
<th>Test:</th>
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<th>Two Factor</th>
<th>One Primary &amp; Variance</th>
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<tbody>
<tr>
<td>Verbal</td>
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<tr>
<td>Number</td>
<td>CMU</td>
<td>CMS</td>
<td>MSI</td>
</tr>
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<td></td>
</tr>
<tr>
<td>13, 17, 21, 24, 28</td>
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</tr>
<tr>
<td>All other items</td>
<td>CMU</td>
<td>CMS</td>
<td>MSI/NSI and specific components</td>
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<tr>
<td>Reasoning</td>
<td>CMU</td>
<td>CMS</td>
<td>CMR</td>
</tr>
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<td>CSS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Part 2</td>
<td>CSS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Part 3</td>
<td>CSS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spatial</td>
<td>CFS-V</td>
<td></td>
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</tbody>
</table>

SI Factors Measured:

Cognition: CFS-V, CSS, CMU, CMC, CMS
Memory: MSI/NSI
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<thead>
<tr>
<th>TEST</th>
<th>NUMBER OF ITEMS</th>
<th>SI FACTORS</th>
<th>S's PERFORMANCE</th>
</tr>
</thead>
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<tr>
<td>Number</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Items:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1, 2, 5, 7, 9, 11, 13, 17, 21, 24, 28</td>
<td>11</td>
<td>CMS (MSI vr.)</td>
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</tr>
<tr>
<td>All others</td>
<td>19</td>
<td>MSI/NSI</td>
<td></td>
</tr>
<tr>
<td>Reasoning</td>
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</tr>
<tr>
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<td>20</td>
<td>CSS</td>
<td></td>
</tr>
<tr>
<td>Part 2</td>
<td>30</td>
<td>CMC (CMR var.)</td>
<td></td>
</tr>
<tr>
<td>Part 3</td>
<td>20</td>
<td>CSS</td>
<td></td>
</tr>
<tr>
<td>Spatial</td>
<td>30</td>
<td>CFS-V</td>
<td></td>
</tr>
</tbody>
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Subject's Cognitive Behaviors now:  

Subject's Behavioral Areas in need of further investigation:  

Other Behaviors now:  
The SRA-PMA at this level measures 70 of the possible 120 SI factors:

Figure 12
SRA-PMA Diagram 4

TABLE 25
SI FACTOR COMPOSITION OF SRA-PMA 9-12

<table>
<thead>
<tr>
<th>Test:</th>
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<th>One Primary &amp; Variance</th>
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</thead>
<tbody>
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<td></td>
<td></td>
</tr>
<tr>
<td>Number</td>
<td></td>
<td></td>
<td>CMS, MSI</td>
</tr>
<tr>
<td>1, 3, 5, 7, 9, 11, 15, 18, 19, 22, 28</td>
<td>All others</td>
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</tr>
<tr>
<td>Reasoning</td>
<td></td>
<td></td>
<td>CMR</td>
</tr>
<tr>
<td>Part 1</td>
<td>CSS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Part 2</td>
<td>CSS</td>
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<tr>
<td>Part 3</td>
<td>CSS</td>
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<td></td>
</tr>
<tr>
<td>Spatial</td>
<td>CFS-V</td>
<td></td>
<td></td>
</tr>
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</table>

SI Factors Measured:

**Cognition:** CFS-V, CSS, CMU, CMC, CMS

**Memory:** MSI/NSI
The SRA-PMA at this level measures 7 SI factors.

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<thead>
<tr>
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<th>S's PERFORMANCE</th>
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</thead>
<tbody>
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<td>CMU</td>
<td></td>
</tr>
<tr>
<td>Number</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Items:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1, 3, 5, 7, 9,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11, 15, 18,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19, 22, 28</td>
<td>11</td>
<td>CMS (MSI var.)</td>
<td></td>
</tr>
<tr>
<td>All others</td>
<td>19</td>
<td>MSI/NSI</td>
<td></td>
</tr>
<tr>
<td>Reasoning</td>
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<td></td>
</tr>
<tr>
<td>Part 1</td>
<td>20</td>
<td>CSS</td>
<td></td>
</tr>
<tr>
<td>Part 2</td>
<td>30</td>
<td>CMC (CMR var.)</td>
<td></td>
</tr>
<tr>
<td>Part 3</td>
<td>20</td>
<td>CSS</td>
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</tr>
<tr>
<td>Spatial</td>
<td>30</td>
<td>CFS-V</td>
<td></td>
</tr>
</tbody>
</table>

Subject's Cognitive Behaviors now:

Subject's Behavioral Areas in need of further investigation:

Other Behaviors now:
Interpretive Aids for the Lorge-Thorndike Tests

Level 1

The Lorge-Thorndike at this level measures 3 of the possible 120 SI factors:

Figure 13
Lorge Thorndike Diagram 1

TABLE 27
SI FACTOR COMPOSITION OF LORGE-THORNDIKE 1

<table>
<thead>
<tr>
<th>Test 1</th>
<th>Essentially One Factor</th>
<th>Two Factors</th>
<th>One Primary &amp; Variance</th>
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</thead>
<tbody>
<tr>
<td>1 to 25</td>
<td></td>
<td></td>
<td>CMU CMS (age)</td>
</tr>
</tbody>
</table>

Test 2
Items:
2, 4, 6, 8, 10, 12,
14, 16, 18

Items:
1, 3, 5, 7, 9, 11,
13, 15, 17, 19, 20

Test 3
1 to 20

CFC, CMU, CMC

Basically, the Lorge-Thorndike at this level measures:

CFC, CMU, CMC
TABLE 28
LORGE-THORNDIKE I SUMMARY

The test at level 1 measures 3 SI factors.

<table>
<thead>
<tr>
<th>TEST</th>
<th>NUMBER OF ITEMS</th>
<th>SI FACTORS</th>
<th>S's PERFORMANCE</th>
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</thead>
<tbody>
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<td>25</td>
<td></td>
<td>CMU</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Variance: CMS</td>
</tr>
<tr>
<td>Test 3</td>
<td></td>
<td>CFC</td>
<td>CMC</td>
</tr>
<tr>
<td>Items:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2, 4, 6, 8, 10,</td>
<td>9</td>
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</tr>
<tr>
<td>12, 14, 16, 18</td>
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<td></td>
</tr>
<tr>
<td>Items:</td>
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<td></td>
<td>CMC, EMU</td>
</tr>
<tr>
<td>1, 3, 5, 7, 9,</td>
<td>11</td>
<td></td>
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</tr>
<tr>
<td>11, 13, 15, 17,</td>
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<tr>
<td>19, 20</td>
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</tr>
<tr>
<td>Test 3</td>
<td></td>
<td>CMC</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Variance:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>CMC, EMU</td>
</tr>
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</table>

Cognitive behaviors subject has now:

Cognitive behaviors needing further investigation:
Level 2

The Lorge-Thorndike at this level measures 3 of the possible 120 SI factors:

Figure 14
Lorge-Thorndike Diagram 2

<table>
<thead>
<tr>
<th>TABLE 29</th>
<th>SI FACTOR COMPOSITION OF LORGE-THORNDIKE II</th>
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<tbody>
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<td></td>
<td>Essentially One Factor</td>
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<tr>
<td>1 to 25</td>
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</tr>
<tr>
<td>Test 2</td>
<td></td>
</tr>
<tr>
<td>Items:</td>
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</tr>
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<td>Page 6</td>
<td>4, 6, 8</td>
</tr>
<tr>
<td>Page 7</td>
<td>1, 3, 8</td>
</tr>
<tr>
<td>Page 8</td>
<td>1, 3, 4, 6, 9</td>
</tr>
<tr>
<td>Test 3</td>
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</tr>
<tr>
<td>Items:</td>
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<tr>
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<td>3, 5, 7, 9</td>
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<tr>
<td>Page 7</td>
<td>2, 4, 5, 6, 7, 9</td>
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<tr>
<td>Page 8</td>
<td>2, 5, 7, 8, 9</td>
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<tr>
<td>Test 3</td>
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<tr>
<td>Items:</td>
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</tr>
<tr>
<td>Page 10</td>
<td>8, 9</td>
</tr>
<tr>
<td>Page 11</td>
<td>2, 4, 5, 6, 8</td>
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<td>All other items</td>
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<td>EMU</td>
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Basically, the Lorge-Thorndike at this level measures: CFC - CMU - CMC
### TABLE 30
**LARGE-THORNDIKE II SUMMARY**

At this level, the test measures 3 SI factors.

<table>
<thead>
<tr>
<th>TEST</th>
<th>NUMBER OF ITEMS</th>
<th>SI FACTORS</th>
<th>S's PERFORMANCE</th>
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<tr>
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<td>CMS</td>
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</tr>
<tr>
<td>Test 2</td>
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<td></td>
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<tr>
<td>Items:</td>
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<td>CMU</td>
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<td>p. 7-1, 3, 8</td>
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<td>p. 8-1, 3, 4,</td>
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<td></td>
<td>6, 9</td>
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<tr>
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<td>p. 6- 3, 5, 7, 9</td>
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<td>p. 7-2, 4, 5, 6, 7, 9</td>
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<tr>
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<td>EMU</td>
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</tr>
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</table>

Cognitive behaviors subject has now:

Cognitive behaviors needing further attention:
The Lorge-Thorndike at this level measures 8 of the possible 120 SI factors:

**Figure 15**  
**Lorge-Thorndike Diagram 3**

---

**TABLE 31**  
**SI FACTOR COMPOSITION OF LORGE-THORNDIKE III**

<table>
<thead>
<tr>
<th>Test:</th>
<th>Essentially One Factor</th>
<th>Two Factor</th>
<th>One Primary &amp; Variance</th>
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<tr>
<td>Items:</td>
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<td>CMU</td>
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<td>NMU, CMU</td>
</tr>
<tr>
<td>All others</td>
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<tr>
<td>Test 2</td>
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</tr>
<tr>
<td>1 - 25</td>
<td>CMC</td>
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<td>Test 3</td>
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</tr>
<tr>
<td>1 - 15</td>
<td>CMU</td>
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<td>CMS, MSI</td>
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<td></td>
<td>CMU</td>
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<td>CFC</td>
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<td>All others</td>
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</tr>
<tr>
<td>Test 2</td>
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</tr>
<tr>
<td>1 - 24</td>
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<td>SI Factors Measured:</td>
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<table>
<thead>
<tr>
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<th>CMU</th>
<th>CMC</th>
<th>CMS (MSI)</th>
<th>NMU(CMU)</th>
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<td>CFC</td>
<td>CSS</td>
<td>CMR</td>
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</table>

All others: CFR
**TABLE 32**

**LORGE-THORNDIKE III SUMMARY**

At this level, the test measures 8 SI factors.

<table>
<thead>
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<th>TEST</th>
<th>NUMBER OF ITEMS</th>
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<td>CMU</td>
</tr>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
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<td>CMC</td>
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<td>MSI</td>
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<td>CMU</td>
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</tr>
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</tr>
<tr>
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<td></td>
<td></td>
</tr>
<tr>
<td>Items:</td>
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<td>All others</td>
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<td>CFC</td>
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</tr>
<tr>
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</tr>
</tbody>
</table>

Behaviors subject has now:

Behaviors needing further investigation:
Level 4

The Lorge-Thorndike at this level measures 8 of the possible 120 SI factors:

Figure 16
Lorge-Thorndike Diagram 4

<table>
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<tr>
<th>Test:</th>
<th>Essentially One Factor</th>
<th>Two Factor</th>
<th>One Primary &amp; Variance</th>
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<td>CMU</td>
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<td>1 to 25</td>
<td>CMC</td>
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SI Factors Measured:

**Verbal:** CMU  CMC  CMR  CMS(MSI)  NMU(CMU)

**Nonverbal:** CFC  CFR  CSS  (not counted one example CFS-V/CSS)
TABLE 34
LORGE-THORNDIKE IV SUMMARY

The test at this level measures 8 SI factors.

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Behaviors subject has now:

Behaviors in need of further investigation:
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SI FACTOR COMPOSITION OF LORGE-THORNDIKE V

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</table>

SI Factors Measured:

Verbal: CMU CMC CMR(CMU) CMS(MSI) NMU

Nonverbal: CFC CFR CSS *(not counted CFU-V/CFC CFU-V/CSS)*
**TABLE 36**
**LORGE-THORNDIKE V SUMMARY**

The test at this level measures 8 SI factors.

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<th>SI FACTORS</th>
<th>S's PERFORMANCE</th>
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<td>Variance: CMU</td>
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</table>

Behaviors subject has now:

Behaviors in need of further investigation:
Interpretive Aids for the California Test of Mental Maturity - Long Form

Level 5

The CTMM-LF at this level measures 10 of the possible 120 SI factors; it is assumed that other levels will also measure 10 SI factors, based on research which has indicated the CTMM-LF factors to be consistently present at all levels:

Figure 18
CTMM-LF Diagram

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<tr>
<th>Test</th>
<th>SI Factor Composition of CTMM-LF</th>
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</table>

Behaviors subject has now:

Behaviors needing further investigation:
Interpretive Aids for the Otis-Lennon Tests

The Otis-Lennon Elementary II measures 11 SI Factors:

Almost one half of the items on the test measure two factors: CMR and CPR.

About one fourth of the items measure: CMU CSS EMI; thus, three fourths of the test involves only 5 SI factors:

Key:
- Cognition
- Evaluation
- Divergent Production
N = 80
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Subject's present behaviors:

Subject's behaviors in need of further investigation:
The Otis-Lennon Intermediate Level measures 11 SI factors:

Figure 21
Otis-Lennon Diagram 3

About one half of the items measure 3 SI factors:

CMR  CFR  CMS

About one fourth of the items measure the SI factors:

CSS  EMI  CMU

Figure 22
Otis-Lennon Diagram 4

Key:
- Cognition
- Evaluation
- Convergent Production

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# TABLE 42
## OTIS-LENNON INTERMEDIATE SUMMARY

Eleven SI factors are measured.

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The Otis-Lennon Advanced Level measures 11 SI factors:

Figure 23
Otis-Lennon Diagram 5

About one half of the items measure 2 SI factors:
CMR  CFR

About one fourth of the items measure 3 SI factors:
CSS  CMS  EMI

Figure 24
Otis-Lennon Diagram 6

Key:
- Cognition
- Evaluation
- Convergent
- Production
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TABLE 44
OTIS-LENNON ADVANCED SUMMARY

Eleven SI factors are measured.

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Subject's present behaviors:

Subject's behaviors in need of further investigation:
CONCLUSION

The expressed purpose of this paper was the improvement of confidence in psychological testing and provision of effective interpretive aids. That psychological testing is regarded with considerable skepticism cannot be denied. Professional psychometrists have attempted to answer the critics by calling attention to two main problem areas: lack of firm theoretical foundation and abuse or misuse of testing information. The fact that psychological measurement has developed from the beginning without a fundamental psychological theory as a basis has been a major cause for the drift away from contemporary psychological thought. There have been surveys and research studies, as well as general observation, that indicate an astonishing lack of understanding regarding the use of a given measurement on the part of persons who make applications of information from test-results.

The alleviation of the first area would seem to rest in the identification of some fundamental psychological theory that can serve as a tenable basis for psychological testing. Guilford is the first to offer such a theory. It was necessary then, to investigate the claims made by Guilford for the Structure of Intellect theory. The claims for SI theory as being firm, comprehensive, and systematic appear to be justified. SI theory includes the relevant concepts of major contributors of the past: Spearman, Binet, and Thurstone; yet it goes beyond their concepts and structures in attempting to move ever closer toward the truth.

Historical perspective provided several interesting situations. First, there
has been a constant growth in understanding intelligence and its composition; the
current trends show intelligence to be a "many-factored splendor." Secondly, many
psychological measures have been designed for express purposes other than the pur­
pose for which they were ultimately used. Some current measures are actually based
on rationales or theories which have been proven inadequate or misleading. Thirdly,
a part of the narrow conceptualization of intelligence has been perpetuated by theories
that provide for very few behaviors, and thus limit the scope of that which may be
called "intelligence," or the means for appraisal.

Current conditions indicate strong needs for a theory of intelligence based on
broad concepts; for the kinds of concepts that would indicate relationships between
parts and the total structure; for concepts which view intelligence as a part of the total
personality structure. Strong needs are seen in the area of test construction and under­
lying rationales; psychological measures should be designed in such a way that the
behaviors which it sets out to measure are not lost somewhere along the way. Quite
obviously, a test-maker should know what he is measuring, and a test-user should know
what the results mean. An answer to this problem appears to concern the measurement
of specific intellectual behaviors, and the interpretation of these specific behaviors as
descriptive, rather than predictive. Until such time as the needed appraisals are de­
developed, validated and utilized, it is necessary to get the most from the measures
currently available. It was thought that this could be accomplished by a reinterpreta­
tion of such tests according to a tenable psychological theory that could be used as a
basis for mental measurement. Guilford's Structure of Intellect theory was selected;
it appears to be the only theory which could meet most of the needs.
The application of SI theory to measures presently in use provides a conceptual framework which forces the test-user to realize how few of the intellectual behaviors are even touched on by current tests. Hopefully, such realizations would modify the applications of the test-results, and would lead to further investigation. Applying SI theory to current measures forces the test-user to speak, not of some kind of encompassing concept, known as "intelligence," but of specific intellectual behaviors. The emphasis is placed on the description of very definite operations with specific kinds of information. Hopefully, such emphasis will be helpful in making obsolete the misleading concept of IQ, or mental age.

In short, it is earnestly desired that application of SI theory to current measures will improve the confidence in psychological testing by indicating a way in which the specific behaviors measured on any given test may be uniformly identified; that this identification will lead to more constructive use of results from testing; such uses as lead to changes: changes in behaviors, changes in attitudes, changes in social conditions.
APPENDIX I

EXPERIMENTAL TESTS AND ADAPTIONS

Item Description:

Trigraph identifies the section in which the test was discussed in Chapter III.

CFU-V

Gestalt Completion Test - Write the names of objects presented in silhouette figures with enough parts blotted out to make the task of cognition sufficiently difficult for testing purposes.

Concealed Words Test - Recognize words in which part of each letter has been erased - adapted from Thurstone's Mutilated Words.

Peripheral Span - Recognize letters flashed 1/25th second in peripheral vision; individually administered.

CFU-A

Copying Behind - Mark the digits 1 to 5 on an answer sheet following the hearing of the scrambled digits read in rapid succession.

Army Radio Code - Discriminate the code signals for the letters I, N, and T after 25 minutes of instruction and practice.

Dot Perception - Report how many dots, from 1 to 5, are given at the beginning or end of a series of code signals.

CSU-V

Word Combinations - Make a new word using the last letters of one word and the initial letters of the next.
Omelet Test - Recognize a word whose letters have been scrambled.

Disemvoweled Words - Recognize a word whose vowels have been removed.

CSU-A

Haphazard Speech - Recognize short phrases spoken with unusual inflection and pitch changes.

Illogical Grouping - Recognize short phrases spoken with grouping contrary to sense of the passage.

Singing - Recognize words in a short selection sung with piano accompaniment.

CBU

Faces - Indicate which man's face expresses the same feeling or intention as a given woman's face.

Expressions - Indicate the gesture, posture, or expression that expresses the same thought, feeling, or intentions as the given gesture, posture, or expression.

CFC

Picture Classification - Assign pictures to classes each defined by a group of three pictures.

Figure Classification - Recognize classes of three sets of figures each, then assign given figures to the classes.

Figural Class Inclusion - Assign, from five alternatives, one figure that contains the same property as two given pictures.

CSC

Number Classification - Select one of five alternative numbers to fit into each of four classes of three given numbers each.

Best Number Pairs - Choose one of three numbered pairs that makes the most exclusive (best) class.
Word Classification - Select the one word in a set of four that does not belong to the class by virtue of its meaning.

Sentence Classification - Decide whether each given sentence conveys fact, possibility, or a name.

Expression Grouping - Choose the alternative expression that belongs with a given group of expressions.

Picture Exclusion - Indicate the one photographed expression that does not belong with three other given photographed expressions on the basis of the thoughts, feeling, or intentions portrayed.

Figure Analogies - From multiple choices, select a figure that completes an analogy.

Figure Matrix - From multiple choices, select a figure to fill a matrix cell, in a 3 x 3 matrix with a different relation in columns and rows.

Seeing Trends II - Find a repeated relationship between successive pairs of words in a series, the relations being in the form of spelling or alphabetical properties.

Word Relations - A kind of analogies test in which the items of information related are words, the relations being in the form of spelling or alphabetical properties.

Verbal Analogies I - From multiple choices select a word to complete a mean-
ingful relationship.

**Word Matrix Test** - Discover relations in rows and columns, then supply the missing word.

**CBR**

**Social Relations** - Select one of three given statements that expresses the feeling of a given face, taking into account the relationship demonstrated in another, interacting, face.

**Silhouette Relations** - Select one of three photographed faces that expresses the individual's feeling or intention in a silhouette relationship between two people.

**CFS**

**Card Rotations Test** - From a group of six drawings of a card shown rotated and/or turned over, indicate which ones show the card not turned over. (Thurstone's Cards adaption)

**CSS**

**Circle Reasoning** - Discover the rule for marking one circle in sequence with other circles and with dashes.

**Letter Triangle** - Find the system by which letters of the alphabet are arranged in a triangular pattern, with some vacant positions, then select one of the five alternative answers (letters) to fill a designated position.

**CMS**

**Ship Destination** - Find the distance of a ship to a port, taking into account the influences of an increasing number of variables.

**Necessary Arithmetical Operations** - Given the facts of a problem, select from multiple choices the pair of number operations needed to solve the problem.

**Necessary Facts** - Given all the necessary facts but one, state the one that is
missing to make the arithmetical problem structure complete.

Problem Solving - Solve five choice verbally stated problems, using arithmetic.

CBS

Missing Pictures - Select one of three photographed social interactions that completes a given story, making sense of the thoughts and feelings of the actors in the photographed story.

Missing Cartoons - Select one of four alternative cartoons that completes a cartoon strip, making sense of the thoughts and feelings of the characters.

CFT

Paper Folding Test - Select one of five drawings of fully-opened paper that shows how a given folded and punched paper would look unfolded. (Thurstone's Punched Holes)

Surface Development Tests - Indicate which lettered edges in a drawing of a solid figure correspond to numbered edges, or dotted fold lines, in a plane diagram of the unfolded sides of the solid.

CMT

Social Institutions - Suggest two improvements each for institutions, such as taxes, divorce, etc. The score is the number of far-sighted needed improvements given.

CBT

Picture Exchange - Select one of three alternative photographs that, when substituted for a given picture in a story sequence, will change the meaning of the story by altering the thoughts, feelings or intentions of the actors.

CFI

Competitive Planning - Starting with four incomplete, adjacent squares, add
one line at a time, playing for two opponents, in such a way as to maximize the numbers of squares completed by both.

**Route Planning** - A maze-tracing test, in which the S indicates through which lettered points he must pass in order to reach the goal.

**CSI**

**Word Patterns** - Arrange a given set of words efficiently in a kind of cross-word puzzle pattern.

**Symbol Grouping** - Rearrange scrambled symbols of three kinds to achieve a specified systematic order in as few moves as possible.

**S-Test** - Discover problems in items composed of numbers, letters and words and solve the problems.

**CMI**

**Alternate Methods** - List as many as six different ways of accomplishing a given test.

**Seeing Problems** - Write as many as five problems arising from the presence of a given object.

**Apparatus Test** - Suggest two improvements in each of some common appliances.

**Cartoon Predictions** - Select one of three cartoon situations that can be predicted from the given cartoon, based on the feelings and intentions of the cartoon characters.

**MFU**

**Reproduction of Designs** - Reproduce geometric type designs having had but a brief exposure to them.

**Map Memory** - Select from multiple choices the segment of a map previously
studied.

**MSU**

Memory for Nonsense Words - Free Recall - Recall three letter nonsense words presented on a previously studied page.

Memory for Digital Units - Recognize whether given two-digit numbers were previously read aloud.

**MMU**

Picture Memory - Recall names of common objects pictured on a previously studied page.

Word Recognition - Recognize whether given words were on a previously studied page.

**MSC**

Memory for Number Classes-Recall - Recall the class properties of groups of three numbers each that were studied on a previous page.

**MMC**

Classified Information - Recognize classes similar to those on a previously studied page.

Picture Class Memory - Indicate whether or not a given two-element class represents the same concept as one given on a previously studied page.

**MSR**

Memory for Word-Number Relations - Remember the connections based on symbolic properties, between words and numbers given in two pairs and then indicate which number from four alternatives is associated with a new word on the basis of the remembered connection.

Memory for Letter Series - Recognize the series rule associated with a given
letter on a previously studied page.

MMR

**Remembered Relations** - Complete sentences from Alts. in a manner consistent with previously studied relationships.

**Recalled Analogies** - Recall missing elements from previously studied incomplete verbal analogies.

MFS-V

**Space Memory** - Identify the form that was previously exposed in each of five sections within five squares.

**Position Memory** - Recall the position of a number-word pair approximately four hours after the initial administration of the Number-Word test.

MSS

**Memory Transpositions** - Recognize changes in two auditory presentations of the order of two sets of numbers.

**Consonant, Digit, and Nonsense Word Span** - Recall series of consonants, digits, and nonsense words in order after auditory or visual presentation.

MMS

**Learned Information** - Reproduce a short essay, with ideas in proper sequence, given several key terms in scrambled order.

MMT

**Double Meanings** - Recognize pairs of definitions that were or were not presented as words with double meanings in sentences previously studied.

DFU

**Make a Figure** - Given three lines, make different combinations in a limited time.

DSU

**Word Fluency** - Write words containing a specified letter.
**Suffixes** - Write words ending with a given suffix.

**DMU**

**Ideational Fluency** - Write names of things that fit relatively broad classes; e.g. things that are white and edible.

**DFC**

**Figural Similarities** - Use figural aspects of six complex figures to form classes of three figures each, based on common elements.

**DSC**

**Multiple Letter Similarities** - Indicate the different common properties that sets of letters may have in common.

**NMU**

**Picture-Group Naming** - Provide the class name for a group of five pictured objects.

**NFC**

**Figure Concept Grouping** - Classify a group of given figures so that the attribute of each class formed as also an attribute of a given target figure.

**NSR**

**Correlate Completion II** - Discover the rule by which two words are related, then apply it to a third word completing it.

**NSS**

**Operations Sequence** - State the order in which a sequence of numerical operations should be performed in going from one number to another.

**NMS**

**Picture Arrangement** - Given the four pictures of a comic strip, scrambled, indicate the temporal order needed to make sense.

**Sentence Order** - Indicate the temporal order in which three stated events should be placed to make sense.
Form Reasoning - Solve simple equations that are given in terms of combinations of similar geometric figures.

Symbol Identities - Judge whether both members of pairs of words and of numbers is the same or different.

Symbol Manipulation - Judge whether symbolic conclusions based upon given premises are true or not.

Adapted from Report No. 36: Guilford, 1966.
## APPENDIX II

### SELECTED TEST DATA

<table>
<thead>
<tr>
<th>Title:</th>
<th>Stanford-Binet Intelligence Scale - Third Revision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Author:</td>
<td>Lewis M. Terman, Maud A. Merrill</td>
</tr>
<tr>
<td>Publisher:</td>
<td>Houghton Mifflin Company</td>
</tr>
<tr>
<td>Cost:</td>
<td>$33.20 per kit; $4.40 per pkg. 35 booklets; $2.20 per pkg. 35 abbreviated booklets.</td>
</tr>
<tr>
<td>Date of Publication:</td>
<td>1960</td>
</tr>
<tr>
<td>General Type:</td>
<td>Individual test of intelligence</td>
</tr>
<tr>
<td>Forms:</td>
<td>1960, Form L-M; 1937, Form L, Form M</td>
</tr>
<tr>
<td>Administration Time:</td>
<td>Varies according to the ability of the S and the experience of the E; generally 1 to 1 1/2 hours.</td>
</tr>
<tr>
<td>Applicability:</td>
<td>Ages 2 1/2 to 18 years; it is probably most valid for ages 6 to 13.</td>
</tr>
<tr>
<td>Type Score:</td>
<td>Single score IQ based on Pinneau Revised IQ Tables, ie. deviation IQ.</td>
</tr>
</tbody>
</table>

Notable studies in which some form of the S-B was used:

- Hollingworth (1922) "Differential Action Upon Sexes of Forces Which Tend to Segregate the Feebleminded;" used Goddard's revision of Binet's scale for 10% of the cases; the rest were taken from data obtained from Terman's revision; 1,142 cases analyzed.

- Gessell (1922) "Mental and Physical Correspondence in Twins"; two cases used.

- Merriman (1924) "The Intellectual Resemblance of Twins"; 105 pairs of twins studied.

- Terman (1925) "Mental and Physical Traits of A Thousand Gifted Children."
Paterson (1930) "Intelligence and Physique"; the paper contains a review and evaluation of numerous attempts to relate intelligence and physique, the S-B was used in several studies discussed.

Burks, Jensen, and Terman (1930) "The Promise of Youth"; part of the longitudinal study of gifted children; more than 1,000 cases analyzed.

Burks and Tolman (1932) "Is Mental Resemblance Related to Physical Resemblance in Sibling Pairs"; 108 cases studied.

Leahy (1935) "Nature-nurture and Intelligence"; 388 cases used.

Weisenberg, Roe and McBride (1936) "Changes in Adult Intelligence"; Binet vocabulary section used.

Witty and Jenkins (1936) "Intra-Race Testing and Negro Intelligence"; 103 cases of 8000 selected.

Wright (1939) "A Factor Analysis of the Original S-B Scales."

Bruce (1940) "Factors Affecting Intelligence Test Performance of Whites and Negroes in the Rural South"; 159 cases used the S-B and formed one subgroup of total N=953.

Woodworth (1941) "Heredity and Environment: Twins"; mentioned in Newman, Freeman, Holzinger study of 19 pairs of identical twins separated and reared apart.

Jones (1949) "A Factor Analysis of the Stanford-Binet at Four Age Levels."

Skodak and Skeels (1949) "A Final Follow-up Study of 100 Adopted Children."

Maxwell (1954) "Intelligence, Fertility and the Future"; 2215 cases.

Bayley (1955) "On the Growth of Intelligence."


Meyers and Dingman (1960) "The Structure of Ability at Preschool Ages."

Bradway and Thompson (1962) "Intelligence at Adulthood: A 25 Year Follow Up."

Stott and Ball (1965) "Infant and Preschool Mental Tests: Review and Evaluation."

Title: Wechsler Adult Intelligence Scale (WAIS)

Author: David Wechsler
<table>
<thead>
<tr>
<th>Publisher:</th>
<th>The Psychological Corporation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost:</td>
<td>Test kit with manual and 25 record forms - $25; Record forms - $2.40 per pkg. 25, $8.50 per pkg. 100.</td>
</tr>
<tr>
<td>Date of Publication:</td>
<td>1947, 1955</td>
</tr>
<tr>
<td>General Type:</td>
<td>Individual test of adult intelligence.</td>
</tr>
<tr>
<td>Forms:</td>
<td>One: revision and complete restandardization of Form I of the Wechsler-Bellevue Intelligence Scale (1939)</td>
</tr>
<tr>
<td>Administration Time:</td>
<td>Untimed generally - 45 to 90 minutes depending upon the experience of the examiner and the ability of the subject.</td>
</tr>
<tr>
<td>Applicability:</td>
<td>Ages 16 and up to over 75 years</td>
</tr>
<tr>
<td>Type Score:</td>
<td>Verbal Score, Performance Score, Full Scale Score; raw scores are converted to standard scores, summed and translated into IQs according to tables provided based on the age of the subject. They are continuous point scales.</td>
</tr>
</tbody>
</table>

**Title:** The Wechsler Intelligence Scale for Children (WISC)

**Author:** David Wechsler

**Publisher:** The Psychological Corporation

**Cost:** WISC kit with manual, mazes and 25 record booklets - $25.00
Record forms per pkg. 25 - $2.50; per pkg. 100-$8.80.

**Date of Publication:** 1949

**General Type:** Individual intelligence

**Forms:** One

**Administration Time:** 45 to 90 minutes, depending on the experience of the examiner and the ability of the subject.

**Applicability:** Ages 5 to 15
<table>
<thead>
<tr>
<th>Type Score:</th>
<th>Verbal Score, Performance Score, Full Scale Score. Raw scores are converted to standard scores, summed and translated to yield an IQ based on point scales for each age level. Five verbal subtests (with one alternate test) are summed to obtain a Verbal score; five performance subtests (with one alternate test) are summed to obtain a Performance score. The verbal and Performance summed scores are combined to give a Full Scale Score determined by means of a separate table according to age level.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title:</td>
<td>SRA Primary Mental Abilities Tests</td>
</tr>
<tr>
<td>Author:</td>
<td>L.L. Thurstone and Thelma Gwinn Thurstone</td>
</tr>
<tr>
<td>Publisher:</td>
<td>Science Research Associates</td>
</tr>
<tr>
<td>Cost:</td>
<td>$3.00 per 20 test booklets; $.70 per 20 profiles; $1.00 per scoring stencil for each level</td>
</tr>
<tr>
<td>Date of Publication:</td>
<td>PMA tests have been published by SRA in one or another forms and combinations for 1941, 1946, 1953. The series under consideration is the 1962 revision of the earlier forms. Some of the earlier forms have been divided according to age levels; the present series is divided according to grade levels.</td>
</tr>
<tr>
<td>General Type:</td>
<td>Group test of mental abilities: SRA refers to them as being &quot;indices of general intelligence.&quot;</td>
</tr>
<tr>
<td>Form:</td>
<td>5 Forms used according to grade level:</td>
</tr>
<tr>
<td></td>
<td>1. K through 1</td>
</tr>
<tr>
<td></td>
<td>2. 2 through 4</td>
</tr>
<tr>
<td></td>
<td>3. 4 through 6</td>
</tr>
<tr>
<td></td>
<td>4. 6 through 9</td>
</tr>
<tr>
<td></td>
<td>5. 9 through 12</td>
</tr>
<tr>
<td>Administration Time:</td>
<td>K-1 and 2-4: 65 to 75 minutes working time; suggest a two session administration.</td>
</tr>
<tr>
<td></td>
<td>4-6: 52 minutes working time; 55 minutes are needed for directions and practice, making a total of 107 minutes necessary.</td>
</tr>
<tr>
<td></td>
<td>6-9: 35 minutes working time; 40 minutes are needed for directions and practice, making a total of 75 minutes</td>
</tr>
</tbody>
</table>
Applicability: Grades Kindergarten through 12

Type Score: Varies according to grade level:

- **K-1 and 2-4:** Verbal, Spatial Relations, Number Facility, Perceptual Speed, and the incongruous Total in terms of Mental Ages and Ratio IQs. Percentiles can be obtained from the Student Profile sheet.

- **4-6:** Verbal Meaning, Spatial Relations, Number Facility, Perceptual Speed, Reasoning, and Total in terms of Deviation IQs and Percentiles.

- **6-9:** Verbal Meaning, Number Facility, Spatial Relations, Reasoning and Total in terms of Deviation IQs and Percentiles.

- **9-12:** Verbal Meaning, Number Facility, Reasoning, Spatial Relations and Total in terms of Deviation IQs and Percentiles.

<table>
<thead>
<tr>
<th>Title:</th>
<th>Lorge-Thorndike Intelligence Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Author:</td>
<td>Irving Lorge and Robert L. Thorndike</td>
</tr>
<tr>
<td>Publisher:</td>
<td>Houghton Mifflin Company</td>
</tr>
<tr>
<td>Cost:</td>
<td>Reusable test booklets for Grades 3 - 13: per single copy $.72; MCR Answer Sheets: per pkg. of 35 - $3.36; per pkg. of 100 - $7.50; per scoring mask for each level - $.48. 805 IBM Answer Sheets: per pkg. of 35 - $1.80; per pkg. of 100 - $3.90; per scoring key - $.75. Consumable Primary Battery for Grades K - 3: Test booklets per pkg. of 35 - $3.60 Machine scorable test booklets per pkg. of 35-$7.50.</td>
</tr>
<tr>
<td>Date of Publication:</td>
<td>1954, 1957</td>
</tr>
</tbody>
</table>
General Type: Group test of intelligence; authors state it as a "measure of abstract intelligence."

Forms: Two forms: Form A, Form B

Levels:
1. Grades K - 1
2. Grades 2 - 3
3. Grades 4 - 6
4. Grades 7 - 9
5. Grades 10 - 12

(This is the data to be analyzed in this paper; it has been taken from a special research specimen kit. The standard commercial forms are assumed to be essentially the same. The standard commercial series has two forms: for Grades 3 - 13 - Forms 1 and 2; for Grades K - 3, Form A and Form B. Level 1 is for K and 1; Level 2 is for Grades 2 and 3. For Grades 3 - 13, Level A-Grade 3; Level B-Grade 4; Level C-Grade 5; Level D-Grade 6; Level E-Grade 7; Level F-Grades 8 and 9; Level G-Grades 10 and 11; Level H-Grades 12 and 13).

Administration

Time: Primary batteries (Levels 1 and 2) untimed 20 to 30 minutes
Levels 3, 4, 5 - Verbal Battery - 34 minutes Nonverbal Battery - 27 minutes

Applicability: Kindergarten through 12th Grade

Type Score: Deviation IQs (Mean of 100, SD of 16) Verbal and Nonverbal
Raw Score tables are provided for Grade Percentiles for each form for summed Verbal battery scores and summed Nonverbal battery scores. Tables for grade and age equivalents of the same are provided.

Title: California Test of Mental Maturity (Long Form) 1963 Revision (CTMM)

Author: Elizabeth T. Sullivan, Willis W. Clark, and Ernest W. Tiegs

Publisher: California Test Bureau, Division of McGraw-Hill Book Company
| Cost: | Test booklets per pkg. of 35: Levels 0 and 1 - $6.65; Levels 2 and 3 - $7.35; Level 4 - $7.75; Level 5 - $8.00
Answer sheets: IBM 850 and IBM 1230: per pkg. of 50 - $2.50; per box of 500 - $22.50
Scoreeze: per pkg. of 25 - $2.50; per box of 250 - $22.50 |
| Date of Publication: | 1963 |
| General Type: | Group test of intelligence; the authors refer to it as "a comprehensive measure of functional capacities basic to learning, problem solving, and responding to new situations." |
| Forms: | California Short-Form Test of Mental Maturity, 1963 Revision: 8 levels
California Short-Form Test of Mental Maturity, 1967 S-Form: 6 levels
California Test of Mental Maturity (Long Form), 1963 Revision: 6 levels |
| Administration Time: | Varies according to level; ranges from 48 minutes for Level 0 to 1 hour and 21 minutes for Level 5 |
| Applicability: | Level 0 - Kindergarten and early Grade 1
Level 1 - Later Grade 1 to Grade 3
Level 2 - Grades 4 - 6
Level 3 - Grades 7 - 9
Level 4 - Grades 9 - 12
Level 5 - Grades 12, College, Adult |
| Type Score: | Mental Ages and Deviation IQs for Language, Non-Language, Non-Language, and Total. Scores are obtained from reference tables; percentiles, standard scores and stanines are provided for each of the five factors, for Language, Non-Language, and Total. |
| Title: | Otis-Lennon Mental Ability Test |
| Author: | Arthur S. Otis and Rogert T. Lennon |
| Publisher: | Harcourt, Brace and World |
| Cost: | Handscore Test Booklets (all levels) - $5.50 per pkg. of 35 |
Primary II Machine-Scorable Test Booklets - $6.50 per pkg. of 35
Elementary I Machine-Scorable Test Booklets - $6.80 per pkg. of 35
Elementary II, Intermediate, Advanced Test Booklets may be 
hand or machine scored.
Answer sheets: IBM 805 and 1230, or Digitek are available at 
standard market price and package.

General Type: Group test of intelligence - authors' state that the test is one of 
"general mental ability, or scholastic aptitude"; they claim that it measures or samples a broad range of cognitive abilities.

Date of 
Publication: 1967

Forms: Two forms at each level: Form J, Form K

Administration 
Time: Working Time

Primary 1 and II 30 minutes
Elementary I 45 minutes
Elementary II Intermediate 40 minutes
Advanced

Applicability: Primary I - last half of kindergarten

Primary II - first half of Grade 1 (suggest that less mature Ss 
take it during the last half of Grade 1)

Elementary I - last half of Grade 1 to end of Grade 3 (also 
suggested for slower Ss and Ss with reading problems 
at beginning of Grade 4)

Elementary II - Grades 4 to 6

Intermediate - Grades 7 - 9

Advanced - Grades 10 - 12

The authors' suggest using the next lower level for slower, less able and the next 
higher level for advanced Ss. No grade designations appear on any materials used by
Type Score: Deviation IQs, Percentile Rank, Stanines (by age), Stanines (by grade).

Primary I, II and Elementary I also have mental age norms.
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The dissertation submitted by Patricia Chisholm has been read and approved by members of the School of Education.

The final copies have been examined by the director of the dissertation and the signature which appears below verifies the fact that any necessary changes have been incorporated and that the dissertation is now given final approval with reference to content and form.

The dissertation is therefore accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

June 2, 1970
Date

Samuel T. May
Signature of Adviser