RELATIONSHIPS BETWEEN SELECTED MUSICAL AURAL DISCRIMINATION SKILLS AND A MULTIVARIATE MEASURE OF INTELLECTUAL SKILLS

DISSERTATION

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By

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This study attempted to explore the strength and nature of relationships between specific intellectual information-processing skills included in a multi-dimensional model conceived by Guilford, and measured by Meeker's *Structure of Intellect - Learning Abilities Test*, and specific musical aural discrimination skills as measured by Gordon's *Musical Aptitude Profile*. Three research questions were posed, which involved determining the strength and the nature of the relationship between *MAP* melodic, rhythmic, and aesthetic discrimination abilities and the intellectual information-processing skills comprising the *SOI - LA*. Both instruments were administered to 387 fourth, fifth, and sixth graders from schools in the Dallas area.

After a pilot study established the feasibility of the study and reliability estimates of the test instruments, multiple regression analysis determined that 10% to 15% of the variance between intellectual information-processing skills and the individual musical aural discrimination abilities was in common (r = +.32 to r = +.39).

It was further determined that only six specific *SOI* intellectual dimensions, all involving the skills of

"Cognition" and "Evaluation", were significantly related to the musical aural discrimination abilities. Through the use of the Coefficient of Partial Correlation, the strength of each individual information-processing skill's unique contribution to that covariance was determined.

The study indicated that "Semantic" mental information-processing skills, involving the ability to recall an abstract meaning or procedure given an external stimulus, play an extremely important part within this relationship. Skills of a "Figural" nature, which involve comprehending either a physical object or an non-physical idea and separating it from other impinging stimuli also enter into the relationship, although not to so high an extent. Finally, it was observed that the dimensions involving an understanding of "Systems", those mental skills which deal with groupings of figures, symbols, or semantic relationships, also was important to the relationship.

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CHAPTER I

INTRODUCTION

From the beginnings of psychological research, investigators have attempted to understand the nature, structure, and distribution of mankind's intellectual and artistic attributes. Gordon noted that "throughout history, man has been concerned with his orgin and destiny. It is no wonder, then, that he has also been constantly concerned with the source of his special talents" (20, p. 3). Among these special talents, few have fascinated researchers more than those labeled "intelligence" and "musical ability". Empirical evidence has suggested that individuals possess differing capacities for knowledge, i.e., intelligence, and capacities for music, i.e., musical ability.

Gardner (15) and Restak (46) have argued that since both intelligence and musical ability are functions of the brain, the mental processes which create both intelligence and musical ability may be the same or similar. Therefore, given the common source of these human attributes, behavioral manifestations of the two phenomena logically should be related. Casual observation, however, has revealed that the same individuals may exhibit widely varying degrees of success in their completion of intellectual and musical tasks. This apparent contradiction has provided an impetus toward continuing study of the relationships within this area.

A review of the related research literature indicated that, in general, there is a small, positive relationship between success at tasks designed to provide inferential information about varying degrees of intellectual ability and success at tasks designed to provide similar information regarding musical ability. Lacking a perfect relationship, these findings have suggested that perhaps there are some related constituent parts of intelligence and musical ability as manifested by various behaviors, while some other constituent parts are unrelated. That same review of prior research, however, revealed that prior investigation has not yielded information about which constituent parts of intelligence enter into the intelligence/musical ability relationship. It was therefore decided that this inadequacy in our body of knowledge ought to be rectified; an effort to explore this relationship in greater detail was the initial basis for the present study.

To clarify the basic for the present study, and to better indicate the area of investigation, the relationship between intelligence as indicated by intellectual behaviors, and musical ability as indicated by musical behaviors, can be depicted graphically by the Venn diagram in Figure 1.

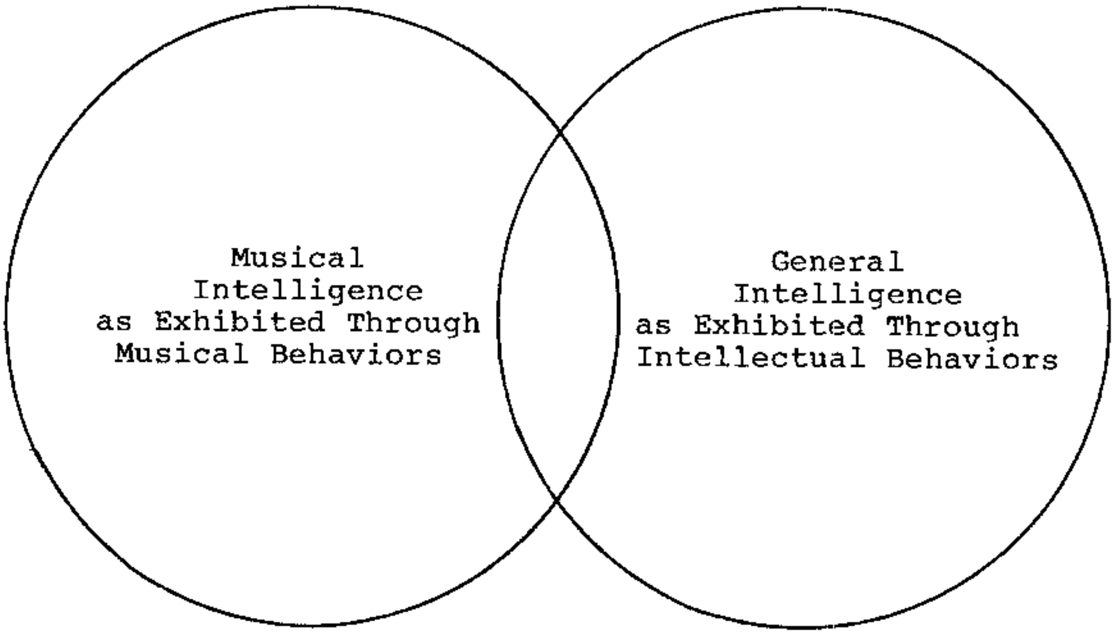

Fig. 1--A Venn diagram of the relationship between musical aural discrimination abilities and mental information-processing skills.

The area of overlap between the two circles represents the portions of these two attributes which exists in common. It is the nature of this shared portion which is the major focus of the present study.

Specifically, this study seeks to explore the intellectual ability/musical ability relationship through the observation of selected musical and intellectual behaviors and the analysis of relationships among those behaviors. It seeks to confirm prior research regarding the magnitude of these relationships and to extend present knowledge by providing information regarding the nature of the relationship's constituent parts.

Background of the Study

Belief in a positive relationship between human musical and intellectual attributes is longstanding. Plato, writing in his Republic, stated that he would begin education of the young "with music and proceed thereafter to gymnastic" (48, p. 14) because of music's effect upon the training of the soul and mind.

> And therefore, musical training is a more potent instrument than any other, because rhythm and harmony find their way into the inward places of the soul, on which they mightily fasten, imparting grace, and making the soul of him who is rightly educated graceful, or of him who is ill-educated ungraceful (43, p. 522).

Lowell Mason, whose efforts resulted in the first inclusion of music in a public school curriculum, stated that musical study was advantageous primarily in three ways: it would benefit the students physically, morally, and intellectually (3, p. 39). A subcommittee of the Boston School Board, reporting on Mason's proposal to the full Board in 1837, agreed with Mason, particularly in regard to a belief in the positive relationship between intellectual development and musical instruction:

> Music had its place among the seven liberal arts, which scholastic ages regarded as pertaining to humanity. Arithmetic, Geometry, Astronomy, and Music -- these formed the quadrivium. Memory,

> comparison, attention, intellectual faculties -- all of them are quickened by a study of its principals. It may be made to some extent a mental discipline (3, p. 41).

Though the impact of music education on intellectual development as a justification for school music has varied in importance over the years since the Boston report, interest in the intellectual/musical ability relationship seems to have continued among researchers, such as Drake (9), Gallagher (14), Gordon (19, 21), Holmstrom (30), Rainbow (44), and Whellams (52). However, a generally-accepted explanation of the nature of this relationship has been an elusive, unreached goal due, in part, to difficulties in defining, describing, and measuring the two phenomena.

Theoretical Foundations of Intellect and Problems of Measurement

In order to understand the rationale for the present study, it is necessary to briefly delve into the nature of the standard measure of intelligence for nearly eighty years, the IQ test.

The IQ (Intelligence Quotient) is a weighted average score on a group of tests of mental skills whose mean was set at 100 and assumed to occur thoughout the population in a normal distribution. Its fundamental assumption has been that intelligence is a single, monolithic attribute. This assumption, however, has remained unproven since it was first asserted in the early years of this century by the pioneer American researchers Goddard (17), Yerkes (55), and Terman (51).

More recently, theorists, such as Gardner (15), Kamin (33, 34), Gould (23), Fincher (11), and Guilford (24), have questioned the veracity of intelligence measures which yield a single general score because they have contended that intelligence is a more complicated, multifaceted phenomenon that cannot be reduced to a single score. Gardner (15) has argued that there may be different kinds of "intelligences" which are present in varying degrees within the cognitive processes of individuals; however, he also has suggested that the exclusivity of each "intelligence" is far from absolute.

> These intelligences are fictions -- at most useful fictions -- for discussing processes and abilities that (like all of life) are continuous with one another; Nature brooks no sharp discontinuities (15, p. 70).

If, then, intellectual ability is multidimensional in nature, information is lost when the attribute is measured using a unidimensional instrument, i.e., one which yields only a single score. In studying a relationship which has been identified by prior research as an imperfect relationship, such as the one in the present study, it is therefore impossible to determine which dimensions of intelligence are or are not related to the other phenomena by using a unidimensional test. All previous studies of the intellectual behaviors/musical behaviors relationship have used the single-score I.Q. test to provide inferences about the attribute of intelligence; therefore, while previous study has provided information about the magnitude of the relationship, it has not yielded information about the dimensionality of intellectual attributes and their relative contribution to the relationship.

Because the exploration of relationships using different intellectual tasks rather than a single I.Q. test had not been previously attempted, the investigator was provided little guidance as to which types of intellectual tasks should be included within such a study. An apparently viable solution was found in the theoretical work of J.P. Guilford who proposed a multi-dimensional model of intellectual functioning, _The Structure of Intellect_ (25).

Unlike the concept of the I.Q., the Guilford _Structure of the Intellect_ holds that it is improper to attempt to reduce the many different mental processes to a single, measurable general factor.

> As to general terminology, the term "intellect" can be meaningfully defined as the system of thinking and memory factors, functions, or processes . . . it is not a unique, unitary phenomenon (41, pp. 13-22).

It should be noted that the Guilford _Structure of the Intellect_ is but a theoretical model, a "useful fiction," created through Guilford's factor analyses applied to existing intelligence tests (24). It does not represent any physical actuality within the brain nor any real structure that may be seen and measured. It simply "is convenient for depicting the intellectual abilities as delineated by multivariate analyses of measured performance. . . . (and) no priority - logical or psychological, developmental or hierarchical - is intended either within or between the categories of classification" (41, pp. 13-22). Guilford thus refuses the error of reification, i.e., regarding something as real simply because it has been named.

Horn and his colleagues, in a critical analysis of the model, concluded that Guilford's SOI provides a valuable "taxonomy of intellectual functions," (31, p. 32) and is valuable because the "development of such a taxonomy is an important, if not a necessary, first step in research" (32, p. 76).

Others have supported the usefulness of Guilford's model. Meeker summarized that, "Even the severest critics of the theory . . . have stated that it has proved a useful stimulus to creative test development and has provoked considerable worthwhile thinking about the nature of human abilities" (41, p. 22).

> SI (Structure of Intellect) theory has been a stimulus to the development of new variables. It has helped to indicate gaps in test batteries and to promote the construction of quite novel and interesting infant, preschool, school-age and adult tests. It is impossible to estimate the importance of this kind of contribution of the

> theory, but it is generally believed to be substantial (41, p. 22).

By relating existing intelligence/academic aptitude tests to Guilford's model (40), Meeker developed and published a test for measuring certain of the SOI intellectual skills that she concluded were critical to school success and success in learning in general. She began "implementation of this kind of research with the logical assignment of Binet items to the SOI" (40, p. 26). Meeker then constructed items suited for use by children, since Guilford's previous tests and materials were designed for use with adults. In her *Structure of Intellect - Learning Abilities Test*, (*SOI-LA*), "the format, content, and response mode of the *SOI-LA* were scaled down to a level that would be appropriate for elementary school students" (42, p. 2).

Theoretical Foundations of Musical Ability and Problems of Measurement

Similar unidimensional versus multidimensional arguments have occured regarding musical ability. Although some factor-analytical studies, most notedly the early studies of Drake, (8), and those reported by Wing (53) and McLeish (39) sought to support the existence of a single general musical factor, other researchers and musicians have felt that musical ability is comprised of a number of different factors or elements.

Seashore, one of the earliest researchers into the psychology of music, regarded musical ability as a chain of factors. He stated his belief that musical ability is "not one, but a hierarchy of talents, branching out along certain trunk lines into the rich arborization, foliage, and fruitage of the tree, which we call the musical mind" (49, p. 2). Seashore did not define his concept of the "musical mind", but it was in an effort to determine some of the components of the "musical mind" that many researchers have attempted factor analytic studies of music and musical ability.

Other writers agreed with Seashore's supposition. Farnsworth indicated his belief in "the existence of several rather independent musical abilities rather than a single all-embracing one" (10, p. 152). Drake (7) later changed his unidimensional view in support of two musical factors. Franklin (13) indicated his belief in the existence of two different musical factors: (1) a "mechanical-acoustic" factor, which involved pitch, timbre, time and intensity discrimination and (2) a "judicious-musical" factor, an aesthetic factor which indicates creative musical talent. Bower (4) concluded that there was no single general factor in musical ability but instead felt her study showed support for the existence of three group factors. Burroughs and

Morris (5) found four factors and Karlin (35, 36,) identified eight. Henkin (28) also argued that there are three musical aural discrimination components: 1. rhythm discrimination, 2. melodic discrimination, and 3. sensitivity to instrumental tone color. His later research (29) identified an additional polyphonic melodic factor.

Many previous researchers have agreed that musical ability consists of several factors, even though general agreement upon how many specific factors may exist and what their general nature may be is yet unachieved. The musical factors defined to this point, however, do seem to include tasks having to do with pitch, rhythm, and some sort of aesthetic sensitivity.

The makers of past musical tests have also felt that musical ability was multi-dimensional, for musical ability tests typically have consisted of a number of different musical aural discrimination tasks, including those that attempted to determine hearing acuity, evaluation of instrumental timbre, and measures of melodic, harmonic, and rhythmic discrimination skills. Gordon has furnished an analysis of the major musical aptitude/achievement tests, and indicated that the nature of each separate task which was included within the musical test belonged to one of five different task types. These different types of tasks were as follows:

1. Audio-Acoustical Perception
2. Tonal Concepts
3. Rhythm Concepts
4. Expressive-Interpretive Concepts
5. Achievement Skills (20, pp. 26-27).

Gordon further indicated that he felt that there appears to be "three main components of musical aptitude" (20, p. 25). He indicated that he felt that the first type of task, the "Audio-Acoustical Perception" task was not really a factor of musical ability, but rather a measure of sensory acuity, involving "'hearing' but not necessarily 'musical understanding' or 'musical anticipation'. Thus, the "Audio-Acoustical Perception" type of task really is a measure of physical sensitivity and not proper to musical understanding.

Some tests, such as those developed by Bentley (2), Drake (7), Wing (54), Kwalwasser/Dykema (37), and Gaston (16), gave instructions for creating a single total score, in a process similar to the I.Q.; however, other test-makers, such as Gordon (19) and Seashore (50) were careful to instruct those who used their tests to examine the individual subtest scores and their general pattern very carefully, in addition to considering any total score that may be computed.

Thus it appears that to regard musical ability as a single, monolithic human attribute is as improper as to regard intelligence in the same manner.

In keeping with the view that musical ability is a complex, multi-dimensional attribute, it was determined that the set of three major musical aural discrimination skills which are measured by the Gordon *Musical Aptitude Profile* (19) would be used. The three main sections of this test measure the subject's melodic, rhythmic, and sensitivity discrimination skills, and correspond with the three major components of music indicated by Gordon (20, p. 25) and Henkin (28, 29). In addition, a number of other factors support its use. It is practical for use (it is in-print and easily available), possesses a high degree of musical quality (the discrimination examples were recorded by professional musicians using modern recording techniques), and a large amount of research has been performed attesting to its reliability and validity by Gordon (18, 19, 21, 22) and others (6, 12, 27).

It was recognized by the researcher that there may very well be additional components of musical ability other than the three that the *Musical Aptitude Profile* is designed to measure; these components may or may not be aural in nature. Based upon the previous research which was discussed above, however, it appears that the three aural musical components of melodic discrimination, rhythmic discrimination, and aesthetic discrimination were deemed proper and sufficient to indicate the major components of musical ability within the bounds of the present study.

Foundations in the Intellectual/Musical Ability Relationship Research

As a result of using different I.Q. and musical aural discrimination tests, comparisons of the many previous correlational studies have yielded large variations in the reported correlations between measured musical abilities, i.e. chiefly musical aural discrimination abilities, and intelligence. Some of those studies have, however, reported correlations between individual musical subtest scores, i.e., measures of specific, individual musical aural discrimination skills, and an I.Q. score as well as correlations between the total music test scores and the I.Q. test scores. Conclusions drawn from these studies seem inconsistent and inconclusive. Some apparently indicate a small relationship between intelligence and musical abilities, but not to generally accepted levels of statistical significance; others found a relationship of statistical significance, but its magnitude was relatively small. Most previous studies have suggested that there is a slight positive relationship between musical aptitude and intelligence, but suggest that subjects who score highly on musical tests tend to possess "a high level of intelligence, although a high level of intelligence cannot necessarily predict high musical ability" (47, p. 21).

Viewed as a whole, previous study of the intelligence/ musical ability relationship has suggested that the nature and magnitude of this relationship fluctuates when the particular musical factor under study changes. Though this is not a surprising conclusion, it does further suggest that perhaps differing components of musical ability may be related to intellectual abilities in different ways.

Thus, in order to more accurately determine the relationship's magnitude and to provide a more detailed assessment of the nature of this relationship, further research was needed.

Definitions

Musical Aural Discrimination Abilities

The large amounts of confusion, contradiction, and misunderstanding in this area's body of prior research was due, in part, to difficulties in defining the elements under investigation. Farnsworth indicated a preference for the use of the word "ability" when dealing with musical capabilities because, the term ability suggested the power to act but indicated nothing about "the heritability or congenital-ness of inferred potentiality" (10, p. 151). However, the term "musical ability", which has been used merely to facilitate discussion to this point, is an extremely general term. Because of the broad nature of the term as indicated by Farnsworth, it is insufficiently detailed to enable the formulation of any research purpose or questions.

The word "capacity" is also discussed by Farnsworth as bearing the "connotation of innate ability" (10, p. 151). However, Farnsworth makes a very important point when he then indicates that capacities are impossible to directly observe or measure. They are "inferred from behavioral manifestations such as test scores" (10, p. 151). Thus the behaviors of the test subjects are assumed to indicate their capacities.

For the present study, therefore, the question of how to define the nature of musical ability was approached from a behavioralist viewpoint. Musical ability was examined through the behaviors of the subjects on tasks intended to provide inferences regarding subject's capacities. It was necessary in the interests of accuracy to adopt a policy of conservatism in the evaluation of the data and drawing of conclusions. It was beyond the scope of this study to settle the issue of the precise nature of musical ability; rather, the study focused upon the musical and intellectual behaviors of the subjects.

Thus, the expression "musical ability" was not used within the present study; instead, the expression, "musical aural discrimination abilities" was used to indicate that the study considered only the measured behaviors of the subjects.

The use of the term "musical aural discrimination abilities" within the present study was defined operationally as a subject's success at a variety of musical aural discrimination tasks which are designed to allow inferences about the subject's unmeasurable musical abilities. It should be pointed out that even if the musical aural discrimination tasks are designed to allow the drawing of inferences about the subject's musical capacities, the tasks are not designed to draw inferences about either the source or the nature of those capacities.

Intelligence

Arrival at a satisfactory definition for "intelligence" seems to be equally elusive. The *Journal of Educational Psychology* sought to solve the definition problem by asking a number of known and respected researchers the question, "What do you conceive intelligence to be and by what means can it best be measured?" (45, p. 2). Resnick summarized the answers.

> Intelligence was defined variously as: the ability to "carry on abstract thinking" (Lewis Terman); "the power of good responses from the point of view of truth or fact" (E.L. Thorndike); "learning or the ability to learn to adjust oneself to the environment" (S.S. Colvin); "general modifiability of the nervous system" (Rudolf Pinter); a "biological mechanism by which the effects of a complexity of stimuli are brought together and given a somewhat unified effect in behavior" (Joseph Peterson); an "acquiring capacity" (Herbert Wodrow); and a "group of complex mental processes traditionally defined . . . as sensation, perception, association, memory, imagination, discrimination, judgement, and reasoning." (M.E. Haggerty) (45, p. 2).

As is apparent from the above excerpt, "there is no general agreement even about what intelligence is, and at least one educational psychologist has defined intelligence as the quality that I.Q. tests measure" (38, p. 94). The previous definition, while sounding circular upon first consideration, indicates that perhaps a adopting a behaviorist definition of intelligence may be more useful than any attempt at creating an absolute definition.

Thus, the word "intelligence" will refer to those "mental information-processsing skills" determined by the subject's degree of success on tests specifically designed to allow the inference about the degree to which the subject possesses that particular mental information-processing skill.

This definition is supported by that achieved by Haggerty above, who viewed mental information-processing skills as complex and multi-dimensional and allowed the measurement of individual components by subject behaviors.

Thus, in the present study, there will be no attempt to combine the individual aural musical discrimination skills into any such concepts as musical "aptitude" or "talent" or into any kind of unitary concept of "intelligence". The individual aural musical discrimination abilities and individual mental information-processing skills will be left as individual skills and no creation of a unitary concept of either musical processing or intelligence will be attempted.

The Present Study

This study attempts to explore the degree and nature of relationships between subjects' success at a variety of different intellectual and musical aural discrimination tasks. On the basis of the nature of the construction of past musical and intelligence tests and recent research findings, this study assumed that both musical aural discrimination skills and intellectual information-processing abilities were complex, multi-dimensional phenomena.

The present investigation is therefore intended to yield information about the magnitude of the relationships between the various intellectual tasks and each individual musical aural discrimination task. It differs from past studies in that it also seeks the identification of specific intellectual tasks whose outcomes are most closely related to the outcomes of the musical aural discrimination tasks, and the examination of possible patterns of intellectual tasks important to the relationship across the musical aural discrimination tasks.

This study examined the magnitude of the total relationship between specific musical aural discrimination abilities and mental information-processing skills in an effort to confirm and extend previous studies; further, the present study also attempted to determine the nature of the specific mental information-processing skills that entered into a relationship with individual musical aural discrimination abilities and their specific contribution to the relationships. Those mental information-processing skills were examined to determine if any sort of pattern in the relationships existed. Specifically, the following research problems were addressed:

1. To estimate the relationship between success at any individual mental task or any group of mental tasks and melodic discrimination skills; if such a relationship is found, what is the estimated magnitude of the unique contribution of each individual mental information-processing skill?

2. To estimate the relationship between success at any individual mental task or any group of mental tasks and rhythmic discrimination skills; if such a relationship is found, what is the estimated magnitude of the unique contribution of each individual mental information-processing skill?

3. To estimate the relationship between success at any individual mental task or any group of mental tasks and discrimination skills in the aesthetic judgement of musical performance; if such a relationship is found, what is the estimated magnitude of the unique contribution of each individual mental information-processing skill?

This study therefore sought to create a more discriminating view of the functions of the mind that create varying skill levels at intellectual and musical aural discrimination tasks so that a more cogent theory of musical aural skills may be developed.

The knowledge gained by this present study may become valuable in the further study of the effects of musical study upon human mental development. For example, if the study of music can be shown to increase specific, individual mental information-processing skills, as was believed by Plato and Lowell Mason, then music educators may be furnished with justification for the study of music for intellectual, as well as aestetic reasons. This study, by itself, is insufficient to prove such a conclusion; however, the present study is a necessary first step in that process in that it seeks to determine which individual mental information-processing skills are related to musical aural discrimination abilities. Once the specific mental information-processing skills are identified, further research can determine the effect of musical studies upon those specific skills.

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CHAPTER II

RELATED LITERATURE

This chapter deals with four major topics, all of which deal with literature related to the present study. The first section consists of a general overview of the results of previous studies into the musical aural discrimination ability/mental information-processing relationship, (all of which used the single IQ figure as a measure of the subjects' mental skills) viewed as a group. The results from these past correlational studies were separated into three groups: correlations between the IQ scores and melodic aural discrimination abilities, correlations between IQ scores and rhythmic aural discrimination abilities, and correlations between IQ scores and aesthetic aural discrimination abilities. This section is intended to indicate the variety of results in past studies and to graphically depict the range of correlations past researchers have reported between the three different musical aural discrimination abilities under consideration and IQ scores.

A detailed discussion of individual studies in this area is next presented, with critical commentary on each study's strengths and weaknesses. This discussion of individual studies is by no means meant to be exhaustive, but is intended to include the major previous studies in this area to indicate that several confounding factors in the previous studies may account for the variety of correlations reported.

The Guilford _Structure of the Intellect_ model is then presented, with comments upon its nature and criticisms that have been voiced to the model. Meeker's _Structure of Intellect - Learning Abilities Test_ is included within this discussion, along with published reliability measures, reviews, and published validity studies.

Finally, a discussion on the Gordon _Musical Aptitude Profile_ is presented, with comments on the specific musical aural discrimination abilities the test is designed to measure, and the test's published reliability and validity estimates.

The Musical Aural Discrimination Ability/Intelligence Relationship

A high degree of variation in the strength of the relationship between intelligence and musical aural discrimination skills has been reported in previous studies. The reported correlations vary to a considerable extent, not only in a some reported global average of musical "aptitude" between the studies, but also between specific musical aural discrimination skills. The reported relationship between IQ scores and the three main musical aural discrimination skills under consideration within the present study, those of pitch discrimination, rhythmic discrimination, and aesthetic discrimination, is now considered.

The Pitch Discrimination/IQ Score Relationship

The musical aural discrimination ability of pitch discrimination has been measured by musical aural discrimination tests using a variety of tasks, including the determination of the extent of a student's ability to recognize if the second tone of a pair is higher or lower than the first, whether a group of notes goes predominately up or down in pitch, or if the second of a pair of intervals is larger or smaller than the first. The observed correlations between pitch discrimination skills and IQ scores (arrived at by various different IQ tests) have varied greatly in prior research, as indicated by Table I.

It will be noted that an extreme amount of variability is present in the correlations reported in Table I, even between studies that have used the same musical aural discrimation test. Different IQ tests use differing mental information-processing tasks and weight the results of these tasks in differing manners to arrive at an IQ score. This high amount of variability seems to indicate that the differing tasks would create a differing relationships with the specific musical aural discrimination ability.

TABLE I

CORRELATIONAL COEFFICIENTS BETWEEN IQ SCORES AND VARIOUS AURAL MEASURES OF PITCH DISCRIMINATION

study	date	musical test	sample size	correlation coefficient
Beard - a	1965	Wing	73	.02
Beard - d	1965	Wing	72	.10
Drake	1940	Seashore	163	.12
Franklin - a	1956	Seashore	79*	.13
		Wing	79*	-.10
Franklin - b	1956	Seashore	157*	.15
		Wing	157*	.12
Farnsworth	1931	Seashore	150	.14
Holmstrom - c	1963	Wing	651	.17
Holmstrom - d	1963	Wing	120	.17
Christy	1956	Seashore	103	.18
Beard - c	1965	Wing	72	.18
Manor	1950	Seashore	not reported	.21
Whittington - b	1957	Wing	24	.21
Rainbow	1956	Seashore	291	.22
Whellams - a (non-verbal IQ)	1971	Wing	129*	.23
Beard - b	1965	Wing	73	.24
Holmstrom - a	1963	Wing	189	.28
Gordon - a (Verbal IQ)	1965	M.A.P.	862*	.30
Bentley	1966	Bentley	166	.30
Salisbury & Smith - a	1929	Seashore	131	.31
Salisbury & Smith - b	1929	Seashore	144	.31
Fracker & Howard	1928	Seashore	230	.32
Whellams - b (verbal IQ)	1971	Wing	129*	.32
Holmstrom - b	1963	Wing	765	.32
Holmstrom - e	1963	Wing	60	.32
Edmonds - a	1960	Wing	60	.33

*Same subjects within the sample group

TABLE I -- Continued

study	date	musical test	sample size	correlation coefficient
Gordon - b (Non-verbal IQ)	1965	M.A.P.	862*	.34
Weaver	1924	Seashore	94	.35
Whittington - a	1957	Wing	24	.36
Edmonds - b	1960	Wing	58	.36
Mainwaring - b	1931	Mainwaring	34	.39
Bentley	1955	Wing	182	.39
Gallagher	1971	M.A.P.	253	.42
Whellams - c (verbal IQ)	1971	Bentley	129*	.45
Whellams - d (non-verbal IQ)	1971	Bentley	129*	.50
Mainwaring - a	1931	Mainwaring	83	.53
Highsmith	1929	Seashore	59	.58

*Same subjects within the sample group

The letters which follow some of the studies (which are listed several times in Table I above) indicate that in these studies, more than one melodic discrimation or IQ test was used on the same subject group. Thus, assuming that the measurement devices are reliable, the differing scores that the same subjects received on different tests (and thus the differing correlations reported) would seem to indicate that the differing tasks which comprise the tests are measuring different attributes.

Figure 2 is a histogram which clarifies the central tendencies of this body of research, taken as a group The largest number of the correlations occurred between r = +.30

and r = +.39; however, as can be seen, a considerable number of studies report different correlations.

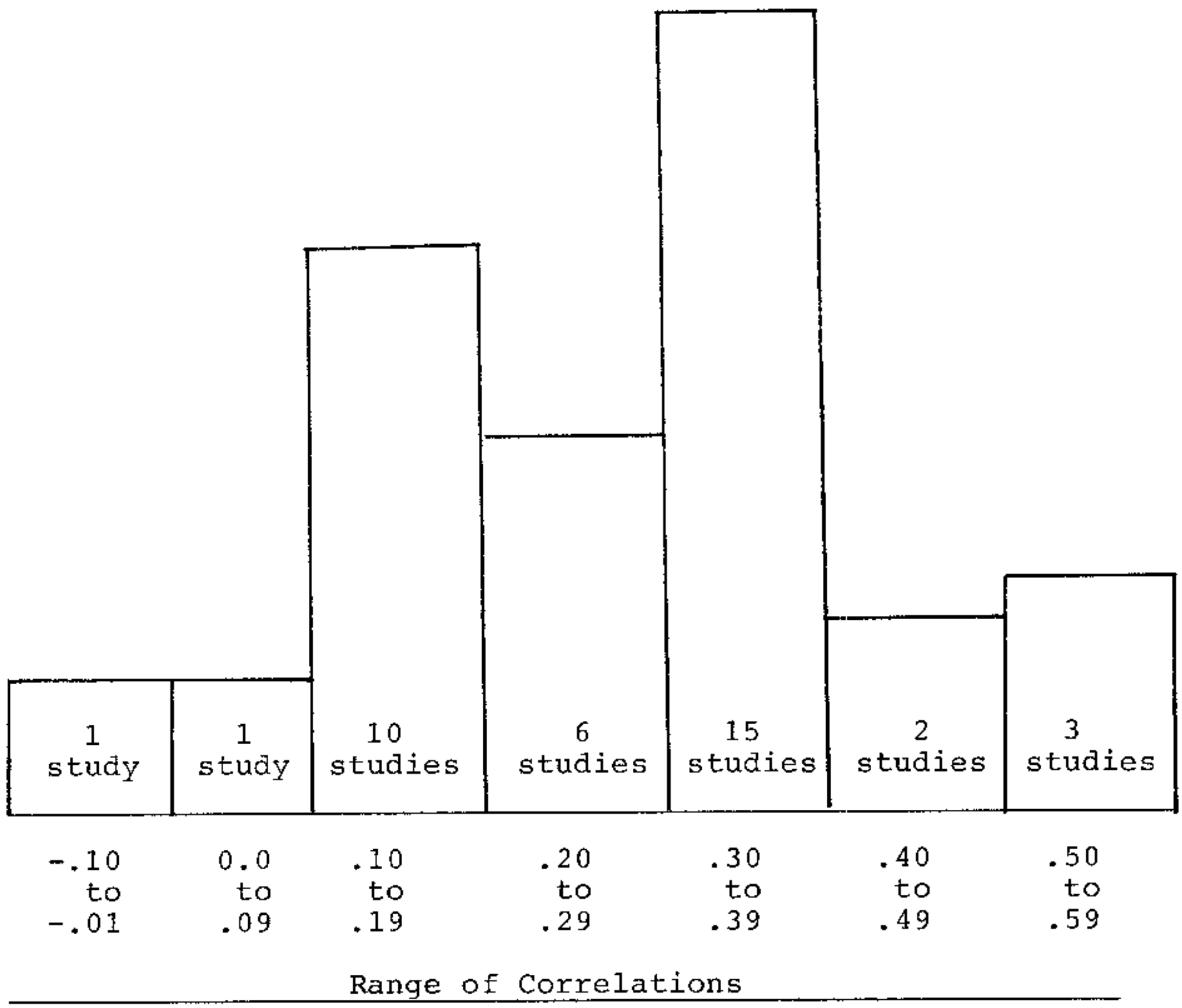

Fig. 1--Range of correlational coefficients of the relationship between pitch aural discrimination ability and IQ scores.

The differences in the correlational coefficients seen in the results of the studies by Whellams and Franklin are important enough to deserve special consideration. Both studies administered several different musical aural tests or IQ tests to the same subject group as indicated above. If the tests were equivalent, or measuring exactly the same thing, the test scores should have been very similar. Instead, Whellams reported differing coefficients of correlation, depending upon which type of IQ or musical test. Table II below expresses the range of results Whellams observed.

TABLE II

RANGE OF CORRELATIONAL COEFFICIENTS REPORTED BY WHELLAMS

	Verbal IQ	Non-Verbal IQ
Bentley Music Test	.50	.45
Wing Music Test	.23	.32

Franklin also reported varying correlations, which varied according to which musical pitch discrimination subtest he used (r = +.13 vs r =.-.10 for one of his groups and r = +.15 vs r = +.12 for the other).

This variation in the observed correlations between the musical aural discrimination ability of pitch discrimination and IQ scores is important to the present study in that it indicates that the measuring instruments used within those studies were either not accurate, or they were not all measuring the same thing. If this were not the condition, and they were all accurate measurement instruments, which measured the same musical/intellectual attributes, then the range of variation in the reported coefficients of correlation would not be large and their distribution would be clustered more closely about a central tendency. Instead, the coefficients of the group of studies, taken as a whole, spread out over a wide range, again indicating that the differing tasks within the tests must correlate differently with the musical aural discrimination skill of pitch/melodic discrimination.

Further, upon extracting all the studies using a single pitch discrimination test, for example, the Seashore pitch subtest, and examing those studies as a group, it can be seen that the reported correlational coefficients vary as much for an individual musical test as they do for the entire group above. Table III below shows the range of coefficients of correlation for the Seashore test in previous studies.

Table III is important for the present study in that, if the same musical test is used within the study, different IQ tests are used within the study and the results vary to a significant extent, it is logical to conclude that the variation in the results may be caused by the use of different IQ tests.

TABLE III

CORRELATIONAL COEFFICIENTS BETWEEN IQ SCORES AND THE SEASHORE PITCH DISCRIMINATION SUBTEST

study	date	musical test	sample size	correlation coefficient
Drake	1940	Seashore	163	.12
Franklin - a	1956	Seashore	79*	.13
Franklin - b	1956	Seashore	157*	.15
Farnsworth	1931	Seashore	150	.14
Christy	1956	Seashore	103	.18
Manor	1950	Seashore	not reported	.21
Rainbow	1956	Seashore	291	.22
Salisbury & Smith - a	1929	Seashore	131	.31
Salisbury & Smith - b	1929	Seashore	144	.31
Fracker & Howard	1928	Seashore	230	.32
Weaver	1924	Seashore	94	.35
Highsmith	1929	Seashore	59	.58

Since the reliability measurements of the major IQ tests have been thoroughly tested, they are assumed to be reliable measurement instruments. It would seem, then, that the different IQ tests are either (1) measuring different mental skills or (2) assigning different weights to the individual measured mental skills in achieving the IQ figure, thus creating differing correlations with the specific musical aural discrimination ability.

Thus, previous research has indicated that there is a small, positive, and statistical significant relationship between pitch discrimination ability and mental information-processing skills, as measured by IQ scores. However, it has also indicated that there is a great deal of disagreement as to the strength of that relationship. Further, the nature of that relationship has not been addressed, i.e., the question of which specific mental information-processing skills may enter into the relationship has not been addressed, researched, or reported.

The Rhythmic Discrimination/IQ Score Relationship

Some type of rhythmic measure has also been part of most musical aural discrimination tests. These tasks have included asking the student to identify the meter, to count the beats within a section, or to discriminate between two musical selections, which varied as to tempo or meter. Table IV below summarizes the results of previous studies of the relationship between measures of rhythmic aural discrimination and IQ scores.

Just as in the case of the reported correlations between pitch discrimination ability and IQ scores, it can be noted that an extreme amount of variability is present in these correlations. And in a similar manner, studies which have used the same musical aural discrimation test also will indicate differing correlations. This high amount of variability would again seem to indicate that the differing tasks would create differing relationships with the specific musical aural discrimination ability of rhythmic discrimination.

TABLE IV

CORRELATIONAL COEFFICIENTS BETWEEN IQ SCORES AND VARIOUS AURAL MEASURES OF RHYTHMIC DISCRIMINATION

study	date	musical test	sample size	correlation coefficient
Drake - c	1957	Drake	130	-.03
Drake - b	1957	Drake	61	.00
Franklin - a	1956	Wing	79	.00
Salisbury & Smith - a	1929	Seashore	131	.02
Bentley - b	1955	Wing	95	.03
Drake	1940	Seashore	163	.05
Drake - d	1957	Drake	130	.05
Parker	1978	Wing	1174	.08
Drake - a	1957	Drake	20	.10
Manor	1950	Seashore	not reported	.11
Fracker & Howard	1928	Seashore	230	.12
Shuter	1964	Wing	200	.15
Farnsworth	1931	Seashore	150	.17
Whittington - b	1957	Wing	24	.20
Bentley - a	1955	Wing	87	.22
Rainbow	1956	Seashore	291	.23
Franklin - b	1956	Wing	157	.23
Salisbury & Smith - b	1929	Seashore	144	.24
Holmstrom - c	1963	Wing	651	.27
Mainwaring - b	1931	Mainwaring	34	.32
Christy	1956	Seashore	103	.33
Holmstrom - a	1963	Wing	189	.33
Holmstrom - b	1963	Wing	765	.33

*Same subjects within the sample group

TABLE IV -- Continued

study	date	musical test	sample size	correlation coefficient
Whellams - b (Non-verbal IQ)	1971	Bentley	129*	.33
Holmstrom - d	1963	Wing	60	.34
Bentley	1966	Bentley	166	.34
Gordon - a (Verbal IQ)	1965	M.A.P.	862	.36
Gordon - b (Non-verbal IQ)	1965	M.A.P.	862	.38
Whittington - a	1957	Wing	24	.40
Mainwaring - a	1931	Mainwaring	83	.46
Holmstrom - e	1963	Wing	60	.47
Whellams - a (Verbal IQ)	1971	Bentley	129*	.51

*Same subjects within the sample group

Figure 3 is a histogram which depicts the range of correlations reported in the above Table. It indicates that the greatest number of coefficients of correlation occur between r = +.30 and r = +.39. This range of correlations may appear similar to the correlations related to pitch, which could cause one to erroneously assume that pitch and rhythm skills are related to the same portion of IQ variance. However, it should be noted that pitch and rhythmic aural musical discrimination skills may be related in similar magnitudes to two different facets of the overall "intelligence" variance. The correlation figures simply report the amount of variance in common; they do not address the nature of that particular variance.

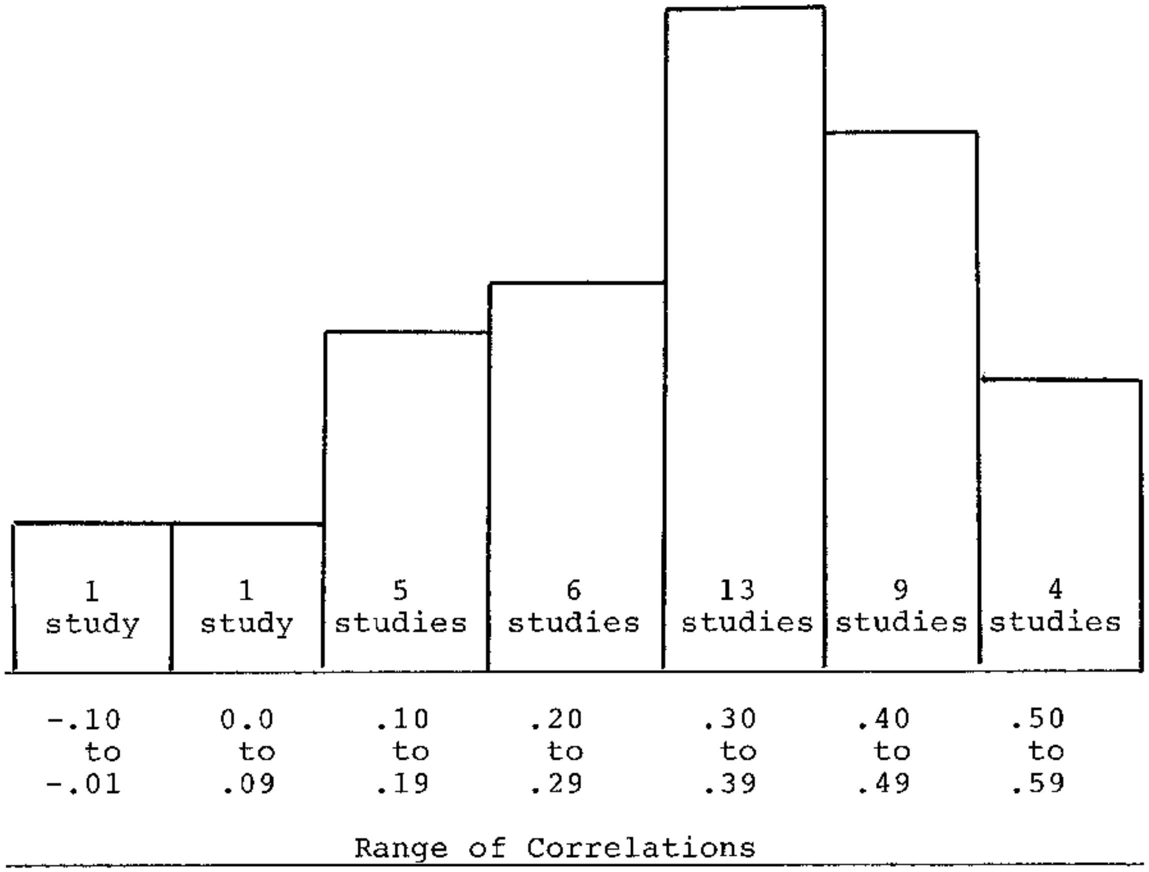

Fig. 3--The range of correlation coefficients of the relationship between rhythmic discrimination abilities and IQ scores.

It is once more important to note the range of variance observed in the correlation coefficients, from r = -.03 to r = +.51. And again, Whellams' study, using the same subject group revealed a large difference between the verbal and non-verbal IQ tests (r = +.33 non-verbal IQ/rhythm vs r = +.51 verbal IQ/rhythm).

Just as in the discussion of the pitch discrimination/ IQ score relationship earlier, it is also important to note the extreme range of coefficients of correlation found for the rhythmic discrimination/IQ score relationship. Table V below extracts the studies from the table above which all used the Seashore rhythm subtest.

TABLE V

CORRELATIONAL COEFFICIENTS BETWEEN IQ SCORES AND THE SEASHORE RHYTHM SUBTEST

study	date	musical test	sample size	correlation coefficient
Salisbury & Smith - a	1929	Seashore	131	.02
Drake	1940	Seashore	163	.05
Manor	1950	Seashore	not reported	.11
Fracker & Howard	1928	Seashore	230	.12
Farnsworth	1931	Seashore	150	.17
Rainbow	1956	Seashore	291	.23
Salisbury & Smith - b	1929	Seashore	144	.24
Christy	1956	Seashore	103	.33

Again, the same argument that was appropriate for the discussion of the variation in the pitch discrimination results is appropriate here, in that if the musical test is the same, then the variation in the results may be caused by many factors, among which may be the use of varying intelligence tests.

The Musical Sensitivity Discrimination/ IQ Score Relationship

A final musical aural discrimination skill that has been previously studied related to the IQ is some sort of measure of the student's musical sensitivity or aesthetic judgment. This usually has been measured by asking the test subject to make some sort of determination as to the quality of a recorded example and decide if it is a "good" or "bad" performance, or which of a pair of performances is "better", based upon criteria such as phrasing, tonal quality, balance, or technical matters of performance, i.e. intonation and articulation. In subjective matters such as these, it is difficult to know the "right" answer. However, usually the test constructors will arrive at the "right" answers by asking many professional musicians their opinion as to the "better" performance. If the clear majority of the professional musicians agree upon one answer, this answer is then accepted; if no clear majority is reached, the item is usually discarded or re-done. Table VI summarizes the results of previous studies in this relationship.

TABLE VI

CORRELATIONAL COEFFICIENTS BETWEEN IQ SCORES AND VARIOUS AURAL MEASURES OF AESTHETIC JUDGMENT

study	date	musical test	sample size	correlation coefficient
Hevner	1931	Oregon	148	-.16
Lowery	1929	Lowery	not reported	.00
Bentley - a	1955	Wing	87	.02
Franklin - a	1956	Wing	79	.04

TABLE VI -- Continued

study	date	musical test	sample size	correlation coefficient
Franklin - b	1956	Wing	157	.08
Bentley - b	1955	Wing	95	.11
Whittington - a	1957	Wing	24	.20
Gordon - a (Verbal IQ)	1965	M.A.P.	862*	.30
Gordon - b (Non-verbal IQ)	1965	M.A.P.	862*	.32
Whittington - b	1957	Wing	24	.40
Long	1971	Oregon	not reported	.47

*Same subjects within sample group

It can be seen that fewer studies have addressed the question of the relationship between the IQ and musical aesthetic judgment, perhaps because of the subjective nature of this musical aural discrimination ability. In a manner similar to the two musical abilities discussed earlier, previous studies of the IQ/musical aesthetic judgment relationship also exhibit great variance in their correlational coefficients, from r = -.16 to r = +.47. Figure 4 below graphically depicts this range of variance in a histogram, similar to the histograms previously presented.

It is once more important to note the range of variance observed in the correlation coefficients, from r = - .16 to r = +.47. Just as in previous discussion of the other two musical aural discrimination ability/IQ score relationship, it is also important to note the extreme range of coefficients of correlation found for the aesthetic discrimination/IQ score relationship.

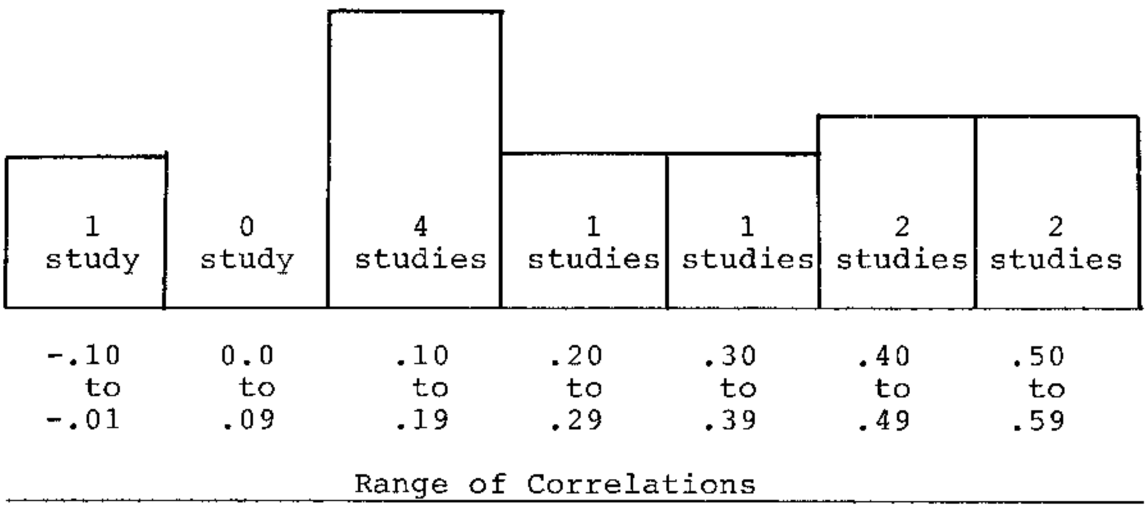

Fig. 4--The range of correlation coefficients of the relationship between IQ scores and various aural measures of musical aesthetic judgment.

Previous Individual Studies of the Musical Aural Discrimination/IQ Relationship

As has been noted, there are a number of past studies which have examined the relationship between various musical aural discrimination abilities and intelligence, as measured by the IQ scores. It has been seen that the conclusions drawn from these studies, although somewhat inconsistent and inconclusive, indicate a slight positive relationship between musical aptitude and intelligence.

Since one of the measurement difficulties of some of the previous studies was improper use of the measurement instruments, poor instruments themselves (i.e., lacking in the generally-accepted standards of reliability and validity), and poor research technique and/or interpretation in some of the studies, it is now appropriate to review a representative number of the studies individually. It should be noted here, however, that it is not strictly necessary to consider this section to understand the rationale behind the present study. The previous section, in which the studies were considered as a whole, is sufficient for that. The present section is presented more as background information regarding the steps which led to the present study.

Beach (4) attempted an early correlational study, significant only in that it was the first correlational study involving the intelligence/music relationship. He measured musical achievement, by the student's individual music teacher's subjective judgement of the student's musicanship and basic musical knowledge, and a musical achievement test of his own devising, measuring chiefly skills in reading musical notation. He found correlations ranging from +.14 to +.94; however, his use of the teachers' subjective judgements to rank the students and his use of an experimentor-designed test, which lacked information as to its reliability and validity, weakened his study.

In another early study, Highsmith (51) correlated applied music and music theory grades of 59 female students at the College of North Carolina with their scores on the Seashore tests (91). He found that the coefficients of correlation were generally low, ranging from +.06 to +.18 except for two series of grades. The grades the co-eds received in applied music achieved a correlation of $r = +.80$ with the Seashore pitch subtest; the Seashore pitch subtest also achieved a correlation of $r = +.41$ with grades in music theory. Again, as in the Beach study, the use of teacher-designed test instruments, i.e., the tests that established the grades in the classes, which had not been subjected to reliability and validity studies, is a major weakness of Highsmith's study.

In one of the first studies that attempted to explore the relationship between musical aptitude and intelligence, Cox (15) attempted to estimate the IQ's of 301 famous men in history in her 1926 article. A number of artists, including such musicians as Bach, Beethoven, and Mozart, were in her group. She estimated the average IQ's of both the group of graphic artists and the group of musicians to be 160.

Gould had harsh words for Cox's study, indicating that the "basic logic of the study was hopelessly flawed from the first" (40, p. 184). Cox's study is more a work of imagination and fiction than science. She estimated IQ's for those persons long-dead on the basis of their achievements. Then, she reversed her reasoning and concluded that high-achieving men always have high IQ's. According to Gould, "Cox's I.Q.'s are artifacts of differential amounts of data, not measures of innate ability" (40, p. 187). This study is reported here only because her estimates and unsupported conclusions have entered the literature and have been cited by a half-century of writers, who did not return to the original source to examine its validity. Most writers on the musical aptitude/intelligence question have cited, and continue to cite, Cox's study as if it were factual instead of based upon her considerable powers of imagination.

Brennan (8,) Wright (113), and Salisbury and Smith (90), all performed studies in the late 1920's, correlating the Seashore battery to various ratings of musical performance, sight-singing, theory grades. The correlations they reported were generally at a moderate level ($r = +.40$ to $+.60$). However, the weaknesses these studies are the same as those of the Beach and Highsmith studies already discussed. Their teacher-designed tests or grades in school classes have not been adequately tested for reliability and validity.

The first study which attempted to directly examine the musical aptitude/intelligence relationship in a rigorous manner was conducted by Fracker and Howard (26) in 1928. They examined the relationship of the scores attained by 230

Freshman, Sophomore, and Junior students at the University of Arkansas on the Seashore tests with their IQ's, as measured by the Otis Intelligence Test (83) and the Army Alpha intelligence test. Fracker and Howard report low coefficients of correlation, from r = +.09 (intelligence/ consonance subtest) to r = +.32 (intelligence/pitch subtest). This study was superior to those which preceded it in that both instruments, the musical test and the intelligence tests, had been subjected to reliability and validity studies. However, even though Fracker and Howard did compute the coefficients of correlation for the individual musical subtest scores on the Seashore with the I.Q. score, they did not consider a possible correlation using the individual subtest scores within the I.Q. test.

Farnsworth's 1935 study (23) was another of the early correlational studies on the musical aural discrimination/ intelligence relationship. His subject population was undergraduate students at San Jose State, undifferentiated as to music majors or non-music majors. He examined their scores on the Thurstone intelligence (IQ) test, the Iowa High School Content test, a measure of academic achievement, and two of the Seashore subtests, the "Sense of Pitch" and "Tonal Memory" tests. He found a moderate relationship between grades in music history and appreciation, which Farnsworth calls "more academic subjects" and the intelligence/achievement tests (r = +.42) and a very weak relationship between the Seashore tests and music history/ appreciation grades (r = + .17). The relationship found between the grades on theory, which he characterizes as "more tonal" and the intelligence/achievement tests was lower than the previous relationship (r = +.27) and the Seashore tests/theory grades was slightly higher (r = +.28).

None of these relationships achieved statistical signficance; however, Farnsworth's conclusion was that "if music grades of an academic type are to be predicted better by intelligence tests, and theory courses in general (emphasis in original) about equally well by these two sorts of psychological tests, surely the most tonal will be predicted far better by the music capacity tests" (23, p. 350). Sight-singing was never mentioned or measured previously in his study and it is difficult to justify the above leap of reasoning; moreover, his study reveals a lack of relationship between his criterion, achievement in music theory, and musical aptitude as measured by the Seashore test.

Writing in 1937, Mursell summed up the research on the musical aural discrimination ability/intelligence relationship to that point, using the Seashore Tests to measure musical aptitude and the standard IQ (measured by the Stanford-Binet) to measure intelligence.

> On the whole, the results seem to amply justify the frequently repeated assertion that performance on the Seashore tests is not

> significantly related to general intelligence and is not affected, within wide limits, by the intelligence of the subjects (79, p. 336).

Drake's 1940 article (18) reported on his correlational study measuring the correlation between scores achieved by 163 English schoolboys on the Seashore battery, two subtests of the *Kwalwasser-Dykema* musical aptitude test (61), four specially constructed music achievement tests, (one by Lowry and three by Drake) and intelligence. Drake did not specify the test or tests that were used to measure intelligence, reported as an I.Q. score. He reported that "The average correlation was .12 with a range of .03 to .27" (18, p. 39).

In the second portion of his study, Drake correlated the scores achieved by a group of college women (N = 44 to 186) on the *Drake Test of Musical Talent* (17) and the grades they received in seventeen college subjects, including chemistry, mathematics, history, and religious education. He found that "not one of the correlations is significant. The musical talent test is hardly sampling any of the ability which accounts for scholastic success" (18, p. 40). His final conclusion is that "when relatively pure measures of musical talent are used no significant relationship is found between musical ability and intelligence, or between musical ability and scholastic success in college" (18, p. 42).

This conclusion is, of course, at odds with that drawn by most other researchers in this area, who conclude that the relationship between musical ability and intelligence is slight, but significant. It must be noted that Drake's conclusions are based largely upon the second part of his study, in which he used the grades his test subjects received as an indicator of intelligence. The danger of using grades (grades may reflect the subject's personality, ability to write, ability to get projects in on time, etc.) to indicate intelligence has already been discussed.

Elizabeth M. Taylor's 1941 report (99) dealt with her attempt to correlate musical aptitude with musical achievement. She tested 150 freshman at the Cincinati College-Conservatory from 1930-1935 with the Seashore tests, the Kwalwasser-Dykema tests, and a test of her own devising. She correlated scores on these three aptitude tests with the grades these students achieved in sight singing, dictation, harmony, and music history courses. The correlations between music grades and the test grades she reported were low, from -.08 to +.27. These correlations were not found statistically significant, using current standards, i.e, alpha = .05.

In 1950, Lehman conducted a correlational study (64) among three standardized tests. They included the Otis Intelligence Test (83), the Kwalwasser-Dykema Music Test (61), and the Minnesota Multiphasic Personality Inventory

(46), a generally-accepted psychological instrument to assess personality. Half of his 450 subjects had studied a musical instrument but had quit, and the other half were either music majors or actual performers or teachers. He reported a higher IQ score was achieved by those who had continued music study (a mean of 112.4 vs 110.1). This difference between the means was reported to be significant at the .10 level, a less stringent confidence level than is accepted in current psychological research. The correlation between the two was reported to be r = +.18. The "continued" group also scored higher on the music test, with results again being reported significant, but again only at the .10 level.

Cooley (13) selected a group of 180 undergraduate students majoring in music at Michigan State University during the 1950-51 academic year and administered them the following standardized tests:

1. The American Council on Education Psychological Examination (103), College Level, 1949 edition. (Despite its name, this examination is designed to measure scholastic aptitude/general intelligence, and not serve to indicate psychological problems or personality disorders).

2. The Cooperative Reading Comprehension Tests (16), 1940 edition.

3. The Bernreuter Personality Inventory (7), 1933.

4. The Seashore Measures of Musical Talents (91), 1939 revision.

Cooley also considered the subject's musical abilities (as evaluated by the Michigan State music faculty) in such areas as general musicality, ability to sight read music, performance ability, and grades in applied music. He performed correlations of his subjects' scores and concluded that "high intelligence and high reading ability as well as superior performance on the Seashore tests tend to go with musicality" (13, p. 115). Unfortunately "musicality" is such a subjective term that it is difficult The Seashore tests are a measure of musical aural discrimination abilities. They do not proport to measure such a subjective quality as "musicality". Cooley's use of a highly selected group (i.e., all music majors) rather than a random population sample throws his general conclusions into doubt; it was improper to generalize for the population at large from a select sample of musicians.

Cowell's study (14) compared scores of children in grades 5 through 8 on the Knuth Music Achievement Mental Test (59) with IQ scores recorded in their permanent records and their academic success as measured by school grades. He also followed the same procedure with a group of high school students, adding the Aliferis Music Achievement Test (2) and the Kwalwasser-Dykema Musical Aptitude Tests. (61) He divided his subjects into three groups: 1.) those who had successfully acquired instrumental skills, 2.) those who had a lower level of instrumental skills, and 3.) those who had no instrumental ability but who had taken vocal music.

In comparing the groups, he found that the group who had been successful in the acquisition of instrumental skills had a higher mean IQ. However, in many cases the differences, although statistically significant, were quite small; for instance, the difference in mean IQ's between the instrumental and non-instrumental group in the 8th grade was 112.2 for the instrumental group and 110.3 for the non-instrumental group. This slight difference, of less than 2 IQ points, falls well within the standard error of most IQ tests. Nevertheless, Colwell drew the conclusion that "there is a definite relationship between musical achievement and intelligence" (14, p. 358). It is quite possible that Colwell's results are due to the chance variation within the standard error of the IQ test and his conclusions are, thus, in doubt.

King's 1954 study (58) compared two groups of 5th and 6th graders drawn from New York City schools. He matched the groups for age, schooling (by total semesters in school), grade, sex, and extra-curricular activities (including music lessons). The groups differed by their abilities in music reading skills. One group had little or no music reading skills and the other was selected to include those students possessing above average music reading skills.

King administered the Otis Self-Administering Tests of Ability (84), and the Knuth Music Achievement Mental Tests (59). He found significant differences in the means between the two groups, for both the IQ and music tests. This should not be surprising. The standard group IQ tests are weighted heavily towards verbal abilities. They are to a large extent a measurement of skill in reading. Skill in reading, no matter whether it is notes or words, will increase scores on IQ tests. Therefore, the more skilled music readers will also be the more skilled in verbal manipulation and score higher on IQ tests. Many other variables, such as home atmosphere and educational level of the parents, enter into this relationship. Thus his conclusion, that his results prove a significant IQ/music aptitude relationship seems unwarranted because of too many confounding variables.

Roby (89) published a correlation study of the relationships among the Seashore Measures of Musical Talents (91), the Aliferis Music Achievement Test (2), and grades achieved in music theory classes by college freshmen and sophomores at the University of Minnesota. He also considered correlations with the American Council on Education Psychological Examination (103), which includes an IQ measurement, and with the University of Minnesota English Entrance Test. Correlation coefficients between music theory grades and the last two tests were modest, the

ACE/theory grades r = +.34 and the English test/theory grades r = +.47. He did not draw any conclusions as to the relationship between intelligence and musical aptitude test scores, indicating that "The fact that scores made on the two non-musical tests showed fair positive correlations with the theory grades indicates that the use of any good IQ test would add a useful segment to a student's profile" (89, p. 142).

Rainbow (87) sought to identify important correlations with musical aptitude in a multi-dimensional study that considered such factors as home enrichment, interest in music and participation in music by relatives as well as more traditional considerations of intelligence, school achievement, and musical achievement and training. He concluded that intelligence, (as measured by the _Lorge-Thorndike Intelligence Test_ (71) and the _Otis Intermediate, Self-Administering Test of Mental Ability_, (84) along with tonal memory, musical achievement, home enrichment, interest in music, and socio-economic background were significant contributers to musical aural discrimination abilities, as measured by by the subtests of the _Seashore Measures of Musical Talents_ (91) and the _Drake Musical Memory Test_ (17). Rainbow also found that the fourteen factors under consideration would contribute different amounts of variance to the relationship at the various ages of his students, i.e., different non-musical would enter into the relationship at the grade school, junior high, and high school levels. (87)

Academic intelligence was not among the important factors Rainbow found related to musical aural discrimination ability at either the elementary or high school levels. It was found an important factor in the junior high level, however, suggesting that if one is to research the musical aural discrimination ability/ intelligence relationship, perhaps the logical age to begin would be with students at the late elementary to junior high age.

As part of the validation procedure for the Musical Aptitude Profile (37), Gordon administered the Lorge-Thorndike Intelligence Tests, Verbal and Non-Verbal Forms (71), a generally-accepted group IQ test, the Iowa Tests of Basic Skills (68), given to grade school students, or the Iowa Tests of Educational Development (69), given to high school students, and his Musical Aptitude Profile (37) to a sample population of students. He found correlations between the MAP Composite scores and the Thorndike intelligence test scores ranging between r = +.31 (Nonverbal/MAP Comp in grades 9-12) to r = +.44 (Nonverbal/MAP Comp in grades 7-8). Correlations between the grade school achievement tests were higher, with correlations of r = +.58 (MAP Comp/Iowa Composite score for grades 4-6) and r = +.56 (MAP Comp/Iowa Composite for grades 7-8). Subtest correlations are also reported and generally achieved lower correlations with the intelligence and achievement tests (37, p. 64).

Gordon concluded that "there is no more than ten or twenty percent common variance between scores on. . . aptitude tests and general intelligence tests" (37, p. 63). He would seem to agree with Gardner (30) that musical aptitude and intellectual functioning are two separate and not closely related "intelligences", for he concluded that, "A good musical aptitude battery would . . . not necessarily have a high correlation with either intelligence or achievement" (37, p. 65). It should be noted that Gordon, like all the other past researchers, used the standard unidimensional IQ to measure intelligence and did not break the relationship down to correlations with any of the I.Q. subtest scores.

Holmstroem's 1969 article (52) reported on a correlational study performed upon students (N = 80) entering Stockholm's Musical Academy (KMH). "Their results on the intelligence subtests (verbal, numerical, inductive, and spatial) were correlated with their results on the entrance test to KMH as well as with their grades in singing, piano, strings, conducting, theory of harmony, musical history, ability to teach, and pedagogic in the music teacher examination" (52, p. 76). The intelligence test used was the F-Test by K. Kaernqvist, a Swedish I.Q. test, which was designed and normed for 8th and 9th graders.

Holmstroem found that "none of the 28 correlation coefficients . . . are significant on the .01 level, and only four on the .05 level" (52, p. 79). He commented that "It is somewhat amazing that the correlation between intellectual variables and the more musical tests . . . seem to be lacking completely" (52, p. 80). It is quite possible, however, that Holmstroem used an inappropriate test to measure his subjects' IQ; some of these students had already had two years of college, and were twenty years old or more. His I.Q.test was designed for junior high school students, whose ages are typically thirteen to fourteen. Also, no data on reliability or validity was presented for the Kaernqvist IQ test; since it is not a test in general use in the United States, no assumptions as to its quality can be made here.

In one of the most important and thorough recent studies, Young (116) performed three correlational studies as part of his doctoral research; in the first, he compared the scores of 91 5th-grade instrumental students on the Gordon Musical Aptitude Profile (37), the Lorge-Thorndike Intelligence Test (71), and the Iowa Tests of Basic Skills (68) with three musical achievement "Criterion Tests". Two of these musical achievement tests were experimental group tests of tonal and rhythmic concepts, notation, and identification of different musical instruments through their sound, that were in a developmental process at the

University of Iowa. The third was an assessment of performance abilities.

He found, "In all cases, the academic achievement test battery (ITBS) produced the highest correlation coefficients with the criteria" (116, p. 387). These correlations ranged from r = +.56 to r = +.70. The MAP scores correlations with the criteria ranged from r = +.45 to r = +.55 while the IQ scores had the lowest correlation with the criteria, from r = +.38 to r = +.55.

Young also reported multiple correlations between combinations of the standardized tests with his criteria and found that, "The combination of MAP and ITBS alone, . . . predicted all criteria equally as well, as all three standardized tests together" (116, p. 387). Thus, the IQ scores added little or nothing to the predictive validity of the other tests.

Young then performed a second analysis, considering subtest scores on the achievement test and the MAP; unfortunately, he did not break down the IQ test into subtests. From the results of this second analysis, he concluded the following:

> Those achievement criteria that did not demand the ability to read music showed a greater relationship with tests from the MAP battery than did those that required music reading ability. On the other hand, those achievement criteria that involved reading ability appeared to be related more to intelligence and academic achievement than those that did not require this ability (116, p. 388).

It is indeed unfortunate, particularly in view of the purposes of this study, that Young did not consider examining the IQ subtest scores as well. His conclusion of the role of the predictor tests was that, "With the single exception of the intelligence test, all of the predictor tests proved to be significantly related to at least one of the achievement criteria" (116, p. 390). The I.Q. test scores were not found significantly related to any of his achievement criteria.

In the second part of his study, Young attempted to suggest a reason for the 32 drop-outs from the program. This is always a major problem with school music programs, although this percentage is larger than usual for the first year of study. He found that "only in the area of musical aptitude, as measured by the *MAP*, did the students who dropped out score lower than students of the same grade level in general" (116, p. 393).

His conclusion of the role played by the IQ scores was that "intelligence, as measured by this test, was not a major factor in determining whether students remained in the program or dropped out" (116, p. 393).

In the final section, Young compared IQ scores from the *Henmon-Nelson Intelligence Test* and ITBS achievement scores from 261 instrumental music students (who had played from one to six years) with their scores on the *Watkins-Farnum Performance Scale*, a musical performance scale heavily weighted towards sight-reading. He found that IQ scores do not seem to affect sight-reading ability; indeed, for this group of students, "an intelligence test score has predictive validity that is inversely proportional to number of years of study" (116, p. 397). It is apparent that the IQ scores had very little importance to either musical aural discrimination abilities or to musical achievement in Young's study.

Whellams carried out a correlational study (110) at the British Royal Marines School of Music using Junior Musicians, who are teen-aged boys training to become musicians in the British military band system. He compared the scores achieved by these boys on Wing's <u>Standardardised Tests of Musical Intelligence</u>, as well as school grades and a "Picture Intelligence" (not defined) to an "ideal" cannonical variate which "produces a total score that <u>most nearly</u> predicts the individual's group membership" (110, p. 17).

Whellams found that the correlation between the cannonical variate and most school grades varied from $r = -.136$ (Series) to $r = +.248$ (Picture Intelligence); the correlations were higher with certain of Wing's subtest scores, particularly Memory ($r = +.48$), Pitch ($r = +.44$) and Harmony ($r = +.42$). Whellams drew no strong conclusions from his study, saying only that "the results suggest some justification for the addition of non-musical tests to aptitude batteries" (110, p. 21). As has been previously noted, the Whellams data are quite valuable to the present study in that it is possible to see the different coefficients of correlation which are achieved when different intelligence and musical aural discrimination tests are given to the same subjects. The conclusion that this may be an effect of the differences between the tasks comprising the tests has already been made.

Gallagher (29) conducted a study which sought to explore musical aptitude by correlating the scores achieved by his test subjects on selected subtests of the Gordon _Musical Aptitude Profile_, the _Music Achievement Tests_ developed by Richard Colwell, (14) and the _Indiana-Oregon Music Discrimination Test_ (50) originally designed by Kate Hevner Mueller and later revised and standardized by Newell H. Long.

The first two tests will undoubtedly be familiar, as they are standard musical tests, the first a measure of musical aural discrimination abilities and the second a measure of musical achievement (subject-oriented); the Mueller/Long test (50) consists of thirty musical examples that are performed for the student. The student is then required to decide which example is performed correctly and which is incorrectly played.

Gallagher also obtained data of a personal nature, including student IQ, through questionaires and from the school records. The method of assessing the IQ was not reported; since his study involved a number of different cities and towns throughout Minnesota, it is quite possible that several different tests were used. As was stated in the earlier discussion of IQ testing, there is little consistency among IQ tests; the same individual may received differing scores from different tests.

He reported multiple correlations of from R = +.61 (Colwell vs Gordon/Mueller) to R = +.28 (Mueller vs Gordon S2 subtest). He also found the following simple correlations between his shortened form of the tests and the IQ scores listed in the student's school records.

Colwell vs. IQ	r = +.57
Gordon vs. IQ	r = +.42
Mueller vs IQ	r = +.38 (29)

These are results generally similar to most previous studies of this relationship.

Unfortunately, a major flaw is present in Gallagher's study. He administered only parts of the Colwell and Gordon tests. However, his conclusions about the relationships involving musical aptitude and musical achievement were stated as if he had used the entire tests. The use of only portions of a test effects the estimates of validity and reliability. Gallagher attempted to justify his omissions for reasons of expediency, but the fact remains that his conclusions must be seriously questioned because of this procedure.

Keen (57) measured 307 students attending the laboratory school at the University of Michigan, from 3rd through 12th grade. In a manner similar to Binet's original tests, and differing sharply from other studies, he did not measure intelligence as a single number. Rather, he used measures which compared the student's abilities to the national norms. Thus, he could speak of "developmental ages" for a number of variables which actually are measures of a level of a student's intellectual and physical functioning, and included the following variables.

1. Reading Age
2. Spelling Age
3. Language Age
4. Arithmetic Age
5. Height Age
6. Mental Maturity
7. Weight Age
8. Grip Age
9. Dental Age
10. Organismic Age
11. Chronological Age

He measured creativity by the Torrance *Creativity Test* (106), and the Barron *Anagram Test*; musical aptitude was measured by the *Musical Aptitude Profile* (37).

Keen concluded that individuals at a high level of development tend to show more sensitivity for factors of musical context. Interestingly, he found that, "the most consistent and strongest relationship is found between musicality and language development" (57, p. 68).

Helwig and Thomas (48) attempted to predict success in a high-school choral program through two tests, Gaston's

Test of Musicality and an IQ test, the California Test of Mental Maturity. Musical achievement, their criterion variable was measured by grades in choir, which were subjective measures "based on the teacher's estimates of a pupil's attitude, effort, and musicality" (48, p. 270). The writers achieved a multiple correlation R = +.39, which was significant at the .05 level.

Helwig and Thomas concluded that "intelligence quotients and Gaston's musicality test scores can predict achievement" (48, p. 280). They did not, however, publish their data as to how the multiple correlation equation was arrived at. Also disturbing in this study is the teacher's subjective assessment of the student's vocal achievement. A definite, pre-established criterion for achievement would have strengthened the study.

Sergeant and Thatcher's article (92) is a major review of previous studies on the relationship between intelligence and musical aptitude and ability. Their table of correlations between musical abilities, (as measured by most of the older musical aptitude measurements, such as the Seashore, Kwalwasser-Dykema, Drake, Wing, and Bentley tests) and intelligence (measured using the unidimensional IQ score) found in 36 individual studies (92, p. 33) is a basic starting point for anyone interested in the intelligence/ musical aptitude relationship. They also present a thorough historical review and many opinions of past researchers as to the nature and extent of this relationship.

Sergeant and Thatcher then reported on studies designed to measure the intelligence/musical aptitude relationship based upon Rainbow's 1963 study using analysis of variance as the major statistical tool applied to the data, and involving a complex correlation of other factors, such as socio-economic class and home atmosphere. They report upon their analysis of the raw data from three experiments (performed by other researchers), feeling that the reason previous relationships were reported to be so low was that improper statistical procedures had been applied to the data collected. The conclusion that they drew was the same thought they proposed at the beginning of the paper, based upon their observation of children in the classroom.

> In the first place, it is a common observation of music teachers that children with high intelligence generally tend to reach higher levels of musical achievement than do children with more modest intellectual abilities (92, p. 32).

They do not expand very much upon this observation in the conclusion that they drew at the close of their article, after their reevaluation of Rainbow's data.

> Intelligence must therefore be regarded as an integral component of musical abilities. A favourable musical environment cannot redeem the absence of the level of intelligence necessary for musical cognition, nor can intelligence alone suffice for the development of musicality (92, p. 56).

They did not draw any conclusions as to the degree of intelligence necessary for musical cognition, nor did they conclude that any direct, measurable relationship between intelligence and any sort of musical aural discrimination ability was present.

Phillips (86) reported on his investigation between musicality and intelligence, "in which the musical cognition subtests of the _Wing Tests of Musical Intelligence_, the _Thackray Tests of Rhythmic Ability_ and the _Thorndike-Hagan Tests of Cognitive Abilities_ were administered to 194 children from four differing social status areas" (86, p. 16). He found some of the highest correlations yet seen between intelligence and musical aptitude. The correlation coefficient for the relationship between scores on the Thorndike-Hagan IQ test and the Wing musical aptitude test (112) was $r = +.61$ and that between the Thackray rhythm test (100) and the Thorndike was $r = +.69$. Even after expressing doubts about the reliability and validity of all three of his tests, Phillips nevertheless concluded that "these figures seem to indicate a substantial relationship between musicality and intelligence" (86, p. 29). It is difficult to agree with Philips that his correlational figures reveal a substantial relationship, particularly since he himself questioned the reliability and validity of the measurement instruments he used.

Parker (85) attempted sought to measure "aesthetic sensitivity" by administering the "Tests of Appreciation" subtest of the Wing _Standardized Tests of Musical Intelligence_ (112) to 1,174 high school students (grades 10, 11, and 12). He correlated scores achieved on this subtest with Gaston's _A Test of Musicality_ and IQ scores obtained from the student's school records. These IQ scores were yielded by five different group intelligence tests, including the following.

1. _Henmon-Nelson Test of Mental Ability_ (62)
2. _Kuhlmann-Finch Intelligence Tests_ (24)
3. _Lorge-Thorndike Intelligence Tests_ (71)
4. _Otis Quick-Scoring Mental Ability Tests_ (84)
5. _California Short Form Test of Mental Maturity_ (96)

Parker achieved a correlation coefficient of $r = +.075$ between "aesthetic sensitivity", (i.e., the scores achieved by the Wing "Tests of Appreciation" subtest) and the student's IQ's (as measured by the five different tests). His only conclusion was that "Aesthetic sensitivity seems to be more dependent on musical ability than it is on intelligence" (85, p. 34).

The obvious error of equating a score on a musical aural discrimination test with something as undefined and of global proportions aside, Parker's study has several weaknesses. As has been pointed out previously, the Wing test has been questioned by Phillips (86) as a reliable and valid measure of musical aptitude. Of even more significance is the fact that Parker used I.Q. scores derived from five different tests; while I.Q. tests tend to show some correlation among themselves, the scores derived from them are not directly comparable in the manner he used them.

Gorder (33) conducted a study of particular interest to the present research in that it is the only other musical study to date which uses the Guilford model. Gorder was interested in developing a method for measuring creativity along lines suggested by the Divergent Production abilities within the Guilford model. He developed a test for music fluency, flexibility, originality, elaboration, and quality that he subjected to correlation with expert opinion (content validity). Unfortunately, the multiple correlation was rather low ($r = +.57$ for the five factors compared with teacher's assessments); nevertheless, his N was large enough to achieve significance for four factors; only the "quality" factor was not distinct from general intelligence scores.

Simmons' study (94) attempted to examine the relationships among musical aptitude, academic achievement and scholastic aptitude (intelligence) in 72 primary (grades 1-3) level students in a university lab school. She admitted that the scores achieved by her subject population considerably exceeded the national averages, which is not unusual in a university laboratory school. She administered the following tests:

1. _Wechsler Preschool and Primary Scale of Intelligence/Wechsler Intelligence Scale for Children-Revised_ (108, 109) to measure scholastic aptitude (IQ scores).

2. _California Achievement Tests, Form C_, (104, 105) to measure academic achievement.

3. Gordon's _Primary Measures of Music Audiation_ (38), to measure music aptitude. Gordon developed this test for primary-age children because the _MAP_ is an unreliable measure for children younger than fourth grade.

In a similar manner to nearly every other study of this relationship, Simmons found that the relationships achieved "statistical but not practical significance" (94, p.123). The relationship between the IQ scores and measured musical aptitude was $r = +.31$ and the achievement/musical aptitude relationship was slightly higher, at $r = +.56$. She therefore concluded that, "these particular tools measure dissimilar mental processing" (94, p. 127). It is again necessary to point out that generalizing to the population at large from a subject group that is not representative of that population at large is a risky business. Simmons indicated that her subject population scored over national norms in all the tests; therefore, the intellectual and musical abilities her subject group possesed was not representative of the population at large.

As can be concluded from the above review of the literature, previous studies of the intelligence/musical aptitude relationship available for examination have almost without exception used the unidimensional measurement of intelligence, the IQ. Generally speaking, the previous studies have reported correlations that may have reached statistical significance, but tended to be of small magnitude. Many of the past studies, however, have used inaccurate musical aural discrimination measures in addition to using the unidimensional IQ as a measurement of intelligence.

Thus the present study differs from previous studies in that it will regard both intelligence and musical aural discrimination abilities as complex, multi-dimensional human attributes and will seek to explore both the nature and the dimensionality of their relationship by using both tests and statistical procedures that are appropriate for the measurement of such complex, multi-dimensional attributes.

The Guilford *Structure of the Intellect* Model and Meeker's *Structure of the Intellect - Learning Abilities Test*.

J.P. Guilford's *Structure of the Intellect* is a multidimensional model of the intellect that postulates 120 different, yet inter-related mental abilities instead of Spearman's single-factor model. Guilford regards these dimensions as abilities capable of training and remediation and rejects the absolutist position of the IQ supporters who believe that the IQ is absolute, inherited, and incapable of change.

> Education is a matter of training the mind or training the intellect . . . The best position for educators to take is that possibly every intellectual factor can be developed in individuals at least to some extent by learning (41, p. 469).

It must be again emphasized that Guilford's Structure of the Intellect is but a useful fiction created by Guilford's analyses of the statistical procedure of factor analysis applied to intelligence testing. It does not represent any physical actuality within the brain nor any real structure that may be seen and measured. It simply "is convenient for depicting the intellectual abilities as delineated multivariate analyses of measured performance. . . . [and] no priority - logical or psychological, developmental or hierarchical - is intended either within or between the categories of classification" (72, pp. 11-12). Guilford thus refuses the error of reification - regarding something as real simply because it has been named.

Guilford is also careful to state that the Structure of Intellect is still but a theory, and may be incorrect in details.

> The structure of intellect as I have presented it to you may not stand the test of time. Even if the general form persists, there are likely to be some modifications. Possibly some different kind of model will be invented. Be that as it may, the fact of a multiplicity of intellectual abilities seems well established (41, p. 479).

Guilford's work in factor analysis caused him to reject even the eight different intelligences proposed by Thurstone as insufficiently describing the mental operations which he had measured. Guilford remarked that he felt Spearman's "g", or "General Intelligence Factor", was too narrow and limited to adequately describe the multitude of aspects of intelligence, even when broken up into Thurstone's eight subgroupings. He felt "[that] 'g' embraces only 8 of the 120 intellectual abilities represented in the S[tructure of] I[ntellect] model" (40, p. 65).

In order to account for the vectors achieved when the rotation of the results of factor analysis was accomplished, He created a structure formed by the three vectors, each rotated at right angles to one another.

Guilford called the first of these three the "Operations" axis. He found that five major components contributed to this axis, and named them 1.) Divergent Production, 2.) Convergent Production, 3.) Evaluation, 4.) Memory, and 5.) Cognition. Meeker defined these terms as follows:

> 1. Divergent Production: Generation of Information from given information, where the emphasis is upon variety and quality of output from the same source. Likely to involve what has been called transfer. This operation is most clearly involved in aptitudes of creative potential.
>
> 2. Convergent Production: Generation of information from given information, where the emphasis is upon achieving unique or conventionally accepted best outcomes. It is likely the given information (cue) fully determines the response.

3. *Evaluation*: Reaching decisions or making judgements concerning criterion satisfaction (correctness, suitability, adequacy, desirability, etc.) of information.

4. *Memory*: Retention or storage, with some degree of availability, of information in the same form it was committed to storage and in response to the same cues in connection with which it was learned.

5. *Cognition*: Immediate discovery, awareness, rediscovery, or recognition of information in various forms; comprehension or understanding. (72, pp. 13-22)

Figure 5 below shows a vector representing the "Operations" axis with Guilford's five dimensions marked upon it.

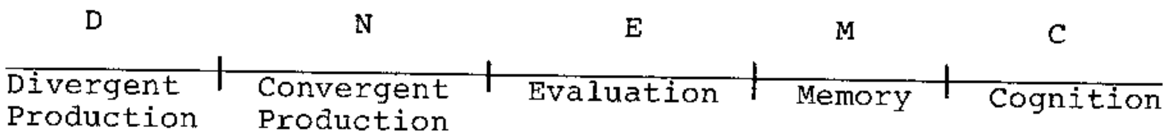

Fig. 5-- The *Structure of Intellect* "Operations" Vector

The second major vector Guilford identified from the results of his rotated factor analysis was named "Contents". Dimensions included under this major vector were 1.) Figural, 2.) Symbolic, 3.) Semantic, and 4.) Behavioral. Meeker defines "Contents" as "Broad classes or types of information discriminable by the organism" (72, p. 22).

Definitions of the separate dimensions along this vector are more difficult to achieve, but Meeker has furnished the following definitions:

> 1. Figural: . . . shapes like trees, forms, or concrete objects . . . most of them . . . cognized or comprehended as visual or kinesthetic forms or totalities.
>
> 2. Symbolic: . . . the stimulus material is cognized in the form of a numeral or a single letter, or a note of music or a code symbol; this kind of stimulus [is] distinguishable from a figural one. . .
>
> 3. Semantic: . . . refers to words and ideas where an abstract meaning is so associated in the individual's repertoire of knowledge that its external referent calls up the internally associated stored word.
>
> 4. Behavioral: . . . both a manifestation of a response and a stimulus. Only a few of the behavioral cell abilities have been identified . . . (72, p. 22).

To further represent the inter-relationships within the structure that Guilford theorized, Figure 6 below shows the matrix formed by the inter-relations between the "Operations" vector and the "Contents" vector. The separate cells within this preliminary structure, which are created by the interaction of the first two primary vectors are named for their sectors, first along the "Operations" vector, then along the "Contents" vector.

Thus, to depict the inter-relations between the mental skills found along the two vectors, the cell labeled "DF" would represent "Divergent Production - Figural" and "ES" would indicate a cell that would be "Evaluation - Symbolic." in nature.

	Divergent	Convergent Production	Evaluation	Memory	Cognition
Figural	DF	NF	EF	MF	CF
Symbolic	DS	NS	ES	MS	CS
Semantic	DM	NM	EM	MM	CM
Behavioral	DB	NB	EB	MB	CB

Fig. 6 --The "Operations" vector, the "Contents" vector, and their inter-relationships.

Guilford named the third major vector "Products" and it is defined as "The organization that information takes in the organism's processing of it" (72, p. 23). It includes the following six sectors: 1.) Units, 2.) Classes, 3.) Relations, 4.) Systems, 5.) Transformations, and 6.) Implications.

> 1. Units: . . . any single item, one of a kind . . . [that] can be processed singly, in which case it is a unit which is being perceived.
>
> 2. Classes: . . . a hierarchy inferred in the products dimension, . . . [which] subsumes the preceding one.
>
> 3. Relations: . . . [the processing of] relations or connections between the content involved.
>
> 4. Systems: . . . [groupings which] may be composed of figures, symbols or semantics.
>
> 5. Transformations: . . . redefinitions or modifications of the existing information . . .

6. Implications: The ability to forsee consequences (72, pp. 23-25).

The addition of the third major vector, that representing "Products" creates a three-dimensional matrix. Guilford and Meeker refer to this matrix of relationships as the SOI "cube". This three-dimensional matrix is depicted in Figure 7. Each SOI cell is read clockwise - CFU stands for Cognition of a Figural Unit. Convergent Production is represented by the letter "N", and Semantic Content by the letter "M"; otherwise, each sector is represented by the first letter of its name.

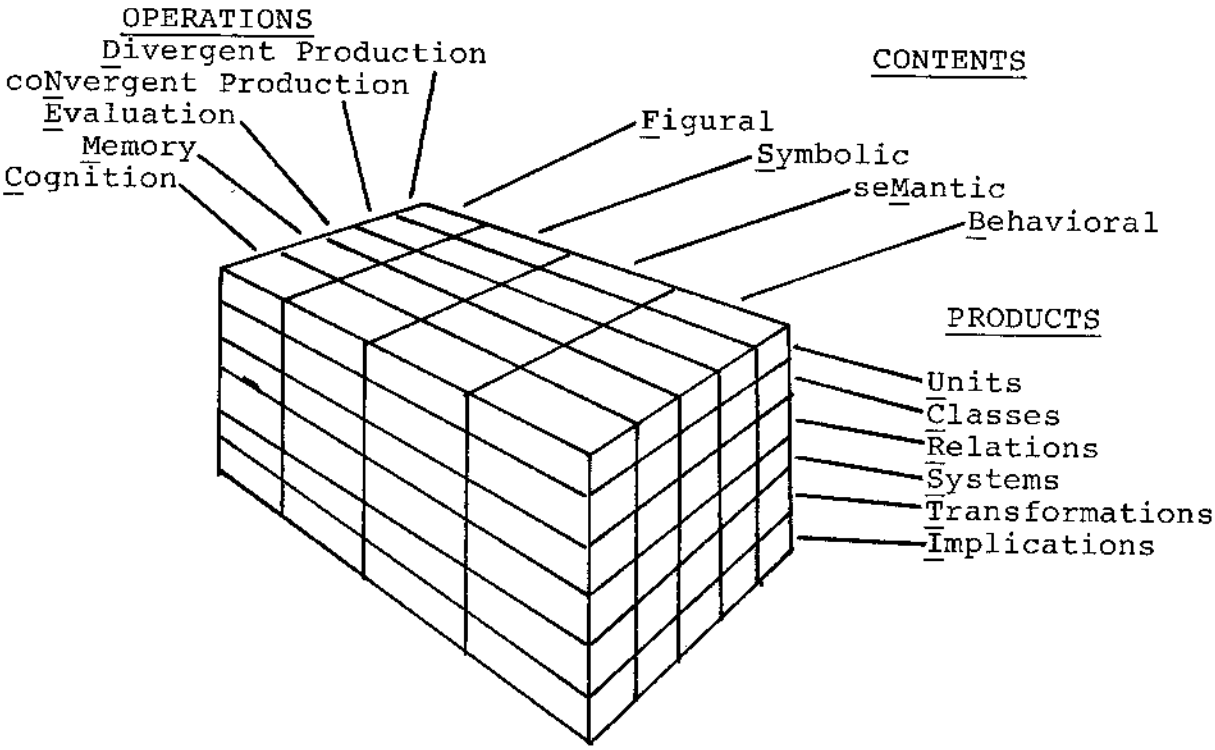

Fig. 7--The Structure of Intellect Cube (72, p. 8)

Thus, it can be shown that 120 different cells are postulated (6 x 5 x 4 = 120). Guilford and his associates have reported 98 factors confirmed to date (38, p. 54), chiefly through factor analytic means, and work is proceeding to identify and confirm the rest of the cells.

A major advantage of Guilford's Structure of Intellect is that the cells can be identified and their characteristics predicted, much as the higher elements were identified and their characteristics predicted by the Periodic Table of the Elements, long before they were actually found in nature.

Meeker has furnished a list of ninety of the SOI cells, defined as to their specific abilities, which is reprinted in Appendix A. The thirty SOI cells not defined by Meeker all involve the B (Behaviors) vector. She felt that the Behavior sector of the SOI model is perhaps the most difficult to measure and is insufficiently researched at this time to justify the drawing of any conclusions as to its nature.

Of special interest to our profession as teachers and performing artists, Guilford also concerned himself with the relationship of creativity in the arts to his Structure of Intellect model. He concluded that creative artistic talent is not a single ability but "is to be accounted for in terms of a large number of factors or primary mental abilities" (153, p. 22). He felt that those mental factors possessed by creative artists will be different from those possesed by creative people in other fields. From what is now known, he feels he can state that creative artists posses certain important factors.

> Fluency, flexibility, and originality are the most obviously creative abilities. All of them come under a general class of factors known as productive-thinking abilities and in a subclass of divergent-thinking abilities (39, p. 117).

Because of the definitions and descriptions of the nature of the specific mental information-processing skills postulated by Guilford's model, we are furnished with guidence as to the specific natures of the mental information-processing skills within the intellect.

Criticisms of the Structure of Intellect Model

Guilford's model has proven useful for our understanding of the intellect and the process of thinking. "Even the severest critics of the theory . . . have stated that it has proved a useful stimulus to creative test development and has provoked considerable worthwhile thinking about the nature of human abilities" (50, p. 33). And again, a comment upon the pragmatic usefulness of the Structure of Intellect model should be mentioned.

> SI theory has been a stimulus to the development of new variables. It has helped to indicate gaps in test batteries and to promote the construction of quite novel and interesting infant, preschool, school-age and adult tests. It is impossible to estimate the importance of this kind of contribution of the theory, but it is generally believed to be substantial (51, p. 76).

It has been noted that the Guilford SOI model can be a valuable "taxonomy of intellectual functions" (51, p. 76). and valuable because the "development of such a taxonomy is an important, if not necessary, first step in research on questions about growth, genetic and environmental influences, physiological associations, and other processes" (51, p. 77).

However, the SOI model has not been universally accepted throughout the psychological and educational communities. This section will present some of the objections that have arisen to it.

Much of the criticism of Guilford's work has come from those who object to the statistical procedure he used to derive his three major vectors. Horn, one of Guilford's major critics, objected particularly to the rotational procedure Guilford used to establish his vectors. In an effort to discredit Guilford's statistical procedures, Horn (51) applied a statistical procedure called the "Procrustes rotational procedure" to a set of completely random data. This, Horn states, was the same type of procedure used by Guilford and his colleagues to derive the three major factors of the Structure of Intellect.

He reported that he achieved "support for a set of substantive hypotheses stated in advance of the analysis" (51, p. 70). Horn argues that since this type of procedure was used by Guilford to establish support for the SOI model, Guilford has claimed a relationship when in truth none exists. Put simply, his criticism is that the relationship found by Guilford does not really exist and is only a statistical artifact.

Guilford, however, had anticipated this criticism and answered it by stating the reasons he used the orthogonal, i.e., geometrically related method of factor rotation.

> This is a somewhat complicated problem for which there is as yet no good solution. The common procedure in vogue at the present time for estimating factor intercorrelations is to do an oblique rotation of axes, locate the primary axes and determine the cosines of their angles of separation. The writer has preferred orthogonal rotations for several reasons. Briefly, any particular oblique solution to a factor problem is a function of several nonpsychological circumstances (40, p. 286).

Guilford then listed some of his objections to the more common procedures for the non-orthogonal factor rotation refered to above. They include the fact that the common factor rotation is influenced by the kind of population studied, that it is extremely test-dependent, i.e. influenced by "inadequacies of test construction and test administration" (40, p. 286), and therefore raises basic questions as to the origins of the factors. Guilford maintains that neither method of rotation has proven to be correct; neither has been proven to be wrong. It is therefore more important to pragmatically consider the results of the procedure. As has been indicated above, even

Guilford's critics admit the usefullness of his model, their objections to his rotational technique notwithstanding.

Undheim and Horn also maintain that "a principal difficulty with SI research is that too many factors have been extracted. This is another way of saying that there are not enough variables per factor to overdetermine the factors" (51, p. 74). They also feel that there is too much interdependence among the factors. However, no evidence other than their assertion is offered for these points.

Humphreys (52) also has "been disturbed for several years at two related tendencies in the work on human abilities" (52, p. 465). He identifies these as an objection to what he considers too many factors (and specifically refers to Guilford), along with defining those factors in too narrow a manner. He prefers an interpretation of factor analysis that recognizes "facets" rather than "factors", and which has a heirarchical ranking of the factors extracted. It is difficult to see what the difference is between his "facets" and Guilford's factors, and he offers no empirical proof that his hypothetical construct is any better than Guilford's.

Humphreys, like many other critics, does pay grudging tribute to Guilford's work, saying that "Guilford has done a great deal of truly creative thinking about the structure of human intellect" (52, p. 483). He further stated that a reading of Guilford's work would be a great help for test constructors.

Guilford's comments about the tentative and theoretical nature of his model, quoted at the beginning of the SOI discussion, need to be remembered here. It is of little importance whether 120 factors are finally determined to be present within intelligence or not. The absolute number of factors is insignificant. What is of critical importance, and perhaps Guilford's greatest contribution to our study of the nature of human intelligence, is that intelligence is now generally accepted to be comprised of of many different mental abilities. Few researchers currently dispute this view.

The Meeker Structure of Intellect - Learning Abilities Test

In 1975, Meeker developed and published a test to measure certain Guilford SOI abilities that she determined were critical to school success and success in learning in general, called the Structure of Intellect - Learning Abilities Test. Meeker realized that the use of all 120 dimensions theorized by the Guilford model would be impractical within a school setting. She therefore began "implementation of this kind of research with the logical assignment of Binet items to the SOI (SOI definitions were used as guides)" (71, p. 112), to help determine which of the 120 Guilford SOI dimensions ought to be included in order to afford an accurate sampling of a student's various mental information-processing skills.

In addition, although the SOI-LA test items were based on those developed by Guilford, his tests were designed for adults. Therefore, "the format, content, and response mode of the SOI-LA were scaled down to a level that would be appropriate for elementary school students" (73, p. 1).

By subjecting existing intelligence/academic aptitude tests to an intellectual process which related them to Guilford's model (71), she concluded that 24 of the Guilford dimensions would yield an accurate picture of a student's mental strengths and weaknesses. Further, she found that two of the memory components yielded different results depending upon either an auditory or visual input. Thus, twenty-four SOI cells are measured by the complete Meeker Structure of Intellect - Learning Abilities Test, but twenty-six scores are yielded. These twenty-four different dimensions included within the SOI - LA are listed and defined below:

CFU - Cognition of Figural Units - Ability to identify objects, visually and auditorially

CFC - Cognition of Figural Classes - Ability to classify perceived objects

CFS - Cognition of Figural Systems - Ability to perceive spatial patterns and maintain orientation

CFT - Cognition of Figural Transformations - Ability to understand transformed objects visually

CSR - Cognition of Symbolic Relations - Ability to discover abstract relations in symbolic patterns

CSS - Cognition of Symbolic Systems - Ability to understand systems involving symbols

CMU - Cognition of Semantic Units - Ability to use vocabulary

CMR - Cognition of Semantic Relations - Ability to discover relations between concepts

CMS - Cognition of Semantic Systems - Ability to comprehend systems of words and ideas (reading, instructions)

MFU - Memory of Figural Units - Ability to recall visual and auditory stimuli

MSU - Memory of Symbolic Units - Ability to recall for immediate production a group of numerals or letters

MSS - Memory of Symbolic Systems - Ability to remember systems of numerals, letters in exact order (spelling, etc.)

MSI - Memory of Symbolic Implications - Ability to remember symbols and their implications

EFU - Evaluation of Figural Units - Ability to identify similarities and differences of shapes

EFC - Evaluation of Figural Classes - Ability to judge whether geometric figures are properly classified

ESC -Evaluation of Symbolic Classes - Ability to judge the applicability of class properties of symbolic information

ESS - Evaluation of Symbolic Systems - Ability to estimate the appropriateness of aspects of a symbolic system

NFU - Convergent Production of Figural Units - Ability to reproduce exact information in spatial forms (writing, copying)

NSS - Convergent Production of Symbolic Systems - Ability to solve correctly a problem using symbolic systems

NST - Convergent Production of Symbolic Transformations - Ability to reproduce new symbolic items of information by revising given items

NSI - Convergent Production of Symbolic Implications - Ability to substitute or derive symbols as expected (logic and algebra)

DFU - Divergent Production of Figural Units - Ability to produce many and unique varieties of figures within structure (art)

DMU - Divergent Production of Semantic Units - Ability to create many ideas spontaneously

DSR - Divergent Production of Symbolic Relations - Ability to generate a variety of relations between numbers or letters

Technical Data on The Meeker *Structure of Intellect - Learning Abilities Test*

The standard statistical measurements of a psychological test's value are measurements of the test's reliability and validity. A test that has a high reliability is a test that will yield similar scores every time the same test subject takes it. It is thus assumed to measure something in a rigid and unchanging manner.

Validity perhaps is the more difficult to determine, since a test that has high validity measures what it is intended to measure, and not some other quantity. The standard IQ tests, for example, are judged valid if they correlate highly with the Stanford-Binet IQ test. The major flaw in this procedure, however, is that if the standard is invalid, the strength of the correlation is meaningless.

Reliability and validity studies are quite difficult to perform on the *Structure of Intellect - Learning Abilities Test*. Since the basic philosophy behind Guilford's model and Meeker's test is that the *SOI* is a group of separate, but mutually inter-active abilities and is not a genetically limited upper limit on mental achievements, it follows that abilities can be improved by learning and practice. The standard techniques, such as test/retest or alternate/-

equivalent form comparisons used to evaluate reliability assume that the test under evaluation is measuring something unchangable and fixed. But if the theory upon which the test is based holds that the measured quantities are fluid and capable of being changed, then the test scores may change over time and with learning. Thus, the standard means of estimating reliability may be inappropriate.

Despite this caveat, Meeker did furnish reliability estimates of each of the subtests within the SOI - LA (73). Her choosen method of evaluation (73, p. 4), was to apply a 4 x 2 split plot design to the results obtained by administering the two equivalant forms of the SOI-LA (forms A and B) to 349 second-graders, 407 third-graders, 468 fourth-graders, 444 fifth-graders, and 340 sixth-graders. Reliability coefficients were among those figures calculated and reported. These measurements for the 4th, 5th, and 6th grade students are reproduced in Table VII, which follows.

Leonhard and House (63) state that the level of acceptable reliability figures will vary according to the use to which the test is put. They feel the following levels of reliability ought to be required for varying test uses.

> .85-.99 high to very high; of value for individual measurement and diagnosis
>
> .80-.84 fairly high; of some value in individual measurement and highly satisfactory for group measurement
>
> .70-.79 rather low; adequate for group measurement but of doubtful value in individual measurement

> .50-.69 low; inadequate for individual measurement but of some value in group measurement
> below .50 very low; inadequate for use (63, p. 385).

Several of the Meeker SOI - LA tests are short, including very few items, so that the many Guilford dimensions could be tested in a reasonable amount of time. Since reliability is often a function of test length, some test reliability estimates of these SOI - LA tests may appear to be unacceptably low, merely due to limitations in estimation. To illustrate, it is obvious that the chance variation of one question counts for more in a four-question test than in a twenty-five question test. Thus, the twenty-five question test would achieve higher reliability estimates than the shorter test simply because it was longer.

It is possible that the test reliabilities which appeared inacceptably low when Meeker measured them have fallen victim to this phenomena; it is likewise possible that the tests do not possess sufficient reliability to meet modern standards for use in research. Unfortunately, there is no way to tell which is actually the case.

When conclusions as to the nature of the measured musical aptitude/intelligence relationship are drawn, it is essential that the test reliabilities be a major consideration. Therefore, it was determined by the researcher that those SOI subtests that do not meet Leonhard and House's standards will be excluded from any conclusions drawn later within this study. It was also determined that reliability estimates on the individual subtests of the SOI - LA should be accomplished by the researcher, using the data gathered in his study.

TABLE VII
REPORTED RELIABILITY MEASURES OF THE MEEKER STRUCTURE OF INTELLECT - LEARNING ABILITY SUBTESTS (73)

	test/retest correlation (Meeker)	number of test items
CFU		16
4th	.74	
5th	.79	
6th	.79	
CFC		8
4th	.33	
5th	.44	
6th	.35	
CFS		26
4th	.64	
5th	.75	
6th	.64	
CFT		26
4th	.36	
5th	.63	
6th	.49	
CSR		8
4th	.38	
5th	.50	
6th	.50	
CSS		8
4th	.60	
5th	.56	
6th	.58	
CMU		28
4th	.52	
5th	.54	
6th	.56	

TABLE VII - Continued

	test/retest correlation (Meeker)	number of test items
CMR		26
4th	.61	
5th	.77	
6th	.74	
CMS		21
4th	.57	
5th	.69	
6th	.74	
MFU		28
4th	.40	
5th	.33	
6th	.45	
MSU-V		4
4th	.32	
5th	.49	
6th	.31	
MSU-A		4
4th	.43	
5th	.43	
6th	.50	
MSS-V		4
4th	.30	
5th	.51	
6th	.35	
MSS-A		4
4th	.32	
5th	.50	
6th	.41	
MSI		4
4th	.32	
5th	.53	
6th	.47	
EFU		26
4th	.65	
5th	.62	
6th	.75	
EFC		17
4th	.31	
5th	.33	
6th	.44	

TABLE VII - Continued

	test/retest correlation (Meeker)	number of test items
ESC		27
4th	.54	
5th	.56	
6th	.67	
ESS		8
4th	.47	
5th	.64	
6th	.58	
NFU		33
4th	.47	
5th	.64	
6th	.58	
NSS		8
4th	.36	
5th	.69	
6th	.68	
NST		161
4th	.69	
5th	.71	
6th	.75	
NSI		21
4th	.70	
5th	.67	
6th	.62	
DFU		56
4th	.36	
5th	.60	
6th	.40	
DMU		140
4th	.56	
5th	.58	
6th	.54	
DSR		5
4th	.55	
5th	.35	
6th	.27	

As can be seen from an examination of Meeker's reported reliability estimates above, certain Structure of Intellect - Learning Abilities Test subtests possess marginal reliabilities at best. This is undoubtedly a function of their shortness (some have only five test items); however, a concern over the low reliabilities of some subtests within the SOI-LA continued to concern the researcher, as they did Coffman (12) and Leton (62). Therefore, a series of reliability estimates, using the Kuder-Richardson KR-20 and KR-21 procedures (57) was computed for the pilot study data. The results of this reliability procedure will be presented later, in Chapter III with the discussion of the pilot study. In addition, it was determined that those SOI-LA subtests with low reliabilities ought to be excluded from the final models; therefore, no conclusions would be based upon those subtests with unacceptably reliability estimates.

Validity studies accomplished in the traditional manner have not been performed upon the Meeker SOI-LA test. Congruent validity, which is a measure of how well a new test correlates with an accepted standard, is only as good as the standard. If the standard is inaccurate or invalid, then the correlational measurement is likewise inaccurate or invalid. The Stanford-Binet is the often-used to which new IQ tests are compared. The validity of the I.Q. score derived from the Stanford-Binet as a true measure of intellectual information-processing skills has been questioned by such writers as Fincher (25), Gardner (30) and Gould (40).

Thompson, Alston, and Cunningham (102) performed a correlational study of the scores achieved by 145 students on the SOI-LA and the Iowa Tests of Basic Skills (68). They found that the SOI-LA scores correlated moderately well with reading achievement (r = +.59) and substantially with arithmetic achievement (r = +.83). Their assessment of the Meeker Structure of Intellect - Learning Abilities Test was that "the SOI Learning Abilities Test generally performed as predicted" (102, p. 1207).

Thompson and Andersson (101) further explored the construct validity of the "Divergent Production" measures from the SOI-LA test. Their study indicated that, "these results were generally supportive of the construct validity of the SOI-LA measure" (101, p. 654). However, they call for further research on the SOI-LA reliability and validity estimates, as "recommendations for the use of tests in placement, diagnosis, and perscription should generally be based on conclusive evidence regarding validity" (101, p. 654).

It is not possible to measure predictive validity within the theoretical framework of the Guilford Structure of Intellect model. The very philosophical basis for Guilford's Structure of the Intellect holds that the intellect is made of inter-related abilities, which are capable of remediation. One cannot predict achievement based upon an ability which can be improved.

Landis and Michael (63) accomplished a study upon the factoral validity of the SOI - LA for purposes of assessing "Critical Thinking Skills" within the context of Guilford's model. They noted that several SOI dimensions did enter into a "Critical Thinking" factor and that their study provided "preliminary and tentative evidence . . . for the viability of using constructs from the SOI model" (63, p. 1165). Their study did not, however, directly address the question of SOI - LA test validity.

A pragmatic evaluation of the Structure of Intellect - Learning Abilities Test is perhaps the best measure of its validity available at the present time, and would tend to support its construct validity. It has been shown that students whose scores on certain SOI - LA subtests are low can remediate those abilities through materials available from the SOI Institute or through others suggested by Meeker and the SOI Institute staff. A re-test on those specific mental skills will show substantial gains in the test scores achieved by the students. It must be noted, however, that the Meeker Structure of Intellect - Learning Abilities Test still has had insufficient research on its validity; it is hoped that further research on both the reliability and validity of the Meeker Structure of Intellect - Learning Abilities Test might soon be accomplished.

The Gordon *Musical Aptitude Profile*

As has been previously indicated, the Gordon *Musical Aptitude Profile* has been highly regarded by many reviewers and researchers. This section will present a discussion of the structure of the *MAP*, and a discussion of its reliability and validity as partial justification for using the musical aural discrimination tasks that comprise it for the purposes of the present study.

The *MAP* is among the more lengthy of the musical aural discrimination ability tests, for it takes 150 minutes to administer (37). No ability in musical notation or familiarity with the structure and materials of music is necesary for the student, apart from an obvious familiarity with music in the European tradition, i.e. based upon seven-note scales and tonality.

Both the instructions and the questions on the *MAP* are aurally presented on a high fidelity tape recording. Gordon has recorded the tape using professional concert artists - the monophonic examples using violin and the polyphonic examples using violin and cello. The students make their responses by blackening in an oval on a printed answer sheet.

The *MAP* is divided into three major subdivisions: 1.) Tonal Imagery, 2.) Rhythm Imagery, and 3.) Musical Sensitivity. The first subdivision, Tonal Imagery, asks the student to decide if two consecutively played melodies are

Like or Different. If the melodies are Like, the second melody is the same as the first, with the addition of secondary notes, usually passing tones or neighboring tones. If they are Different, they differ to a signifcant degree. The student may also indicate an "I am not sure" response by marking the oval marked "?". The addition of the "?" eliminates guessing, and thus improves the validity of the test, according to Gordon (37, p. 13).

Tonal Imagery has two sections, T1, which is monophonic (using violin alone), and T2, which is polophonic (using violin and cello). In T2, the students are instructed to attend only the cello part, because the violin parts are the same in each example. The "Practice Songs" for each section of the *Musical Aptitude Profile* are notated in Chapter III of the present study.

Rhythm Imagery also has two sections, in which the student is asked to decide whether the two selections are exactly the same or different; however, the differences in this section are those of rhythm. Again, the selections that are different differ to a substantial degree. In R1, the differences are those of tempo - the second playing may speed up or slow down from the first, or it may remain exactly the same. The second melodies in R2 that are different will vary from the first by being played in a different meter; the tempo will remain the same.

The final subdivision, Musical Sensitivity, is the only subdivision that is further divided into three sections. In the first, (S1), the students are required to decide which of two alternatives has the most musical phrasing; in the second, (S2), which alternative melody has the best ending section (cadence); and the third, (S3), which alternative is played in the best style. This subdivision is an attempt to discover if the student can select which performance is more musical. Again, the differences are usually glaringly obvious to a trained musical ear. They are not subtle.

The MAP kit includes templates which are placed over the answer sheets to grade the individual papers. The raw scores are converted to standard scores by a conversion table printed on the template. Both Gordon (36) and Young (115) have furnished percentile conversion charts for use by students from 4th grade through college, music and non-music majors.

There are seven individual scores and percentile rankings for each test subject, i.e. T1, T2, R1, R2, S1, S2, and S3. Gordon then takes a arithmetic mean of each of the groups of individual scores, to arrive at a composite subdivision score (TC, RC, and SC). Finally, an arithmetic mean of the composite subdivision scores is taken to arrive at a grand Composite score (COMP). Thus, eleven different scores are yielded by the Musical Aptitude Profile.

It is not Gordon's intent to use the results of the MAP to create a musical elite by excluding those who do not score above a certain level. He feels the contributions of tests to our profession are most valuable as indicators of teaching effectiveness.

> Test scores are used as objective aids to music administrators and teachers to help them better understand each student's musical strengths and weaknesses, and thereby better provide for each student's musical potential and needs through curriculum development and advising (36, p. 32).

Gordon computed reliability estimates by applying the split-halves procedures using to the MAP scores of the 12,809 students who were used to set the norms. He reports reliability estimates of all the subtests (37, p. 50) and all the grades, as well as reporting scores of the group of "Musically Select" students separately as well as included within the total group. His Composite scores (COMP) achieve reliabilities of +.90 or above for all grades from 4-12 and most of the subtests achieve individual reliability estimates of well over +.70. Only two grades, the 4th and 5th, have any subtest reliability figures in the .60's, two in the 5th and five in the 4th.

In comparing Gordon's reliability figures to Leonhard and House's standards, we see that the MAP Comp can be reliable for making decisions about individuals; the entire MAP is certainly exceptional in its reliability estimates for making decisions about groups.

Tarrell (98), Gordon's student, investigated the validity of the MAP by administering the MAP to 1487 Iowa students in grades 4-12. He then selected 900 music students from this parent body and divided them into three groups: 1.) selected instrumental music students, 2.) selected vocal music students, and 3.) non-selected students who were participating in either vocal or instrumental music programs. He further also divided the students further into grade levels.

During the next two months, all the students tape-recorded special etudes (written by Tarrell). Adjudicated scores from 7-35 points were awarded to these performances by three judges on the basis of seven criteria. These scores were then correlated with the Musical Aptitude Profile TC, RC, SC, and Composite test scores using the Pearson product moment correlation technique, corrected for attenuation by Gullickson's method. Gullickson's method, according to Tarrell, enables a researcher to estimate "what the validity coefficients would have been if it were possible to work with a normal group of musically heterogeneous students in a study of this type" (98, p. 199).

Tarrell found all the correlations between the four MAP scores and the performance scores on each of his age levels were significant to the .05 level except four. To achieve significance at the .05 level, the r's needed to be at least

+.17. Those four not achieving that level were the following:

grade level	MAP subtest	correlation with performance score
Elementary Instrumental	RC	+.13
Senior High Instrumental	RC	+.16
Senior High Instrumental	SC	+.12
Senior High Vocal	RC	+.15

All the Musical Aptitude Profile Composite scores (COMP) achieved significance to the .05 level. Put in simplier terms, those students who achieved high scores on the MAP tended to be those who performed better.

Gordon's own validity study for the Musical Aptitude Profile (34) was an extensive three-year longitudinal study of the MAP's predictive validity. With support from the National Association of Band Instrument Manufacturers, every student in a group of randomly-selected classrooms was given a band instrument (N = 193) and instrumental instruction. The students were given the complete Musical Aptitude Profile prior to the commencement of instrumental training and their scores kept from their instrumental teachers, thus achieving a double-blind study.

The students tape-recorded etudes at the end of each year of study. Two judges independently adjudicated the performance of the etudes, and correlational studies were run between the scores achieved on the etude performances and the MAP scores. Gordon achieved predicitve validity coefficients of r = + .77 for the relationship between MAP composite scores and his three judgemental criteria (etude performance, teacher evaluation, and composite musical achievement test score.) Predicitive validity figures for musical tests have rarely been achieved with previous tests. Gordon's results are the best yet achieved using any predictive measurement.

Gordon (35) also became interested in the contribution of each of the subtests to the overall validity of the MAP. Responding to criticism that the 150-minute length of the MAP makes the test difficult to administer, he sought to determine if "fewer than the seven subtests could sufficiently maintain the comparatively high experimental validity of the composite test score" (35, p. 32). He applied the statistical technique of multiple regression analysis to the raw data obtained in his three-year longitudinal study of the predictive validity of the MAP (34).

Using the grand composite score, which was composed of the same testing etudes used to measure the predictive validity of the MAP, the teacher's subjective evaluation of the student's progress in musical studies, and an achievement test designed to measure the student's progress in music reading as the dependent variable, and the scores of the seven MAP subtests as the independent variables, he found that only two subtests, the Rhythm Imagery-Meter (R2) and the Musical Sensitivity-Balance (S2) "did not contribute significantly to the prediction of musical success" (35, p. 34), because the Beta F-values achieved through multiple regression analysis did not achieve significance at the .05 level.

Gordon felt, however, that omission of the two tests was not justified at this time, because of the subtest intercorrelations. This deletion "in order to 'save time' in identifying overall musically talented students could possibly result in overlooking students who are highly musically creative" (35, p. 36). Considering these diminished results, Gordon feels that the small amount of time that may be saved by omitting sections could not be justified.

Also responding to criticisms of the MAP's length, Brown (9) sought to determine if the subtests could be shortened to any degree without affecting the reliability of the total test. He did this because of his feeling that, "For a test to be most efficient, it must offer maximum reliability in a minimal amount of administration time" (9, p. 240).

He investigated the reliability of each subtest as a function of its length by first administering the MAP as a test-retest situation. he then divided each subtest into portions of five items in length. He then compared test-retest reliability coefficients for each test portion. "The optimum length of each subtest (at each grade level) was determined by examining the reliability coefficient for each 'test portion' of sequentially increased length" (9, p. 242).

Brown concluded that, "Although it was recognized that an increase in reliability is a general consequence of increased test length" (9, p. 243), shortening the MAP would cause an inacceptable decrease in test reliability. Brown also rejects the idea of lengthening the MAP to increase reliability because of the earlier-mentioned administration time difficulty and the fact that, "the reliability of the test battery, as it now stands is of sufficient magnitude that it can be used with a rather high degree of confidence" (9, p. 247).

McLeish, in his review of the MAP (77, p. 529), concludes his assessment of the Musical Aptitude Profile with the conclusions that the MAP is a valid and worthwhile test for the purpose of measuring musical aural discrimination abilities.

> [It] succeeds in measuring the higher level functions of musical aptitude and avoids the trap of measuring the effects of training. The simple nature of the task(s) . . . and the nature of the stimuli, insure that differences in intelligence, previous training, and musical interest have little effect on the score (77, p. 530).

Because of the extensive work in the development, measurements of reliability and validity, and in the presentation of the musical materials, it is possible to conclude that the Gordon _Musical Aptitude Profile_ is a satisfactory instrument for the purposes of this study, and the best instrument currently available for the measurement of the specific musical aural discrimination skills under consideration.

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CHAPTER III

METHODOLOGY

This study is justified upon the premise that previous studies of the relationship between those mental skills which have been called "intelligence" and those mental skills that create musical discrimination ability have used insufficiently detailed measures of both sets of functions to determine precisely which mental skills entered into a relationship with differing musical aural discrimination abilities. In order to answer the research questions, the methodology proceeded using the following sequential steps:

> 1. The research questions were formulated; they inquired into the nature and magnitude of the relationship between various individual mental information-processing skills and specific musical aural discrimination abilities.
>
> 2. Measurement instruments were selected that would enable the researcher to answer the research questions, i.e., that were sufficiently detailed to measure specific mental information-processing skills and musical aural discrimination abilities.
>
> 3. The selection of a body of test subjects whose age, mental, educational, and emotional characteristics would most logically assist in the answering of the research questions was made.
>
> 4. A pilot study was accomplished in order to achieve two aims; first, it was found desirable to measure the reliability and validity of the measurement instruments and second, to test the feasibility of the statistical procedures selected for the study.

5. The results of the pilot study were evaluated in order to determine if the test instruments were of sufficient quality for research and to ascertain whether the statistical procedures were valid and justified the continuance of the study.

6. The main study was accomplished, using a larger body of test subjects in order to stabilize the statistical procedures. Detailed statistical procedures to determine the validity of the results were also accomplished.

The process of formulation of the research questions has already been discussed previously; each of the succeeding methodological steps shall be further discussed in turn.

Selection of the Measurement Instruments

This study used two tests that yielded more detailed information to examine the relationship: the Gordon *Musical Aptitude Profile* was used to measure individual musical discrimination skills and the Meeker *Structure of Intellect-Learning Abilities Test*, which is based upon the Guilford *Structure of the Intellect* model of intelligence, was used to measure selected mental skills. These tests have already been discussed in Chapter Two of the present study; however, since one of the most important research questions of the present study deals with the specific mental information-processing skills and musical aural discrimination abilities, the individual subtests within each measurement instrument take on a new importance. It is now appropriate to discuss each measurement instrument in some detail.

The Specific Musical Aural Discrimination Skills Measured by Gordon's *Musical Aptitude Profile*

Melodic Discrimination Skills

Melodic Discrimation Skills are measured in two ways in the *Musical Aptitude Profile*. The first (T1) is a measure of the test subject's ability to assess whether two melodies are "Similar" or "Different". The second (T2) is regarded (and titled by Gordon) as a measure of harmonic discrimination. Examination of the tasks within this subtest, however, reveals that the task posed by this subtest is quite similar to the task posed by T1, in that it asks the student the same question - whether or not two melodies are "Similar" or "Different". T2 differs from T1 in that it is polyphonic in nature whereas T1 is monophonic. The second melody may have a confounding effect upon the student's decision of whether the melodies are "Similar" or "Different"; it certainly makes this decision more difficult. Because of the nature of the task within the *MAP* T2 subtest, it will be regarded as a further measure of melodic discrimination skills, rather than any skill at harmonic discrimination. As can be seen from an examination of the sample exercises for T1 from the *Musical Aptitude Profile* below, if the second melody is "Similar" to the first, it will be the same melody, with the addition of passing and neighboring tones - i.e. made more complex. If it is "Different" it is clearly different from the first melody.

Example 1a: "Similar"

Example 1b: "Different"

Fig. 8--Sample Exercises from Subtest T1 of the _Musical Aptitude Profile_

Success at this task seems to involve the ability to hold the tune of the first melody in memory while comparing it with the input furnished by the second melody and processing both to determine if the basic structure of the first and second melody is similar or different. A decision also must be made as to what degree of difference is sufficient before the test subject will decide the second melody is sufficiently dissimilar from the first to mark the "Different" response.

T2, the second _MAP_ subtest and the other _MAP_ subtest in which the posed task measures musical melodic discrimination, is intended by Gordon to measure harmonic discrimination skills. However, as was previously noted, the actual tasks are more a further measure of melodic discrimination skills. The sample exercises 1a and 1b are notated below. The musical examples are brief selections in counterpoint, played by a cello and violin; the task posed by this subtest is to compare the cello part in the first and second parts and determine if it is "Like" or "Different" in the second part. The violin part is exactly the same in both parts. This is similar to subtest T1, in that a cello part is determined to be "Like" if it is the same melodic passage, decorated by passing tones, neighboring tones, or melodic skips to other chord members; if it is different, it is completely different. In the sample exercises below, the student would mark the "Like" response for sample exercise 1a and the "Different" response for sample exercise 1b. Note that the violin part remains the same in both parts; only the cello part will vary.

Example 1a: "Similar"

Example 1b: "Different"

Fig. 9--Sample exercises from Subtest T2 of the <u>Musical Aptitude Profile</u>

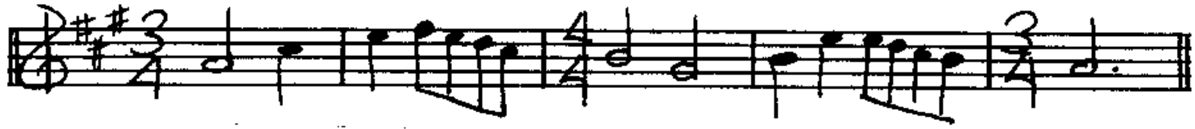
Rhythmic Discrimination Abilities

The first of the musical aural discrimination task posed by the Musical Aptitude Profile, R1 (tempo) consists of pairs of short, monophonic musical passages played by the violin alone. The student is to determine if the second playing of the selection is the "Same" or "Different" from the first. If the second playing is the "Same", it will be exactly the same; if it is different, the ending of the second playing will either ritard or accelerate. The differences are pronounced -- there are no very close judgmental calls in this subtest.

In sample exercises 1a, 1b, and 2a, notated below, the student would mark the "Same" box for 1a, and "Different" boxes for sample exercises 1b and 2a.

Example 1a: "Same" (both times exactly the same)

Example 1b: "Different" (second time acc.)



Example 2a: "Different" (second time rit.)

Fig. 10--Sample Exercises from Subtest R1 of the MUSICAL APTITUDE PROFILE.

The MAP subtest R2 is intended to measure the rhythmic aural discrimination skill of meter discrimination. It consists of a series of pairs of short musical phrases played on the violin. If the first and second are the "Same", the performance of both parts will be exactly the same. If they are "Different", the meter will change, along with the rhythmic values of some of the notes, but the pitches played will remain the same. In sample exercise 1a below, the proper response would be the "Same"; in sample exercise 1b, the second playing of the phrase was in 4/4 instead of 3/4 meter, with the attendent lengthing of some of the note values. Sample exercise 2a is also "Different", being played in 2/4 the first time and 3/4 the second.

Example 1a: "Same"

Example 1b: "Different"

Example 2a: "Different"

Fig. 11--Sample Exercises from Subtest R2 of the Musical Aptitude Profile.

Sensitivity Discrimination Abilities

The three final MAP subtests, S1, S2, and S3 all are designed to measure skills of musical sensitivity. Specifically, they call for the test subject to decide which of two alternative preformances of a musical phrase is "better" or "more musical"; no criteria for this type of aesthetic judgment is given the subjects. However, Gordon based his answers as to which was the better performance upon the answers given by a representative group of professional musicians. He concluded that this procedure would reflect the norms of musical judgement. The sample exercises for S1 (Phrasing discrimination) are notated below.

Example 1a: first time legato; second time non-legato, very stiff and harsh

Example 1b: first time detache; second time legato

Fig. 12--Sample exercises from subtest S1 of the *Musical Aptitude Profile*.

In sample exercise 1a above, the subject would mark the first block, as the first performance was more musical. In sample exercise 1b, the second performance was better. However, the exercises do not necessarily always regard a legato performance as the better performance. As was mentioned earlier, Gordon established the "correct" answers as to the "better" performance by consulting a number of professional musicians as to their assessment of the performances. He included only those test items in the Musical Aptitude Profile on which an overwhelming majority of the professional musicians consulted agreed.

The MAP S2 subtest is designed to measure the musical aesthetic discrimination skill Gordon has called "Balance". Gordon uses the word in a somewhat unusual manner. Most musicians would associate "Balance" with the comparitive and appropriate loudness of instruments or voices in an ensemble. Instead, Gordon's test for "Balance" is a test of phrase completion, i.e. whether the phrase ending "Balances" the phrase beginning and makes a satisfactory closing.

In a similar manner to earlier MAP subtests, the MAP S2 subtest requires the subject to listen to two melodies. They have the same initial bars, but the endings differ. The subject is required to determine, based upon his aesthetic judgment, which of the melodies has the "best" ending. The sample exercises for S2 follow.

Example 1a

Example 1b

Fig. 13--Sample exercises from subtest S2 of the Musical Aptitude Profile.

The final MAP aural musical discrimination skill is another Sensitivity discrimination skill, that of S3 (Style). The musical examples are performed twice; the notes remain the same, but the style of performance will change. In sample exercise 1a, notated below, the first time the melody is played, it is performed in a fast tempo with a bouncing bow (spiccato); the second time, it is andante and legato. The better performance, according to Gordon, is the second one, because the "second one sounded better (2, p. 26x)." However, in the next sample exercise, exercise 1b, the first playing (allegro) of the melody is the correct answer.

Example 1a: first time allegro and spiccato; second time andante and legato

Example 1b: first time allegro; second time andante

Fig. 14--Sample Exercises from subtest S3 of the Musical Aptitude Profile

The Specific Intellectual Information-Processing Abilities Measured by the Meeker Structure of Intellect - Learning Abilities Test

As was discussed previously, Meeker selected 26 of Guilford's theoretical 120 individual mental information-processing abilities to include within the Structure of Intellect - Learning Abilities Test. Each of these is measured by its own subtest, with its own individual mental task.

To allow for greater clarity in the discussion of the results of later research procedures, it is appropriate at this time to discuss the defined nature of each SOI-LA dimension Meeker choose to include within Structure of Intellect - Learning Abilities Test and describe the mental task that is designed to measure it.

The first vector that Guilford derived from his factor analytical studies of previous research into the nature of intelligence was named the "Operations" vector. Guilford defined it as representing, "Major kinds of intellectual activities or processes; things the organism does with the raw materials of information, information being defined as 'that which the organism discriminates'" (7, p. 13). It will be remembered from the previous discussion on the nature of the Guilford _Structure of Intellect_, this "Operations" vector is comprised of five sectors; they are 1.) Divergent Production, 2.) Convergent Production, 3.) Evaluation, 4.) Memory, and 5.) Cognition. Meeker has included nine mental skills from the "Cognition" sector, six from the "Memory" sector, four each from the "Evaluation" and "Convergent Production" sectors, and three from the "Divergent Production" sector within her _Structure of Intellect - Learning Ability Test_.

Guilford defines "Cognition" as "Immediate discovery, awareness, rediscovery, or recognition of information in various forms; comprehension or understanding" (7, p. 15). It is the skill of "knowing" or "perceiving" information and of processing that information to imagine it even from an altered perspective. Meeker feels that "Cognition" is "perhaps the most obvious of all the operations. . . it seems to be the primary process since every other activity presupposes perception and awareness of stimuli with the associated ability to discriminate or attend" (7, p. 14).

CFU, the Cognition of Figural Units, is the "ability to recognize a figural entity, that is, to 'close' figural information or perceive a complete visual form" (7, p. 30). The test is a "test of the student's ability to recognize familiar figures that have been partially obscured" (8, p. 3). Line drawings of bicycle handlebars, a train, a cup and saucer, and other objects are presented with large amounts of the drawing "whited-out". The student is presented with the task of identifying the picture from the incomplete visual clues given.

CFC is the Cognition of Figural Classes and is the "ability to recognize classes of figural items of information" (7, p. 32). In this subtest, the student "identifies the class or classes to which a presented figure belongs; it is figural classification since the student does not need to know the name of the class" (8, p. 49). The student is presented with a given figure, for instance, a circle, and a group of several other boxes, all containing various geometric shapes. He must identify the given geometric figure and realize it belongs to a box with many other circles of different sizes rather than a box of other geometric figures. He indicates his choice by drawing a line between the box and figure. In this subtest, the student thus decides which group a single figure would most logically fit with because of similarities he perceives with the group of figures.

CMS, the Cognition of SeMantic Systems, is the "ability to comprehend systems of words and ideas . . . the ability to comprehend relatively complex ideas" (7, p. 44). Meeker indicates that most achievement tests and both the WISC and Stanford-Binet I.Q. tests include similar tests and further states that this particular intellectual skill involves "the analysis of the rudiments of solutions" (7, p. 44). According to Meeker, this is a complex intellectual skill.

> The student must first observe a phenomenon; then to demonstrate that he comprehends it he must attempt to explain it -- by ordering his thoughts into a systematic whole he arrives at the totality (7, p. 44).

The task by which the SOI - LA measures this mental information-processing skill is a "type of 'form reasoning'" (8, p. 9). In this subtest, the student is assigned the task of translating a verbal description into a set of shape relationships by meas of a set of "'word-shape' equivalencies" (8, p. 9). For example, "WATER" is defined to be represented by a circle and "FIRE" to be represented by a triangle. The word description of "Something that is wet around something that burns" would translate to a geometric figure of a triangle within a circle. CMS, then, is a form of translation from one semantic system (word descriptions) to another semantic system (geometric symbols).

CFS, the Cognition of Figural Systems, is "the ability to comprehend arrangements and positions of visual objects in space" (7, p. 34), and is a "test of the ability to perceive a system from any viewpoint" (8, p. 5). The student is instructed to determine which of the four alternative choices given would be the appearance of a criterion figure, if the figure would be rotated to varying degrees (indicated by an arrow in the criterion figure).

CMU, the Cognition of SeMantic Units, is the SOI dimension which most closely resembles activities on traditional I.Q. and achievement tests. It is "the ability to comprehend the meanings of words or ideas" (7, p. 41). and is an indication of both knowledge and past success at learning. There are two parts to CMU; in the first, learned numerical/arithmetic concepts are tested by asking the subject to circle the alternative which is the same as the criterion expression appearing at the left side of the box. The second part is a vocabulary test, in which the subject is asked to circle the word that means the same as the word given at the left.

CSR, the Cognition of Symbolic Relations, is the "ability to see relations between items of symbolic information" (7, p. 39). The subtest which measures this ability consists of word pairs. The task assigned to the student is to find "the relationship between letters embedded in pairs of wrds to select the correct word to complete the third pair" (8, p. 11). However, CSR is most emphatically not an analogy test; the meanings of the words are completely irrelevant to the exercise. "It is the relationship between the letters, and not the meanings of words, that is being tested" (8, p. 11).

To illustrate this concept further, the example exercise for the CSR subtest which appears in the SOI - LA consists of the following word pairs:

EXHAUST - FAUNA
PAIL - MOUNTAIN
COACH - __________ (CAIN; CATCH; LOAD; CHIME)

The word from the four alternative choices which most properly completes the third pair is "LOAD". The intellectual process for arriving at this decision is that the first word-pair, "EXHAUST" and "FAUNA" have a vowel-pair in common, "au". The second word-pair, "PAIL" and "MOUNTAIN" have a different vowel-pair in common, "ai". Therefore, the vowel-pair in "COACH", "oa" is present only in "LOAD".

CFT, the Cognition of Figural Transformations, is a visualization ability; it is the "ability to visualize how a given figure or object will appear after given changes, such as unfolding or rotation" (7, p. 35). This test is designed to measure the students ability to "recognize a figure when it has been rotated into a new orientation" (8, p. 6). A given geometric figure is presented, and the student asked which of the given alternative answers would be the same figure rotated to various degrees. CFT differs from CFS in that CFS specifies the amount of rotation that the geometric figure is given; CFS, however, does not specify the amount of rotation but instead changes the figure itself as well as rotates it.

CMR, the Cognition of SeMantic Relations, is the "ability to see relations between ideas or meanings of words" (7, p. 43). The task posed by this subtest causes the student to "find the relation between two givens -- the task is to identify what comes between two stimulus items" (8, p. 8). The test presents two items, either written in words or pictured with line drawings. The student is to determine which of the four given responses would most logically go between the two given items -- perhaps in time, perhaps in physical proximity. An example would be to present a line drawing of a foot and a drawing of a shoe. The possible answers given are a boot, a girl, and a sock; the correct answer is a sock -- a sock goes between a foot and a shoe.

The final SOI - LA subtest, CSS, the Cognition of Symbolic Systems, measures the "ability to understand the systematic interrelatedness of symbols within an organized set" (7, p. 39). The task with which this test measures the CSS ability asks the student to "find the rule that is generating a number series" (8, p. 52). It is the "Which number comes next in the series?" test, familiar to everyone who has taken I.Q. tests or any of the tests of scholastic aptitude. A number series is presented (such as 1, 3, 5, ____), and the student is to pick which number of the four answers most logically fits the pattern.

The "Evaluation" sector of the "Operations" vector represents those skills that are necessary in "reaching decisions or making judgement concerning criterion satisfaction (correctness, suitability, adequacy, desirability, etc.) of information" (7, p. 17). Meeker has included four "Evaluation" subtests within the SOI - LA in order to measure the student's "sensitivity to error or discrepancy on the one hand, . . . (and) the ability to make judgements in relationship to known or understood standards" (7, p 17).

EFU, the Evaluation of Figural Units, is the "ability to identify similarities and differences of shapes . . . the ability to judge units of figural information as being similar or different. Judgements are based on minor aspects of the information" (7, p. 63). It requires the test subject to determine which of the five possible responses is exactly the same as the given criterion in the left-hand box. The responses may vary in shape, orientation, or size, and the students "must compare figures to find the one that is exactly the same as the stimulus figure" (8, p. 48). The task begins very easy, but the figures become more complex and the differences more subtle as the student proceeds through the exercise. EFU appears to be a direct measure of the ability to mentally compare two different inputs (the criterion and each of the possible responses individually) and make a decision as to the degree of similarity.

According to Meeker, EFC, the Evaluation of Figural Content, is one of the Guilford SOI dimensions which is still under investigation; however, she feels that enough of EFC's nature is known to define it thusly:

> EFC would define an ability to classify units specified in some way. The task for the students would be to analzye how they are classified and then judge how other units are similarly classified in another group of figures or forms (7, p. 64).

It measures an important ability for success in school, for "classification ability indicaters conceptual development; students high in CFC and EFC will read with good conceptualization" (8, p. 50). The task posed by EFC is to determine which of a group of geometric figures is similar to the figure given in the left-hand box to belong in the same group. For example, if the criterion is a solid triangle, and the responses are a circle, a square, and a smaller solid triangle, the response would be the triangle; it is similar enough to the criterion to belong to the same group. EFC, therefore, is task which measures the mental skill of determining the degree of similarity and deciding which alternative is similiar enough to be grouped with the criterion.

ESC, the Evaluation of Symbolic Classes, involves the ability to judge applicability of class properties of symbolic information, that is, judging of a class in which to place numbers, letters, or signs" (7, p. 65). This task calls for the student to "classify numbers by different criteria; when more than one of the criteria apply, the student must be selective to produce the correct answer" (8, p. 51). The student is to try to see how close he can come to hitting a bulls-eye by determining what "ring" a given number belongs in (by such given criteria as "divisible by 3", or "is an odd number"). This "Evaluation" skill obviously involves a certain amount of learned arithmetic skills.

ESS, the Evaluation of Symbolic Systems, is the "ability to estimate appropriateness of aspects of a symbolic system" (7, p. 66). In this test, "rules are presented and the student examines series of numbers to find the series that has been described by the rule" (8, p. 53). The rule is some arithmetic operation, such as "Each number is two more than the number before it." Therefore, like ESC above, it also involves a certain amount of learned arithmetic skills.

Meeker choose four tests selected from those comprising the SOI sector that Guilford named "Memory". However, Guilford found that different results were achieved on two of these tests, depending upon whether an aural or visual input was presented; thus, although only four dimensions are measured, six tests are included within this segment. Guilford defined this sector, "Memory" as "retention or storage, with some degree of availabiity, of information in the same form it was committed to storage" (7, p. 16). Meeker has indicated the importance of the mental abilities belonging within this sector of the "Operations" vector.

> It would be hard to overestimate the importance of memory abilities in the education process, especially in terms of the measured achievement which often stands as a measure of the educational system itself . . . we have neither explored nor developed some of the most promising avenues in an absolutely essential area of academic learning (7, p. 17).

There are two tests which measure the skill of MSU, the Memory of Symbolic Units; one with a visual input, and the other with an aural input. MSU measures the "ability to remember isolated items of symbolic information, such as syllables and words" (7, p. 53), and involves "recall which requires students to write down their responses" (8, p. 12). The students are presented with lists of numbers, consisting of 4 to 7 digits, and instructed to write the numbers down in the order presented. MSUV involves a Visual input i.e., the numbers are shown to the students for one second per digit, and MSUA involves an Aural input, in which the list of numbers is read out loud at the speed of approximately one per second.

MSS, the Memory of Symbolic Systems is the "ability to remember the order of symbolic information" (7, p. 56). Like MSU, numbers are presented in both visual and aural format. However, it differs form MSU in that an additional mental step is requried; the students are required to write the numbers down in the reverse order from that in which they were originally presented. Success at either MSSV (Visual input) or MSSA (Aural input) therefore requires not only short-term memory skill but an additional mental information-processing skill as well.

MSI, the Memory for Symbolic Implications is the "ability to remember arbitrary connections between symbols" (7, p. 57). The task posed by the SOI - LA to measure this mental information-processing skill "tests the ability to hold in mind contiguously unrelated visual symbolic information" (8, p. 36). This task visually presents number-letter pairs to the student, from three to six number-letter pairs, giving the student one second per symbol to study the pairs, and then having them write the pairs. According to Guilford, the addition of the paired relationship causes this memory skill to be different from those measured above.

The final "Memory" skill, MFU, is the Memory for Figural Units. It is the ability "to remember given figural objects" (7, p. 51), and is basically a "test of incidental memory" (8, p. 57). The nature of this task indicates that this is the only long-term memory skill to be measured by the SOI - LA. It is the next-to-last subtest in the test booklet; the students are presented with a page of fifty line drawings and geometric shapes. They are to indicate, without looking back in the test booklet, which drawings and shapes they remember as having appeared earlier, as parts of other subtests.

The SOI sector which Guilford called "Convergent Production" represents the group of mental information-processing abilities that involve the "generation of information from given information where the emphasis is upon achieving unique or conventionally accepted best outcomes" (7, p. 19). Meeker included four tests of this sector in the SOI - LA because this SOI sector "is the most familiar SOI ability expected in schools . . . [it] is 'rigorous thinking' -- the process of finding the answer where 'finding' is more than mere retrieval" (7, p. 19). Unlike the skills of pure memory, where the answer is simply brought forward from a memorized data bank, the sector of "Convergent Production" involves the application of rules or principles for manipulating or processing information to achieve at an answer.

NSS, the CoNvergent Production of Symbolic Systems, is the ability "to produce a fully determined order or sequence of symbols" (7, p. 79), and is a "test of the ability to solve complicated arithmetic problems which do not depend upon verbal skills" (8, p. 54). To solve the problems which comprise this task, the student is given a starting number and an ending number; he must arrive at the latter by one of three different methods presented him (such as "Multiply by 2 and subtract 1").

The CoNvergent Production of Symbolic Transformations, NST, is the "ability to produce new symbolic items of information by revising given items" (7, p. 80). The task posed to measure this ability is to "unscramble written words and sentences in order to read them. The test asks the student to perform at levels from reading simple run-on sentences, to recognize words that have had quite complex alterations (such as backwards, upside-down, mirror images, and words hidden within sentences).

Like NST, NSI, the CoNvergent Production of Symbolic Implications, is also a measure of symbolic relationships and is the "ability to produce a completely determined symbolic deduction from given symbolic information, where the implication has not been practiced as such" (7, p. 80). The task calls for the student to perform arithmetic operations, but uses geometric shapes instead of common numbers. For example, if the student is presented the information that a triangle plus a circle equals a star, and a star plus an square equals a half-circle, what does a triangle plus a circle plus a square equal? The answer, of course, is a half-circle.

Unlike the other three subtests in the "Convergent Production" sector, the final "Convergent Production" subtest in the SOI - LA is not a measure of the student's ability to work with symbols. NFU, the CoNvergent Production of Figural Units instead "gives an indication of eye-hand coordination" (8, p. 58), and is used in the same way as other "perceptual motor and psychomotor tests" (8, p. 58), in the Wechsler and Bender-Gestalt. The relatively simple task is that the student is required to accurately copy simple geometric forms, i.e., circles, squares, triangles, and wavy lines, as many times as he can within two minutes. It is largely a measure of the student's pencil-handling skills rather than a measure of any intellectual information-processing abilities.

"Divergent Production" is the "Generation of information from given information, where the emphasis is upon variety and quality of output from the same course" (7, p. 20), and is measured in the Structure of Intellect - Learning Abilities Test by three subtests; Divergent Production of Figural Units (DFU), Divergent Production of SeMantic Units (DMU), and Divergent Production of Symbolic Relations (DSR). Meeker included these tests of "Divergent Production" in the SOI - LA because of the importance of divergent/creative thinking to success in learning and because of its implied relationship with convergent production.

> On the one hand, divergent production should show fluency, flexibility, and individuality, an ability to break away from the conventional; but on the other hand it should also show quality, relevance, and discipline, an ability to stay within "reasonable" bounds (7, p. 20).

The tasks differ for each subtest. In DFU, which is the first task presented in the *SOI - LA* test booklet, the students are given a matrix of one-inch squares and told to "make each square into something different" (8, p. 1). The intention is to "produce many figures conforming to simple specifications" (7, p. 87). and is "a test of the student's ability to use ambiguous stimuli in creative ways" (8, p. 1). It is similar to Torrance's *Minnesota Tests of Creativity for Children* (10) not because Meeker indulged in any plagiarism, but because both Torrance and Meeker based their work on Guilford's original tests. A student's responses are regarded as showing a high degree of "Divergent Production" through such items as fluency, which is defined as using many different squares, set change, e.g. many different ideas are shown, transformation, which is the use of two or more squares to draw one idea, and orginality, such as labeling, three-dimensional representation, perspective, movement, humor, very unusual or detailed designs, or a macabre subject.

DMU, the Divergent Production of SeMantic Units, is the "ability to produce many elementary ideas appropriate to given requirements" (7, p. 96). In the SOI - LA, it is measured by the task of having the student create a story based upon any of the drawings he has just completed for the DFU subtest. It is a test of "verbal fluency - the willingness to express one's ideas freely" (8, p. 3), and the stories may be either written down or dictated to the person administering the test. In an evaluation process similar to DFU students show a high degree of "Divergent Production" in this area by such criteria as fluency, measured by the number of words in the story, and originality, such as plays on words or puns, personification of inanimate objects, stories that are written as poetry, which have a moral, or that evoke a moving emotional response.

The final subtest of "Divergent Thinking", DSR, (Divergent Production of Symbolic Relations), measures the student's "ability to relate letters or numbers in many different ways" (7, p. 93). The task given the students is that a matrix of nine boxes is arranged in a 3 x 3 grid with letters or numbers in some boxes and the others empty. The student is to complete the gride by filling in the empty squares, according to specific rules given for each grid. These may be such things as each row must add across to total six or each row and column must sum to twelve. This subtest asks the student to produce "symbolic relations with virtually no limitation. Any answer that shows some relationship is acceptable" (8, p. 10).

Selection of the Subject Body

It was determined that the subject population of this study would be middle-school students, specifically from the 4th, 5th, and 6th grades. This age group was selected because this developmental period is critically important to music education. It is at this time when most students make the decision to study instrumental music and begin to establish their musical independence from the influences of school and home. General music classes traditionally concentrate on musical notation during this time; and for those students who choose not to engage in further musical study, it is the time of their last contact ith music education. Therefore, a close examination of the structure of the relationship between these students' musical aural discrimination abilities and their mental information-processing skills during this developmental period could yield valuable information to music educators.

The lower age limit of the test population has been set at the 4th grade because neither Meeker's Structure of Intellect - Learning Abilities Test nor the Gordon Musical Aptitude Profile has been found to possess sufficient accuracy of measurement for children younger than that age level.

Gordon has determined that the Musical Aptitude Profile does not yield reliable results before the approximate age of ten; his speculation is that musical aural discrimination skills are more under the influence of environmental factors in the early grades (3, p. 5). It is also possible that the shorter attention spans of the younger students does not allow them to complete the rather lengthy tasks comprising the MAP with acceptable reliability. According to Gordon, scores on the MAP appear to become relatively constant throughout later life (3, p. 5).

The Meeker Structure of Intellect - Learning Abilities Test, "is not appropriate for general populations below grade two" (8, p. 4). However, the SOI-LA must be used with extreme caution in the lower grades since many of the SOI-LA median scores are zero or one for grades two and three; this makes true discrimination difficult and affects test reliability negatively. As will be seen in later discussions of the SOI-LA reliability and validity measures, some SOI-LA subtest reliability figures are unacceptably low for grades two and three; Meeker has recently addressed this problem by publishing a separate SOI test for K-3 grades.

Since the Guilford Structure of Intellect model postulates that intelligence consists of a group of separate but inter-related mental information-processing skills that are capable of remediation, it follows that these mental information-processing skills can be improved through specific classes and specific learning activities. Beyond sixth grade, students begin to have greater curricular choices. Beginning in the seventh grade, students traditionally have the opportunity to take such varying subjects as more advanced math coursces, (usually in several different tracks), industrial arts, science, and a variety of other alternative classes. Thus the assumption of a heterogeneous subject body for study would be violated for students in the seventh grade and older. But up to and including the sixth grade, students generally take the same classes and have the same educational opportunities. By selecting the subject body from the fourth, fifith, and sixth grades, the possibility of external influences affecting the students through their different curricula can be reduced, if not entirely eliminated.

Pilot Study Methodology

Since an attempt to explore precisely which intellectual skills may enter into a significant relationship with individual musical aural discrimination abilities has never before been undertaken, it was determined necessary to ascertain the reliability and validity of the measurement instruments; in addition, a test of the research procedures and statistical techniques was called for in order to determine if the research plan of the study was feasible. Therefore, a pilot study, using both measurement instruments was undertaken. This pilot study also allowed the experimentor to determine which statistical technique would be the most revealing of the relationship between musical aural discrimination abilities and the various mental skills within the intellect.

In this pilot study, fourth, fifth, and sixth graders from two private schools (N = 135) in the Dallas/Ft. Worth area were administered both the Meeker _Structure of Intellect Learning Abilities Test_ and the Gordon _Musical Aptitude Profile_ between November, 1983, and May, 1984.

The schools and the students' parents were promised anonymity in return for their authorization for the students to participate in this research. Thus, the schools only can be identified and described as follows:

> School A: An open-learning, Montessori-concept school with a student body of 100.
>
> School B: A parochial school with traditional self-contained classrooms and a student body of 320.

Only those students whose parents returned the authorization form were given the tests. To further preserve the student's anonymity within this study, the students were identified by code number only.

Both the _MAP_ and the _SOI-LA_ were administered by the researcher according to the test directions printed in the test manuals (2, 8) and presented aurally on the _MAP_ tape. The testing was done in several sessions, (see Table VIII) as the test manuals recommend, to avoid student fatigue effects. The students in school A took the test in the same room every session; in school B, the tests were administered in their self-contained classrooms. Those students missing parts of the tests were given make-ups at the end of the testing; if this was not possible and their tests were incomplete, their scores were excluded from further study. Table VIII below lists the dates, session lengths, and group sizes at both schools:

TABLE VIII

DATES, TIMES, AND GROUP SIZES OF THE SOI/MAP TESTING FOR THE PILOT STUDY

	Group Size	Session Length	Time of Day	Dates
School A		30 minutes	AM	November 5-10, 12-15, 18-20, 1983
group 1	13			
group 2	10			
group 3	12			
group 4	11			
School B		50 minutes	AM	May 7-11, 14-18, 1984
4th	34			
5th	24			
6th	31			

The testing rooms were quiet, comfortable, air-conditioned classrooms and the MAP tape was played on a modern, high-fidelity tape-recorder, capable of sufficient volume to reach the entire room.

The classroom teachers assisted the researcher in the administration of the tests, and the testing proceeded without incident. Based upon personal observation of the testing procedure and the fact that the results achieved fit within the normal range and distribution of the scores, as printed in the test manuals, the investigator assumed that students were able to perform without external influence and therefore that the data gathered represented the test subject's true abilities.

The tests were scored by the researcher according to the directions given in each test manual, yielding eleven MAP scores and 26 SOI scores for each student. The scoring procedure was expedited by the use of scoring overlays, designed to facilitate scoring, which are available for each test.

The scoring procedure is objective for both tests, with clearly correct or incorrect responses, with the exception of the three SOI-LA measures of divergent thinking (DMU, DSR, and DFU). Meeker has given careful directions, with examples, as to the proper scoring procedure for the divergent thinking measures, but there is an inescapable subjective element in deciding such matters as originality, uniqueness, and variations from a previous response. To insure consistency in scoring, all the tests were graded by the researcher. The effects of these scoring inadequacies continued to concern the researcher; however, in all but one case, the divergent thinking measures were eliminated from further consideration because they did not enter into the statistical models. For that reason, concern over the subjective nature of the grading procedure for these three SOI subtests seemed to be moot.

Scores were then transfered to an experimenter-designed reporting form to facilitate analysis. Reliability estimates for the entire pilot study group were then computed using either the Kuder-Richardson 20, or Kuder-Richardson 21 (4), generally-accepted statistical procedures for determining reliability estimates of tests. The choice of which procedure to be used was based upon the nature of each subtest.

The data were then subjected to further statistical processing, through the SAS (9) statistical analysis program using the facilities of the North Texas State University Computing Center. The results of this process follow.

Pilot Study Results and Evaluation

Since a major concern of the pilot study was to establish confidence in the use of the two measurement devices, that concern was first addressed in the evaluation of the results of the pilot study. Through the Kuder-Richardson reliability procedures, a reliability estimate for each individual MAP and SOI - LA subtest was determined.

As noted above, these statistical procedures are a generally accepted technique for determining reliability estimates of tests; they compare the variance of the test as a whole with the sum of the variances of the individual test questions. The assumption made by these procedures is that if the test is a reliable test, those subjects that did well tended to get the same questions correct; those that did poorly will tend to get the same questions wrong. The Kuder-Richardson procedures determine the extent of this situation through mathematical procedures.

For purposes of comparison, Table IX below lists both the reliability estimates which were computed for each individual SOI-LA subtest within the pilot study group and Meeker's published reliability estimates for each test.

TABLE IX

STRUCTURE OF THE INTELLECT - LEARNING ABILITIES PILOT STUDY SUBTEST RELIABILITY ESTIMATES COMPARED WITH PUBLISHED RELIABILITY ESTIMATES

	Reliability estimates of the entire Pilot Study	Published Reliability Estimates		
		4th grade	5th grade	6th grade
CMS	.73	.57	.61	.74
CFS	.92	.64	.75	.64
CMU	.62	.52	.54	.56
CSR	.60	.38	.50	.50
CFC	.48	.33	.44	.35
CSS	.35	.60	.56	.58
CFU	.78	.74	.79	.79

TABLE IX - Continued

	Reliability estimates of the entire Pilot Study	Published Reliability Estimates 4th grade	5th grade	6th grade
CFT	.56	.36	.63	.49
CMR	.45	.61	.77	.74
EFU	.70	.65	.62	.75
EFC	.50	.31	.33	.44
ESS	.34	.47	.64	.58
ESC	.79	.54	.56	.67
MSUV	.92	.32	.49	.31
MSSV	.77	.30	.51	.35
MSUA	.85	.43	.43	.50
MSSA	.86	.32	.50	.41
MSI	.54	.32	.53	.47
MFU	.34	.40	.33	.45
NSS	.60	.36	.69	.68
NSI	.66	.70	.67	.62
NST	.92	.69	.71	.75
NFU	.76	.47	.64	.58
DFU	.75	.36	.60	.40
DMU	.87	.56	.58	.54
DSR	.47	.55	.35	.27

Also for purposes of comparison, Table X below lists both the reliability estimates which were accomplished for each individual MAP subtest within the pilot study group and Gordon's published reliability estimates for each test.

TABLE X

MUSICAL APTITUDE PROFILE PILOT STUDY SUBTEST RELIABILITY ESTIMATES COMPARED WITH PUBLISHED RELIABILITY ESTIMATES

	Reliability estimates of the Pilot Study	Published 4th grade	Reliability 5th grade	Estimates 6th grade
T1	.93	.73	.75	.76
T2	.90	.66	.68	.70
R1	.87	.72	.76	.77
R2	.90	.66	.70	.75
S1	.93	.67	.70	.73
S2	.97	.66	.70	.73
S3	.93	.66	.68	.70

As can be seen by an examination of the tables above, the actual reliability estimates from the pilot study group tend to be higher than both tests' published reliability estimates. However, certain SOI-LA tests, specifically CFC (.48), CSS (.35), CMR (.45), ESS (.34), MFU (.34), and DSR (.47), were still below the generally-accepted reliability standards for research accepted by the researcher. This caused considerable concern to the researcher, for as the reliability of a test drops, it becomes more and more likely that the effects seen within the research are due to chance variation and not actual measured variance. Therefore, another conclusion drawn from the pilot study was that this problem ought to be addressed by a decision to omit those subtests from the final statistical models whose reliability measures, either published or those computed from the pilot study data, fell below .50. This is the level recommended by Leonhard and House (6) and seems a reasonable and rational standard for basing conclusions upon test results.

Simple Correlation Within Each Separate Test

Complete results of the zero-order correlation among all SOI and MAP variables within each individual test may be found in the Appendix. As a general comment, however, it can be seen that the highest correlation was found within the cells comprising the SOI-LA Test was between CMR and CMU (r = +.79) and the lowest correlation between DSR and CFU (r = +.002) with the average correlation r = +.35 among the separate subtests of the SOI-LA.

The highest correlation within the separate scores of the MAP test was r = +.64, (R1/R2) and the lowest r = +.31 (R1/S1), with an average correlation of r = +.52 among the subtests comprising the MAP. Thus, it seems reasonable to accept the assertion of the test writers that although the abilities measured by the subtest are interrelated, each subtest provided enough unique variance to warrant inclusion. The investigator did recognize, however, that complex inter-correlation among the sets of variables could contribute to problems of collinearity in later analysis. This concern was later addressed by more powerful statistical techniques and the results of these tests will be later reported.

further tests for multicolinearity and will be reported later in this study, in the data analysis section.

Simple Correlation between Tests

The results of zero-order correlation between the separate dimensions of the SOI and MAP, that is, between the two measurement instruments were examined; the full results of this procedure may be found in Appendix B. However, in an effort make the stronger correlations stand out more prominently, Table XI below omits the SOI/MAP correlations below the arbitrary point of r = +.25 (There were no strong negative correlations, i.e. below r = -.10.)

TABLE XI

SIMPLE CORRELATIONS BETWEEN SOI AND MAP VARIABLES*

	T1	T2	R1	R2	S1	S2	S3
CFU	. .	. .	. .	. .	. .	.25	. .
CFC	. .	. .	. .	. .	. .	.25	. .
CFS	.35	.33	.30	.28	. .	.35	.32
CFT	. .	. .	. .	. .	. .	.31	. .
CSR	.26	.25	.40	.30	. .	.29	.40
CSS	.29	.25	.37	.29	. .	.29	. .
CMU	.29	.26	.32	.27	.31	.31	.36
CMR	.34	.35	.34	.26	. .	.25	.31
CMS	.46	.40	.48	.40	.28	.37	.44
MFU	. .	. .	.28	.26	. .	.26	. .
MSU-V	.33	. .	.30	. .	. .	. .	. .
MSU-A	.31	.29	.39	.33	. .	. .	.26
MSS-V	.31	.27	.41	.28	. .	. .	.28
MSS-A	.34	.25	.32	. .	. .	. .	.29
MSI-V	.31	. .	.26	. .	. .	. .	. .
MSI-A	.32	.32	.31	. .	. .	. .	. .

TABLE XI - Continued

	T1	T2	R1	R2	S1	S2	S3
EFU	.42	.33	.46	.39	. .	.37	.37
EFC	. .	. .	.24	. .	. .	. .	. .
ESC	.34	. .	.33	.30	. .	.32	.27
ESS	.33	.30	.35	.31	. .	.28	.31
NFU	. .	. .	. .	. .	. .	. .	. .
NSS	.39	.32	.39	.37	. .	.32	.37
NST	.41	.41	.42	.34	.26	.36	.40
NSI	.27	. .	.35	.32	. .	.25	.34
DFU	. .	. .	. .	. .	. .	. .	. .
DMU	.30	.32	.29	.31	. .	.30	.35
DSR	. .	. .	. .	. .	. .	. .	. .

*All correlations below +.25 are omitted.

As can be seen from an examination of Table XI, no extremely strong correlations were noted between the individual subtests which comprise the SOI-LA test and the MAP. Zero-order correlation can suggest the presence or absence of a relationship; however, it is insufficiently detailed to allow the measurement of the magnitude of each relationship or to identify the components of a complex relationship involving several variables of mental information-processing skills. Thus, the statistical techniques of zero-order correlation are insufficiently detailed for the purposes of this study, and it was determined to analyze the data further, using multiple regression analysis.

Results of Multiple Regression Analysis Applied to the Pilot Study Data

It was determined to use the statistical technique of multiple regression analysis as the major tool to explore the musical aural discrimination ability/intelligence relationship because it was a statistical technique which is better able to measure the effects of a number of variables, both working individually and in combination with each other, upon a single criterion variable than other statistical techniques, such as simple correlation. In this study, each individual musical aural discrimination ability was used as the criterion variable, and the twenty-six dimensions within the Meeker SOI - LA were examined as to their effect upon the criterion variable.

A full discussion of the techniques and assumptions of multiple regression analysis will more properly appear in the discussion of the main study results. However, in order to accurately interpret the results obtained from the multiple regression analysis, procedure applied to the pilot study, it is necessary to discuss briefly this sophisticated procedure, and explain the form that the data derived from it will follow.

Multiple Regression Analysis

The statistical procedure of multiple regression analysis attempts to measure the relationship between a group of variables (referred to as the independent variables) and a single criterion variable (referred to as the dependent variable). It is an extension of the procedure of simple regression analysis, which is a technique for predicting the quantitative value of a variable, given the quantitative value of another variable, and a mathematical model of the relationship between the two variables.

In simple regression, the value of the dependent variable (usually represented as "y") is predicted as a function of the value of an independent variable "x" and a constant.

$$y = \beta_0 + \beta_1 x + \epsilon$$

In the model above, "y" is the dependent variable, "x" is the independent variable, β_0 is the y-intercept (the point at which the graph of the equation crosses the vertical axis), β_1 is the slope of the equation (the amount that "y" will change for each unit of change in "x"), and ϵ is the random error term of the model, the amount to which the Beta terms cannot predict the "y" value accurately. The smaller the random error term (ϵ), the better the mathematical model of the relationship between the independent and dependent variables. A good model will have a small random error term and therefore good accuracy in prediction of the "y" value.

Multiple linear regression differs from simple linear regression in that multiple regression involves an attempt to predict the value of the dependent variable from the values of several independent variables and their respective Beta weights, rather than the value and Beta weight of only the single independent variable found in simple regression. It is a "Probabilistic model that includes terms involving x^2, x^3, (or higher-order terms), or more than one independent variable" (5, p. 456).

The general form of the multiple regression model is stated below:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_k x_k + \epsilon$$

> The dependent variable "y" is now written as a function of "k" independent variables, x_1, x_2, . . . , x_k. The random error term is added to make the model probabilistic rather than deterministic. The value of the coefficient β_1 determines the contribution of the independent variable x_1, given that the other x variables are held constant, and β_0 is the y-intercept (5, p. 570).

An immediate concern of any researcher who uses the technique of multiple regression is the process of model building, i.e., creating the specific formula which will best express the relationship between the independent variables and the dependent variable. It is necessary not only to compute the various Beta-weights, but also to select those independent variables which add a significant amount to the predictive ability of the model.

> The biggest problem in building a model . . . is choosing the important independent variables to be included in the model. The list of potentially important independent variables is extremely long, and we need some objective method of screening out those that are not important. The problem of deciding which of a large set of independent variables to include in a model is common (5, p. 570).

The research intent of this study calls for some way of reducing the extremely large number of SOI dimensions which may enter into a relationship with the individual MAP subtest scores to a few, highly significant independent (SOI) variables while at the same time keeping the error term as small as possible.

A statistical screening procedure known as "stepwise regression" is used as an initial step to remove those independent variables that do not contribute significantly to the relationship between the independent variables and dependent variable. The SAS computer statistical analysis program offers five different procedures of model selection for stepwise regression. For the purposes of this study, it was decided to process the data collected in the pilot study using two different procedures for stepwise regression, the STEPWISE procedure and the MAXR (Maximum R^2 Improvement) procedure.

Two of the other three procedures, the FORWARD and BACKWARD procedures, are not as statistically powerful as those chosen, but are faster in terms of computer CPU time. They are similar to the STEPWISE procedure, but differ in that they do not exclude any variable once it is entered into the model, even if its F statistic is no longer significiant. Computer CPU time was not a limiting factor in this study, and it was determined to use the more powerful statistical procedures. The final procedure, the MINR procedure, will usually produce the same results as MAXR and was therefore also considered unnecessary.

Both the STEPWISE AND THE MAXR procedures will be described and the results obtained from these procedures reported. However, interpretations and conclusions drawn will be largely based upon the STEPWISE procedure, for reasons that will be addressed later.

The effectiveness of the multiple regression model is reported as R^2, the "Coefficient of Determination". R^2 will be a positive number between 0.00 and 1.00, and can be converted directly to a percentage by multiplying by 100 and adding a per cent sign. Hence, if the multiple regression model has an R = .74, 74 per cent of the variation in "y" (the dependent variable) can be accounted for and predicted by the multiple regression model. However, 26 per cent of the variation is due to sources not controlled or accounted for by the multiple regression model. These two components of the error term are called "Lack of Fit" and "Pure Error." Pure Error is "that portion of unexplained variation which measures the random fluctuations or inherent scatter in the response variable" (1, p. 220), or random error of measurement. Pure Error will always occur in real world situations, but can be dealt with through the use of many observations (assuming then that the Pure Errors of each individual observation will tend to cancel each other out when put into a group), or through the use of confidence intervals in prediction. Lack of Fit, on the other hand, is "that portion of unexplained variation due to the inappropriate choice of model . . . or the omission of important predictor variables" (1, p. 220). Lack of Fit is a serious consideration for multiple regression models, and various statistical procedures have been developed to assess the amount of Lack of Fit within a regression model and to confirm that the model is the best possible or to suggest that another model may be appropriate.

A model with a high R^2 value will serve as a better predictor of the "y" value, given the "x" values. But more important to its desired use within the present study, it will reveal more about the relationship between the independent variables and the dependent variable than a model with a lower R^2 value.

The difference between the two stepwise regression procedures is in how they approach the creation of the multiple regression model to maximize R^2, thereby minimizing the error term. In the STEPWISE procedure, the computer program first finds the single independent variable (SOI dimension cell) which, by itself, has the highest R^2 value with the dependent variable. This variable is tested for significance, using the program default α = .15 level. (However, any level of significance may be requested from the program.) To create the model in its final form, the program adopts the following procedure.

> Variables are added one by one to the model, and the F statistic for a variable to be added must be significant at the SLENTRY = (.50 for default) level. After a variable is added, however, the stepwise method looks at all the variables already included in the model and deletes any variable that does not produce an F statistic significant at the SLSTAY = (.15 for default) level. . . The stepwise process ends when none of the variables outside the model has an F statistic significant at the SLENTRY = level and every variable in the model is significant at the SLSTAY= level (9, p. 102).

Thus, every independent variable remaining within the multiple regression model created by the STEPWISE procedure is significant at the .15 level. Those that are not are excluded. The SAS manual recommends using this level of significance at this preliminary stage, even though it is lower than that which is usually used in modern psychological research (α= .05).

> In most applications many variables considered have some predictive power, however small. If you want to choose the model that provides the best prediction using the sample estimates, you need only guard against estimating more parameters than can be reliably estimated with the given sample size, so you should use a moderate significance level, perhaps in the range of .10 to .25 (9, p. 103).

Significance levels are not as important to the MAXR procedure. Instead, it seeks to find the model which would yield the best R^2 improvement with each step. It begins like the STEPWISE procedure, selecting the single independent variable that yields the highest R^2. The procedure does not test this variable for statistical significance, but then attempts to find which two-variable model would yield the largest increase in R^2 by adding each remaining independent variable in turn.

However, if the process finds that, due to collinearity between the independent variables, replacing one of the independent variables already in the model with another variable would increase the R^2 for that total number of variables, it will make that replacement instead of adding another variable. Thus, an independent variable added to the model early in the process may be replaced by a different independent variable, and leave the model for several steps. This can cause difficulties in interpretation of the true relationship between the independent variables and the dependent variable.

> The process continues until MAXR finds that no switch could increase R^2. The two-variable model thus achieved is considered the "best" two-variable model the technique can find. Another variable is then added to the model, and the comparing-and-switching process is repeated to find the "best" three-variable model, and so forth (9, p. 102).

The MAXR procedure will therefore yield many more terms for a multiple regression model than the STEPWISE procedure because there is no restriction that the independent variables added by the MAXR procedure be statistically significant; they only have to increase R^2 . The final terms added to the multiple regression model will increase R^2 by only a minute amount (sometimes less than .001) and therefore do not add as much to the strength of the multiple regression model as do the earlier terms.

It is necessary to note at this point, however, that stepwise regression is a preliminary step, designed to suggest which independent variables are important to a relationship with the dependent variable. If the process errs, it is designed to err by including too many variables within the relationship. It thus will avoid Type II statistical errors (failing to reject a false null hypothesis when there actually is a relationship present). Because of this intentional design bias in the stepwise regression procedures, further statistical treatments of the data are necessary in order to draw conclusions in the main study, chiefly using the SAS "PROC GLM" procedure (General Linear Models Procedure).

Table IX below will summarize the R^2 values found by both procedures for each separate musical aural discrimination ability as measured by the MAP subtests, using the STEPWISE and MAXR procedures of SAS.

TABLE IX

SUMMARY OF RESULTS OF STEPWISE AND MAXR STEPWISE REGRESSION PROCEDURES

	STEPWISE		MAXR	
	Final R^2 Value	Number of Steps	Final R^2 Value	Number of Steps
T1	.289	5	.351	15
T2	.239	4	.339	24
R1	.371	6	.424	27
R2	.275	7	.335	27
S1	.169	5	.289	25
S2	.259	7	.305	25
S3	.265	5	.330	26

It is important to note at this point that the R^2's achieved by the use of the SOI to measure mental information processing-skills account for a much higher proportion of the variance than any previous study. The highest relationship (Pearson Product Moment Correlation) that had been previously found between IQ measurements and aural musical discrimination ability (the MAP) was $r = +.44$ (2, p. 64); It is possible to convert the Pearson Product Moment Correlation to percentages by squaring it and multiplying by 100. A Pearson Product Moment Correlation figure of $r = +.44$ will account for 19.36% of the variance between the two variables. A multiple regression R^2 can be directly converted into percentage by multiplying by 100. Therefore, all the MAXR and most of the STEPWISE results above exceed all previous reported figures for the relationship under study.

As was previously stated, a major difficulty in interpretation of the results of the MAXR procedure is when to stop adding variables to the multiple regression model. A major goal of stepwise regression is economy; that is, to create a model for prediction of the dependent variable (in the case of the present study, the individual MAP subtest scores) with as few independent variables as possible. However, a major goal of multiple regression is that the model will predict the dependent variable as well as possible, that is, have a high R^2. These two concerns must be balanced against each other to create the best possible mathematical model of the relationship.

Since the final terms added in the MAXR process increase the R^2 by only a minute amount, the use of all the SOI variables would not appreciably add to the accuracy of the multiple regression model and would create a model of such size as to be extremely unwieldy and clumsy to manipulate. Also, since a major aim of the present study is to determine which of the SOI variables, individually or in groups, is significantly related to the various musical differentiation abilities measured by the subtests of the MAP, the use of all the SOI variables within the multiple regression model would directly violate that research question.

It is therefore necessary to decide where the process should stop and how many variables should be admitted to the mathematical model. The question does not arise in the STEPWISE procedure; the process stops when no more significant variables are left. However, the MAXR procedure, which does not consider the significance of the relationship of the independent variables with the dependent variable, will continue until the addition of a variable does not increase the absolute value of R^2.

Normally, a form of the "F" test could be used to make this decision; the procedure would add variables until the differences in variances between the steps were no longer found significant by the "F" test.

This use of the "F" distribution is computed by dividing the Mean Square of the Regression (MSR, which is equal to the Sum of Squares due to Regression, (SSR) divided by the number of independent variables, "p"), by the Mean Square of the Error (MSE, equal to the Error Sums of Squares, (SSE) divided by the number of observations "n", minus the number of independent variables "p", minus 1) (1, p. 272).

$$F = \frac{MSR}{MSE}, \quad \text{where} \quad MSR = \frac{SSR}{p} \quad \text{and} \quad MSE = \frac{SSE}{n-p-1}$$

The above F formula in simplified form would yield the following equation:

$$F = \frac{SSR\ (n-p-1)}{SSE\ (p)}$$

However, due to the large number of test subjects in the present pilot study (N = 135), this procedure is of no use for deciding where to stop adding variables using the MAXR procedure; with a subject population of this size, a very small computed value of F is all that is needed to find a significant difference. Hence, for the MAP subtest R2, all the SOI variables are added by the MAXR procedure, and the "F" test finds the difference in R^2 of 0.00004271 between the 26th and 27th steps (R^2 for step 26 = 0.33463113, R^2 for step 27 = 0.33467384) to be significant! This is certainly an example of statistical, but not practical significance.

For the above reason and because of the previously-mentioned problem of collinearity among the independent variables which adversely affects the MAXR procedure, conclusions in this study shall be primarily based upon results obtained by the STEPWISE procedure and not the MAXR.

Mathematical Models Created by the STEPWISE Procedure

It will be remembered that the general form of the multiple regression model is as follows:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_k x_k + \epsilon$$

This section of the data analysis of the pilot study will attempt to create mathematical models of the SOI/individual MAP subtest relationship, using the results of the STEPWISE procedure. Because the interest of this study lies in determining the structure of the relationship, and not in an attempt to predict MAP scores from SOI tests, the models will be reported in tabular, rather than equation form. However, it must be remembered that the tables could be converted to an equation and an attempt made to predict "y" from the values of the various "x's".

As an illustration, taking the five SOI dimensions found significantly related to the MAP T1 subtest from Table xx and creating an equation with their Beta weights would yield the following:

T1 score = 33.556 + .640(CMS score) + .257(MSSA score) + .562(EFU score) + .043(NST score) - .490(NSI score)

Thus, the above model would attempt to predict the quantitative value of "y" (the MAP T1 score) from the five SOI scores multiplied by their Beta weights. However, it must be noted that the above model was found to have a R of only .289. If one attempted to predict the T1 scores from this model, such a low R^2 figure would mean that over 70% of the variation in the T1 scores was not accounted for by the model. Therefore, a 95% confidence interval (i.e., the range of T1 scores that would be expected to encompass 95%

of the actual T1 scores) would be so large as to be useless for purposes of prediction.

In Table XII, which follows, the SOI dimensions found significantly related to each MAP subtest are reported, along with their Beta weights, the standard error of the Beta weights, and the probability that they are significantly related to the dependent variable.

TABLE XII

COMPLETE RESULTS OF THE STEPWISE REGRESSION PROCESS APPLIED TO THE PILOT STUDY DATA

T1 $R^2 = .289$

Independent Variables	Beta Weights	Standard Error of the Beta Weights	Significance Level
y-Intercept	33.556		
CMS	.640	.232	.0067
MSSA	.257	.177	.1495
EFU	.562	.242	.0214
NST	.043	.029	.1357
NSI	-.490	.191	.0114

T2 $R^2 = .239$

Independent Variables	Beta Weights	Standard Error of the Beta Weights	Significance Level
y-Intercept	38.214		
CMS	.648	.231	.0057
MSUV	-.336	.226	.1397
NST	.106	.030	.0005
NSI	-.400	.185	.0326

TABLE XII--Continued

R1 $R^2 = .371$

Independent Variables	Beta Weights	Standard Error of the Beta Weights	Significance Level
y-Intercept	24.126		
CSR	.833	.472	.0802
CMR	-.644	.218	.0037
CMS	.663	.232	.0049
MSSV	.349	.165	.0366
EFU	.760	.238	.0018
EFC	.918	.344	.0086

R2 $R^2 = .289$

Independent Variables	Beta Weights	Standard Error of the Beta Weights	Significance Level
y-Intercept	34.900		
CFC	-.640	.424	.1335
CMR	-.421	.214	.0512
CMS	.578	.252	.0236
MSUA	.366	.185	.0504
MSSA	-.274	.171	.1103
EFU	.721	.248	.0043
NSS	.683	.379	.0738

TABLE XII--Continued

S1 R^2 = .169

Independent Variables	Beta Weights	Standard Error of the Beta Weights	Significance Level
Y-Intercept	35.188		
CFU	-.485	.306	.1150
CMU	.906	.228	.0001
MFU	.335	.201	.0977
MSUV	-.396	.258	.1272
DFU	.196	.091	.0327

S2 R^2 = .259

Independent Variables	Beta Weights	Standard Error of the Beta Weights	Significance Level
Y-Intercept	31.640		
CFS	.200	.121	.1006
CFT	.400	.225	.0781
CSS	-.865	.478	.0728
CMR	-.559	.245	.0245
CMS	.477	.274	.0842
EFU	.650	.275	.0194
NST	.053	.030	.0749

S3 R^2 = .289

Independent Variables	Beta Weights	Standard Error of the Beta Weights	Significance Level
Y-Intercept	33.556		
CMS	.640	.232	.0067
MSSA	.257	.177	.1495
EFU	.562	.242	.0214
NST	.043	.029	.1357
NSI	-.490	.191	.0114

It may be illuminating for a further understanding of the musical discrimination skills/mental skills relationship to observe the individual "x" (SOI dimension) relationships to the various "y" dependent variables (MAP subtest scores), (which would be the converse of the above table.) Table XIII below reveals which SOI dimensions figure into the seven MAP dimensions, based upon the pilot study data. The Beta weight figures for the independent variables are omited, because they cannot be directly compared across different regression equations. However, the levels of significance, (i.e. how certain it is that each independent variable adds a significant amount to the strength of the multiple regression model), are the numerical values which are reported. It will be remembered that they can be converted to probabilities and expressed in percentages by multiplying the significance levels by 100. Thus a significance level of .0067 (CMS using T1 as the criterion variable below) would mean that there is a probability of less than one per cent (.6 per cent) that the relationship found was due to chance variations in the data and that no true relationship exists.

By using the levels of significance rather than the Beta weights, the SOI dimensions may be compared across the differing MAP criterion variables.

TABLE XIII

SUMMARY OF THE RESULTS OF THE STEPWISE REGRESSION PROCESS APPLIED TO ALL THE CRITERION (MAP) VARIABLES, USING LEVELS OF SIGNIFICANCE DERRIVED FROM THE MULTIPLE REGRESSION EQUATIONS

	T1	T2	R1	R2	S1	S2	S3
CMS	.0067	.0057	.0049	.0236	.0842	. .	.1495
CMR	. .	. .	.0037	.0512	. .	.0245	. .
CSR	. .	. .	.0802	. .	. .	. .	. .
CFC	. .	. .	. .	.1335	. .	. .	. .
CFU	. .	. .	. .	. .	.1150	. .	. .
CMU	. .	. .	. .	. .	.0001	. .	. .
CFS	. .	. .	. .	. .	. .	.1006	. .
CFT	. .	. .	. .	. .	. .	.0781	. .
CSS	. .	. .	. .	. .	. .	.0728	. .
EFU	.0214	. .	.0018	.0043	. .	.0194	.1357
EFC	. .	. .	.0086	. .	. .	. .	. .
NST	.1357	.0005	. .	. .	. .	.0749	.0114
NSI	.0114	.0326	. .	. .	. .	. .	.0114
NSS	. .	. .	. .	.0738	. .	. .	. .
MSSA	.1495	. .	. .	.1103	. .	. .	.0214
MSUV	. .	.1397	. .	. .	.1272	. .	. .
MFU	. .	. .	. .	. .	.0077	. .	. .
MSSV	. .	. .	.0366	. .	. .	. .	. .
MSUA	. .	. .	. .	.0504	. .	. .	. .
DFU	. .	. .	. .	. .	.0327	. .	. .

It becomes apparent from an examination of Table XIII that the SOI dimensions of CMS, EFU, and NST have the greatest number of relations and greatest strengths within the pilot study with those relationships with the differing aural musical discrimination skills measured by the MAP. NSI and CMR have indicated a slightly weaker relationship, both in number of appearances in the multiple regression models, and in their significance levels. The remainder of the *SOI* variables enter into only one multiple regression model, or show relatively low levels of significance (i.e., high percentages that the relationship is occuring through chance). They may be important to one criterion variable (*MAP* subtest score), but do not show a consistent importance throughout the range of criterion variables.

Pilot Study Conclusions

Two major conclusions, both important to the present study, can be drawn from the results of the pilot study; first, it was found that both measurement instruments were, for the most part, reliable instruments to use for the purposes of research. However, it was determined necessary to exclude six *SOI* - *LA* subtests (CFC, CSS, CMR, ESS, MFU, and DSR) from the final models because of the unsatisfactory reliability estimates they exhibited within the pilot study. Second, it was found possible to create multiple regression models of sufficient reliability and validity to assist in the process of examining the relationship between musical aural discrimination skills and the mental skills postulated within Guilford's *Structure of the Intellect.* Further conclusions, such as definite answers to the four research questions, need to await the additional data from the main study. However, it was possible to make tentative conclusions as to which SOI dimensions may be the most important to musical discrimination skills from the results of the pilot study. Based upon the statistical procedures and taking into account the reliability figures, it appeared that the following SOI dimensions tend to be the strongest in their relationship with the aural musical discrimination skills that are indicated by the MAP scores: CMS, EFU, NST, and NSI.

It was indeed interesting, in view of the prevailing musical intuition that musical ability and mathematical abilities are related, to note that the above SOI dimensions are related to reading and language arts skills rather than math skills. Meeker maintains that the mental skill measured by EFU is most importantly related to Reading (Foundational Abilities); CMS, and NST are also related to Reading (however, are Enabling Skills), and NSI is the only SOI variable in the above list that is defined as a mental skill which is related to Arithmetic ability.

The above SOI-LA dimensions involve Cognition (those dimensions with "N" as the first letter), Evaluation (those beginning with "E"), and Convergent Production (those which begin with "C"). The dimensions of Memory and Divergent Production are absent.

It should be remembered that the MAP test is completely aural - no prior knowledge of notation or music theory is assumed and no musical response is asked of the students. The above SOI mental information-processing abilities then appear to be a significant part of those mental informnation-processing abilities that also enter into musical aural discrimination abilities.

Main Study Methodology

Based upon the results and evaluation of the pilot study, it was decided that the following should be the design of the main study:

1. Administer or obtain scores for the entire Musical Aptitude Profile to as large a subject population as possible of fourth, fifth, and sixth grade students from a variety of schools and settings.

2. Administer or obtain SOI-LA scores for the same student population.

3. Apply appropriate statistical procedures (chiefly multiple regression analysis) to the data collected from the main study to determine if the SOI dimensions identified in the pilot study are in truth significantly related to any of the separate MAP scores. Also, apply statistical measures of goodness-of-fit to determine if linear regression is the best method of determining the model or if possible quadratic terms may yield a better regression model of the relationship.

4. Evaluate the results of the above procedures by applying the customary psychological research standards (ie., significance at the .05 level), and draw conclusions as to why the relationship may exist (if found), or why not.

5. Examine these SOI dimensions as to a possible commonality among themselves and with the

> MAP scores through both philosophical and statistical methods, in an effort to further discern and define those mental information abilities responsible for musical aural discrimination skills.

It must be restated that the general purpose of this study is to examine both the strength and the nature of the relationship between musical aural discrimination skills and various mental information-processing skills that comprise the construct commonly referred to as "intelligence".

Even though the relationship between musical aural discrimination abilities and mental information-processing skills achieves statistical significance, in both past studies and in the pilot study, it is not a large relationship; previous studies of the relationship between musical aural discrimination skills and IQ scores indicate that approximately 20% of the variance is in common between musical aural discrimination abilities and mental information-processing skills.

Nevertheless, a statistically significant relationship between the two human attributes, music and intelligence, has been found to exist, even though most of the variance is not in common. The percentage of common variance is high enough to justify the main purpose of this study; to examine that relationship to determine its size and nature through identifying which mental information-processing skills are present in that area of common variance, and their relative importance to the variance. The technique of multiple linear regression analysis was selected as the most appropriate for determining the answers to that question, and the pilot study was accomplished to test the research methodology and the measurment instruments.

Since no problems in either data gathering or analysis were revealed by the pilot study, the pilot study group subjects were included within the data group of the main study. The final subjects to be added to the data group of the main study were students from a Dallas-area public school, representing a mix of racial, socio-economic, and cultural backgrounds. The Meeker/Guilford Structure of Intellect - Learning Abilities Test was administered to 252 additional students (making the total number of subjects within the study N = 387), during the months of September and October, 1984 by school testing personnel and the test scored by the SOI Institute Testing Service. The Musical Aptitude Profile was administered to the students in their regular music classes by their music teacher during the months of March and April, 1985, and scored by the researcher. The results of both tests were entered into the researcher's computer files at the Academic Computing Center, North Texas State University, and various statistical procedures performed. The nature and the results of those statistical procedures and will be reported in the next chapter.

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CHAPTER IV

DATA ANALYSIS

Basic Assumptions

The pilot study confirmed that the use of multiple regression analysis to determine answers to the research problems was both feasible and appropriate for the present study. However, for the results of multiple regression analysis to be valid and in order to achieve satisfactory conclusions based upon those results, it was necessary to examine the data to see if the data fit a number of assumptions which are essential to the proper use of multiple regression analysis. Therefore, the results of the first set of procedures to be reported within this chapter deal with an assessment of how well the data gathered during the field research phase of the study met these basic assumptions.

Multiple regression analysis requires that four primary assumptions be met. These four assumpions, according to Berenson, Levine, and Goldstein (1, pps. 209-212), are the following:

> 1. Normality. At each fixed "X" the (sub-) population of "Y" values follows a normal distribution.
>
> 2. Linearity. There is a positive linear relationship between "X" and "Y".

3. Independence. The observed "Y" values are independent of one another for each value of "X".

4. Homoscedasticity. The variation or scatter of the actual observations about the line of regression is constant for all values of "X"; i.e., "Y" will vary the same amount when "X" is fixed at a low level as when "X" is fixed at a high level.

While various statistical procedures for dealing with departures from these assumptions do exist, it is possible to have a greater level of confidence in the conclusions drawn from the results of the statistical procedures if the basic assumptions are already met and it is not necessary to apply any mathematical transformation procedures to the data.

The SAS PROC PLOT procedure was used to determine if the data fit the first assumption, that of a normal distribution. Each of the SOI dimensions was plotted against each of the seven aural discrimination abilities measured by the MAP. It was observed that for each individual (fixed) value of "X" (the SOI score), the "Y" scores (the MAP scores) varied about a central median in a normal distribution. However, even if this assumption were not perfectly met, "regression analysis is robust against moderate departures from the normality assumption" (1, p. 210). It was thus concluded that the acceptance of the first assumption necessary for the use of multiple regression analysis, that of a normal distribution of the data, was justified.

The second assumption, that of linearity, can also be tested both through an examination of the plots achieved previously and the use of an additional plotting. Berenson, Levine, and Goldstein feel that this assumption can be best evaluated by "plotting the residuals on the vertical axis against the corresponding values of the independent variable 'X' on the horizontal axis for all n observations" (1, p. 224). The residuals are actually the errors, that is, the amount of difference between each individual predicted "Y" value and the actual observed "Y" value ($Y - Y_o$).

Again using the SAS PROC PLOT procedure, the residuals were plotted against the independent variable observations for all MAP and SOI dimensions. And again, an examination of the plots revealed that there was no apparent pattern, i.e., some sort of "fanning out" shape or a possible sine-curve shape, to the residual plots; thus, it was concluded that a linear relationship is appropriate and there are no quadratic or higher-term relationships, which would necessitate non-linear procedures.

It is also possible to test this assumption within the process of model-building. A variable that is suspected of having a quadratic or higher relationship within the model can be entered as a quadratic variable and the effects upon the model's general R value (the measure of the model's accuracy) and the individual variable's F statistic (the measure of the variable's significance) observed. If the R^2

value declines, and/or the F statistic for the individual variable shows a loss of significance, it can be concluded that the suspected quadratic relationship does not exist. If addition of the quadratic variable improves the R^2 and it is determined to be significant, then the quadratic relationship does exist and the term belongs within the final model.

Several suspected SOI variables were checked in this manner within the final model-building process; however, none of them were found to belong within the model as a quadratic term.

The third assumption, that of independence, can be evaluated both through an examination of the correlation matrix and the colinearity diagnostics section of the SAS PROC REG procedure. An examination of the correlation matrix in Appendix A shows that although there are a few correlations that are above $r = +.7$, the majority are safely below that point. In addition, the colinearity diagnostics of the PROC REG procedure confirmed that the multiple regression model is not seriously affected by any problems of multicolinearity.

Homoscedasticity, the fourth assumption, can also be evaluated from the plot of the error terms against each independent variable "X" (the SOI variables). If a fanning pattern were present in any of these plots, that is, if the plots seemed to begin with a narrow band at the "Y"-

intercept and grow steadily wider as "X" increased, then the assumption of homoscedasticity would have been violated. No such fanning effect was observed in the plots used to check the validity of the first two assumptions.

It can be thus be concluded that the data and models meet the assumptions necessary for the validation of the procedure of multiple linear regression and the discussion of the selection of the models can proceed.

Building the Final Multiple Regression Models

It is necessary to again state that the process of multiple regression analysis yields a mathematical model, which is an equation for estimating or predicting the value of "Y", the dependent variable (in this case, the scores of the various individual subtests of the MAP), from the scores achieved upon a group of independent variables (the SOI subtest scores). The usual use of multiple regression, then, is as a tool for prediction; however, a secondary use of the procedure is that it can be used to determine the precise relationship between a group of variables and a criterion variable. It is to this secondary use of the procedure that the present study was addressed.

The efficiency of the model for predicting the dependent variable "Y", that is, a measure of its accuracy, can be determined, (as will be remembered from the discussion of the pilot study). This measurement is called the Coefficient of Multiple Determination (R^2). However, it is essential for the proper understanding of the statistical procedures which follow to note that the Coefficient of Multiple Determination is actually a measure of the proportion of the total variance that is accounted for by the model.

As in previous studies, it was determined that most of the variance of the two skills, the musical aural discrimination abilities and the SOI dimensions, measured within this study exists independently of one another, as the Coefficients of Multiple Determination of the final models revealed values of only R = .10 to .20. This conclusion agrees with the results of both the previous studies in the area and from the data analysis of the pilot study. However, the present study is not interested so much in the total variance as in the nature and strength of the covariance - the nature of only that variance which the two human attributes have in common.

The Coefficient of Multiple Determination, (R^2) is a measurement of how well the model predicts the dependent variable. The research intent of the present study is not to attempt to develop a model for prediction but rather to examine the structure and shape of the covariance that the two human attributes have in common. Since the Coefficient of Multiple Determination is a measurement which uses the total amount of variance and is not exclusive to that smaller portion of the total variance that intellectual abilities and aural musical discrimination abilities hold in common, its computation is a but a beginning step for the understanding of the relationship. It must be again stressed that the use of multiple regression analysis within this study is not for its predictive function, but as a tool to better understand a relationship.

The STEPWISE procedure produced tentative models with the pilot study data; however, the default setting for the level of significiance that the independent variables must meet using this procedure (alpha = .15) does not meet generally-accepted standards for psychological research. Too many variables of questionable significance were included. Therefore, for the process of model-building in the main study, it was determined that every independent variable had to meet the currently-accepted level of significance, alpha = .05 (1, p. 10) to be included in the model . This criterion resulted in lower coefficients of determination (R^2) for the final models; however, the use of this more stringent significance standard allows greater confidence in the interpretation of the actions of the independent variables.

The STEPWISE process was run upon the entire data, with the level of significance changed to a level of $\alpha = .05$. This initial process yielded the following multiple regression models for the individual aural musical discrimination skills measured by Gordon's Musical Aptitude Profile.

TABLE XIV
INITIAL MULTIPLE REGRESSION MODELS DETERMINED USING SAS 'STEPWISE' FUNCTION

T1 = 40.057 + .412 CMS + .376 EFU	(R^2 = .115)
T2 = 42.870 + .616 CMS - .563 ESC + .060 NST + .162 CFS - .265 MSUV	(R^2 = .181)
R1 = 30.329 + .669 CMS + .579 EFC + .257 MFU - .308 ESC + .315 EFU	(R^2 = .211)
R2 = 35.220 + .490 EFU + .269 MSUA + .150 CFS	(R^2 = .143)
S1 = 39.375 + .369 CMS + .488 CMU - .051 DMU + .162 CFS - .301 MSSV	(R^2 = .149)
S2 = 35.548 + .492 CMS + .835 CFC - .647 CSS + .191 CFS + .255 MFU - .188 MSSV	(R^2 = .205)
S3 = 40.938 + .617 CMS - .458 CFT + .931 CSR	(R^2 = .170)

It is necessary to note that the building of a final multiple regression model is as much art as science. No computer procedure will reveal the single "best" model; it is necessary to consider "the process being modeled, geometry, and formal statistical testing" (3, p. 362). Therefore, a number of criteria must be used in order to move from the initial models achieved above to the final multiple regression models used to draw conclusions and answer the research questions of the present study.

As was concluded from the results of the reliability procedures run upon the pilot study data, in order to increase the confidence in the regression equations, those SOI subtests which had reliability estimates (either those published estimates measured by Meeker or those which were measured by the researcher) lower than those accepted by Leonhard and House (2, p. 398), would be excluded. Those SOI subtests with a reliability lower than +.50 must be excluded from any further consideration within the study.

Those subtests with a reliability between +.50 and +.60 would be examined very carefully to determine their effect upon the regression equation. It was determined to also exclude those SOI dimensions, with reliability estimates between +.50 and +.60 which had small Beta weights within the final models could also be safely excluded as having little effect. In short, where there was any doubt as to the reliability or the utility of the SOI subtest, it was excluded.

Table XV below lists the SOI subtests that entered into regression equations in the initial, STEPWISE-created models, along with their reliability measures.

TABLE XX

RELIABILITY MEASURES OF SOI SUBTESTS WHICH APPEARED IN THE INITIAL MULTIPLE REGRESSION EQUATIONS

SOI Dimension	Experimentor-Measured	Reliability Estimates (Measured by Meeker) 4th grade	5th grade	6th grade
CMS	.73	.57	.69	.74
CFS	.92	.64	.75	.64
CMU	.62	.52	.54	.56
CFC	.48	.33	.44	.35
CSS	.35	.60	.56	.58
CFT	.56	.36	.63	.49
CSR	.60	.38	.50	.50
EFU	.70	.65	.62	.75
ESC	.79	.54	.56	.67
EFC	.50	.31	.33	.44
NST	.92	.69	.71	.75
MSUV	.92	.32	.49	.31
MFU	.34	.40	.33	.45
MSUA	.85	.43	.43	.50
MSSV	.77	.30	.51	.35
DMU	.87	.56	.35	.27

It can be seen, by an examination of the Table above, that many of the SOI subtests (such as DMU, CFC, MSUV, or MFU) which were included in the initial models by the STEPWISE procedure do not possess sufficient reliability estimates to allow any confidence in interpreting their results and should be eliminated.

In an further effort to remove experimental error and avoid the creation of statistical artifacts, the data were also examined in a split-halves manner. The odd-numbered test subjects and the even-numbered subjects were examined separately and multiple regression models run upon each in order to compare the results. In order to attain the greatest confidence in the models, it was decided that an independent variable (an SOI dimension) which appears in one half of the subject population but not the other also should not be included in the final model.

However, the effects of the process of exclusion of variables from a multiple regression model can be quite complex. Each time a variable is excluded, the entire relationship between independent and dependent variables (and between the independent variables themselves) changes. It is not appropriate to simply drop a group of variables and proceed with the analysis from there. An entirely new regression equation must be created every time a variable is dropped. Because of inter-active effects, some variables which were found significant in the initial model may not be significant if another variable is dropped from the model. Thus, it is necessary to run a series of models before deciding upon the final model of the relationship.

With these restrictions in mind, a series of GLM procedures were run upon the main study data, excluding the questionable variables, in an effort to arrive at the final multiple regression models. These final multiple regression models appear in Table XVI following, in equation form.

TABLE XVI
FINAL MULTIPLE REGRESSION MODELS USING SOI DIMENSIONS AS INDEPENDENT VARIABLES AND MAP DIMENSIONS AS DEPENDENT VARIABLES

Multiple Regression Model	Coefficient of Multiple Determination (R^2)
T1 = 40.057 + .412 CMS + .376 EFU.	.115
T2 = 39.056 + .482 CMS + .115 CFS.	.120
R1 = 32.418 + .508 CMS + .547 EFC + .260 EFU .	.187
R2 = 37.786 + .526 EFU + .184 CFS.	.125
S1 = 39.155 + .185 CMS + .324 CMU.	.100
S2 = 39.067 + .416 CMS + .209 CFS.	.137
S3 = 39.015 + .476 CMS + .808 CSR.	.143

The Coefficient of Multiple Determination (R^2) can be converted to the measure of zero-order correlation (r) (Pearson-Product Moment Correlation) simply by determining its square root. Therefore, Table XVII below shows the simple correlations for the multiple regression models above between with their respective musical aural discrimination skills and the mental information-processing skills found significantly related to them:

TABLE XVII
ZERO-ORDER CORRELATIONS BETWEEN THE FINAL MULTIPLE REGRESSION MODELS AND THEIR RESPECTIVE MUSICAL AURAL DISCRIMINATION SKILLS

Musical Aural Discrimination Skill	Zero-Order Correlation with the Multiple Regression Model
T1 - melodic	r = +.339
T2 - harmonic	r = +.346
R1 - beat	r = +.432
R2 - tempo	r = +.353
S1 - phrasing	r = +.316
S2 - balance	r = +.370
S3 - sensitivity	r = +.378

With the exclusion of various independent variables from the model, the R^2 value will decrease; however, this was not found to be an appreciable decrease and it should be here noted that the final models still accounted for a greater proportion of the general covariance between musical aural discrimination skills and mental information-processing skills than in previous studies, by using only two or three of the mental information-processing subtests.

It must be re-emphasized that the research intention of this study is not an attempt to predict the MAP subtest scores by using the SOI-LA test; the R^2 values are not high enough. The beta weights (the SOI numerical coefficients) achieved in the table above are only a starting point for further study of the relationship. For additional study of the contribution of these SOI dimensions to the relationship, additional computations are necessary.

Of more importance than either the beta weights or Coefficient of Multiple Determination (R^2) of the entire model are the values of the Coefficient of Partial Determination (r^2) for each of the SOI dimensions included within the above models. The Coefficient of Partial Determination is "the proportion of the variation in the dependent variable that is explained by each independent variable while controlling for, or holding constant, the other independent variables" (1, p. 280). Thus, the Coefficient of Partial Determination measures the contribution of each individual independent variable to the entire variance, as opposed to the Coefficient of Multiple Determination (R^2), which is a measure of the proportion of the total variance accounted for by the entire multiple regression model. Again, both coefficients can be converted into percentages by the expedient of multiplying by 100.

While SAS does not yield the Coefficient of Partial Determination directly within the output for any of its procedures, it does provide the necessary information for its simple computation.

Within the SAS PROC GLM procedures output is a column headed TYPE III SS (Sum of Squares) which is a series of numbers. These "represent the sum of squares of the contribution of the Variable X1 to the regression model, given that varable X2 has already been included" (1, p. 280). Thus, the TYPE III SS figures represent the unique contribution to the model of the specific independent variable under consideration.

The other term needed for the computation of the Coefficient of Partial Determination is the SSE (Sum of Squares for Error), which reflects the distance (along the "Y" axis) between each individual observation and the regression line established by the multiple regression model. This figure is also furnished in the GLM output. The formula for the computation of the Coefficient of Partial Determination is given below.

$$r^2 = \frac{\text{TYPE III SS of X1}}{\text{SSE + TYPE III SS of X1}}$$ (3, p.576).

The results of this computation are shown in the left-hand column of Table XVII; the Coefficients of Partial Determination are converted into percentages by multiplying by 100 and are shown in the right column of Table XVII.

It must be noted, however, that the Coefficient of Partial Determination, like the Coefficient of Multiple Determination, reflects the contribution of the independent variable to the total variance. That is, the the Coefficient of Partial Determination is not an indication of the strength of each of the dependent variables exclusively within the area of covariance (e.g. , the area of overlap between the two circles in the Venn diagram of Chapter I). Therefore, the Coefficients of Partial Determination will appear to be quite small. When interpreting the results of the computation of the Coefficient of Partial Determination, it is therefore necessary to consider the sizes of the different Coefficients of Partial Determination relative to each other, and not to the total variance.

Also, since the Y-intercept of the multiple regression model is a constant which predicts an average value of the MAP score, it is not part of the variance common to the seven musical aural discrimination skills and the SOI dimensions. It merely predicts what the value of the dependent variable would be if all the independent variables were zero and is useful when the dependent variables use different scales to achieve their numberical ranking (i.e. NST used a scale from 1 - 161; MSI, however, used a scale from 0 - 4). Thus the value of the Y-intercept is useless for the purposes of this study and should not enter into the interpretation of the results. Its effects upon the covariant relationship can be ignored for the purposes of drawing conclusions.

The right column in Table XVIII below expresses the percentage of total variance accounted for by each individual mental information-processing skill that enters into the multiple regression model and is the most important result of the data analysis for the purposes of drawing conclusions about the nature of the relationship.

TABLE XVIII

COEFFICIENTS OF PARTICAL DETERMINATION AND PERCENTAGES OF VARIANCE ACCOUNTED FOR BY SOI DIMENSIONS INCLUDED IN THE MULTIPLE REGRESSION MODELS

	Coefficient of Partial Determination	Percentage of Total Variance Accounted for
	T1 (R^2 = .115)	
Intercept	.0691	6.91%
CMS	.0311	3.11%
EFU	.0149	1.49%
	T2 (R^2 =.120)	
Intercept	.0625	6.25%
CMS	.0505	5.05%
CFS	.0070	0.70%
	R1 (R^2 = .187)	
Intercept	.1085	10.85%
CMS	.0524	5.24%
EFC	.0171	1.71%
EFU	.0090	0.90%
	R2 (R^2 =.125)	
Intercept	.0636	6.36%
EFU	.0406	4.06%
CFS	.0208	2.08%

TABLE XVIII-Continued

	Coefficient of Partial Determination	Percentage of Total Variance Accounted for
	S1 (R^2 =.100)	
Intercept	.0736	7.36%
CMU	.0136	1.36%
CMS	.0128	1.28%
	S2 (R^2 =.137)	
Intercept	.0773	7.73%
CMS	.0371	3.71%
CFS	.0226	2.26%
	S3 (R^2 =.143)	
Intercept	.0668	6.68%
CMS	.0570	5.70%
CSR	.0192	1.92%

Table XIX below lists the same information as above in slightly different form. In an attempt to more clearly depict the relationship, it lists the respective percentage of covariance (derived from the compution of the Coefficient of Partial Determination) of each SOI variable for each MAP subtest. It also excludes the value of the y-intercept, for the reasons indicated above (i.e., it merely reflects differences of scale among the tests and does not reflect the variance between dependent and independent variables.)

TABLE XIX

PERCENTAGE OF COVARIANCE ACCOUNTED FOR BY SOI DIMENSIONS

	T1	T2	R1	R2	S1	S2	S3
CMS	3.11%	5.05%	5.24%	----	1.36%	3.71%	5.70%
CFS	----	0.70%	----	4.06%	----	2.26%	----
CMU	----	----	----	----	1.28%	----	----
CSR	----	----	----	----	----	----	1.92%
EFU	1.49%	----	1.71%	2.08%	----	----	----
EFC	----	----	0.90%	----	----	----	----

It should be noted that those SOI dimensions that did not appear in this table (and therefore, in the table above,) did not enter into any of the final multiple regression models.

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CHAPTER V

DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS

The research intent of the present study was to determine the specific mental information-processing skills that enter into a significant relationship with specific musical aural discrimination abilities. In an effort to pursue this intent, three research problems were posed; each problem can now be addressed and conclusions drawn from the data analysis carried on within the research problems. But first, for clarity in discussion, Table XXI, which expresses the percentage of covariance which was accounted for by individual SOI Dimensions is reprinted from Chapter IV. The process of addressing each research problem is facilitated by reference back to this table.

TABLE XXI
PERCENTAGE OF COVARIANCE ACCOUNTED FOR BY SOI DIMENSIONS

	T1	T2	R1	R2	S1	S2	S3
CMS	3.11%	5.05%	5.24%	----	1.36%	3.71%	5.70%
CFS	----	0.70%	----	4.06%	----	2.26%	----
CMU	----	----	----	----	1.28%	----	----
CSR	----	----	----	----	----	----	1.92%
EFU	1.49%	----	1.71%	2.08%	----	----	----
EFC	----	----	0.90%	----	----	----	----

Each research problem that was posed in Chapter I will be now re-stated and an attempt made to draw conclusions based upon the results of the research described in the preceding chapters. It must be again noted, however, that the absolute magnitude of the Coefficient of Partial Correlation is of only limited importannce to this discussion. Rather, two other considerations are of greater importance for the present study. First, the inclusion of each specific mental information - processing skill within the model of the relationship is important for drawing conclusions as to the nature of the relationship. Second, the strengths of the individual mental information-processing skills within the relationship are important; it must be remembered, however, that the strengths of the SOI variables relative to each other within that relationship are of much more importance than their strengths for the total relationship. Thus, the small sizes of the Coefficients of Partial Correlation reported are of slight concern. What is important is their relative sizes.

> 1. To estimate the significant relationship between success at any individual mental task or any group of mental tasks and melodic discrimination skills; if such a relationship is found, what is the estimated magnitude of the unique contribution of each individual mental information-processing skill?

Based upon the analysis of the data, there was a small but statistically signficant relationship between a group of Guilford SOI dimensions and melodic discrimination skills.

Specifically, 11.5% of the variance between a group of intellectual information-processing skills and melodic discrimination ability - monophonic (r = +.34) and 12% of the variance between those intellectual skills and melodic discrimination ability - polyphonic (r = + .35) was found to be in common. This amount of variance in common between the two human attributes found within the present study agrees with the amount found in most previous studies into this area.

However, reporting merely the amount of covariance found is would be insufficient to justify the present study; this has been accomplished and a similar amount of covariance has been found many times before. The unique contribution of the present study is that the specific skills present within that relationship are identified and their strengths measured.

It will be recalled that the second part of each research problem dealt with estimating the magnitude of the unique contribution of each individual mental information-processing skill within the group of skills which were found to occur in a relationship with the specific musical aural discrimination ability.

This part of the research problem was answered by using the Guilford <u>Structure of Intellect</u> as a model for defining the nature, identifying, and determining specific mental information-processing skills. Two individual mental information-processing skills, within the Structure of Intellect dimensions measured by Meeker's test, Cognition of Semantic Systems (3.11% of the total variance) and Evaluation of Figural Units (1.49% of the total variance) comprised the relationship with the musical aural discrimination skill of melodic discrimination - monophonic. Cognition of Semantic Systems (5.05%) and Cognition of Figural Systems (0.70%) were the components of the area of joint variance between the SOI intellectual skills and the musical ability of melodic aural discrimination - polyphonic.

This suggests that the mental information-processing skills which involve Cognition (knowing) and Evaluation (comparing) are important to the aural musical discrimination skill of melodic discrimination; other mental information-processing skills do not appear to be necessary for this musical aural discrimination skill.

> 2. To estimate the relationship between success at any individual mental task or any group of mental tasks and rhythmic discrimination skills; if such a relationship is found, what is the estimated magnitude of the unique mental information-processing skill?

There is a small but signficant relationship between a group of Guilford SOI dimensions and rhythmic discrimination skills. The data analysis found 18.7% of the variance between intellectual information-processing skills and rhythmic discrimination ability - tempo ($r = +.43$), and 13%

of the variance between those intellectual skills and rhythmic discrimination ability - meter (r = + .36) to be in common.

Three intellectual information-processing skills were present in the relationship with rhythmic discrimination ability - tempo. They were Cognition of Semantic Systems (5.24% of the total variance), Evaluation of Figural Classes (1.71%), and Evaluation of Figural Units (0.90% of the total variance).

Only two intellectual information-processing skills were involved within the relationship with the rhythmic discrimination ability - meter. They were the skills of Evaluation of Figural Units (4.06%) and the Cognition of Figural Systems (2.08%)

As with the previous musical aural discrimination ability, the mental information-processing skills of Cognition and Evaluation were the only ones to enter into the relationship. This suggests that a portion of rhythmic discrimination abilities is due to these mental information-processing skills.

> 3. To estimate the relationship between success at any individual mental task or any group of mental tasks and discrimination skills in the aesthetic judgment of musical performance; if such a relationship is found, what is the estimated magnitude of the unique contribution of each individual mental information-processing skill?

It appears that there is a small but signficant relationship between a group of Guilford SOI dimensions and skills of musical aesthetic judgment; 10% of the variance between the group mental information-processing skills and aesthetic judgment of musical performance abilities - phrasing (r = +.32) was in common, as was 13.7% of the variance between those intellectual skills and aesthetic judgment of musical performance abilities - balance (r = + .37), and 14.3% of the variance between those intellectual skills and aesthetic judgment of musical performance abilities - style (r = + .38).

The mental information-processing skills involving Cognition were the only ones which appeared to comprise this relationship. Each individual musical aural discrimination skill involved the mental information-processing skill of the Cognition of Semantic Systems to a high degree (phrasing 1.36%; balance 3.71%; style 5.70%).

The musical aural discrimination ability of phrasing discrimination also involved the mental information-processing skill of the Cognition of SeMantic Units, which was of almost equal importance to the Cognition of SeMantic Systems, i.e. 1.28%. The musical aural discrimination ability of balance (phrase ending) was related to the mental information-processing skill of the Cognition of Figural Systems (2.26%) as well as the Cognition of SeMantic Systems. And finally, the musical aural discrimination ability of style discrimination was related most strongly to the mental information processing skill of the Cognition of SeMantic Relations (1.92%).

Since Cognition is defined by Guilford as involving the skill of "knowing", the complete absence of any other mental information-processing skills, other than Cognition, suggests that aesthetic discrimination skills may be learned skills and that a portion of musical aesthetic aural discrimination skills is due to the strength of this mental information-processing skill.

The results achieved by this study tend to agree with most previous studies, in that the data suggest that there does appear to be a small, but definite and discernible region where intellectual functioning skills and musical aural discrimination abilities do seem to vary with each other. The strength of this relationship, i.e., the size of the region of covariance, also seems to vary with the type of musical aural discrimation skill involved.

Given the observed relationships, the study further sought to explore the nature of the relationships i.e., does success at certain mental tasks seem to be consistently related to success at a number of different aural musical discrimination tasks? This question was answered in the affirmative. Certain mental information-processing skills, as defined by the Guilford Structure of Intellect model, consistently entered into a relationship with different musical aural discrimination abilities. It was observed that other mental information-processing skills entered into a relationship with only a few musical aural discrimination skills, or with only a single musical aural discrimination skill. Thus, it is likely that the SOI dimensions which enter into a relationship with only a single musical aural discrimination ability were specific to that particular musical aural discrimination ability and apparently no general relationship throughout the group of musical aural discrimination abilities was present.

However, it was also necessary to consider the relationships the SOI dimensions may have with each other; if a high correlation between two SOI dimensions was present, then the above figures may have reflected merely that correlation and not specific individual variance identified within the relationship. Table XXII below expresses the zero-order correlations among the six SOI dimensions which entered into the models of the relationship with musical aural discrimination abilities.

TABLE XXII

ZERO-ORDER CORRELATIONS AMONG SOI DIMENSIONS FOUND TO ENTER INTO A COVARIANT RELATIONSHIP WITH THE GROUP OF MUSICAL AURAL DISCRIMINATION ABILITIES

	CMS	CFS	CMU	CSR	EFU	EFC
CMS	1.00					
CFS	.63	1.00				
CMU	.67	.52	1.00			
CSR	.61	.46	.54	1.00		
EFU	.61	.49	.55	.47	1.00	
EFC	.07	.12	.06	.09	.12	1.00

It will be noted from an examination of Table XXII above that the "Cognition" group of SOI dimensions have fairly high intercorrelations; however, even though the figures reported above are not sufficiently high to question whether the subtests are reporting individual variances, they can indicate a possible effect of one SOI dimension upon the other. The reader should continue to bear this caution in mind throughout the following discussion.

The Nature of the Tasks Comprising the SOI - LA Dimensions Which Entered into the Models

In order to clarify further conclusions, it is necessary to discuss more thoroughly the nature of the specific tasks which were designed to measure the specific mental information-processing abilities. Only six SOI dimensions entered into multiple regression models with the seven musical aural discrimination abilities considered.

The nature of the task which evaluates each of these SOI dimensions will now be discussed.

The Guilford dimension of the Cognition of SeMantic Systems (CMS) accounts by far for the largest amount of covariance within the relationship between mental information-processing skills and musical aural discrimination abilities. The nature of the task by which the SOI - LA measures this information-processing skill is described by Meeker as follows:

> [CMS is] a type of "form reasoning"; in this task, the student must translate a verbal description into a set of shape relationships by means of a set of "word-shape" equivalencies (6, p. 9).

It is, therefore, a form of translation from one semantic system (word descriptions) to another semantic system (geometric symbols), using information provided within the exercise.

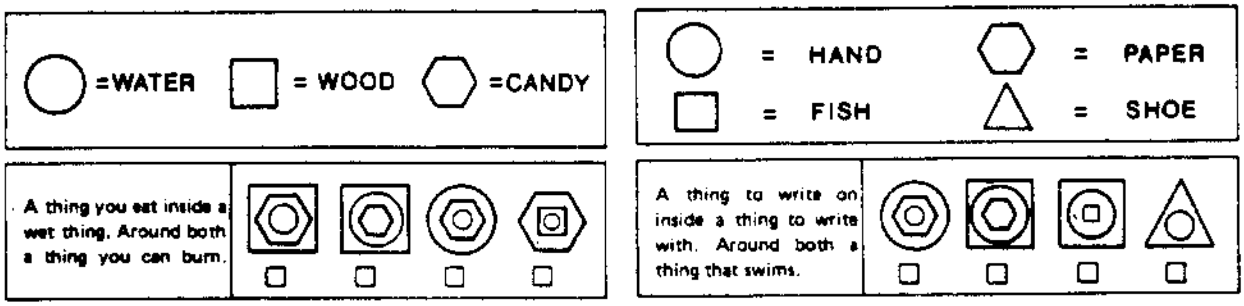

Fig. 15--CMS sample exercises from the Structure of Intellect - Learning Abilities Test.

As can be seen from an examination of the CMS sample exercises above, the task requires the student to hold information in memory and translate it into different forms for output in order to conform with the limits specified within the task. This mental information-processing skill appears to be also extremely important for success in musical aural discrimination tasks; it was determined that CMS entered into a significant relationship and accounts for a significant portion of the covariance, with all the musical aural discrimination abilities examined except for one, the one measured by the MAP subtest R2, that of meter discrimination.

This result seems to imply that the intellectual skill which involves the ability to hold information within the mind, at least over a short time, and compare it with other stimuli (whether received by visual or aural means), is a necessary component of several musical aural discrimination abilities.

An SOI dimension which belongs to "Evaluations", another sector of Guilford's "Operations" vector accounts for the next-highest amount of covariance within the relationships between mental information-processing skills and musical aural discrimiation abilities. EFU, the Evaluation of Figural Units is defined by Meeker as follows:

> [EFU is] the ability to identify similarities and differences of shapes . . . the ability to judge units of figural information as being similar or different. Judgements are based on minor aspects of the information (5, p. 63).

The task designed to measure the EFU dimension is reprinted below; it asks the test subject to determine which of the five possible responses is exactly the same as the criterion figure in the left-hand box.

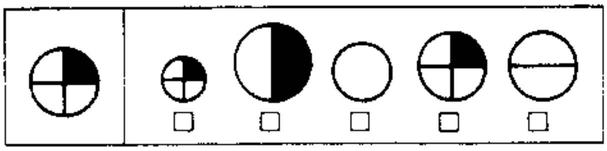

Fig. 16--EFU sample exercises from the Structure of Intellect - Learning Abilities Test.

This task does not seem to involve as much memory for geometric shapes as did the CMS task, chiefly because the subject can refer directly back to the criterion at the beginning of the line; it appears rather to be a more direct measure of the ability to mentally compare two different information inputs and make a decision as to the degree of similarity. This may be because it is simply a measure of skill at decision-making as to "Similar" and "Different" and does not involve the higher-order mental information-processing and translation steps that CMS does. Part of the relationship may also reflect the fairly high degree of correlation between CMS and EFU, $r = +.61$, which means that 37% of the variance between CMS and EFU is in common.

A second Guilford Structure of Intellect dimension which appears on the "Cognition" sector of the "Operations" vector and which entered into a significant covariant relationship with more than one musical aural discrimination ability is CFS, the Cognition of Figural Systems. This mental information-processing skill is defined as "the ability to comprehend arrangements and positions of visual objects in space" (2, p. 34), and the CFS sample exercise from the SOI - LA is reprinted below. In the CFS series of exercises, the student is instructed to pick which alternative would represent the correct appearance of the criterion figure in the left box if the point-of-view of the observer were to change from the star to that indicated by the arrow.

Fig. 17--CFS sample exercises from the Structure of Intellect - Learning Abilities Test.

Like EFU, CFS is a task which calls for the ability to discriminate between "Similar" and "Different", with the added requirement of imagination of rotation in two dimensions. CFS also was found to be fairly highly correlated with CMS (r = .63), as would be expected between two SOI "Cognition" dimensions; CFS showed a lower correlation with EFU (r = .49), however, leading one to conclude that the "Evaluations" dimension was measuring different variance from that of the "Cognition" dimension.

Two other SOI "Cognition" dimensions, the Cognition of SeMantic Units (CMU) and the Cognition of Symbolic Relations (CSR) each appear only once within the series of multiple regression models, CMU in a relationship with S1, a measure of the subject's aural musical discrimination abilities with respect to musical phrasing and CSR with S3, a measure of the subject's aural musical discrimination abilities with respect to musical style.

CMU is the SOI dimension which most closely resembles activities on traditional I.Q. tests. It is the "ability to comprehend the meanings of words or ideas" (2, p. 41). As can be seen from the sample exercises below, there are two parts to CMU. In the first part, learned numerical concepts are tested by asking the subject to circle the alternative which is the same as the expression appearing at the left side of the box; the second is a vocabulary test, in which the subject is asked to circle the word that means the same as the criterion at the left.

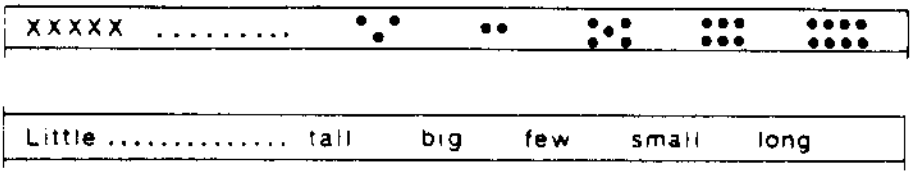

Fig. 18--CMU sample exercises from the *Structure of Intellect - Learning Abilities Test*.

CMU therefore measures the student's ability to recall concepts previously learned.

The final SOI dimension, the Evaluation of Figural Content (EFC) enters into the series of models of the relationship between mental information-processing skills and musical aural discrimination abilities only once, in a relationship with R1, which measures the student's tempo discrimination skills. Meeker has furnished a thorough definition for EFC.

> [EFC is] the ability to classify units specified in some way. The task for the student would be to analyze how they are classified and then judge how other units are similarly classified in another group of figures or forms (2, p. 64).

It measures an important ability for school success, for "classification ability indicates conceptual development; students high in CFC and EFC will read with good conceptualization" (3, p. 50).

The sample exercise for EFC is reprinted below. The task posed by EFC is to determine which of a group of geometric figures is similar enough to the criterion figure given in the left-hand box to "belong in the same group". It is a task of determining the degree of similarity and deciding which alternative is similar enough to the criterion.

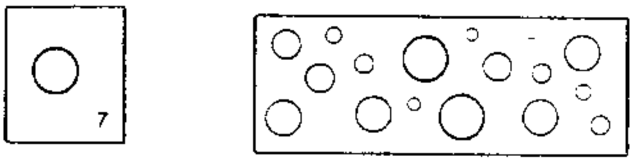

Fig. 19--EFC sample exercises from the *Structure of Intellect - Learning Abilities Test*.

A discussion of the results of the data analysis of the present study which would relate those results to Guilford's theoretical structure would also be helpful. It will be remembered that Guilford's model was based upon a three-dimensional structure created by the interactions of three vectors. Guilford entitled these three vectors "Operations", which was comprised of five components, "Contents", with four components, and "Products", comprised of six components, or sectors. Figure 20 below lists the major vectors and their components.

OPERATIONS	CONTENTS	PRODUCTS
Divergent Production	Figural	Units
CoNvergent Production	Symbolic	Classes
Evaluation	SeMantic	Relations
Memory	Behavioral	Systems
Cognition		Transformations
		Implications

Fig. 20--Guilford *Structure of Intellect* vectors, with their major sectors.

In order to clarify the roles of those variables which do not enter into the relationships as well as those which do enter, it is necessary to consider the contributions of the components of all three vectors, and not just the

"Operations" vector. The SOI dimensions are created and defined by the interaction of three equally-important vectors. Thus, it is important to note that four of the six SOI dimensions which appeared in the final models belonged to the "Cognition" sector (CMS, CFS, CMU, and CSR) and the other two belonged to the "Evaluation" sector, (EFU, and EFC) of the "Operations" vector. However, it is just as important to note that three belonged to the "Figural" sector, two to the "SeMantic" sector, and one to the "Symbolic" sector of the "Contents" vector. Further, two belonged to the "Systems" sector, two to the "Units" sector, and one each to the "Relations" and "Classes" sectors of the "Products" vector. Table XXIII below will express this relationship in tabular form.

Table XXIII

GUILFORD STRUCTURE OF INTELLECT VECTORS WHICH ENTERED INTO THE MULTIPLE REGRESSION MODELS WITH THEIR MAJOR COMPONENTS

OPERATIONS	
Divergent Production	none found
CoNvergent Production	none found
Evaluation	EFU, EFC
Memory	none found
Cognition	CMS, CFS, CMU, CSR
CONTENTS	
Figural	EFU, EFC, CFS
Symbolic	CSR
SeMantic	CMS, CMU
Behavioral	none found

Table XXIII - Continued

PRODUCTS	
Units	EFU, CMU
Classes	EFC
Relations	CSR
Systems	CMS, CFS
Transformations	none found
Implications	none found

Thus, the present study both identified the specific mental information-processing skills involved within a relationship with a group of seven individual musical aural discrimination abilities. Two of the group of mental information-processing skills which comprise Guilford's first main vector, (entitled "Operations") are included within the relationship. The "Operations" vector represents the types of skills which operate upon the information inputed into the organism. The skills included within the group which Guilford called "Cognition", or "Knowing" are very important to the relationship; the major intellectual functioning skill Guilford named "Evaluation" seems also important to the relationship, but not as important as "Cognition".

The three other Guilford mental information-processing skills upon the "Operations" vector, those of "Memory", "Convergent Production", and "Divergent Production" do not seem to be involved in a significant relationship with the particular musical aural discrimination tasks involved, that is, those of melodic discrimination, rhythmic discrimination, and musical performance sensitivity discrimination.

It is also necessary to consider the other two vectors which help to create Guilford's Structure of the Intellect, (which are represented in the naming of the skills by the second and third letters). The second, or "Contents" vector represents "Broad classes or types of information discriminable by the organism" (3, p. 22). These may be of a Figural, Symbolic, SeMantic, or Behavioral nature, according to SOI theory. No clear pattern of relationships with the musical aural discrimination abilities under consideration seemed to emerge with this vector; however, those abilities which entailed the "Semantic" relationship included 65% of the covariant relationships, while those involving the "Figural" dimension accounted for a further 32%. The final component of the "Contents" vector, the "Symbolic" class, accounted for only 3%. The SOI - LA contains no tests designed to address the Behavioral dimension.

The relative weakness of the Symbolic dimension may seem unexpected, since we are accustomed to thinking of music as a set of symbols; however, when it is recalled that the musical tasks posed were completely aural in nature, and involved no written use of symbols (i.e., musical notation), it may become easier to understand the slight part played by the "Symbolic" class.

Of considerably more importance to the relationship is the SeMantic dimension, which "refers to words and ideas where an abstract meaning is so associated in the individuals repertoire of knowledge that its external referent calls up the internally associated stored word" (3, p. 22). If one substitutes a "note" or "pitch" for "word" in the above statement, it becomes clear from the definition why the SeMantic dimension played a large part within the relationship. Those students who had a high level of SeMantic skills were apparantly better able to "call up" an internal criterion for comparison when prompted by the "external referent", i.e., the test item of the musical aural discrimination measurement device.

Guilford named the third vector suggested by his research the "Products" vector; it is defined as "the organization that informationtakes in the organism's processing of it" (3, p. 23). There are six dimensions which comprise this vector. They are those of Units, Classes, Relations, Systems, Transformations , and Implications. The respective strengths of the four of the six dimensions which appear within the final models may indicate an important heirarchy within the relationship; those SOI mental information-processing skills involving the Systems dimension accounted for 70% of the total variance.

The skills involving the Units dimension accounted for a further 24%, and those involving the other two dimensions (Relations and Classes) account for only 3% each.

The Systems dimension refers to "groupings which may be composed of figures, symbols, or semantics" (3, p. 25). Thus, the importance of the Systems dimension within the relationship with the aural musical discrimination skills logically follows the importance of the SeMantic dimension. The Units dimension refers to "that which can be processed singly, in which case it is a unit which is being perceived" (3, p. 23), and it may be necessary for success in the musical task of deciding whether a second performance is the "same" or "different" from a first.

The weakness of the "Relations" dimension within the covariance is surprising, since it is defined as "the processing of relations or connections between the content involved" (3, p. 24). It would seem logical that Relations would go hand-in-hand with the SeMantic dimension above. The fact that the data analysis of the present study does not indicate that Relations enters into a relationship with aural musical discrimination abilities to a large extent may reflect one of two things; either there is not a relationship in fact, or a weakness may be present within the SOI-LA test. Meeker included only two tests (of the 26 subtests) which attempted to measure Relations; thus a relationship with one or more aural musical discrimination abilities may be present with one of the Guilford SOI mental information-processing skills which is not included in the SOI-LA. This would suggest that further study involving the inclusion of those omitted Relations dimensions, i.e., those not selected for inclusion within the Meeker Structure of Intellect - Learning Abilities Test is indicated.

SOI Dimensions Not Included within the Models

For a full understanding of the relationship between musical aural discrimination abilities and mental information-processing skills, it is also necessary that the nature of the SOI mental information-processing skills that did not enter into a relationship with the individual aural musical discrimination abilities be considered. As was noted above, three of the main mental skill sectors in Guilford's "Operations" vector, those of "Divergent Thinking, "Memory", and "Convergent Production" are absent from the models of the relationship. The second vector in Guilford's model, which he felt represented "Contents", did have representatives of all its sectors in the final models, with the exception of the "Behavorial" sector, which the Meeker Structure of Intellect - Learning Abilities Test does not attempt to measure. The final vector, that of "Products" also has representatives from all its measured sectors, except "Transformations"; the Meeker SOI - LA has no subtests which attempt to measure "Implications".

When the nature of the tasks which are designed to measure "Divergent Thinking" (described fully previously, in Chapter Three), is considered, it is not surprising that no SOI dimensions which involve the sector of "Divergent Thinking" entered into the final models. The three "Divergent Thinking" dimensions included within the Meeker SOI - LA test (DFU, DMU, and DSR) all involve areas of creativity different from musical creativity. DFU involves elements of visual (drawing) creativity, DMU verbal creativity and fluency, and DSR involves creativity in relating groups of letters and numbers. None of the three SOI dimensions involves creativity with any aural elements.

However, it must be emphasized at this point that these dimensions did not enter into a relationship with the specific musical aural discrimination abilities under consideration within the present study. It is indeed possible that had the musical tasks which were used as the dependent (criterion) variable been different, e.g. a test of creating melodies, it is possible that these mental information-processing skills may have entered into a relationship with that musical ability.

The absence of any of the mental information-processing skills grouped by Guilford under the title of "Convergent Production" is perhaps more surprising than the absence of the skills of "Divergent Thinking". However, it is possible to suggest the reason for their absence by again examining the construction of the specific tasks within each subtest comprising the Meeker Structure of Intellect - Learning Abilities Test.

NSS (CoNvergent Production of Symbolic Systems) tests the "ability to produce a fully determined order or sequence of symbols" (2, p. 79). The task designed to measure this ability is mathematical in nature, and depended a great deal upon previously-learned concepts. This particular mental information-processing skill, of a mathematical nature, did not seem to be required for the specific musical aural discrimination skills used within this study.

The second SOI task which belongs to the "Convergent Production" group is NST, the CoNvergent Production of Symbolic Transformations, which measures the "ability to produce new symbolic items of information by revising given items" (2, p. 80). It must be remembered that the criterion musical aural discrimination abilities under consideration within the present study were completely aural - no written musical question or response was involved. Therefore, since the SOI sub-test of NST involves the use of Symbols, in this case, words of the written English language, it is logical that it did not enter into a model of the relationship with a musical aural discrimination ability.

In the same light, NSI, the CoNvergent Production of Symbolic Implications, is also a measure of symbolic relationships and the lack of a relationship with musical aural discrimination abilities is perhaps consistent with the previous two SOI "Convergent Production" dimensions. NSI is the "ability to produce a completely determined symbolicdeduction from given symbolic information, where the implication has not been practiced as such" (2, p. 80). The test which is designed to measure NSI is mathematical as well as symbolic in nature, and involves mentally translating from one written symbolic system (numbers) to another (geometric shapes).

Unlike the other three subtests included within the "Convergent Production" group, the final "Convergent Production" subtest, NFU, (CoNvergent Production of Figural Units), is not a measure of the student's ability to work with symbols. Instead, it "gives an indication of eye-hand coordination" (3, p. 58). and is used in the same way as other "perceptual motor and psychomotor tests" (3, p. 58). Since NFU largely involves psychomotor skills, it was logically unrelated to the musical aural discrimination abilities under consideration within this study.

Dealing with the absence of Guilford's "Memory" group of mental information-processing skills is more problematic. The complete absence of this group of mental information-processing-skills within the final models of the relationship was unexpected. Logically, the various tasks of melodic, rhythmic, and musical sensitivity discrimination tasks should require the use of aural short-term memory, particularly in those tasks such as the MAP T1, T2, R1, and R2, where the student had to determine if the two performances were "like" or "unlike".

One possible reason for the absence of any of the SOI "Memory" group from the models of the relationship can be found in Gordon's writings . He indicates that he feels "rhythm memory and tonal memory are mainly achievement factors" (1, p. 28), and "the extent to which these memory learnings can be developed may be largely dependent upon the aptitudes of rhythm imagery and tonal imagery" (1, p. 28). Thus, any kind of musical memory, in Gordon's view, then is a learned skill, dependent upon the musical aural discrimination abilities used as a criterion within this study. Musical memory would then logically be a dependent variable and not enter into the group of independent variables within the models.

Thus, it is possible that the nature of the SOI-LA Memory tests is not proper to attempt to measure the type of Memory skills necessary for musical aural short-term memory. The first four tests of short-term memory (MSUV, MSSV, MSUA, and MSSA) involve remembering lists of numbers forwards and backwards. Since, in Gordon's view, musical memory is a learned skill, it may be that a memory test which requires short-term memory for numbers rather than of aural tones would not be related to any sort of musical aural discrimination abilities.

However, a second reason for the absence of these Memory subtests from the final multiple regression models may exist. A statistical artifact may have been present, reflecting a weakness of Meeker's Structure of Intellect - Learning Abilities Test which was noted earlier. Subtests of the "Memory" group were included within the initial models created by the SAS STEPWISE procedure for both the pilot study and final study data. However, it was determined in the reliability estimates achieved upon the pilot study data and noted in Meeker's published reliability estimates that there was a question of whether the "Memory" group of subtests met currently-accepted standards for psychological research. Therefore, it will be recalled that one of the conclusions drawn from the analysis of the pilot study results was that the final models would exclude all SOI-LA subtests whose reliability estimates were below +.50, either published or experimentor-computed.

A characteristic of the "Memory" group of subtests within the Meeker SOI-LA test was their extreme brevity; five of the six tests had only four test items. Thus the chance variation of one question had more effect upon the test score than in a longer test. Even the application of the Spearman-Brown Prophecy Formula to the published reliability estimates of the SOI-LA "Memory" group left a considerable amount of doubt as to the soundess of conclusions based upon these tests.

However, it is quite possible that the decision made to exclude subtests from the final models if either their published or experimentor-measured reliabilities were below +.50 was overly restrictive. A fertile field for further research, however, would be to examine this relationship with more reliable tests of short-term memory than are available within the Meeker SOI-LA.

Two of the four "Evaluation" group did not appear within the final multiple regression models; ESC (Evaluation of Symbolic Classes) and ESS (Evaluation of Symbolic Systems). ESC involves the "ability to judge applicability of class properties of symbolic information, that is, the judging of a class in which to place numbers, letters, or signs" (2, p. 65). ESC is the "ability to estimate appropriateness of aspects of a symbolic system" (2, p. 66). Both dimensions are measured in the SOI-LA by tasks which involve learned arithmetic skills; they also both involve the use of symbols (the second "S" in their names stands for "Symbolic"). As was noted earlier, the MAP does not use visual systems, but is instead completely aural in the nature of the tasks; perhaps a musical test which involved some knowledge of or use of musical notation would show greater strength of relationship to Guilford's "Symbolic" sector.

Five of the nine subtests belonging to the "Cognition" group did not enter into the final multiple regression models. CFU, the Cognition of Figural Units, is the "ability to recognize a figural entity, that is, to 'close' figural information or perceive a complete visual form" (2, p. 30). CFT, the Cognition of Figural Transformations, is also a visualization ability, involving skill at imagining the appearance of a geometric shape after rotation. As tasks involving visual perception and analysis, neither CFU nor CFT would logically enter into a relationship with musical aural discrimination abilities.

CMR, the Cognition of SeMantic Relations, is the "ability to see relations betweens ideas or meanings of words" (2, p. 43). It would seem that its failure to appear within the initial models would indicate that the ability to determine "what comes between", while doubtlessly important for success in some schoolwork, is not a necessary skill for musical discrimination.

CFC, the Cognition of Figural Classes, is the "ability to recognize classes of figural items of information" (2, p. 32). The nature of the task posed by the SOI-LA to measure this skill is of a visual nature, calling for the proper grouping of geometric figures; it would not logically belong in a relationship with musical aural discrimination abilities.

The final SOI-LA subtest which belongs to the "Cognition" group is CSS, the Cognition of Symbolic Systems. CSS measures the student's "ability to understand the systematic interrelatedness of symbols within an organized set" (2, p. 39). This, like many of the SOI-LA tests which did not appear within the final models, is also a test involving arithmetic skills, as it is the familiar "which number comes next within the series" test. As a test of arithmetic skills, it would also logically not fit within a relationship with musical aural discrimination abilities. In addition, CSS deals with the "Symbolic" sector of the "Contents" vector; like every other SOI-LA subtest located within the "Symbolic" sector, it deal with written symbols. The musical aural discrimination skills under consideration within the present study were completely aural and did not involve the understanding, manipulation, or processing of symbols.

Summary

The present study attempted to explore the strength and nature of relations between subjects' success at a variety of different intellectual and musical aural discrimination tasks, recognizing both as complex, multi-dimensional phenomena. The test subjects included 350 fourth, fifth, and sixth grade students from a variety of suburban Dallas schools. Based upon field research conducted upon those children, the study determined which specific intellectual information-processing tasks, based upon a multi-dimensional model of intellectual information processing theorized by J.P. Guilford, the *Structure of the Intellect*, were related to specific musical aural discrimination skills for that particular age grouping.

Three research questions were posed, which involved determining the strength of the relationship between specific musical aural discrimiation abilities (of melodic discrimination, rhythmic discrimination, and aesthetic sensitivity discrimination abilities) and the intellectual information-processing skills comprising the *Structure of Intellect* . It was determined, through both a pilot and a main study, that the total relationship between intellectual information-processing skills, taken as a group, and various separate musical aural discrimination abilities was similar to past studies, i.e. from 10% to 15% of the variance was in common ($r = +.32$ to $r = +.39$). But uniquely to the present study, it was determined that six dimensions (all of which involved the skills of "Cognition" and "Evaluation") of the twenty-six *Structure of Intellect* dimensions under consideration were related to these specific musical aural discrimination abilities; further, the strengths of each individual information-processing skill's contribution to the covariance with the specific musical aural discrimination ability was measured.

It was also indicated that "Semantic" mental information-processing skills, which involve the ability to "call up" an abstract meaning or procedure from an external stimulus play an extremely important part within this relationship. Skills of a "Figural" nature, which involves the skill of comprehending "either a physical object or an non-physical idea/concept and separating it from other impinging stimuli" (2, p. 22), also enter into the relationship, although not to so high an extent as those of a Semantic nature. Finally, it was observed that the Guilford dimensions involving an understanding of "Systems" (those mental skills which deal with groupings of figures, symbols, or semantic relationships), was very important to the relationship.

These results tended to agree with the contention of many writers and past researchers, that musical aural discrimination abilities and intelligence are separate abilities with a small but statistically significant amount of overlap between them. But the importance of the present study was that it further indicates that the nature of the intellectual information-processing skills within that area of overlap. These skills involve the abilities of Cognition, Evaluation, an ability to deal with Semantic distinctions, an ability to handle and manipulate information of a Figural nature, and an understanding of the workings of Systems. Other mental information-processing skills do not seem to enter into the relationship between musical aural discrimination abilities and mental information-processing skills.

Suggestions for Further Study

The present study achieved its goals of determining which specific mental information-processing skills entered into a relationship with various musical aural discrimination abilities. Further, it determined their respective contributions to the area of covariance and indicated several patterns within the relationship.

The nature of the intellectual component of various musical aural discrimination abilities is thus suggested; however, further research is now indicated to identify the best ways to use this information. Certainly it would be wise to call for replication; thus, before the music education community actually changes curricula or bases other decisions upon the research it can be confirmed.

In addition, it would be desirable to replicate the study using different age groups within the study population. The age scope of the present study included only 4th, 5th, and 6th grade students; the conclusions drawn are properly limited only to students of that general age groups. It is possible that different ages would show different relationships, but this is yet unresearched and unproven.

Meeker's SOI-LA test is designed primarily for school children; it has its greatest reliability with that age group and many of the original test items (designed for adults), were simplified for school children. Therefore, it would be extremely desirable to have further adult studies which would use Guilford's original test materials. In addition, the SOI-LA measures only 26 of the possible 120 SOI dimensions; research as to possible relationships with the omitted dimensions ought to be carried on.

It must be noted that the relationships found within this study are only suggested, and not proven, by the statistical techniques of multiple regression analysis. Multiple regression analysis, which was the major statistical procedure used within this study, derives from simple Pearson-product-moment correlation. It is a maxim of statistical analysis that "Correlation does not imply causation". Causation is not within the scope of this study; it was designed to consider relationships, (i.e. correlation) only.

Controlled experimentation is necessary to establish any causation. Thus a logical and important extension of the results of the present study would be research using experimental and control groups to determine if either of the following reciprocal possibilities would hold true:

1. That the study of music, which increases the aural musical discrimination abilities measured by the MAP would also increase the Cognition, Evaluation, Semantic and Figural understanding, and Systems understanding skills measured by the SOI-LA; and/or,

2. That the study of the same Guilford Structure of Intellect dimensions would increase the aural musical discrimination abilities measured by the MAP.

A positive answer to the first possiblility could be very important to music education, for it would yield a definite and intellectual rationale for the study of music within the public schools. It is particularly important in the present time, when music education is under extreme budget presures, in order to prove the value of the study of our Art. It is particularly valuable to be able to prove this value using non-aesthetic reasons, for aesthetic reasons for justification of the expense of a music program are extremely difficult for non-musicians to appreciate.

As Guilford himself indicated, it is likely that a further refinement of both the Structure of Intellect and of the measuring devices based upon the SOI concept will take place and later research can use the improved versions of the testing material and analylitical tools created by that refinement. However, it seems likely that a multi-dimensional view of the intellect will continue to be accepted among the research community. Thus, Guilford's Structure of the Intellect has offered a useful structure for research into the musical attributes of melodic, rhythmic, and aesthetic aural discrimination abilities.

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APPENDIX A

STRUCTURE OF INTELLECT CELLS DEFINED

Cognition - Comprehension

CFU - Cognition of Figural Units - Ability to identify objects, visually and auditorially
CFC - Cognition of Figural Classes - Ability to classify perceived objects
CFR - Cognition of Figural Relations - Ability to discover relations in perceptual material
CFS - Cognition of Figural Systems - Ability to perceive spatial patterns and maintain orientation
CFT - Cognition of Figural Transformations - Ability to understand transformed objects visually
CFI- Cognition of Figural Implications - Ability to explore visually ways to select most effective action

CSU - Cognition of Symbolic Units - Ability to recognize graphic symbols; codes, numbers, notes
CSC - Cognition of Symbolic Classes - Ability to identify attributes of patterns
CSR - Cognition of Symbolic Relations - Ability to discover abstract relations in symbolic patterns
CSS - Cognition of Symbolic Systems - Ability to understand systems involving symbols
CST - Cognition of Symbolic Transformations - Ability to recognize that a specific transformation of symbolic information has occurred.
CSI - Cognition of Symbolic Implications - Ability to forsee or be sensitive to consequences in a symbolic problem.

CMU - Cognition of Semantic Units - Ability to use vocabulary
CMC - Cognition of Semantic Classes - Ability to comprehend concepts and classes of ideas and words
CMR - Cognition of Semantic Relations - Ability to discover relations between concepts
CMS - Cognition of Semantic Systems - Ability to comprehend systems of words and ideas (reading, instructions)
CMT - Cognition of Semantic Transformations - Ability to see several meanings in words or ideas
CMI - Cognition of Semantic Implications - Ability to anticipate needs or consequences

Memory

MFU - Memory of Figural Units - Ability to recall visual and auditory stimuli

MFC - Memory of Figural Classes - Ability to remember previously presented classes of figural material; visual, auditory, or kinesthetic

MFR - Memory of Figural Relations - Ability to memorize relations betweens items of figural information presented

MFS - Memory of Figural Systems - Ability to recall arrangements of objects previously presented

MFT - Memory of Figural Transformations - Ability to remember transformations of figural material previously changed

MFI - Memory of Figural Implications - Ability to remember circumstantial connections between or among items of figural information as a basis for logical or causal extrapolation

MSU - Memory of Symbolic Units - Ability to recall for immediate production a group of numerals or letters

MSC - Memory of Symbolic Classes - Ability to remember symbolic class properties

MSR - Memory of Symbolic Relations - Ability to remember definitive connections between units of symbolic information

MSS - Memory of Symbolic Systems - Ability to remember systems of numerals, letters in exact order (spelling)

MST - Memory of Symbolic Transformations - Ability to remember changes in symbolic information

MSI - Memory of Symbolic Implications - Ability to remember symbols and their implications

MMU - Memory of Semantic Units - Ability to reproduce previously presented ideas or words

MMC - Memory of Semantic Classes - Ability to remember verbal or ideational class properties

MMR - Memory of Semantic Relations - Ability to remember meaningful connections between items of verbal information

MMS - Memory of Semantic Systems - Ability to remember a system of ideas presented visually or auditorially

MMT - Memory of Semantic Transformations - Ability to remember changes in meanings or redefinitions

MMI - Memory of Semantic Implications - Ability to remember arbitrary connections between pairs of meaningful ideas.

Evaluation - Judgement, planning, reasoning, and critical decision making

EFU - Evaluation of Figural Units - Ability to identify similarities and differences of shapes

EFC - Evaluation of Figural Classes - Ability to develop the ability to judge whether figures are properly classified

EFR - Evaluation of Figural Relations - Ability to evaluate spatial relationships

EFS - Evaluation of Figural Systems - Ability to evaluate total systems of spatial information

EFT - Evaluation of Figural Transformations - Ability to judge or analyze how figures or objects will appear after changes

EFI - Evaluation of Figural Implications - Ability to predict and evaluate defects and deficiencies in spatial information

ESU - Evaluation of Symbolic Units - Ability to make rapid decisions identifying letter or number sets

ESC - Evaluation of Symbolic Classes - Ability to judge the applicability of class properties of symbolic information

ESR - Evaluation of Symbolic Relations - Ability to determine the consistency of symbolic relations

ESS - Evaluation of Symbolic Systems - Ability to estimate the appropriateness of aspects of a symbolic system

EST - Evaluation of Symbolic Transformations - Ability to judge adequacy of substitutive symbols

ESI - Evaluation of Symbolic Implications - Ability to judge consistency of, and inferences from, symbolic information

EMU - Evaluation of Semantic Units - Ability to select appropriate variations in word meanings

EMC - Evaluation of Semantic Classes - Ability to judge applicability of class properties of semantic information

EMR - Evaluation of Semantic Relations - Ability to make choices among semantic relationships based on the similarity and consistency of meanings (analogies)

EMS - Evaluation of Semantic Systems - Ability to appraise aspects of systems of words

EMT - Evaluation of Semantic Transformatins - Ability to apply changes in judgement about ideas

EMI - Evaluation of Semantic Implications - Ability to judge the adequacy of a meaningful deduction (deductive reasoning)

Convergent Production - Solving problems where answers are known

NFU - Convergent Production of Figural Units - Ability to reproduce exact information in spatial forms (writing, copying)
NFC - Convergent Production of Figural Classes - Ability to sort or classify as pre-specified
NFR - Convergent Production of Figural Relations - Ability to reproduce figural relationships
NFS - Convergent Production of Figural Systems - Ability to reproduce a known system or design
NFT - Convergent Production of Figural Transformations- Ability to change figural information into new forms
NFI - Convergent Production of Figural Implications - Ability to solve simple equations in terms of familiar forms from inferred data

NSU - Convergent Production of Symbolic Units - Ability to reproduce patterns of single, simple symbols (coding)
NSC - Convergent Production of Symbolic Classes - Ability to classify items of symbolic information in pre-specificed ways (filing)
NSR - Convergent Production of Symbolic Relations - Ability to find nonverbal responses in relationships between numerals or letters
NSS - Convergent Production of Symbolic Systems - Ability to solve correctly a problem using symbolic systems
NST - Convergent Production of Symbolic Transformations - Ability to reproduce new symbolic items of information by revising given items
NSI - Convergent Production of Symbolic Implications - Ability to substitute or derive symbols as expected (logic and algebra)

NMU - Convergent Production of Semantic Units - Ability to correctly name semantic concepts and ideas
NMC - Convergent Production of Semantic Classes - Ability to classify correctly words or ideas
NMR - Convergent Production of Semantic Relations - Ability to correlate verbal representations (analogies)
NMS - Convergent Production of Semantic Systems - Ability to arrange ideas into a meaningful sequence (essay writing)
NMT - Convergent Production of Semantic Transformations - Ability to shift functins of ideas for use in new ways
NMI - Convergent Production of Semantic Implications - Ability to infer correctly from given, known information

Divergent Production - Solving problems creatively

DFU - Divergent Production of Figural Units - Ability to produce many and unique varieties of figures within structure (art)

DFC - Divergent Production of Figural Classes - Ability to reclassify perceived objects in unique ways

DFR - Divergent Production of Figural Relations - Ability to generate new and constructive relatins between figural items

DFS - Divergent Production of Figural Systems - Ability to produce composites of figural information in new systems

DFT - Divergent Production of Figural Transformations - Ability to devise figural information

DFI - Divergent Production of Figural Implications - Ability to elaborate on figural information in unexpected forms

DSU - Divergent Production of Symbolic Units - Ability to produce many symbolic units which conform to simple specifications

DSC - Divergent Production of Symbolic Classes - Ability to group items of symbolic information in different ways

DSR - Divergent Production of Symbolic Relations - Ability to generate a variety of relations between numbers or letters

DSS - Divergent Production of Symbolic Systems - Ability to produce symbolic systems in unique ways

DST - Divergent Production of Symbolic Transformations - Ability to transform symbolic material

DSI - Divergent Production of Symbolic Implications - Ability to produce varied implications from given symbolic information

DMU - Divergent Production of Semantic Units - Ability to create many ideas spontaneously (brain-storming)

DMC - Divergent Production of Semantic Classes - Ability to produce new ideas appropriate in meaning to given categories

DMR - Divergent Production of Semantic Relations - Ability to produce unique ideas from associated words (poetry)

DMS - Divergent Production of Semantic Systems - Ability to originate unique verbal ideas (creative writing)

DMT - Divergent Production of Semantic Transformations - Ability to produce remotely associated, clever, or uncommon verbal responses (puns)

DMI - Divergent Production of Semantic Implications - Ability to specify details that develop a scheme or variation of an idea (joke, humor)

APPENDIX B

SIMPLE CORRELATIONS BETWEEN AND AMONG SOI AND MAP DIMENSIONS

TABLE XXIV

SIMPLE CORRELATIONS AMONG ALL SOI DIMENSIONS

	CFU	CFC	CFS	CFT	CSR	CSS	CMU
CFU	1.00						
CFC	.35	1.00					
CFS	.31	.34	1.00				
CFT	.35	.31	.26	1.00			
CSR	.26	.25	.46	.40	1.00		
CSS	.30	.25	.48	.27	.45	1.00	
CMU	.51	.41	.52	.43	.54	.55	1.00
CMR	.52	.41	.56	.38	.62	.58	.79
CMS	.46	.49	.63	.39	.61	.58	.67
MFU	.22	.31	.21	.28	.31	.19	.30
MSU-V	.43	.33	.48	.31	.38	.52	.64
MSU-A	.32	.19	.41	.30	.40	.46	.46
MSS-V	.38	.26	.42	.32	.48	.49	.59
MSS-A	.32	.39	.42	.39	.35	.42	.55
MSI-V	.27	.29	.40	.18	.26	.34	.46
MSI-A	.42	.32	.40	.18	.34	.39	.51
EFU	.41	.39	.49	.39	.47	.49	.55
EFC	.04	-.04	.12	-.01	.09	.07	.06
ESC	.45	.32	.51	.46	.58	.51	.66
ESS	.39	.36	.58	.39	.47	.58	.66
NFU	.35	.24	.04	.26	.12	.09	.35
NSS	.45	.48	.53	.39	.54	.56	.68
NST	.52	.38	.56	.39	.59	.59	.74
NSI	.46	.42	.54	.40	.50	.58	.72
DFU	-.02	.06	.08	-.04	.06	.10	.02
DMU	.42	.38	.42	.40	.44	.43	.63
DSR	.00	.11	.03	.09	.10	.22	.15

TABLE XXIV--Continued

	CMR	CMS	MFU	MSU-V	MSU-A	MSS-V	MSS-A
CMR	1.00						
CMS	.76	1.00					
MFU	.34	.40	1.00				
MSU-V	.63	.57	.27	1.00			
MSU-A	.50	.54	.26	.62	1.00		
MSS-V	.67	.64	.33	.66	.67	1.00	
MSS-A	.57	.54	.28	.61	.58	.63	1.00
MSI-V	.46	. 43	.32	.47	.40	.45	.43
MSI-A	.55	.57	.28	.56	.57	.60	.53
EFU	.67	.61	.33	.41	.37	.48	.46
EFC	.11	.07	.14	.11	.09	.09	.04
ESC	.65	.65	.38	.52	.51	.57	.56
ESS	.66	.59	.28	.57	.42	.55	.56
NFU	.21	.16	.03	.36	.23	.22	.32
NSS	.67	.71	.32	.54	.51	.58	.56
NST	.74	.72	.37	.65	.62	.70	.64
NSI	.72	.69	.31	.58	.56	.65	.66
DFU	-.01	.08	-.13	.08	.08	.08	.04
DMU	.56	.56	.29	.53	.50	.51	.57
DSR	.17	.26	-.01	.12	.09	.06	-.01

TABLE XXIV--Continued

	MSI-V	MSI-A	EFU	EFC	ESC	ESS	NFU
MSI-V	1.00						
MSI-A	.50	1.00					
EFU	.48	.44	1.00				
EFC	-.01	.03	.12	1.00			
ESC	.44	.55	.58	.03	1.00		
ESS	.41	.48	.52	.02	.66	1.00	
NFU	.01	.20	.09	-.09	.20	.25	1.00
NSS	.45	.54	.57	.03	.73	.70	.24
NST	.50	.63	.56	.08	.73	.67	.28
NSI	.52	.56	.57	.05	.68	.67	.26
DFU	.02	.02	.10	.02	-.05	.00	-.05
DMU	.32	.49	.45	-.01	.54	.51	.34
DSR	.06	.08	.20	-.09	.11	.13	.01

TABLE XXIV - Continued

	NSS	NST	NSI	DFU	DMU	DSR
NSS	1.00					
NST	.72	1.00				
NSI	.68	.74	1.00			
DFU	.04	.03	.08	1.00		
DMU	.58	.68	.61	.10	1.00	
DSR	.04	.12	.11	.24	.14	1.00

TABLE XXV

SIMPLE CORRELATIONS AMONG ALL MAP VARIABLES

	T1	T2	R1	R2	S1	S2	S3
T1	1.00						
T2	.63	1.00					
R1	.53	.50	1.00				
R2	.49	.52	.64	1.00			
S1	.32	.40	.31	.43	1.00		
S2	.42	.47	.49	.60	.47	1.00	
S3	.35	.42	.53	.59	.48	.51	1.00

TABLE XXVI

SIMPLE CORRELATION BETWEEN ALL SOI AND MAP VARIABLES

	T1	T2	R1	R2	S1	S2	S3
CFU	.21	.21	.17	.20	.03	.25	.23
CFC	.21	.10	.14	.09	.13	.25	.23
CFS	.35	.33	.30	.28	.19	.35	.32
CFT	.20	.10	.22	.24	.17	.31	.10
CSR	.26	.25	.40	.30	.21	.29	.40
CSS	.29	.25	.37	.29	.15	.16	.29
CMU	.29	.26	.32	.27	.31	.31	.36
CMR	.34	.35	.34	.26	.22	.25	.31
CMS	.46	.40	.48	.40	.28	.37	.44
MFU	.21	.15	.28	.26	.18	.26	.22
MSUV	.33	.19	.30	.19	.11	.17	.22
MSUA	.31	.29	.39	.33	.12	.23	.26
MSSV	.31	.27	.41	.28	.12	.22	.28
MSSA	.34	.25	.32	.17	.16	.22	.29
MSIV	.31	.23	.26	.24	.10	.23	.15
MSIA	.32	.32	.31	.20	.08	.24	.23

TABLE XXVI - Continued

	T1	T2	R1	R2	S1	S2	S3
EFU	.42	.33	.46	.39	.22	.37	.37
EFC	.02	-.01	.24	.10	-.07	.00	.12
ESC	.34	.24	.33	.30	.12	.32	.27
ESS	.33	.30	.35	.31	.14	.28	.31
NFU	.15	.01	-.01	-.02	-.02	.00	.04
NSS	.39	.32	.39	.37	.18	.32	.37
NST	.41	.41	.42	.34	.26	.36	.40
NSI	.27	.22	.35	.32	.16	.25	.34
DFU	-.05	.10	.07	.06	.16	.06	.12
DMU	.30	.32	.29	.31	.16	.30	.35
DSR	.17	.13	.09	.09	.11	.08	.05

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