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AN INVESTIGATION INTO THE PERCEPTIBILITY
OF TWELVE-TONE ROWS

DISSERTATION

Presented in Partial Fulfillment of the Requirements for
the Degree Doctor of Philosophy in the Graduate
School of the Ohio State University

by

Edward James Largent, Jr., B.Sci., B.Mus., M.Mus.

* * * * * *

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CHAPTER I
EXPLORATION OF THE PROBLEM

Introduction

Since its inception, Arnold Schoenberg's method of composing music using "Twelve Tones Which are Related Only with One Another" (Schoenberg, 1950) has exerted considerable influence upon twentieth century music. However, the propagation of twelve-tone music has met with resistance from the general public, and the music has generated mixed reactions among professional musicians. The mixed reaction, and especially the negative attitudes toward the twelve-tone system and its product were the generating forces for this dissertation.

Purposes of the Investigation. The purposes of this investigation were to survey the negative reaction to twelve-tone music; to review reports of related perceptual or auditory studies involving twelve-tone music; to explore the perceptual qualities of twelve-tone rows; and to determine the changes in perceptual quality when twelve-tone rows are subjected to serial treatment.

Investigative Procedure. Articles critical of Arnold Schoenberg's method of composition using the twelve-tone technic and of Schoenberg's twelve-tone music were studied as a means of determining what people felt was wrong with both the style and the music. Articles that dealt with perceptual or auditory studies which involved twelve-tone
rows were reviewed to determine the kinds of investigations performed. From these articles hypotheses were generated for testing and an aural discrimination test was constructed using four twelve-tone rows which were subjected to serial treatment. The test was administered to six hundred twenty-one college students and the results were subjected to statistical analysis. Conclusions were drawn from the findings and additional research was suggested.

Source Materials. Biographical information and partial lists of compositions of Arnold Schoenberg can be found in several books dealing with twentieth-century music, among them Machlis (1961), Austin (1966), Stuckenschmidt (1967) and Hansen (1971); and in general histories of music such as Grout (1960) and Crocker (1966). Complete and chronological lists of the Schoenberg compositions can be found in Searle's (1954) article which appeared in Vol. VII of Grove's Dictionary of Music and Musicians, and in Stuckenschmidt's (1965) article in Vol. XII of die Musik in Geschichte und Gegenwart. Accounts of the rules for composing twelve-tone music can be found in Schoenberg (1950), Austin (1966) and Hansen (1971). The two most definitive works dealing with the twelve-tone system are Rufer (1954) and Perle (1968). Basart (1963) serves as a bibliography of books and articles dealing with the twelve-tone system. The periodicals die Reihe, Journal of Music Theory and Perspectives in New Music serve as vehicles for publication of research results and dialogue on the twelve-tone system and its products.
Criticism of Schoenberg's Twelve-Tone Music, and the Schoenbergian Twelve-Tone System

In order to determine what, if anything, is wrong with twelve-tone music and the twelve-tone system of composition, a number of articles that were antagonistic to the music and the system which Schoenberg devised were collected and are presented below. While it is impossible to read every criticism of the twelve-tone system and its product, it is considered that the following antagonistic criticisms are representative of the thinking of most people who dislike Schoenberg's twelve-tone system and his twelve-tone music.

Namenwirth (1965) collected and translated one hundred reviews of performances of Schoenberg's works, these reviews taken from the Berlin newspapers between the years 1912 and 1932. The reviews were of performances of works from the pre-twelve-tone and early twelve-tone phases of Schoenberg's development. Namenwirth concluded that the reviewers evaded musical constructs and created judgements on the basis of non-musical criteria.

In 1951, the editor of Music and Letters, a British periodical, invited a number of English men of music to present their views of Schoenberg and his music as letters to the editor. Subsequently, an article entitled "Arnold Schönberg 1874-1951" was printed in the October, 1951 issue of the magazine, comprising twenty five letters to the editor, of which thirteen were decidedly anti-Schoenberg, seven pro-Schoenberg, and the remaining five noncommittal. The following comments and quotes are drawn from this article.

Two of the writers criticized the twelve-tone system because it
was not based on natural law theory or on the harmonic series.

Aprahamian (p. 306) said that Schoenberg "sins against the natural physical law governing sound. A sort of arbitrary mathematics is substituted for elementary accoustical law." Jacob (p. 313) said that "enharmonic modulations depend on the acceptance of an artificial scale. There is, however, an inescapable scientific phenomenon which his system does ignore, namely, the Harmonic series."

The following comments written by four of the contributors to the article in *Music and Letters* criticized the twelve-tone system from another point of view, namely its lack of tradition or heritage. Aprahamian (p. 306) said that Schoenberg "must ... shoulder the responsibility for some of the worst music written in any style. Twelve-note technique has proved a dangerous plaything in the hands of the musically young." Aprahamian (pp. 306-307) said further that Schoenberg "never supplied a satisfactory link between the old and the new. That is the essential weakness of his system, which is something he artificially attached to, rather than developed from, traditional technique." Blom (p. 308) said:

> Twelve-note music could be judged even by those engaged to teach it by nothing but its behaviour on paper. At the same time, to decide if that behaviour accords with the rules of what is a preconceived artificial system, as distinct from procedures evolved by age-long aesthetic experience, is so easy that the composer himself is as good a judge as any teacher.

Jacob (p. 313) said that "the twelve-note system can too easily be used to cover up poverty of invention." Myers (p. 320), criticizing the system because of its lack of upbringing, said:
The greatest mistake musicians have made ... is to have imagined that a purely experimental procedure invented by one brain and not evolved from the natural expansion of our musical language, could or should ever become a model for other composers to copy, still less a system on which a music of the future may be built.

Three of the contributors attacked the twelve-tone system as being too intellectual or brainy. Bax (p. 307) said that the system will "never produce anything more than morbid or entirely cerebral growth." Howells (p. 213) said that he lacked the conviction "that any creative mind can, by cold intellectual exercise, divorce itself from its common inheritance." Mann (p. 316) said that the system "has been many times branded as cerebral, mathematical, limiting." Mellers (p. 319) acknowledged the apparent intellectualism of the twelve-tone system but said that "the fact that Schoenberg writes in an 'intellectual system' is in itself neither here nor there."

Two comments strike at the system as being mathematical. Aprahamian (p. 306) considered that the system was based on "arbitrary mathematics," while Bax (p. 307) said that Schoenberg "deliberately resolved to turn himself into the world's premier mathematician in sound."

Howell's comment (p. 312) that he was "unable to see how theory could precede practice in musical composition" points to criticism from the point of view that the twelve-tone system is illogical theoretically. Dyson (p. 310) said:

It has yet to be proved that the theoretical construction of new conventions, however logical in themselves, can replace the more gradual and intuitive development of a traditional artistic language.
Lockhart (p. 315) brought equal temperament into the picture. He said:

> If this brutally equalized temperament [of Schoenberg's] is truly the medium of our music, art is indeed in a decline.

Keys (p. 314) asked, "are Schoenberg's sequences of notes supposed to be recognized, that is, remembered, by the listener?" Jacob (p. 313) called the tone row an "artificial scale", while Lockhart (p. 315) said:

> No vigorous sort of intention can be expressed when the very medium is as rotten as Schöenberg's scale.

The following comments, again drawn from the Music and Letters article, express dislike for Schoenberg's twelve-tone music. Bliss (p. 307) said that he could "see only an inhuman lunar landscape; I cannot warm to the music." Jacob (p. 313) said:

> The real objection to twelve-note music is that it is a manufactured language ... It has no associations for the listener and therefore can give him no surprises.

Keys (p. 314), quoted above, asked about the listener's ability to remember the notes in a twelve-tone composition. Lockhart (p. 315) wrote part of his criticism from the point of view of a string player who is confronted with a page of Schoenberg's music which contains augmented fourths and diminished fifths. He said:

> That there is a fundamental falsity in Schöenberg's art seems to me to be proved by the fact that a violinist, faced with a page of Schöenberg's, does not know what to play.

Mellers (p. 319), said that "we cannot feel [Schönberg's early dodecaphonic works] as wholes, in the way we can experience the Berg
Myers (p. 320) considered Schoenberg's music to "be outside the main current of Western music," and felt that a composer who employed the twelve-tone system for the composition of music was living in a situation of "brooding stagnation." Rubbra (p. 321) said that it was "difficult to accept Schönberg's music either as 'modern' in the accepted sense or as original in its essential aural impact."

The lack of musical enjoyment gained from listening to Schoenberg's music was expressed by four of the contributors. Amis (p. 305) said that the music was "undramatic, unrhythmic, unspontaneous, and points to emotional atrophy." Aprahamian (p. 305) said that Schoenberg's music has "contributed little to the sum of my musical happiness."

Boult (p. 308) said:

I have never derived any real musical enjoyment from Schonberg's work, but simply a craftman's interest in trying to interpret the printed page as faithfully as possible.

Howells (p. 312) said that he failed to "get any enrichment of feeling from so much of the music."

Critical comments of Schoenberg as a composer were written by two of the contributors to the article in Music and Letters. Dean (p. 310) added: "The fact remains that the musical world has not been convinced that Schönberg was a great composer." Lockhart (p. 315), quoted above, considered the art of music in decline because of the use of the twelve-tone system.

In summarizing the comments from the article in Music and Letters it appears that there is a great deal of variegated criticism
of Schoenberg's system and his twelve-tone music. However, the
comments can be grouped into three categories of unequal dispersion.
The Schoenbergian twelve-tone system received the greatest number of
criticisms, the twelve-tone music written by Schoenberg received a
lesser degree of criticism, while Schoenberg himself received only a
few critical comments. The contributors considered the system as
dangerous, artificial, cerebral, intellectual, mathematical, as a
system which does not bridge the gap between old tradition and new,
as an experimental procedure, as a system which preceded practice,
and as a sequence of notes. The writers considered the music written
by Schoenberg in the twelve-tone style as inhuman, not modern, not
original, undramatic, unenjoyable, as a manufactured language, and
as unenriching. Of Schoenberg the writers said that they felt he was
not a great artist or composer.

More Criticism. Glock (1952) has provided interesting comment
about twelve-tone music:

We all know the commonest objections to twelve-tone
music. First, that it sounds unnatural to the ear;
and the answer is probably: the ear must educate
itself. Secondly, 'twelve-tone music takes as its
norm the well-tempered scale, which is artificial and
man-made' ... But there is no scientific accoustical
proof that the scale used by the twelve-tone com-
posers is wrong or unnatural ... A third, and different
objection is that as we no longer believe in the
absolute character of the pre-Schönbergian system -
and Schönberg himself helped to destroy this belief
for us - we no longer need to be in revolt (p. 3).

Despite Schoenberg's claim (1950) that "composition with twelve
tones has no other aim than comprehensibility," (p. 103), this
supposed comprehensibility is lost to some people. Myhill (1955) analyzed the situation thus:

Those who describe contemporary music as cerebral have in mind the idea that a preconceived theory or form is ruthlessly and mechanically imposed upon a composition without regard to the resulting sound. It must be admitted that much of the current talk about twelve-tone music created the impression of a completely purposeless and neurotic activity (p. 191).

Lang and Broder (1968) wrote:

Since dodecaphony was an invented academicism it too soon ran its course and was presently succeeded by total serialism in the hope of lending new life or revealing new resources to an exhausted art ... Again and again one is struck when studying their music [the total serialists] by the intrusion of intellectual problems that are esthetically resolved (p. 7).

Even as late as 1968 there were people who still considered the twelve-tone method of composition to be an intellectual, an extra-aesthetic activity.

Criticisms, Summarized. Of all the critical comments about the Schoenbergian twelve-tone system, Schoenberg's twelve-tone music, and the criticisms of the man himself, only five comments presented above appear to come close to what the real problem with twelve-tone music is. Blom (1951) suggested that the system is analyzable only on paper, and hints that the sounds represented by the symbols on the paper are unbehavioural or incapable of eliciting response from a listener. Jacob (1951) said that in order for Schoenberg's twelve-tone music to be understandable there has to be something for the listener to associate with, and he suggests that there is no
associative quality about the music. Glock (1952), while suggesting a possible cure for the problem, said that one reason twelve-tone music is objectionable is that it doesn't sound natural to the ear. This perhaps suggests that there may be certain aural expectations that are not fulfilled in twelve-tone music. Myhill (1955) wrote about the apparent disregard that the twelve-tone composers have for the resulting sounds, hinting that the system was created without concern for the aural product. Keys (1951) perhaps comes closest to the fundamental problem when he asked whether the sequences of notes were supposed to be remembered or not. There is a semantic problem here, in that one cannot hear sequences of notes which are the visual representations of musical tones. The writer assumes that Keys meant that the sequences of tones be heard and remembered rather than the sequences of notes. This suggests that there is some kind of aural retention process necessary to understand music, and that it may be impossible to understand twelve-tone music because of the lack of some recognizable quality in the music which can be remembered. This points to the fundamental problems. What is it that makes twelve-tone music unrememberable? What is it about twelve-tone music that makes it hard to listen to: that makes it hard to understand? Is it the overall product resultant from the structuring of the basic components of the system within a composition, or is it the row itself, the row and its derivatives? Are the basic components of the system the causative agents? I contend that the twelve-tone row and its derivatives may be the initial sources to the problems.
Audibility versus Perceptibility of Twelve-Tone Structures

Since the twelve-tone row and its derivatives are the basic building blocks of the system, it has been considered by some musicians, Stein (1930), Hill (1936), Gerhard (1952), Stadlen (1958), Kelterborn (1960), and Perle (1962), as necessary to hear the row and its derivatives regardless of treatment within a composition. Another school, as represented by Brainard (1953), Keller (1953), and Thrall (1962), suggests that it is not necessary to hear what is happening to the row and derivatives within a composition. It is not the intent of this writer at this point to offer a solution. The pertinent question here is: Are the row and its derivatives audible or perceptible musical phenomena?

Regarding the general dislike for twelve-tone music, Keller (1955) said:

The whole problem ... hinges upon the ... question of audibility ... of the row in question and its mirror forms ... which is to say with the ear hearing them or not hearing them (p. 232).

It would appear by this quote that Keller has delineated the problem exactly, i.e., that the problem "with the ear hearing" the row and derivatives is one of audibility. However, Keller may have had more in mind than mere audition, that is, the process of hearing the row and derivatives. Thrall (1962) also investigated the twelve-tone problem, and proposed six definitions that audible may have in a serial context. It should be clarified that while Thrall used the term "serial structure," this does not rule out the use of "twelve-tone row and derivatives" as substitutable terms in the following definitions,
since a twelve-tone row is a serial structure. Thrall said that audible may mean:

1. that the listener becomes aware of the serial structures of a composition upon listening to it appreciatively (as opposed to analytically);
2. that the listener can become aware of the serial structures of a composition upon repeated, critically analytical hearings of it;
3. that the listener can become aware of the serial structures of a composition upon listening to it in conjunction with the use of a score;
4. that the listener can distinguish between a serial composition and a non-serial one, with or without being able to distinguish the serial structures themselves;
5. that the listener experiences the unifying effect which results from the use of serial structures without being able to distinguish the serial structures themselves;
6. that one or more of the above meanings apply, provided that the listener is already familiar with (1) the series, the row and its derivatives, and (2) the rules of the twelve-tone technique (p. 19).

In the first three definitions of audible proposed by Thrall, the phrase, "to be aware of" was used to describe the listeners' activity. In definitions four and five the activity phrase was "to distinguish." The use of these phrases seems to imply that Thrall considered understanding to be a part of the listening process, and thus, the term audible or audibility is not representative of the intent in this case.

According to English and English (1958), audibility is:

That property of a sound by which it can be heard. Dist. Fr. intelligibility or discriminability of a sound. Audibility requires merely that a sound be heard ... Properly, audition is the sense of capacity, hearing the act or process (p. 52).
In other words, audition is simply the presence of the ability to hear sounds. Then audibility of a sound or a set of sounds refers to its potential to be heard by a person capable of audition. Audition, as such, does not involve the creation of thought patterns from what can be heard. This pattern creating process, which goes on in the brain after nervous impulses have been sent from the ear, is one of perception. According to Allport (1955) perception:

... has something to do with our awareness of the objects or conditions about us. It is dependent to a large extent upon the impressions these objects make upon our senses ... Perception also involves, to some degree, an understanding awareness, a "meaning" or a "recognition" of these objects (p. 14).

English and English (1958) considered perception to be:

An event in the person or organism primarily controlled by the excitation of sensory receptors, yet also influenced by other factors of a kind that can be shown to have originated in the life history of the organism. The event is primarily cognitive (p. 378).

Wickens and Meyer (1960) defined perception as:

The grasping of the meaning of a stimulus by the use of a partial stimulus to predict the coming or the presence of the total stimulus complex (p. 748).

Wyburn, Pickford and Hirst (1964) considered perception as:

... concerned with the influence of judgements about experience and the external world ... Perception is the product of the stimulus pattern interacting with inner function, processes, and stresses, and its study entails an account of how the stimulus pattern appears under various conditions ... It is still true that associative processes play a large part (p. 239).

Hebb (1966) considered perception to be "the activity of mediating processes to which sensation gives rise directly (p. 258)."
Whittaker (1966) defined perception thus:

Perception is not a rigid, stimulus-bound response determined solely by the physical characteristics of the environment, but rather, a bipolar process resulting from the interaction of stimulus conditions on one hand, and factors within the perceiver (and/or external social factors) on the other (p. 423).

One essential difference between audition and perception that can be derived from the above definitions is that with perception, pattern creating is involved, even if subliminally, whereas, in audition the cognitive or thought processes are secondary, that is, occur after audition. The auditory process could be accomplished without creating any thought or cognitive responses from the organism.

Perception then can be succinctly defined as a mental process that involves receiving stimuli from the environment, both past and present, and responding to these stimuli in a cognitive, sensible fashion. Then, perceptibility can be described as that property by which stimuli can be perceived by an organism capable of perception, and the perceptibility of a pattern of sounds such as a twelve-tone row can be defined as a quality which allows or enables the patterns to be perceived by a listener.

Milner (1956) and Thrall (1962) wrote about the argument regarding the necessity to perceive or not to perceive the row and its derivatives in twelve-tone music. The two sides of the argument were 1) that a listener must be able to perceive the twelve-tone structures within a composition, and 2) that only the "total effect" is important, that is, it is not necessary to perceive what is happening to the row and its derivatives. Of import here is the fact
that Milner and Thrall considered the basic problem to be a perceptual one.

Related Studies

Guilford and Hilton (1933) performed an experiment which tested the ability of listeners to distinguish differences in short melodies which have different shapes or configurations, and which had certain tones altered. They reached the following conclusions:

1. The tones, altered, or unaltered, seem to be rendered unstable by the presence of the other tones in the melody ... The unaltered tones are more stable at the beginning than at the end of the melody, and at either end than they are in the middle.

2. Introspections and objective results seem to agree that the first tone in a melody tends on the average to seem raised in pitch when the melody is repeated, and the last tone seems to be lowered in pitch ...

3. When one tone is raised or lowered, all the other tones in the melody tend to change along with it in the same direction ...

4. The dynamic effect of the altered tones is apparently greater with those tones which come before than those which come after it. A strong retroaction effect upon those tones preceding the altered tone is established.

5. The law of proximity does not hold, except when the altered tone is raised. The maximum effect may be felt at the third tone distant from the altered one.

6. There is some evidence that the shape of the whole melody is a potent factor in determining the phenomenal changes, both in the altered tone and in the others (p. 54).

While Guilford and Hilton did not use twelve-tone rows as the melodies in their work, the study of the effects of altered tones on the configurational properties of the melodies is pertinent to this dissertation, since serial treatment of a twelve-tone row can involve a similar kind of alteration, i.e., the octave displacement of a tone within the row. Francès (1958) was the first investigator
to employ twelve-tone rows in what was essentially a study of the
feeling of unity that is supposed to pervade a serial (twelve-tone)
composition. This unifying effect, which supposedly was derived from
the twelve-tone row(s) used in a composition, was, as Schoenberg stated,
"the main advantage of ... composing with twelve tones" (1950, p. 143).
Francès' experiment was created to test the hypothesis that the unifying
effects of different twelve-tone rows would be distinguishable. The
results of the experiment showed that the different twelve-tone rows
employed in the experiment did not generate distinguishable unifying
effects, and that twelve-tone rows were not audible, that is perceptible,
even though a unifying effect generated by all the twelve-tone rows was
present. This investigation is important not only because it seems
to have been the first using twelve-tone rows, but especially because
it delved into the problem of the perceptibility of the twelve-tone
row. Thrall (1962), while investigating the audibility of serial
structures, reviewed Francès' experiment, discovered errors in the
computations and suggested that the results were inconclusive. How­
ever, Thrall suggested additional research along the lines of the
Francès experiment.

A. Walker (1960) reported the results of a twelve-tone audi­
bility test. The test and its results are discussed in detail below.

White (1960) performed an experiment in which the melodies of
ten well known songs were distorted by "performing various operations
on the intervals between adjacent notes in each melodic pattern"
(p. 101). White also reversed the melodies and incorporated the
interval operations. The interval operations were:

1. Doubling the size of the interval.
2. Doubling the size of the interval and decreasing its size by 1, regardless of sign.
3. Increasing the size of the interval by 1, regardless of sign.
4. Increasing the size of the interval by 2, regardless of sign.
5. Decreasing the size of the interval by 1, regardless of sign.
6. Decreasing the size of the interval by 2, regardless of sign.
7. Algebraic addition of +1 to the interval.
8. Algebraic subtraction of +1 from the interval.
9. Setting all intervals equal to 1 and maintaining sign.
10. Randomly permuting the set of intervals.
11. Setting all the note durations equal to a quarter note value, leaving pitch intervals unchanged.
12. Setting all the pitch intervals equal to zero, leaving the duration unchanged (p. 105).

In discussing the results of the experiment, White said:

These experiments confirm the observation that temporal reversal of an auditory pattern makes it's correct identification extremely difficult. Other transformations which had shown significant and specific effects on recognition of these melodic patterns played forward, showed no such effects on the temporally reversed patterns. Disruptive though temporal inversion was, Ss nevertheless identified more reversed melodies correctly than would be expected had they been guessing randomly (p. 105).

These results are of importance because both the interval operations and temporal reversal of the melodies are akin to certain treatments given twelve-tone rows in a serial composition, to wit: the displacement of a note or notes within a row and the use of the retrograde form of the row. White did not incorporate total transposition of the melodies as part of his experiment, and explained "simple transposition has virtually no effect on the ease with which a melody is
recognized" (p. 101). While this may be true of tonal melodies, it may not hold for atonal and twelve-tone melodic patterns.

Duerksen (1967), using high school and college aged students, investigated the recognition of altered and repeated themes in orchestral music and sought relationships between the results and the kind and extent of musical experience of the subjects who took his test. He concluded that some participation in musical activities was reflected in recognition scores on his test, but he also found that those subjects who had high scores had extensive musical backgrounds, and those subjects who were collegiate music majors had the highest scores. The most influential, single factor in test score results was the amount of listening experience of the subjects.

Analysis of a Twelve-Tone Audibility Study

Of particular interest is the study performed by Alan Walker, reported in the *Music Review* (Vol. 21, 1960, pp. 140-147) and in his book *A Study of Musical Analysis* (Barrie and Rockliff, London, 1962), which dealt with the audibility of the twelve-tone row and its derivatives. Walker was concerned with the apparent disparity between what Schoenberg proposed in his rules for writing twelve-tone music and what Schoenberg actually did in his compositions. Walker designed a test to determine if there was some kind of relationship between the twelve-tone row and its derivatives, and to "discover just how far Schönberg's basic theories were musically true" (1960, p. 142). Unfortunately, Walker did not indicate what he considered these theories to be. The subjects for the Walker test were fifteen
students at the Guildhall School of Music (London), who were ignorant of Schoenberg's rules for writing twelve-tone music, and who had never heard any of Schoenberg's music prior to testing. The goals Walker set for himself were:

First: to preserve as much of the subjects' serial ignorance as possible, so that any findings would be based on spontaneous reactions rather than on my promptings. Second: to educate indirectly by carefully grading my tests so that the difficulties were cumulative. Finally: to test only the horizontal aspect of the tone-row (1960, p. 142).

The Walker test was designed as follows:

Starting with the original melodic line the students were asked to identify the three derivatives ... in the exact order of their appearance. There were five stages of increasing difficulty ... and at each new stage a further serial device was introduced. For example: stage I was concerned with short tonal lines; the elements of rhythm and transposition were excluded ... At the second stage the elements of atonality were included and the lines became fully-fledged twelve-tone rows ... Row transposition on any pitch was introduced at the third stage ... Probably the most important factor of all was incorporated at the fourth stage, the hitherto de-rhythmicized rows being presented, in contrasting rhythmic patterns ... Finally came the octave transposition of individual notes within the row (1960, p. 142).

Walker reported that a total of thirty-six tests were administered yielding over fifteen hundred individual scores. Musical examples were included within the text of the article, and details of procedure were explained as they pertained to each phase of the test.

The results reported were printed in a single table which showed per cent for all correct responses, per cent for partially correct responses, and per cent for all incorrect responses for each of the five test stages. In the article, Walker presented a total
of six conclusions, of which the following are of greater importance:  
1) that the retrograde form of the row was easier to identify than the inversion (1960, p. 143), 2) that the use of a Schoenberg row resulted in poorer results (1960, p. 144), 3) that octave displacement of a note within a row did not produce "serial disunity" (1960, p. 146), and 4) that:  

Schoenberg was right on two counts; (a) the row and its derivatives are related; (b) people can be educated to a higher sense of awareness of this fact (1960, p. 147).  

In his book Walker wrote three "important points" which he derived from the test results. First he indicated that it appeared possible "to educate people to a greater sense of horizontal awareness than one might normally suppose" (1962, p. 69). Second, he said that "Among those who failed to determine the nature of the unity between a model tone row and its mirror derivatives, were some who strongly felt unity but were yet unable to identify the correct order of the derivatives" (1962, pp. 70-71). Thirdly, Walker said that "It was generally agreed that it was simpler to comprehend retrograde relationships than inversions" (1962, p. 71).  

Regarding the conclusion that the retrograde form of a row was easier to identify than the inversion, unfortunately Walker provided no data and we are forced to take his word in this case. It would be of interest to learn what the data were that led him to make this statement. Also of interest would be the figures that would show the degree of difficulty in identification of the retrograde inversion in relation to the other derivatives. In the conclusion that the
Schoenbergian rows yielded fewer correct responses, again we are without figures for comparison. What can be determined from reading Walker's report is that there were two Schoenberg rows used in the test (one from the Wind Quintet, Opus 26, the other from the Variations for Orchestra, Opus 31) and one Stravinsky row was used (from Threni). The row from the Wind Quintet was nearly symmetrical, in that the second hexachord is the transposition of the first except for the last note. Walker said only that there was a certain "internal unity" and that all the Schoenberg rows used in his test exhibited this characteristic. Regarding the third conclusion that octave displacement of a note within a row did not produce "serial disunity," Walker provided no figures for inspection. The problem of octave displacement of a note within a row or derivatives was gleaned by Walker from Schoenberg's essay "Composition with Twelve Tones Which are Related Only with One Another" (1950). Walker insisted that, even though Schoenberg never mentioned octave displacement as such in his essay, the use of octave displacement of a note within a row was not following the rules of the twelve-tone system and therefore, according to Walker, "the unifying function of the row was jeopardized when haphazard use was made of octave transposition" (1960, p. 145). Concerning part (a) of the bipartite conclusion, Walker does not define what he considers the relationship between a twelve-tone row and its derivatives to be, and of part (b), we are able to understand to a small degree that some learning did take place during testing, this from Walker's incidental comments of test
procedure rather than from the table of results.

Because of the unusual way in which Walker arrived at his conclusions, I contend the conclusions should be considered indicative rather than evidential. There was no statistical treatment of the results other than computation of per cent correct, per cent partially correct, and per cent incorrect responses. We have no way of knowing whether Walker subjected the results to tests of significance. Of interest would be the Schoenbergian row results versus the Stravinsky row results; the differences, if any, due to rows being combinatorial or not; a comparative analysis of the patterning of responses for the original and the derivatives; and a detailed analysis of the differences between the results for the various test stages for each row versus all the rows. Walker appears to have made some strong conclusions with little as basis for judgement. He also exhibited confusion concerning the meaning of the term audibility. It appears that while Walker used the word audibility his concern was perception.

Walker's study has, however, pointed to some fundamental problems that seem to plague the twelve-tone system and its adherents. Foremost among these problems is the separation of intent and product, in that Schoenberg's intent was toward unity within a composition via twelve-tone employment, with the resultant product being harder to understand than any music from any other style heretofore developed. Unfortunately Walker did not elaborate upon his conclusion that the row and derivatives are related. While there is an obvious mathematical relationship between a row and its derivatives, it would have
been interesting to know if Walker discovered some other, perhaps psychological or perceptual relationship.

**Hypotheses Generated for Testing**

The Walker experiment served as a model for the test used in this dissertation. Three of Walker's conclusions presented above represent testable hypotheses and were used as bases for creating new hypotheses. Walker concluded that the retrograde form of a row was easier to identify than the inversion. The new hypothesis was created, to wit:

1. The order of difficulty in identifying a row and its derivatives is as follows: the easiest to identify is the original row itself, followed in order by retrograde, inversion, and retrograde inversion.

This hypothesis was tested in order to determine if there was a patterning to the difficulty in identifying the row and its derivatives.

Walker further concluded that the use of rows composed by Schoenberg with a certain internal symmetry resulted in poorer results. By internal symmetry Walker, citing the row from Schoenberg's Wind Quintet, Opus 26, referred to the repetition of the first four intervals of the row transposed in the second hexachord, giving the row a nearly symmetrical quality. The row lacks total symmetry because the end of the second hexachord does not follow the pattern found at the end of the first hexachord. The new hypothesis created was:

2. A Schoenberghian row and derivatives are harder to identify than a symmetrical row and derivatives not composed by Schoenberg.
This hypothesis was created for testing to determine if there was any difference in the identifiability of symmetrical and non-symmetrical rows and derivatives. Walker concluded that the octave displacement of a note from within the row did not produce serial disunity. The new hypothesis created was:

3. The octave displacement of a note within a row makes it harder to identify a row and its derivatives with such displacement, than a row and derivatives without displacement.

As part of stage three of his test, Walker used transposition of derivatives at any pitch. He did not report any conclusions on the results of transposing the derivatives, but this idea served as the basis for another new hypothesis, to wit:


Combining the concepts of transposition of derivatives and octave displacement of a note within a row, another hypothesis was created:

5. The transposition of a row and its derivatives in conjunction with octave displacement of a note within the same row and derivatives will make identification of a row and derivatives treated in this fashion harder than a row and derivatives which are untreated.

Summary.

Because of apparent dislike for Arnold Schoenberg's system of twelve-tone composition and toward his twelve-tone music, it was considered appropriate to inspect critical articles that presented opinion and comment about the system, the music and the man. It was found that many writers were critical of the twelve-tone
system for a variety of reasons. There were fewer criticisms of the music that Schoenberg composed in the twelve-tone style, and very few of the man himself. It is of interest to note that there were more criticisms of the system rather than of the music or the system and the music together. While criticizing the product of any composer one perhaps does not normally separate the method from the product, considering both of equal importance in a discussion. Thus, it seems unusual that the greater number of criticisms were aimed at the system rather than at the system and its product. Of course, Schoenberg created a compositional system that is easy to understand. This points to the possibility that the critics avoided criticizing the music in favor of the system because of the simplicity of the latter.

Only a few writers pointed to the perceptual problems that exist in twelve-tone music, but even they skirted the problem without directly identifying it. The current terminology used in verbalizing the problem has added to the difficulty of its delineation, but it appeared that a few of the writers were aware that perceptual problems did exist even though they did not say so directly.

A number of research projects performed over the past thirty five years have dealt with perceptual problems in music, but only two of those found dealt with perceptual problems in twelve-tone music. One of these investigations comprised an identification test in which twelve-tone rows were incorporated and treated in ways similar to those found in serial compositions. The conclusions of
this investigation seem to go beyond the data without adequate substantiation, although problems that exist in twelve-tone music were elucidated. The following hypotheses were generated from the conclusions for testing:

1. The order of difficulty in identifying a row and its derivatives is as follows: the easiest to identify is the original row itself, followed in order by retrograde, inversion, and retrograde inversion.
2. A Schoenbergian row and derivatives are harder to identify than a symmetrical row and derivatives not composed by Schoenberg.
3. The octave displacement of a note within a row makes it harder to identify a row and its derivatives with such displacement, than a row and derivatives without displacement.
5. The transposition of a row and its derivatives in conjunction with octave displacement of a note within the same row and derivatives will make identification of a row and derivatives treated in this fashion harder than a row and derivatives which are untreated.

An aural discrimination test was designed by this writer to determine whether a twelve-tone row and its derivatives are perceptible musical phenomena when subjected to serial treatment. A description of this test and the results follows.
CHAPTER II
THE EXPERIMENT

Description of the Test

As a means of determining the answers to questions posed, and as a means of testing hypotheses generated from the problems that exist in twelve-tone music, the following test was designed. The test comprised three parts. Part one involved the collection of biographical information about the subjects, part two contained instructions for taking part three, and the third part comprised one hundred twenty-eight pairs of twelve-tone rows. Six hundred twenty-one students at Western Kentucky University, Bowling Green, Kentucky, took the test, these students were drawn from the classes taught in the Music Department. Prior to the test none of the music majors had been exposed to the rules for composing twelve-tone music, and none of the non-music majors had heard any twelve-tone music in their classes.

Test Part One. Biographical information collected from the subjects included the following items:

Name, Age, Sex.
Academic Major, Rank.
College in which subject was enrolled.

Pre-college experience in the following ensembles:
- Marching Band
- Concert Band
- Dance Band
- Orchestra
- Chamber Ensemble
- Mixed Chorus
- Glee Club
- Church Choir
- Other Ensemble
College level experience in the following ensembles:
- Marching Band
- Concert Band
- Dance Band
- Orchestra
- Chamber Ensemble
- Mixed Chorus
- Glee Club
- Church Choir
- Other Ensemble

Perfect pitch.

Years of experience on musical instruments:
- Woodwind
- String
- Brass
- Voice
- Percussion
- Other
- Keyboard

Years of Private Instruction on voice or instrument.

Grade Point Average (GPA).

Standard ACT Scores for:
- English
- Mathematics
- Social Sciences
- Natural Sciences
- Composite

Test Part Two. The second part of the test comprised a set of instructions which the subjects both read and listened to. In the instructions for taking the test no reference was made to nor were the terms twelve-tone or serial used. The test items were referred to as melodies, and the derivative forms were given the names backward (retrograde), upside down (inversion), and upside down and backward (retrograde inversion). Likewise, on the answer sheets the symbols S for same, B for backward, U for upside down and UB for upside down and backward were used for the subjects to circle. The reason for not using the terms twelve-tone or serial was to avoid exploitation of a bias on the part of those who knew something about twelve-tone music and who formed opinions of the music without ever having heard any.

Four sample pairs and two practice pairs were included in the instruction. After each practice pair the subjects were given the
Test Part Three. Four twelve-tone rows were selected for use in the test. One was taken from Schoenberg's *Variations for Orchestra* (Opus 31), and the other three were drawn from a table of symmetrical tone row hexachords created by Dr. Paul Brink, presently of the School of Music, University of Louisville, Kentucky. Rows two, three and four were symmetrical, and in each case, the second hexachord is the inversion of the first. The Schoenberg row was chosen because it was felt that the opening and closing intervals would serve as distinctive aural guides for discrimination purposes, and because the row was not symmetrical. The three symmetrical rows, each of which has a unique contour and sequence of intervals, were used to determine to what extent the symmetry would be a confusing factor in discrimination tasks. The symmetrical rows were also selected because it was thought that since the second hexachord of each was the inversion of the first hexachord, identification of the row and its derivatives would be difficult when the row was transposed and reversed, making one of the derivatives sound like the original. Example one contains the four rows employed.

Example 1

#1 (Schoenberg)  #2

#3  #4
Each identification item consisted of a pair of twelve-tone rows. The first item of each pair was always one of the tone rows in its original form. The second item of each test pair was the same row or one of its own derivatives. The task was to identify the shape of the second row using the first row as a basis for judgement. The second row of each pair was presented in one of four treatment phases.

Aural Characteristics of the Rows.

Of the eleven melodic intervals contained in Row 1 there are five 2nds, two 3rds, two tritones, one perfect 5th and one 6th. Analysis of the intervals was made on an aural basis since the subjects heard the rows and were never shown what they looked like. In its original form the Schoenberg row has three special traits that I felt would help in the identification: the opening tritone, the perfect 5th in the middle, and the closing minor 2nd. In its retrograde form the beginning interval is the minor 2nd while the closing interval is the tritone. In inversion, while the pitch sequence is different, the melodic intervals are the same as the original with the melodic direction reversed, so that in the original the opening interval is a descending tritone while in the inversion the opening interval is an ascending tritone. The retrograde inversion has the reversed pitch sequence of the inversion and has the reversed melodic interval sequence of the retrograde.

Row 2 is symmetrical with the second hexachord being the inversion of the first. Of the eleven melodic intervals in the
original, there are six 2nds, two tritones, one 6th and two 7ths. The characteristic aural traits of this row are the 7ths at the end of each hexachord and the 6th in the middle of the row. In retrograde form the 7ths appear at the beginning of the hexachords with the 6th still in the middle of the row. In inversion the row has the same melodic sequence as the original with the melodic direction of each interval reversed. The retrograde inversion has the reversed pitch sequence of the inversion and has the reversed melodic interval sequence of the retrograde.

Row 3 is also symmetrical: the second hexachord is the inversion of the first. Of the eleven melodic intervals in the original row there are eight 2nds and three 3rds. The most characteristic trait of this row is its shape, which can be described as peaked with a high point in the middle and low points at the ends. This row is essentially an ascending scale pattern followed by a descending scale pattern. In retrograde form the shape is almost the same which could make discrimination difficult. Likewise the inversion and retrograde inversion are inverted, troughed melodic lines which could well make discrimination of these derivatives difficult.

Row 4 is symmetrical: the second hexachord is the inversion of the first. The eleven melodic intervals in this row comprise six 2nds, three perfect 4ths and two tritones. The characteristics which make this row unique are the tritone-perfect 4th patterns at the beginning of the hexachords. In retrograde the tritone-perfect 4th pattern lies at the ends of the hexachords.
inversion the tritones and perfect 4ths are at the beginning of the hexachords but the melodic peak of the row is at the beginning rather than at pitch seven as in the original. In the retrograde inversion form the melodic peak of the row is at the beginning, and the tritone-perfect 4th patterns are at the ends of the hexachords.

In addition to the special traits each row has, there are aural factors that all rows possess that I considered influential in discrimination or identification tasks. Of the three derivatives the retrograde was considered most like the original, since, in creating a retrograde derivative, nothing is changed except the order of the pitches which is reversed. In creating an inversion, another sequence of pitches is created, using the reversed melodic intervals of the original row. This derivative can be more difficult to relate to the original than the retrograde. The retrograde inversion can be created by reversing the pitch sequence of the inversion, creating an additional degree of difficulty in identifying shape in relation to the original. It would appear that there is an ordering to the difficulty of identifying derivatives, with the original being the easiest to identify, the retrograde being the next in rank, the inversion being hard, and the retrograde inversion being hardest to identify.

Serial Treatments

The first treatment involved no change of the row or derivatives. This means that the second item of each identification pair was reproduced without any alteration.
The second treatment involved the transposition of the second item of each pair. The transposition was at the fifth, since Schoenberg appeared to have an affinity for transposing a row and its derivatives at the fifth despite the fact that this could not be heard. Perle (1962) explained this intervalic relationship "as an unjustified transference of tonal concepts" (p. 128). Example two shows this treatment.

Example 2

#1 Original # 1 Original - Transposed

The third treatment introduced the displacement of one note up an octave within the row or derivative, taking it out of the closed range of the original row. Guilford and Hilton (1933) explored the effect of pitch displacement in non-twelve-tone music and Walker (1960) employed the octave displacement of a pitch within a row in his twelve-tone audibility study. In the retrograde forms this displacement occurred at a reciprocal place in the succession of tones. For example, in Row 1 the tenth note was displaced up an octave and in the retrograde and retrograde inversion forms the third note was displaced. In Row 2 the seventh note was displaced up an octave, and in the two retrograde forms the sixth note was displaced. In Row 3 the eighth note was displaced, with note five displaced in the retrograde forms. In Row 4 the
ninth note was displaced, making the fourth note displaced in the retrograde forms. In the inversion forms, the note displaced was the same as that in the original row. Example three shows the displacement treatment in the second item of a pair.

Example 3

#1 Original  #1 Original with displaced note

The fourth treatment involved the combination of transposition of the row and derivatives in the second item of each pair with octave displacement as described above. Example four shows the fourth treatment.

Example 4

#1 Original  #1 Original, transposed with displaced note

Each twelve-tone row used in the test was treated in these four different ways. With four rows, each having four forms (original, retrograde, inversion, and retrograde inversion) and four treatments, there were sixty-four different paired items used in the test. Each paired item was presented twice, once in the first half of the test, and once in the second half of the test.

Administration of the Test

The one hundred twenty-eight test pairs were scrambled with
the aid of a random number table for presentation in the test. The pairs of tone rows were recorded on magnetic tape using an Ampex 606-2 tape recorder; the sound source was a Steinway piano. All items were played in the middle range of the piano, from the d in the middle of the bass clef to e₂-flat in the treble clef. Administration of the test was accomplished with the aid of the same Ampex tape recorder and two Ampex 622 speakers.

There were four pages of answer sheets, each containing thirty-two response items. After the sixty-fourth pair there was a short rest period to allow the test administrator to change the tape. There were shorter pauses after the thirty-second and ninety-sixth pairs to allow the subjects time to turn the pages. The test took about fifty-five minutes to administer including the collection of the biographical information. The twelve-tone rows and derivatives were played at a speed of one hundred twenty tones per minute, with a five beat interval between the two items of each pair, and approximately a seven second delay, equivalent to fifteen tones, between pairs.

Collection of the Results

The biographical information and test responses were punched onto data cards for processing and statistical analysis. The biography page of the test is reproduced in Appendix A, and coding systems for punching the data onto cards for various statistical tests are contained in Appendix B.

Tests Performed on the Results

Four tests were used to analyze the data. These tests were
analyses of variance, contingency table analysis, regression analysis, and information theory analysis.

**Analysis of Variance.** An analysis of variance was performed in order to determine significant differences in the test results due to various factors such as the rows, melodic shapes, treatments and academic majors.

**Contingency Table Analysis.** This analysis involved smaller blocks of test data. The procedure of analysis involved grouping results by treatments and twelve-tone row, and computing the chi-square.

**Regression Analyses.** These tests were performed to estimate the extent of relationships between test results and biographical information.

**Information Theory Analysis.** The same set of data used in the contingency table analyses was subjected to an information theory analysis as a means of determining how much information present in the test questions actually reached or was transmitted to the test subjects. Other measures computed were the information per stimulus, per response, how much stimulus information was lost by the test subjects and how much uncertainty there was in the responses, or the amount of guessing.

In addition to the tests of the data, frequency distributions of the biographical questions were tabulated.

**Summary.**

A test involving the collecting of biographical information and
the aural discrimination of one hundred twenty-eight twelve-tone pairs was designed and administered to six hundred twenty-one college students. The aural test comprised four treatments which included no treatment of the second item of each test pair, transposition of the second item, octave displacement of one pitch in the second item, and transposition and octave displacement of one pitch in the second item. The results of the test were transferred to data cards and three statistical procedures were employed in analyzing the results. An information theory analysis was used to determine transfer of information in the test questions.
Parameters for the Analysis

This investigation involves the simultaneous study of several different factors and the effects they had on the test scores. These factors can be grouped into two classes. The first class, which shall be called first order variables, comprised the following factors:

1) six groups of college majors, being Elementary Education (128 subjects), Music (81 subjects), Physical Education (74 subjects), Business Administration (71 subjects), History (58 subjects), and all other majors (209 subjects). The selection of these groups was based on the sample size of each, the first five being the highest five of the thirty-three majors represented;

2) the four twelve-tone rows used in the test;

3) the melodic shape of the twelve-tone rows and derivatives, that is the melodic shapes of the original, retrograde, inversion, and retrograde inversion; and

4) the four treatments.

The second class, which was called second order variables, comprised the following factors:

1) the interaction between the twelve-tone row test responses and the six groups of college majors;
2) the interaction between the melodic shape test responses and the six groups of college majors; and

3) the interaction between the treatment responses and the six groups of college majors.

In order to determine whether the differences in test scores due to the effect of these variables were meaningful, they were subjected to analysis of variance tests. The test design used was a P x Q, repeated measures with unequal group size and unweighted means solution, described in Winer (1962), Chapter 7, pages 374 to 378.

According to Ferguson (1966):

In its simplest form the analysis of variance is used to test the significance of the differences between the means of a number of different samples (p. 281).

The means calculated in the analysis of variance tests were also used to determine rankings of the groups of college majors, the rankings of the twelve-tone rows, the rankings of the melodic shapes, and the rankings of the treatments.

Differences in Scores Between the Six College Major Groups Within the Test Population

This section deals with the differences in scores due to the effect of the six groups of college majors exclusive of the effects of the four twelve-tone rows, the effects of the melodic shapes of the twelve-tone rows, and the effects of the four treatments.

Table 1 contains the results of the analysis of variance test of differences between the mean scores of the six groups of college majors. In this table, as in all others in this chapter, the F values followed by a double asterisk (**) indicate significance at the
one per cent level (p. = 0.01). The symbol DF indicates degrees of freedom. Mean correct scores not underlined or connected by the same line are significantly different at the one per cent level (p. = 0.01).

Table 1

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Sums of Squares</th>
<th>DF</th>
<th>Mean Square</th>
<th>F Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Majors</td>
<td>2631.24</td>
<td>5</td>
<td>526.25</td>
<td>22.75 **</td>
</tr>
<tr>
<td>Error Term</td>
<td>14227.75</td>
<td>615</td>
<td>23.13</td>
<td></td>
</tr>
</tbody>
</table>

The F value of 22.75 for the college majors is significant, which is to say that the differences in test scores due to the different majors are significant.

Of the group of six majors, the Music majors had the highest mean score, 56.3 correct responses of 128 possible. This is less than fifty per cent correct. The Business Administration majors had the lowest mean score. Significant differences between mean scores can be attributed to the differences between the Music majors and the other five college major groups.
Differences in Scores Due to the Effects of the Four Twelve-Tone Rows

This section deals with the differences in results due to the effect of the four twelve-tone rows employed in the discrimination test exclusive of the effect of the groups of college majors, the effect of the melodic shapes of the twelve-tone rows, and the effects of the four treatments.

Table 2 contains the results of the analysis of variance test of the scores grouped by the twelve-tone row and the interaction between the twelve-tone rows and all college majors and the mean scores for each of the twelve-tone rows. The number of possible responses in this case is thirty-two.

The differences in test scores due to the four twelve-tone rows were shown to be significant. However, the differences due to the interaction of the twelve-tone rows and all college majors were shown not significant. This permits discussion of the effect of the twelve-tone rows independent of the effect of the six college major groups.

Of the four twelve-tone rows used in the test, Row 3, the symmetrical row which approximates a melody with a low beginning and end, and a peak in the middle, received the highest mean score of 12.89 correct of a possible 32, and Row 1, the Schoenberg twelve-tone row, received the lowest mean score of 10.29 correct of 32 possible. Row 2, the symmetrical row which contained leaps of a major seventh at the ends of the hexachords in the original form, received the next best mean score of 11.88 correct of 32 possible.
Table 2

Results of the Analysis of Variance Test of Scores of the 621 Subjects Grouped by Twelve-Tone Rows and the Interaction Between the Twelve-Tone Rows and All College Majors, and Mean Scores for the Twelve-Tone Rows

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Sums of Squares</th>
<th>DF</th>
<th>Mean Square</th>
<th>F Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Four Twelve-Tone Rows</td>
<td>1788.83</td>
<td>3</td>
<td>596.28</td>
<td>84.46 **</td>
</tr>
<tr>
<td>Interaction Between Twelve-Tone Rows and All Majors</td>
<td>120.34</td>
<td>15</td>
<td>8.02</td>
<td>1.14</td>
</tr>
<tr>
<td>Error Term</td>
<td>13031.74</td>
<td>1845</td>
<td>7.06</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Twelve-Tone Rows</th>
<th>1</th>
<th>4</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Correct Score</td>
<td>10.29</td>
<td>11.47</td>
<td>11.88</td>
<td>12.89</td>
</tr>
<tr>
<td>Possible Score</td>
<td>32.0</td>
<td>32.0</td>
<td>32.0</td>
<td>32.0</td>
</tr>
</tbody>
</table>

Row 1, then, is least like Row 3. Mean test scores for twelve-tone rows 1 and 2, 1 and 3, 1 and 4, 2 and 3, and 3 and 4 were significantly different, while those for Rows 2 and 4 were not. Rows 2 and 4 were harder to identify than Row 3 and easier to identify than Row 1. Row 1, composed by Schoenberg, was the hardest to identify.

Differences in Scores Due to the Effects of the Four Melodic Shapes of the Twelve-Tone Rows

This section deals with the effects of the melodic shapes of the twelve-tone rows on the test scores exclusive of the effects of the six groups of college majors, the effects of the twelve-tone rows,
and the effects of the treatments. The melodic shapes of the twelve-tone rows are the shape of the original form of the row, the retrograde form, the inversion form, and the retrograde inversion form.

Table 3 contains the analysis of variance test results of the scores grouped by melodic shape of the twelve-tone rows, and the interaction between the melodic shapes and all college majors, as well as the mean scores for the four melodic shapes.

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Sums of Squares</th>
<th>DF</th>
<th>Mean Square</th>
<th>F Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Melodic Shapes 0, R, I, and RI</td>
<td>8455.03</td>
<td>3</td>
<td>2818.34</td>
<td>203.05 **</td>
</tr>
<tr>
<td>Interaction Between Melodic Shapes and All Majors</td>
<td>319.77</td>
<td>15</td>
<td>21.32</td>
<td>1.54</td>
</tr>
<tr>
<td>Error Term</td>
<td>25600.61</td>
<td>1845</td>
<td>13.88</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Melodic Shapes</th>
<th>RI</th>
<th>I</th>
<th>R</th>
<th>O</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Correct Score</td>
<td>8.44</td>
<td>11.75</td>
<td>12.21</td>
<td>14.14</td>
</tr>
<tr>
<td>Possible Score</td>
<td>32.0</td>
<td>32.0</td>
<td>32.0</td>
<td>32.0</td>
</tr>
</tbody>
</table>

The table shows that the differences in mean test scores due to the four melodic shapes of the twelve-tone rows are significant.
The differences due to the interaction of the melodic shapes and all college majors were shown not significant allowing discussion of the effect of the melodic shapes independent of effect of the six college major groups.

The melodic shape which was identified most easily was original, which received the highest mean score. The shape retrograde inversion showed the poorest results with the lowest mean score. This indicates that, of the four melodic shapes, the retrograde inversion shape is least like the original shape. Significant differences in mean scores exist between the four melodic shapes except between the shapes retrograde and inversion, indicating that the differences between melodic shapes O and R, O and I, O and RI, R and RI, and I and RI, were significant. The differences between the shapes R and I were not significant. It can be said then that the shapes retrograde and inversion were harder to identify than original and easier to identify than the retrograde inversion.

**Differences in Scores Due to the Effects of the Serial Treatments**

This section deals with the effects of the serial treatments of the twelve-tone rows on the test scores exclusive of the effect of the six groups of college majors, the effect of the twelve-tone rows, and the effect of the melodic shapes of the twelve-tone rows. There were four treatments. The first treatment involved no alteration of the second item of each test pair. The second treatment involved transposition of the second item of each test pair, the third treatment involved octave displacement of a note within the
second item of each test pair, and the fourth treatment involved the combination of transposition and octave displacement of a note within the second item of each test pair.

Table 4 contains the results of the analysis of variance test of the scores grouped by treatments and the interaction between the treatments and all college majors as well as the mean scores for each of the four treatments.

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Sums of Squares</th>
<th>DF</th>
<th>Mean Square</th>
<th>F Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Four Treatments</td>
<td>10642.71</td>
<td>3</td>
<td>3547.57</td>
<td>464.95 **</td>
</tr>
<tr>
<td>Interaction Between Treatments and All College Majors</td>
<td>278.51</td>
<td>15</td>
<td>18.57</td>
<td>2.43</td>
</tr>
<tr>
<td>Error Term</td>
<td>14071.01</td>
<td>1845</td>
<td>7.63</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Treatments</th>
<th>IV</th>
<th>II</th>
<th>III</th>
<th>I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Correct Score</td>
<td>9.25</td>
<td>10.17</td>
<td>11.96</td>
<td>15.16</td>
</tr>
<tr>
<td>Possible Score</td>
<td>32.0</td>
<td>32.0</td>
<td>32.0</td>
<td>32.0</td>
</tr>
</tbody>
</table>

Table 4 shows that the differences in test scores due to the four treatments are significant. The differences due to the interaction of the treatments and all college majors were shown not significant which permits discussion of the effect of the treatments.
independent of the effect of the six college majors.

A ranking of the treatments is shown in Table 4. Treatment I received highest mean score, followed in turn by Treatments III, II and IV.

Treatment I, which involved no serial alteration of the second item of each test pair showed the highest mean score, 15.16 correct of 32 possible. Treatment IV, in which the second item of each test pair was transposed and had a displaced note, received the lowest mean score of 9.25 correct of 32 possible. This means that Treatment IV was least like Treatment I. The differences between the mean scores for the four treatments are all significant.

Summary

Six groups of college majors were isolated from the test population of 621 subjects on the basis of the high number of people in each. These groups were Elementary Education majors, Music majors, Physical Education majors, Business Administration majors, and History majors. All the other majors were grouped together. The scores of these six groups were then subjected to an analysis of variance test and it was found that the differences in mean test scores due to the differences of the six groups were significant. It was found that the Music majors had the best mean score on the test, that the differences in mean scores between the Music majors and the other groups were significant, and that no differences were found between the mean scores for the other five groups.

The scores of the 621 subjects were grouped by twelve-tone
row and further analysis of variance tests were performed. It was found that the differences in results due to the different twelve-tone rows used were significant, but differences due to the interaction between the twelve-tone rows and all six groups of college majors were found not significant. The differences in scores between the twelve-tone rows, with the exception of between Rows 4 and 2, were significant. It was found, on the basis of the mean scores, that twelve-tone Row 3 had the highest mean score while twelve-tone Row 1, composed by Schoenberg, had the lowest mean score. It can be said that Rows 2 and 4 were harder to identify than Row 3 but easier to identify than Row 1.

In order to determine the effect of the melodic shapes of the twelve-tone rows on the test scores, the scores of the 621 subjects were grouped by melodic shape (0, R, I, and RI) and they were subjected to an analysis of variance test. It was found that the differences in mean scores due to the different melodic shapes were significant, but differences due to the interaction between the melodic shapes and all six groups of college majors were found not significant. The differences in mean scores between the melodic shapes were found significant with the exception of the differences between the shapes retrograde and inversion. Original was the shape that received the highest mean score, indicating it was the easiest shape to identify and retrograde inversion received the lowest mean score, indicating it was the hardest shape to identify. The shapes retrograde and inversion were harder to identify than the original but easier to identify than the retrograde inversion.
The scores of the 621 subjects were grouped by treatments and subjected to analysis of variance. It was found that the differences in results due to the different treatments were significant. The differences due to the interaction between the treatments and all six groups of college majors were found not significant. The differences in scores between the treatments were all significant. The ranking of the treatments was derived from the mean scores for each of the treatments. It was found that Treatment I, in which nothing was done to the second item of each test pair, had the highest mean score and twelve-tone rows for this treatment were easiest to identify. Treatment III, in which octave displacement of a note within a row was introduced, had the next best mean score, followed in turn by Treatment II, which involved transposition, and finally Treatment IV, which involved transposition and octave displacement of a note within the row.

By reviewing the highest and lowest mean scores by row, melodic shape and treatment, it can be seen that the combination which was easiest to identify was Row 3 original with no serial treatment, and the combination which was hardest to identify was Row 1 retrograde inversion transposed with octave displacement of a note within the row.

The first hypothesis, (supra, p. 23) projected an ordering of difficulty in identifying a row and its derivatives. This hypothesis has been substantiated to the extent that, based on the results of the analysis of variance test of scores grouped by melodic shape,
the original was shown easiest to identify and the retrograde inversion was shown hardest to identify. The derivatives retrograde and inversion, while their mean scores were found not significantly different, were harder to identify than the original, and were easier to identify than the retrograde inversion.

The second hypothesis (supra, p. 23) appears to be substantiated. The analysis of variance results showed that Row 1, which was the Schoenberg row, received the lowest mean score of the four rows, which indicates that it is the hardest of the rows to identify.

The third, fourth, and fifth hypotheses (supra, p. 24) also appear to be substantiated. The analysis of variance test of scores grouped according to treatment phase showed that transposition, octave displacement of a note within the row or derivative and the combination of transposition and octave displacement of a note made the rows and derivatives so treated harder to identify than a row and derivatives not treated in these ways. The results also showed the ranking of the treatments as described above.
CHAPTER IV
RESULTS OF FREQUENCY DISTRIBUTION AND CONTINGENCY TABLE ANALYSES

This chapter deals with the results of the frequency distribution and contingency table analyses performed on the data obtained from the aural discrimination test.

**Biographical Data.** There was essentially an equal distribution of men and women who took the test: 311 men (50.1%) and 310 women (49.9%). The ages of the test subjects ranged from sixteen years to over twenty-five years, with most of the subjects between the ages of eighteen and twenty years. About half of the subjects were enrolled in the College of Education, 301 or 48.5%, with the remainder unequally dispersed in the other four colleges. More than half of the students who took the test were freshmen, 340 or 54.8%, the other half being largely sophomores, 155 or 25.0%, with the seniors being the smallest group, 35 or 5.6%.

Less than half of the subjects reported some ensemble participation in at least one high school instrumental group, while fewer subjects reported some ensemble participation in at least one college
level instrumental group (See Table 5).

Table 5
Instrumental Ensemble Participation

<table>
<thead>
<tr>
<th>High School Instrumental</th>
<th>College Instrumental</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Subjects</td>
<td>Number of Subjects</td>
</tr>
<tr>
<td></td>
<td>%</td>
</tr>
<tr>
<td>Marching Band</td>
<td>168</td>
</tr>
<tr>
<td>Concert Band</td>
<td>159</td>
</tr>
<tr>
<td>Dance Band</td>
<td>61</td>
</tr>
<tr>
<td>Orchestra</td>
<td>28</td>
</tr>
</tbody>
</table>

Much the same situation appears to be true when comparing the high school versus college participation in at least one vocal ensemble. The subjects reported that more of them participated in at least one vocal ensemble rather than instrumental ensembles while in high school and fewer of the subjects reported participation in a vocal ensemble while in college versus participation in high school (See Table 6).

Table 6
Vocal Ensemble Participation

<table>
<thead>
<tr>
<th>High School Vocal</th>
<th>College Vocal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Subjects</td>
<td>Number of Subjects</td>
</tr>
<tr>
<td></td>
<td>%</td>
</tr>
<tr>
<td>Mixed Chorus</td>
<td>210</td>
</tr>
<tr>
<td>Glee Club</td>
<td>124</td>
</tr>
<tr>
<td>Church Choir</td>
<td>243</td>
</tr>
</tbody>
</table>

One explanation for the reduced participation in instrumental and vocal ensembles while in college is obvious, in that participation in high school is extra-curricular and the populations of these ensembles are drawn from the entire high school student body. However, in college these ensembles tend to be curricular and
comprise mostly music majors and very few nonmusic people.

The responses to the question concerning perfect or absolute pitch show that 13 or 2.0% of the subjects thought they had this ability while 608 or 98.0% of the subjects either didn't know whether they had this ability or knew they did not. Only one of the music majors who took the test is known to have perfect pitch. There was no measure for this ability built into the structure of the aural discrimination phase of the test.

Of the 621 students who took the test, grade averages were obtained for 609 or 98.1%. The category with the highest frequency was the C or average grade with 294 or 47.3%. There were 212 or 34.2% of the subjects with averages below C and 103 or 16.6% with averages above C.

A Brief Explanation of the Nature of Contingency Table Analyses

According to Alder and Roessler (1964) a contingency table:

... is an arrangement in which a set of objects is classified according to two criteria of classification, one criterion being entered in rows, the other in columns (p. 189).

The variables reported in the contingency tables below are the test pairs presented for aural discrimination and the subjects' responses to the discrimination tasks.

The chi-square was computed for each contingency table as a means of determining whether the differences which are present in the cells are significant or not. While a high chi-square value indicates significance of differences, one thing a contingency table analysis cannot provide is the reasons for the differences. According
to Alder and Roessler (1964):

Whenever the $x^2$ [chi-square] value in a contingency table gives a significant result, it indicates that the two criteria of classification are not independent but related. However, such a result does not indicate a causal relationship (p. 191).

If the chi-square value for a contingency table is high enough to indicate significance of differences, this indicates relationships between the two variables but does not indicate reasons for the relationship.

Contingency Table Analysis of Row Responses

The results reported in this section are drawn from all subjects' responses to the twelve-tone row pairs, with sectional subdivisions by treatments. From this point on the following abbreviations in tables and text will be employed:

O - original row  
R - retrograde form of a row  
I - inversion form of a row  
RI - retrograde inversion form of a row  
0-0 - original - original test pair  
0-R - original - retrograde test pair  
0-I - original - inversion test pair  
0-RI - original - retrograde inversion test pair  
MCIA - most common incorrect answer  
LCIA - least common incorrect answer

Treatment I - Untreated Rows and Derivatives. Table 7 shows the results of all subjects' responses to the test pairs in which the second item of each pair was unaltered. The column on the left side of the table identifies the four test pairs for each of the four twelve-tone rows used in the test and shows the chi-square value for the responses grouped by twelve-tone row. Chi-square values above 9.34 at the one per cent level (p. = 0.01) with three degrees of
## Table 7

All 621 Subjects’ Responses to Untreated Test Pairs

<table>
<thead>
<tr>
<th>Test Pair</th>
<th>Possible Responses</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>O</td>
<td>R</td>
</tr>
<tr>
<td>0-0</td>
<td>988</td>
<td>144</td>
</tr>
<tr>
<td>Row 1</td>
<td>79.55%</td>
<td>11.59%</td>
</tr>
<tr>
<td>0-R</td>
<td>107</td>
<td>646</td>
</tr>
<tr>
<td>(x^2=2254.81^{*})</td>
<td>8.62%</td>
<td>51.01%</td>
</tr>
<tr>
<td>0-I</td>
<td>117</td>
<td>617</td>
</tr>
<tr>
<td>0-RI</td>
<td>193</td>
<td>419</td>
</tr>
<tr>
<td></td>
<td>15.54%</td>
<td>33.74%</td>
</tr>
<tr>
<td>0-0</td>
<td>979</td>
<td>125</td>
</tr>
<tr>
<td>Row 2</td>
<td>78.82%</td>
<td>10.06%</td>
</tr>
<tr>
<td>0-R</td>
<td>101</td>
<td>822</td>
</tr>
<tr>
<td>(x^2=2809.11^{*})</td>
<td>8.13%</td>
<td>66.18%</td>
</tr>
<tr>
<td>0-I</td>
<td>118</td>
<td>455</td>
</tr>
<tr>
<td>0-RI</td>
<td>127</td>
<td>366</td>
</tr>
<tr>
<td></td>
<td>10.23%</td>
<td>29.47%</td>
</tr>
<tr>
<td>0-0</td>
<td>1102</td>
<td>93</td>
</tr>
<tr>
<td>Row 3</td>
<td>88.73%</td>
<td>7.49%</td>
</tr>
<tr>
<td>0-R</td>
<td>450</td>
<td>583</td>
</tr>
<tr>
<td>(x^2=2774.13^{*})</td>
<td>36.23%</td>
<td>46.94%</td>
</tr>
<tr>
<td>0-I</td>
<td>124</td>
<td>360</td>
</tr>
<tr>
<td>0-RI</td>
<td>119</td>
<td>318</td>
</tr>
<tr>
<td></td>
<td>9.58%</td>
<td>25.60%</td>
</tr>
<tr>
<td>0-0</td>
<td>973</td>
<td>148</td>
</tr>
<tr>
<td>Row 4</td>
<td>78.34%</td>
<td>11.92%</td>
</tr>
<tr>
<td>0-R</td>
<td>83</td>
<td>689</td>
</tr>
<tr>
<td>(x^2=2546.35^{*})</td>
<td>6.68%</td>
<td>55.48%</td>
</tr>
<tr>
<td>0-I</td>
<td>127</td>
<td>680</td>
</tr>
<tr>
<td>0-RI</td>
<td>139</td>
<td>378</td>
</tr>
<tr>
<td></td>
<td>11.19%</td>
<td>30.43%</td>
</tr>
</tbody>
</table>

*Chi-square values above 9.84 with three degrees of freedom indicate significance at the one per cent level.*
freedom indicate significant differences. In Table 7 all the differences in responses were shown significant. The row across the top of the table identifies the possible responses for each test pair. The numbers in the table are the number of responses for each test item and the per cent figure for each number. The row totals in Table 7 are 1242 responses per test pair, which is double the number of test subjects. This is because each test pair was presented twice during the test, yielding two responses for each test item per subject. The underlined numbers show the correct responses for each test pair.

For test pairs 0-0, Table 7 shows correct responses ranging from a high of 1102 (88.73%) for Row 3 to a low of 973 (78.34%) for Row 4. The MCIA to test pairs 0-0 was retrograde for all four twelve-tone rows, and the LCIA was retrograde inversion for all four twelve-tone rows. The number of correct responses to test pair 0-R ranged from a high of 822 (66.18%) for Row 2 to a low of 583 (46.94%) for Row 3. The MCIA to test pair 0-R was inversion for Rows 1, 2, and 4, and original for Row 3. The LCIA to test pair 0-R was original for Rows 1, 2, and 4, and retrograde inversion for Row 3. The range of correct responses for test pairs 0-0 is higher than the range of correct responses for test pairs 0-R, which is not surprising since it was considered that identification of the original row should be easier than identifying the retrograde form of the row. The range of correct responses to test pairs 0-1 is lower than the ranges for test pairs 0-0 and 0-R. The highest number of correct responses for test pair 0-1 was 588 (47.34%) for Row 3, which is barely above the lowest.
number of correct responses for test pairs 0-R (583 responses for Row 3), and considerably below the lowest number of correct responses for test pairs 0-0 (973 responses for Row 4). The lowest number of correct responses was 321 (25.85%) for Row 1. The MCIA to test pair 0-I was retrograde for all four twelve-tone rows, and the LCIA was original for Rows 1, 2, and 3, and retrograde inversion for Row 4. In two cases, test pairs 0-I of Rows 1 and 4, the number of responses for the most common incorrect answer was nearly double the number of correct responses. The untreated test pairs 0-RI received the lowest number of correct responses for all untreated test pairs. The correct responses for test pair 0-RI ranged from a high of 311 (25.04%) for Row 2 to a low of 216 (17.39%) for Row 1. The number of correct responses to Row 1 test pair 0-RI (216 or 17.39%) was the lowest correct figure for all untreated test pairs. The MCIA to test pair 0-RI for Row 1 was either retrograde, which received 419 (33.74%) responses, or inversion, which received 414 (33.33%). Because of the closeness of the number of responses, no clear differences can be made between the two incorrect categories. The MCIA for Rows 2, 3, and 4 was inversion, and the LCIA for all four twelve-tone rows was original. The MCIA for test pair 0-RI for Rows 3 and 4, inversion, showed twice the number of responses than did the correct answer, retrograde inversion.

Table 8 shows the number of correct responses to each untreated test pair for each twelve-tone row. It can be seen that the curves for Rows 1, 2, and 4 describe nearly the same descending course, while the curve for Row 3 drops, but rises slightly in
the middle before descending again. This table also shows that for each successive shape of the second row of the test pairs the number of correct responses drops. The table shows that the original was easier to identify than the derivatives, and of the derivatives, the retrograde was easier to identify than the retrograde inversion. This indicates a ranking of difficulty in identifying a row and its derivatives in an untreated situation.

Table 8

<table>
<thead>
<tr>
<th>Test Pairs</th>
<th>0-0</th>
<th>0-R</th>
<th>0-I</th>
<th>0-RI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number Correct</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1100</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1000</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>900</td>
<td>o</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>800</td>
<td>o</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>700</td>
<td>o</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>600</td>
<td>o</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>500</td>
<td>o</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>400</td>
<td>o</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>300</td>
<td>o</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>200</td>
<td>o</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

x = Row 1
* = Row 3
o = Row 2
= Row 4

Table 9 shows the pattern of responses for the most and least common incorrect answers for each untreated test pair. The abbreviation MCIA identifies the most common incorrect answers and the abbreviation LCIA identifies the least common incorrect answers.

The table shows that for test pairs 0-0 the most common incorrect answer was retrograde for each of the four twelve-tone rows, which is to say that of those people who incorrectly identified the second row of the test pair 0-0, most of them thought they
Table 9

Most and Least Common Incorrect Answers for Untreated Test Pairs

<table>
<thead>
<tr>
<th>Test Pair</th>
<th>Row 1</th>
<th>Row 2</th>
<th>Row 3</th>
<th>Row 4</th>
<th>Correct Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MCIA</td>
<td>LCIA</td>
<td>MCIA</td>
<td>LCIA</td>
<td></td>
</tr>
<tr>
<td>0-0</td>
<td>R</td>
<td>RI</td>
<td>R</td>
<td>RI</td>
<td>R</td>
</tr>
<tr>
<td>0-R</td>
<td>I</td>
<td>0</td>
<td>I</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0-I</td>
<td>R</td>
<td>O</td>
<td>R</td>
<td>O</td>
<td>0</td>
</tr>
<tr>
<td>0-RI</td>
<td>RorI</td>
<td>0</td>
<td>I</td>
<td>0</td>
<td>I</td>
</tr>
</tbody>
</table>

heard the retrograde form of the row. For test pair 0-0 the least common incorrect answer was retrograde inversion for each of the four twelve-tone rows. This indicates that of those who incorrectly identified the second row of test pair 0-0, the smallest group of them thought they heard the retrograde inversion form of the row. It appears that for untreated test pair 0-0 the pattern of most and least common incorrect answers was consistent for all four twelve-tone rows used in the test.

For test pair 0-R Table 9 shows that the most common incorrect answer for Rows 1, 2, and 4 was inversion, but for Row 3 it was original. The least common incorrect answer was original for Rows 1, 2, and 4, but was retrograde inversion for Row 3. For the untreated pair 0-R the pattern of most and least common incorrect answer was consistent for Rows 1, 2, and 4, with a different pattern for Row 3 in both most and least common incorrect answers.

Test pair 0-I showed a consistent pattern of most and least common incorrect answers except in Row 4 results. The most common incorrect answer for all four twelve-tone rows was original, and the least common incorrect answer was original for Rows 1, 2, and 3,
and retrograde inversion for Row 4.

Table 9 results for untreated test pair O-RI show a consistent pattern for most and least common incorrect answers except for Row 1 results, where retrograde and inversion received nearly the same number of responses as the most common incorrect answer making a distinction between them impossible. If inversion had clearly been the most common incorrect answer then the pattern of inversion as most and original as least common incorrect answers would have held for all four twelve-tone rows.

Table 9 also shows that the retrograde inversion was never the MCIA and retrograde and inversion were never the LCIA. Original was the form that appeared the highest number of times as the LCIA, while retrograde appeared the highest number of times as the MCIA.

Another pattern that appears in Table 9 is the consistency in most and least common incorrect answers on a pair by pair basis, rather than on a row by row basis, which is to say that there appears to be greater consistency of incorrect response based on melodic shapes rather than on twelve-tone rows used. A comparison of the ranges of the number of correct responses to the ranges of most and least common incorrect answers shows a decrease in the number of correct responses and an increase in the number of responses for most and least incorrect answers, which in indicative of the increasing difficulty of identifying the derivatives of a row.

Treatment II - Transposed Rows and Derivatives. Table 10 shows the results of all subjects' responses to the test pairs in which the
Table 10

All 621 Subjects' Responses to Transposed Rows and Derivatives Test Pairs

<table>
<thead>
<tr>
<th>Test Pair</th>
<th>Possible Responses</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>O</td>
<td>R</td>
</tr>
<tr>
<td>O-O</td>
<td>369</td>
<td>293</td>
</tr>
<tr>
<td></td>
<td>29.71%</td>
<td>23.59%</td>
</tr>
<tr>
<td>O-R</td>
<td>99</td>
<td>347</td>
</tr>
<tr>
<td></td>
<td>7.97%</td>
<td>27.94%</td>
</tr>
<tr>
<td>Row 1</td>
<td>140</td>
<td>403</td>
</tr>
<tr>
<td></td>
<td>11.27%</td>
<td>32.45%</td>
</tr>
<tr>
<td>x²=289.84*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>O-RI</td>
<td>211</td>
<td>405</td>
</tr>
<tr>
<td></td>
<td>16.99%</td>
<td>32.61%</td>
</tr>
<tr>
<td>O-R</td>
<td>125</td>
<td>578</td>
</tr>
<tr>
<td>Row 2</td>
<td>142</td>
<td>474</td>
</tr>
<tr>
<td></td>
<td>10.06%</td>
<td>46.54%</td>
</tr>
<tr>
<td>x²=476.91*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>O-RI</td>
<td>122</td>
<td>601</td>
</tr>
<tr>
<td></td>
<td>9.82%</td>
<td>48.39%</td>
</tr>
<tr>
<td>O-O</td>
<td>599</td>
<td>343</td>
</tr>
<tr>
<td></td>
<td>48.23%</td>
<td>27.62%</td>
</tr>
<tr>
<td>O-R</td>
<td>437</td>
<td>399</td>
</tr>
<tr>
<td>Row 3</td>
<td>104</td>
<td>243</td>
</tr>
<tr>
<td></td>
<td>35.19%</td>
<td>32.13%</td>
</tr>
<tr>
<td>x²=1088.33*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>O-RI</td>
<td>145</td>
<td>242</td>
</tr>
<tr>
<td></td>
<td>11.67%</td>
<td>19.48%</td>
</tr>
<tr>
<td>O-O</td>
<td>271</td>
<td>380</td>
</tr>
<tr>
<td></td>
<td>21.82%</td>
<td>30.60%</td>
</tr>
<tr>
<td>O-R</td>
<td>120</td>
<td>349</td>
</tr>
<tr>
<td>Row 4</td>
<td>66</td>
<td>280</td>
</tr>
<tr>
<td></td>
<td>9.66%</td>
<td>28.10%</td>
</tr>
<tr>
<td>x²=245.71*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>O-RI</td>
<td>160</td>
<td>320</td>
</tr>
<tr>
<td></td>
<td>12.88%</td>
<td>25.76%</td>
</tr>
</tbody>
</table>

* Chi-square values above 9.84 with three degrees of freedom indicate significance at the one percent level.
second item or each pair was transposed and the chi-square values for the responses grouped by twelve-tone row. In Table 10 all the differences in responses were shown significant. The format for this table is the same as in Table 7.

For transposed test pairs 0-0 Table 10 shows correct responses ranging from a high of 599 (48.23%) for Row 3 to a low of 271 (21.82%) for Row 4. The MCIA to transposed test pairs 0-0 was inversion for Rows 1, 2, and 4 and retrograde for Row 3. The LCIA was retrograde inversion for all four rows used.

Transposed test pairs 0-R received correct answers ranging from a high of 578 (46.54%) for Row 2 to a low of 347 (27.94%) for Row 1. The MCIA for transposed test pairs 0-R was inversion for Rows 1, 2, and 4, and original for Row 3. The LCIA was original for Rows 1, 2, and 4, and retrograde inversion for Row 3.

The ranges of correct answers for transposed test pairs 0-0 and 0-R are somewhat the same, with the greatest differences in lowest number correct: 271 for 0-0 and 347 for 0-R. These ranges are considerably below the ranges for correct answers for untreated test pairs.

Transposed test pairs 0-1 received correct answers ranging from a high of 626 (50.40%) for Row 4 to a low of 359 (28.90%) for Row 2. The MCIA for transposed test pairs 0-1 was inversion for Rows 1, 2, and 3, and retrograde inversion for Row 4. The LCIA was original for all four rows. The range of correct answers for transposed test pairs 0-1 is slightly higher than the ranges for transposed test pairs 0-0 and 0-R.
Transposed test pairs O-RI received correct answers ranging from a high of 321 (25.85%) for Row 3 to a low of 185 (14.90%) for Row 1. The MCIA for transposed test pairs O-RI was inversion for Rows 1, 3, and 4, and retrograde for Row 2. The LCIA was original for all four rows. The lowest correct figure for transposed test pairs was 185 (14.90%) for test pair O-RI of Row 1, and the highest correct figure was 626 (50.40%) for pair O-I of Row 4.

Table 11 shows the range of correct responses to each transposed test pair for each twelve-tone row. The curves for each row are different from each other, and the over-all pattern shown in the table is different from the pattern shown in Table 8 which shows the number of correct responses for each untreated test pair. The pattern of increasing difficulty in identifying the row and derivatives as shown in Table 8 is not present in Table 11, indicating

Table 11

<table>
<thead>
<tr>
<th>Test Pairs</th>
<th>1100</th>
<th>1000</th>
<th>900</th>
<th>800</th>
<th>700</th>
<th>600</th>
<th>500</th>
<th>400</th>
<th>300</th>
<th>200</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-0</td>
<td>x</td>
<td>o</td>
<td>a</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-R</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-I</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>O-RI</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

x = Row 1
o = Row 2
a = Row 3
* = Row 4
the influence of transposing the second item of the test pairs. The range of correct responses for transposed test pair 0-1 is highest of the four transposed pairs, whereas in the untreated pairs the original received the highest range of correct responses. The transposed pair 0-0 had the second highest range of correct responses and the transposed pairs 0-RI received the lowest range of correct responses. The ranges of correct responses for transposed test pairs were lower than the ranges of correct responses for untreated test pairs.

Table 12 shows the pattern of responses for the most and least common incorrect answers for each transposed test pair. The abbreviation MCIA identifies the most common incorrect answers and LCIA identifies the least common incorrect answers.

<table>
<thead>
<tr>
<th>Test Pair</th>
<th>MCIA</th>
<th>LCIA</th>
<th>MCIA</th>
<th>LCIA</th>
<th>MCIA</th>
<th>LCIA</th>
<th>MCIA</th>
<th>LCIA</th>
<th>Correct Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-0</td>
<td>I</td>
<td>RI</td>
<td>I</td>
<td>RI</td>
<td>I</td>
<td>RI</td>
<td>I</td>
<td>RI</td>
<td>O</td>
</tr>
<tr>
<td>0-R</td>
<td>RI</td>
<td>O</td>
<td>RI</td>
<td>O</td>
<td>I</td>
<td>RI</td>
<td>I</td>
<td>O</td>
<td>R</td>
</tr>
<tr>
<td>0-I</td>
<td>RI</td>
<td>O</td>
<td>RI</td>
<td>O</td>
<td>R</td>
<td>O</td>
<td>R</td>
<td>O</td>
<td>I</td>
</tr>
<tr>
<td>0-RI</td>
<td>I</td>
<td>O</td>
<td>I</td>
<td>O</td>
<td>I</td>
<td>O</td>
<td>R</td>
<td>O</td>
<td>RI</td>
</tr>
</tbody>
</table>

Comparing the results shown in Tables 9 (MCIA and LCIA for untransposed rows) and 12 (MCIA and LCIA for transposed rows) a pattern of treatment influence is shown. The MCIA pattern for test pairs 0-0 is different for untransposed and transposed rows and derivatives. In the untransposed treatment situation the MCIA was retrograde for all four rows, and in the transposed treatment
situation the MCIA was inversion. The LCIA for test pairs 0-0 was
the same for untransposed and transposed situations, indicating no
influence due to transposing the second row or derivative of each
test pair.

For test pairs 0-R, the MCIA patterns differ: untransposed MCIA
were inversion and original, and transposed MCIA were retrograde
inversion and inversion. This indicates influence due to transposition.
The LCIA pattern for test pairs 0-R is the same for both treatments,
indicating no influence due to transposition.

For test pairs 0-I, the MCIA patterns differ. The untransposed
MCIA's were retrograde, but the transposed MCIA's for transposed rows
and derivatives were retrograde inversion and retrograde. This
indicates influence due to transposition. The LCIA pattern for
untransposed and transposed rows and derivatives are nearly the
same, the only difference being the results for Row 4 test pairs,
where the untransposed LCIA was retrograde inversion and the trans­
posed LCIA was original.

Both MCIA and LCIA patterns for transposed and untransposed test
pairs 0-RI are nearly the same, with only two possible differences
being 1) Row 1 MCIA results differ (depending on which untreated
response is to be considered the MCIA), and 2) Row 4 MCIA results
differ. It would appear that the influence of transposition on
MCIA's for test pairs 0-RI is much less than for the other test pairs,
and that transposition of the second row of each test pair 0-RI has
no effect on LCIA's

Thus the pattern is developing, to wit: transposition appears
to influence the MCIA for all test pairs except 0-RI, and transposition appears to have no influence on LCIA.

Table 12 shows that original was never the MCIA for transposed rows, whereas retrograde inversion was never the MCIA in the untransposed phase. Retrograde and inversion were never chosen as LCIA for transposed rows while for untransposed rows inversion was never chosen LCIA. Inversion was chosen MCIA more often than any other form for transposed rows while retrograde received the highest number of responses for untransposed rows. Original received the highest number of responses as LCIA for both untransposed and transposed rows.

While there are differences between Tables 9 and 12, both tables exhibit a consistency of pattern that appears to be based on test pair rather than twelve-tone rows used.

Treatment III - Displaced Note within a Row or Derivative.

Table 13 shows the results of all subjects' responses to the test pairs in which there was a note displaced in the second row or derivative of each pair, and the chi-square values for the responses grouped by twelve-tone row.

For test pairs 0-0 with displaced note Table 13 shows correct responses ranging from a high of 677 (54.51%) for Row 4 to a low of 368 (29.63%) for Row 2. The MCIA was inversion for all four rows and the LCIA was retrograde inversion for all four rows. The range of correct answers for test pairs 0-0 with displaced note is not as high as that for untreated test pairs 0-0, but is slightly higher than the range of correct answers for transposed test pairs 0-0.
Table 13

All 621 Subjects' Responses to Rows and Derivatives with Displaced Note

<table>
<thead>
<tr>
<th>Test Pair</th>
<th>Possible Responses</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-0</td>
<td>O 491, R 212, I 396, RI 143</td>
<td>1242</td>
</tr>
<tr>
<td></td>
<td>39.53%, 17.07%, 31.88%, 11.51%</td>
<td>100%</td>
</tr>
<tr>
<td>0-R</td>
<td>O 31, R 333, I 342, RI 536</td>
<td>1242</td>
</tr>
<tr>
<td></td>
<td>2.50%, 26.81%, 27.54%, 43.16%</td>
<td>100%</td>
</tr>
<tr>
<td>0-I ^2=1028.92*</td>
<td>O 5.72%, R 29.55%, I 28.42%, RI 36.31%</td>
<td>100%</td>
</tr>
<tr>
<td>0-RI</td>
<td>O 128, R 257, I 377, RI 480</td>
<td>1242</td>
</tr>
<tr>
<td></td>
<td>10.31%, 20.69%, 30.35%, 38.65%</td>
<td>100%</td>
</tr>
<tr>
<td>0-0</td>
<td>O 368, R 201, I 515, RI 158</td>
<td>1242</td>
</tr>
<tr>
<td></td>
<td>29.63%, 16.18%, 41.47%, 12.72%</td>
<td>100%</td>
</tr>
<tr>
<td>0-R</td>
<td>O 56, R 442, I 269, RI 475</td>
<td>1242</td>
</tr>
<tr>
<td></td>
<td>4.51%, 35.59%, 21.66%, 38.24%</td>
<td>100%</td>
</tr>
<tr>
<td>0-I ^2=872.91*</td>
<td>O 4.91%, R 26.57%, I 31.96%, RI 36.55%</td>
<td>100%</td>
</tr>
<tr>
<td>0-RI</td>
<td>O 77, R 265, I 386, RI 514</td>
<td>1242</td>
</tr>
<tr>
<td></td>
<td>6.20%, 21.34%, 31.08%, 41.38%</td>
<td>100%</td>
</tr>
<tr>
<td>0-0</td>
<td>O 561, R 260, I 323, RI 98</td>
<td>1242</td>
</tr>
<tr>
<td></td>
<td>45.17%, 20.93%, 26.01%, 7.89%</td>
<td>100%</td>
</tr>
<tr>
<td>0-R</td>
<td>O 247, R 497, I 319, RI 179</td>
<td>1242</td>
</tr>
<tr>
<td></td>
<td>19.89%, 40.12%, 25.68%, 14.41%</td>
<td>100%</td>
</tr>
<tr>
<td>0-I ^2=1223.99*</td>
<td>O 5.39%, R 29.71%, I 44.52%, RI 20.37%</td>
<td>100%</td>
</tr>
<tr>
<td>0-RI</td>
<td>O 51, R 235, I 518, RI 438</td>
<td>1242</td>
</tr>
<tr>
<td></td>
<td>4.11%, 18.92%, 41.71%, 35.27%</td>
<td>100%</td>
</tr>
<tr>
<td>0-0</td>
<td>O 677, R 181, I 304, RI 80</td>
<td>1242</td>
</tr>
<tr>
<td></td>
<td>54.51%, 14.57%, 24.48%, 6.44%</td>
<td>100%</td>
</tr>
<tr>
<td>0-R</td>
<td>O 128, R 635, I 296, RI 183</td>
<td>1242</td>
</tr>
<tr>
<td></td>
<td>10.31%, 51.13%, 23.83%, 14.73%</td>
<td>100%</td>
</tr>
<tr>
<td>0-I ^2=1443.48*</td>
<td>O 7.97%, R 43.40%, I 29.71%, RI 18.92%</td>
<td>100%</td>
</tr>
<tr>
<td>0-RI</td>
<td>O 83, R 421, I 415, RI 325</td>
<td>1242</td>
</tr>
<tr>
<td></td>
<td>6.68%, 33.90%, 33.25%, 26.17%</td>
<td>100%</td>
</tr>
</tbody>
</table>

* Chi-square values above 9.84 with three degrees of freedom indicate significance at the one percent level.
Table 13 shows a range of correct responses for test pairs O-R with displaced note from a high of 635 (51.13%) for Row 4 to a low of 333 (26.81%) for Row 1. The MCIA was retrograde inversion for Rows 1, 2, and 3, and inversion for Row 4. The LCIA was original for Rows 1, 2, and 4, and retrograde inversion for Row 3. The range of correct responses is lower than the untreated test pairs O-R range but is slightly higher than the range of correct answers for transposed test pairs O-R.

Test pairs O-I with displaced note received correct answers ranging from a high of 553 (44.52%) for Row 3 to a low of 353 (28.42%) for Row 1. The MCIA for Rows 1 and 2 was retrograde inversion, and for Rows 3 and 4 was retrograde. The LCIA was original for all four rows. The range of correct answers for test pairs O-I with displaced note was close to that for untreated test pairs O-I, which was lower than for transposed test pairs O-I.

Table 13 shows a range of correct responses for test pairs O-RI with displaced note from a high of 514 (41.38%) for Row 2 to a low of 325 (26.17%) for Row 4. The MCIA was inversion for Rows 1, 2, and 3, and retrograde for Row 4. The LCIA was original for all four rows. The range of correct responses is higher than the ranges for test pairs O-RI in the untreated and transposed treatments. The ranges for correct responses for test pairs which had a note displaced in the second row of each test pair were slightly higher than the ranges for correct responses for transposed test pairs, but much lower than the ranges for untreated test pairs.
Table 14 shows the range of correct responses to each test pair with displaced note for each twelve-tone row. The curves generally show a decrease in correct identification but not nearly to the extent displayed by untreated test pair results. The curve for Row 4 results shows a drop in correct responses, but the curve for Row 2 shows a rise in correct responses. The pattern of increasing difficulty in identifying the row and derivatives as shown in Table 8 is not present for the other two rows (1 and 3). The highest range of correct responses was for test pairs 0-0, which was also the case in the untreated test pairs. The second highest range was for test pairs 0-R with displaced note, as was the case in untreated test pairs, but the difference in ranges for test pairs with displaced note is less than the difference in ranges for untreated test pairs.

Table 14

<table>
<thead>
<tr>
<th>Test Pairs</th>
<th>Number of Correct Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>O-O</td>
<td>1100</td>
</tr>
<tr>
<td>O-R</td>
<td>1000</td>
</tr>
<tr>
<td>O-I</td>
<td>900</td>
</tr>
<tr>
<td>O-RI</td>
<td>800</td>
</tr>
<tr>
<td>1100</td>
<td>1000</td>
</tr>
<tr>
<td>900</td>
<td>800</td>
</tr>
<tr>
<td>700</td>
<td>600</td>
</tr>
<tr>
<td>600</td>
<td>500</td>
</tr>
<tr>
<td>500</td>
<td>400</td>
</tr>
<tr>
<td>400</td>
<td>300</td>
</tr>
<tr>
<td>300</td>
<td>200</td>
</tr>
</tbody>
</table>

Table 15 shows the pattern of responses for the most and least
common incorrect answers for test pairs with displaced note. The abbreviation MCIA identifies the most common incorrect answers and LCIA identifies the least common incorrect answers.

Table 15

<table>
<thead>
<tr>
<th>Test Pair</th>
<th>Row 1 MCIA</th>
<th>Row 1 LCIA</th>
<th>Row 2 MCIA</th>
<th>Row 2 LCIA</th>
<th>Row 3 MCIA</th>
<th>Row 3 LCIA</th>
<th>Row 4 MCIA</th>
<th>Row 4 LCIA</th>
<th>Correct Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-O</td>
<td>I</td>
<td>RI</td>
<td>I</td>
<td>RI</td>
<td>I</td>
<td>RI</td>
<td>I</td>
<td>RI</td>
<td>0</td>
</tr>
<tr>
<td>0-R</td>
<td>RI</td>
<td>0</td>
<td>RI</td>
<td>0</td>
<td>I</td>
<td>RI</td>
<td>I</td>
<td>O</td>
<td>R</td>
</tr>
<tr>
<td>0-I</td>
<td>RI</td>
<td>0</td>
<td>RI</td>
<td>0</td>
<td>R</td>
<td>0</td>
<td>R</td>
<td>0</td>
<td>I</td>
</tr>
<tr>
<td>0-RI</td>
<td>I</td>
<td>0</td>
<td>I</td>
<td>0</td>
<td>I</td>
<td>0</td>
<td>R</td>
<td>0</td>
<td>RI</td>
</tr>
</tbody>
</table>

The pattern of MCIA and LCIA for test pairs 0-0 with displaced note is the same for transposed test pairs, and the pattern of LCIA is the same for untreated test pairs 0-0 as well. This indicates that, regardless of treatment, when the second item of the test pair was original the incorrect answer which appeared least often was retrograde inversion. Treatment has no effect on LCIA for test pairs 0-0.

The pattern of MCIA and LCIA for test pairs 0-R with displaced note is the same for transposed test pairs 0-R: MCIA is retrograde inversion for Rows 1 and 2, and inversion for Rows 3 and 4. The LCIA of original for Rows 1, 2, and 3 and retrograde inversion for Row 4 holds for transposed test pairs as well as untreated test pairs.

The pattern of MCIA and LCIA for test pairs 0-I with displaced note is the same for transposed test pairs: MCIA is retrograde inversion for Rows 1 and 2, and retrograde for Rows 3 and 4. LCIA is original for all four rows, but this pattern is not the same as in the
untreated test pairs. The MCIA for test pairs O-RI was inversion for Rows 1, 2, and 3, and retrograde for Row 4, which is the same pattern for transposed test pairs. The LCIA was original for all four rows, which is the same pattern for transposed test pairs but not for untreated test pairs.

**Treatment IV: Transposed Rows and Derivatives with Displaced Notes.** Table 16 shows the results of all the subjects' responses to test pairs in which transposition and displacement of a note were employed and the chi-square values for the responses grouped by twelve-tone row. All the differences in responses in Table 16 were shown significant.

Transposed test pairs 0-0 with displaced note showed a range of correct answers from a high of 273 (21.98%) for Row 3 to a low of 239 (19.24%) for Row 2. This range is lower than the ranges for test pairs 0-0 which were untreated and which were treated with displaced note, and is slightly lower than the range for test pairs 0-0 which were transposed. This indicates that for test pairs 0-0 the combination of transposition and displaced note had only slightly more influence than transposition alone, and had more influence than displaced note alone. The MCIA was inversion for all four rows used, and the LCIA was retrograde for Rows 1 and 2, and retrograde inversion for Rows 3 and 4.

In Table 16 the transposed test pairs 0-R with displaced note showed a range of correct answers from a high of 414 (33.33%) for Row 2 to a low of 217 (17.47%) for Row 1. This range is lower than
Table 16

All 621 Subjects' Responses to Transposed Rows and Derivatives with Displaced Note

<table>
<thead>
<tr>
<th>Test Pair</th>
<th>Possible Responses</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>O</td>
<td>R</td>
</tr>
<tr>
<td>0-0</td>
<td>265</td>
<td>205</td>
</tr>
<tr>
<td></td>
<td>21.34%</td>
<td>16.51%</td>
</tr>
<tr>
<td>0-R</td>
<td>45</td>
<td>217</td>
</tr>
<tr>
<td></td>
<td>3.62%</td>
<td>17.47%</td>
</tr>
<tr>
<td>0-I</td>
<td>48</td>
<td>176</td>
</tr>
<tr>
<td></td>
<td>3.86%</td>
<td>14.17%</td>
</tr>
<tr>
<td>0-RI</td>
<td>101</td>
<td>342</td>
</tr>
<tr>
<td></td>
<td>8.13%</td>
<td>27.54%</td>
</tr>
<tr>
<td>Row 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>x²=479.73*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-0</td>
<td>239</td>
<td>233</td>
</tr>
<tr>
<td></td>
<td>19.24%</td>
<td>18.76%</td>
</tr>
<tr>
<td>0-R</td>
<td>61</td>
<td>414</td>
</tr>
<tr>
<td></td>
<td>4.91%</td>
<td>33.33%</td>
</tr>
<tr>
<td>0-I</td>
<td>54</td>
<td>311</td>
</tr>
<tr>
<td></td>
<td>4.35%</td>
<td>25.04%</td>
</tr>
<tr>
<td>0-RI</td>
<td>72</td>
<td>399</td>
</tr>
<tr>
<td></td>
<td>5.80%</td>
<td>32.13%</td>
</tr>
<tr>
<td>Row 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>x²=389.96*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-0</td>
<td>273</td>
<td>272</td>
</tr>
<tr>
<td></td>
<td>21.98%</td>
<td>21.90%</td>
</tr>
<tr>
<td>0-R</td>
<td>180</td>
<td>289</td>
</tr>
<tr>
<td></td>
<td>14.49%</td>
<td>23.27%</td>
</tr>
<tr>
<td>0-I</td>
<td>75</td>
<td>190</td>
</tr>
<tr>
<td></td>
<td>6.04%</td>
<td>15.30%</td>
</tr>
<tr>
<td>0-RI</td>
<td>88</td>
<td>176</td>
</tr>
<tr>
<td></td>
<td>7.09%</td>
<td>14.17%</td>
</tr>
<tr>
<td>Row 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>x²=347.74*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-0</td>
<td>256</td>
<td>337</td>
</tr>
<tr>
<td></td>
<td>20.61%</td>
<td>27.13%</td>
</tr>
<tr>
<td>0-R</td>
<td>129</td>
<td>344</td>
</tr>
<tr>
<td></td>
<td>10.39%</td>
<td>27.70%</td>
</tr>
<tr>
<td>0-I</td>
<td>86</td>
<td>429</td>
</tr>
<tr>
<td></td>
<td>6.92%</td>
<td>34.54%</td>
</tr>
<tr>
<td>0-RI</td>
<td>142</td>
<td>323</td>
</tr>
<tr>
<td></td>
<td>11.43%</td>
<td>26.01%</td>
</tr>
<tr>
<td>Row 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>x²=142.35*</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Chi-square values above 9.84 with three degrees of freedom indicate significance at the one per cent level.
the ranges for test pairs 0-R which were untreated and test pairs which were treated with displaced note, but only slightly lower than the range for test pairs 0-R which were transposed, indicating slightly more influence than transposition alone and more influence than displaced note alone. The MCIA for Rows 1 and 2 was retrograde inversion, and inversion for Rows 3 and 4. The LCIA was original for all four rows.

Transposed test pairs 0-I with displaced note showed a range of correct answers from a high of 506 (40.74%) for Row 3 to a low of 464 (37.36%) for Rows 1 and 2. This range is the lowest for test pairs 0-I in all four treatment phases. The MCIA for Rows 1, 2, and 3 was retrograde inversion, and the LCIA was original for all four rows.

Transposed test pairs 0-RI with displaced note showed a range of correct answers from a high of 473 (38.08%) for Row 2 to a low of 280 (22.54%) for Row 4. This range is lower than the ranges for test pairs 0-RI which had displaced note, but was higher than the ranges for test pairs 0-RI which were untreated and transposed. The MCIA for Rows 1, 3, and 4 was inversion, and retrograde for Row 2. The LCIA was original for all four rows.

Table 17 shows the range of correct responses to each transposed test pair with displaced note for each twelve-tone row. The curves show an overall increase in correct identifications.

The general pattern of decreasing accuracy of identification found in the untreated test pairs is absent in Table 17 and it would appear that the overall effect of transposition in conjunction with
displaced note was opposite to the untreated test pairs. The curve for Row 2 results shows a continued rise in correct responses, but the curves for the other three rows are erratic. It would appear that the combination of displaced note and transposition of the second row in each test pair made identification easier for the derivatives than for the original.

Table 17

<table>
<thead>
<tr>
<th>Test Pairs</th>
<th>Correct Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-0</td>
<td>1100</td>
</tr>
<tr>
<td>0-R</td>
<td>1000</td>
</tr>
<tr>
<td>0-I</td>
<td>900</td>
</tr>
<tr>
<td>0-R1</td>
<td>800</td>
</tr>
</tbody>
</table>

**Table 18** shows the pattern of responses for the most and least common incorrect answers for transposed test pairs with displaced note.

The patterns for MCIA and LCIA for test pairs 0-0 are different from those patterns shown in the other three treatments. The MCIA and LCIA pattern for Rows 1 and 2 is different from all other 0-0 patterns, but the MCIA and LCIA for Rows 3 and 4 is the same as the pattern found in the untreated test pair results. The pattern of
MCIA for Rows 1 and 2 is the same for transposed 0-0 pairs and 0-0 pairs with displaced note. The pattern for MCIA for Rows 3 and 4 is the same as that found in the untreated test pair results. The LCIA pattern for Rows 3 and 4 is the same as that for the other three treatments of test pairs 0-0.

Table 18
Most and Least Common Incorrect Answers for Transposed Test Pairs with Displaced Note

<table>
<thead>
<tr>
<th>Test Pair</th>
<th>Row 1 MCIA</th>
<th>Row 1 LCIA</th>
<th>Row 2 MCIA</th>
<th>Row 2 LCIA</th>
<th>Row 3 MCIA</th>
<th>Row 3 LCIA</th>
<th>Row 4 MCIA</th>
<th>Row 4 LCIA</th>
<th>Correct Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-0</td>
<td>I</td>
<td>R</td>
<td>I</td>
<td>R</td>
<td>R</td>
<td>RI</td>
<td>R</td>
<td>RI</td>
<td>0</td>
</tr>
<tr>
<td>0-R</td>
<td>RI</td>
<td>0</td>
<td>RI</td>
<td>0</td>
<td>I</td>
<td>0</td>
<td>I</td>
<td>0</td>
<td>R</td>
</tr>
<tr>
<td>0-I</td>
<td>RI</td>
<td>0</td>
<td>RI</td>
<td>0</td>
<td>O</td>
<td>R</td>
<td>R</td>
<td>0</td>
<td>I</td>
</tr>
<tr>
<td>0-RI</td>
<td>I</td>
<td>0</td>
<td>R</td>
<td>0</td>
<td>I</td>
<td>0</td>
<td>I</td>
<td>0</td>
<td>RI</td>
</tr>
</tbody>
</table>

The patterns for MCIA and LCIA for test pairs 0-R as shown in Table 18 are different from the 0-R patterns in the other three treatments. The MCIA and LCIA patterns for Rows 1 and 2 are the same when the test pairs 0-R were transposed, and when displaced note was introduced. The MCIA and LCIA pattern for Rows 3 and 4 is different from the patterns in the other three treatments. However, the MCIA pattern for all four rows is the same as the MCIA pattern when transposition and displaced note were introduced.

The patterns for MCIA and LCIA for test pairs 0-I are different from the 0-R patterns in the other treatments. The MCIA and LCIA patterns for Rows 1 and 2 are the same for the transposed and displaced note test pairs 0-I, but the MCIA and LCIA patterns for Rows 3 and 4 are not like the patterns in any of the other treatments.
The MCIA pattern for Rows 1, 2, and 4 is the same as the pattern found for transposed test pairs and test pairs with displaced note.

The patterns for MCIA and LCIA for test pairs O-RI as shown in Table 18 are also different from the O-RI patterns in the other three treatments. The Row 1 pattern of MCIA and LCIA is the same for the other three treatments, and the MCIA and LCIA pattern for Rows 3 and 4 is the same as the pattern in untreated test pair results. The MCIA and LCIA pattern for Row 2 is different from the results in the other three treatments.

The differences between the Treatment IV MCIA and LCIA patterns and the MCIA and LCIA patterns in the other three treatments indicates an influence of test results due to displaced note in conjunction with transposition, and indicates distinct differences due to the other treatments. The only large pattern which appears in three of the four treatments is the LCIA pattern for pairs O-R, O-I, and O-RI test pairs for Rows 1, 2, and 4. In each case, original was the least common incorrect answer.

Summary

Of the students who took the aural discrimination test, the majority of these were enrolled in teacher training programs, and there was an equal number of men and women. The average age was between 18 and 19 years.

The contingency table analyses show results twelve-tone row by twelve-tone row through the four treatments. All differences in test responses for each of the twelve-tone rows in each of the treatments were shown significant. The ranges for correct responses
in Treatment I show 0-O test pairs received the highest number of correct responses, followed in order by 0-R test pairs, 0-I test pairs, 0-RI test pairs. This would seem to support the first hypothesis to the effect that there is a ranking of difficulty in correctly identifying the second row of each test pair with the original easiest to identify, the retrograde harder, followed by the inversion and retrograde inversion. However, when transposition was introduced as Treatment II, the ranges for correct responses dropped significantly and the easiest shape to identify was not the original but the inversion. Test pairs 0-I received the highest number of correct responses in Treatment II. Test pairs 0-R and 0-O followed, with 0-RI test pairs receiving the lowest range of correct responses. Thus, when the second row of each test pair was transposed, the ranking of difficulty did not match that of the untreated test pairs, and there were generally fewer correct responses.

The introduction of displaced note in the second row of each test pair in Treatment III showed results slightly better than those for transposed rows. The ranges of correct responses are higher for rows with displaced note than for test pairs with transposed rows, and in Treatment III the hypothesized ranking of difficulty is present. The ranges of correct responses for test pairs 0-0 and 0-R are very close, and the ranges for test pairs 0-I and 0-RI are also very close, but the latter ranges are lower than the former. The combination of displaced note and transposition in the second row of each test pair in Treatment IV showed results much lower than any of the other treatments. The ranking of difficulty pattern is different from the
other patterns: test pairs 0-I received the highest number of correct responses in Treatment IV. This was also present in Treatment II, but the test pair in Treatment IV with the next highest number of correct responses was O-RI and not O-R as in Treatment II. Test pairs 0-R received the next highest number of correct responses in Treatment IV, and test pairs 0-0 received the lowest number of correct responses. Thus, it appears that the hypothesis of ranking of difficulty of a row and its derivatives, the first hypothesis, holds only when there is no treatment, and when the treatment involves only displacement of a note within the row.

A ranking of the influence of the treatments has developed from the contingency table analysis results. The treatment that showed the highest correct responses was Treatment I in which the second row of each test pair was presented without alteration. Treatment III results show the next highest number of correct responses, followed in turn by Treatment II and finally Treatment IV. This indicates that octave displacement of a note within the second row of a test pair showed more correct response than transposition of the second row of each test pair, and the combination of transposition and octave displacement showed the fewest correct responses.

The results of the contingency table analysis are in agreement with hypothesis two, that a Schoenberg row and derivatives would be harder to identify than non-Schoenberg rows. By reviewing Tables 7, 10, 13, and 16, it can be seen that in not one instance did Row 1 receive the highest number of correct responses. However, in eight
of a possible sixteen instances, shapes R, I, and RI in Treatment I; shapes R and RI in Treatment II; shapes R and I in Treatment III; and shape R in Treatment IV, Row 1 received the lowest number of correct responses, and in one case, shape I in Treatment IV, Rows 1 and 2 had the same low figure for correct responses.

The results of the contingency table analysis are in agreement with hypothesis three, that octave displacement of a note within a twelve-tone row would make identification of a row so treated harder to identify than an untreated row. The contingency tables showed that Treatment III, in which a note within the second row of each test pair was displaced an octave, had lower correct scores than Treatment I in which the second row of each test pair was unaltered.

The results of the contingency table analysis are in agreement with hypothesis four, that transposing a row and derivatives makes its identification harder than an untransposed row and derivatives. The contingency tables showed that Treatment II, in which the second row of each test pair was transposed, had lower correct scores than Treatment I in which the second row of each test pair was unaltered.

The results of the contingency table analysis are in agreement with hypothesis five, that transposing a row and derivatives in conjunction with octave displacement of a note within the row makes its identification harder than an untreated row. The contingency tables showed that Treatment IV, in which the second row of each test pair was transposed in conjunction with octave displacement of a note within the row, had lower correct scores than Treatment I in
which the second row of each test pair was unaltered.

There were four patterns for MCIA which developed in at least two of the treatments. For test pair O-O, the MCIA pattern of inversion for all four rows was shown in Treatments II and III. For test pair O-R the MCIA pattern retrograde inversion for Rows 1 and 2, and inversion for Rows 3 and 4 was shown in Treatments II, III, and IV. For test pair O-I the pattern retrograde inversion for Rows 1 and 2 and retrograde for Rows 3 and 4 was shown for Treatments II and III. For test pair O-RI the MCIA pattern inversion for Rows 1, 2, and 3 and retrograde for Row 4 was shown in Treatments II and III.

For LCIA there were three patterns which appeared in at least two treatments. For test pair O-O the LCIA pattern of retrograde inversion for all four rows appeared in Treatments I, II, and III. For O-R the LCIA pattern of original for Rows 1, 2, and 4, and retrograde inversion for Row 3 appeared in Treatments I, II, and III. The LCIA pattern of original for all four rows appeared in Treatments II and III for test pair O-I, and in all treatments for test pair O-RI.
Parameters for the Analysis

In order to estimate the extent of relationships, if any, there were between responses to the test items and background factors, a stepwise linear regression analysis was performed. In this analysis only the results of those subjects who had ACT scores and grade point averages (GPA) were used, yielding a sample of 510 cases. The 43 biographical variables used were:

- Sex, Age,
- Major - Accounting, Major - History
- Major - Agriculture, Major - Music
- Major - Business Administration, Major - Physical Education
- Major - Elementary Education, Major - Undecided
- Major - English, College Rank

Pre-College Ensemble Experience in:
- Marching Band, Mixed Chorus
- Concert Band, Glee Club
- Dance Band, Church Choir
- Orchestra, Other Ensemble

Collegiate Ensemble Experience in:
- Marching Band, Mixed Chorus
- Concert Band, Glee Club
- Dance Band, Church Choir
- Orchestra, Other Ensemble

Subjects with Perfect Pitch
- Woodwind player, String player
- Brass player, Vocalist
- Percussionist, Experience with other instrument
- Keyboard player, Years of Instruction on Instrument or Voice
Grade Point Average (GPA)
Standard ACT scores in:
   English        Natural Sciences
   Mathematics    Composite Score
   Social Sciences

The eleven test score variables were:

Scores on the total test
Scores on the first test half
Scores on the second test half
Total test scores for Treatment I
Total test scores for Treatment II
Total test scores for Treatment III
Total test scores for Treatment IV
Total test scores for 0 as correct response
Total test scores for R as correct response
Total test scores for I as correct response
Total test scores for RI as correct response

The results of the regression analyses will be reported in four steps:

1) the scores on the two test halves and the total test scores
   and their relationships to the biographical variables;

2) the total test scores for the four treatments and their
   relationships to the biographical variables;

3) the total test scores for the melodic shapes of the four
   twelve-tone rows and the relationships to the biographical variables;

and

4) the total test scores and their relationship to certain condensed biographical variables.

The tables presented in this chapter contain the following symbols:

\[ R = \text{the cumulative multiple correlation coefficient as variables are added to the regression equation;} \]

\[ R^2 = \text{the squared multiple correlation coefficient which is expressed as a percent;} \]

\[ DF = \text{degrees of freedom;} \]
GPA = grade point average; and

\[ F = \text{the test of significance of the cumulative relationship of the variables as they are added to the regression equation.} \]

For the purposes of this investigation variables that show less than a one per cent increment in \( R^2 \) or an \( F \) value of less than 6.0 will not be reported since their addition to the regression equation is unstable.

**Relationships of the Scores on the Two Test Halves and the Total Test Scores to the Biographical Variables**

Table 19 contains the results of the regression analysis test of scores on the two test halves and the total test scores compared with the biographical variables.

**First Test Half Scores Versus Biographical Variables.** Table 19 shows that when the interrelation of all biographical variables are taken into account only three variables contributed significantly to the multiple correlation coefficient. They were ACT English scores, College Dance Band experience, and experience in Other High School ensembles. These variables accounted for about 13% of the variance in the scores on the first test half, leaving 87% unaccounted for. ACT English scores accounted for 6.25% of the variance, College Dance Band experience added 5.31% and Other High School Ensemble experience accounted for 1.40% of the variance.

**Second Test Half Scores Versus Biographical Variables.** Table 19 shows that five biographical variables contributed significantly to the multiple correlation coefficient. Years of Private Applied Lessons
Table 19
Relationships Between the Scores on the Two Test Halves (64 Test Pairs in Each Half) and the Total Test Scores (128 Test Pairs) with the Biographical Variables of 510 Subjects

Scores on the First Test Half: 64 Test Pairs

<table>
<thead>
<tr>
<th>Biographical Variables</th>
<th>R</th>
<th>R²</th>
<th>Increase in R²</th>
<th>F *</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 ACT English Scores</td>
<td>0.26</td>
<td>6.25</td>
<td>--</td>
<td>36.68</td>
</tr>
<tr>
<td>2 College Dance Band Experience</td>
<td>0.33</td>
<td>11.56</td>
<td>5.31</td>
<td>28.04</td>
</tr>
<tr>
<td>3 Other High School Ensemble Experience</td>
<td>0.36</td>
<td>12.96</td>
<td>1.40</td>
<td>9.03</td>
</tr>
<tr>
<td>4 High School Mixed Chorus Experience</td>
<td>0.44</td>
<td>19.36</td>
<td>1.72</td>
<td>11.06</td>
</tr>
<tr>
<td>5 ACT English Scores</td>
<td>0.46</td>
<td>21.16</td>
<td>1.80</td>
<td>9.04</td>
</tr>
<tr>
<td>6 High School Concert Band Experience</td>
<td>0.48</td>
<td>23.04</td>
<td>1.88</td>
<td>6.61</td>
</tr>
</tbody>
</table>

Scores on the Second Test Half: 64 Test Pairs

<table>
<thead>
<tr>
<th>Biographical Variables</th>
<th>R</th>
<th>R²</th>
<th>Increase in R²</th>
<th>F *</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 ACT English Scores</td>
<td>0.30</td>
<td>9.00</td>
<td>--</td>
<td>51.08</td>
</tr>
<tr>
<td>2 College Dance Band Experience</td>
<td>0.39</td>
<td>15.21</td>
<td>6.21</td>
<td>33.94</td>
</tr>
<tr>
<td>3 Other High School Ensemble Experience</td>
<td>0.42</td>
<td>17.64</td>
<td>2.43</td>
<td>16.68</td>
</tr>
<tr>
<td>4 High School Mixed Chorus Experience</td>
<td>0.44</td>
<td>19.36</td>
<td>1.72</td>
<td>11.06</td>
</tr>
<tr>
<td>5 ACT English Scores</td>
<td>0.46</td>
<td>21.16</td>
<td>1.80</td>
<td>9.04</td>
</tr>
<tr>
<td>6 High School Concert Band Experience</td>
<td>0.48</td>
<td>23.04</td>
<td>1.88</td>
<td>6.61</td>
</tr>
</tbody>
</table>

Total Test Scores: 128 Test Pairs

<table>
<thead>
<tr>
<th>Biographical Variables</th>
<th>R</th>
<th>R²</th>
<th>Increase in R²</th>
<th>F *</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 ACT English Scores</td>
<td>0.30</td>
<td>9.00</td>
<td>--</td>
<td>51.98</td>
</tr>
<tr>
<td>2 College Dance Band Experience</td>
<td>0.39</td>
<td>15.21</td>
<td>6.21</td>
<td>35.48</td>
</tr>
<tr>
<td>3 Other High School Ensemble Experience</td>
<td>0.42</td>
<td>17.64</td>
<td>2.43</td>
<td>21.05</td>
</tr>
<tr>
<td>4 High School Mixed Chorus Experience</td>
<td>0.44</td>
<td>19.36</td>
<td>1.72</td>
<td>10.78</td>
</tr>
<tr>
<td>5 ACT English Scores</td>
<td>0.46</td>
<td>21.16</td>
<td>1.80</td>
<td>8.23</td>
</tr>
<tr>
<td>6 High School Concert Band Experience</td>
<td>0.48</td>
<td>23.04</td>
<td>1.88</td>
<td>6.61</td>
</tr>
</tbody>
</table>

* Significance is indicated by an F value of at least 6.00 at the one per cent level.
had the highest contribution of 9.00%, followed in turn by ACT Mathematics Scores with 6.21%, College Dance Band experience with 2.43%, High School Mixed Chorus experience with 1.72%, and ACT English Scores with 1.80%. The total contribution of the five variables is 21.16% of the variance of the scores, which leaves about 78% of the variance unaccounted for.

**Total Test Scores Versus Biographical Variables.** Table 19 shows that there were six biographical variables which contributed significantly to the multiple correlation coefficient, accounting for about 23% of the variance of the total test scores. ACT English scores had the highest contribution of 9.00%, followed in turn by College Dance Band experience with 6.21%, Years of Private Applied Lessons with 3.28%, ACT Mathematics scores with 1.76%, High School Mixed Chorus experience with 0.91%, and High School Concert Band experience with 1.88%.

Two variables, ACT English scores and College Dance Band experience made significant contributions to the multiple correlation coefficient in both test halves as well as in the total test scores. Of the six variables which made a significant contribution to R in the total test scores, five of them also made a significant contribution to R in the scores in the second test half, while only two variables made significant contributions in the scores on the first test half and total test scores.

Of the six variables which contributed significantly to R on the total test scores, four were variables which reflect musical background.
One variable reflected college level musical experience while two reflected experience at the high school level. The fourth musical variable reflected musical experience at both levels. The two non-music variables reflected academic experience at the high school level only.

Relationships of the Total Test Scores for the Four Melodic Shapes of the Twelve-Tone Rows to the Biographical Variables

Tables 20 and 21 contain the results of the regression analysis tests of total test scores for the four melodic shapes, 0, R, I, and RI, for the twelve-tone rows compared with the biographical variables.

Original Scores Versus Biographical Variables. Of the 43 biographical variables Table 20 shows that only four contributed significantly to R, accounting for about 15% of the variance in Original scores. ACT Composite scores contributed the most with 9.51%, followed in turn by High School Concert Band experience with 3.35%, High School Mixed Chorus experience with 1.48% and experience as a String player with 0.77%.

Retrograde Scores Versus Biographical Variables. Table 20 shows that only two biographical variables made significant contribution to R, accounting for 3.24% of the variance in the scores for Retrograde melodic shape. Experience as a String player made the greatest contribution to R, and Years of Private Applied Lessons made a smaller contribution.

Inversion Scores Versus Biographical Variables. Table 21 shows that four biographical variables made significant contributions to R,
Table 20

Relationships Between the Total Test Scores (128 Test Pairs) for Original and Retrograde Melodic Shapes and the Biographical Variables of 510 Subjects

<table>
<thead>
<tr>
<th>Original Scores</th>
<th>Biographical Variables</th>
<th>R</th>
<th>R^2</th>
<th>F</th>
<th>Per cent Increase in R^2</th>
</tr>
</thead>
<tbody>
<tr>
<td>DF 1</td>
<td>ACT Composite Scores</td>
<td>0.31</td>
<td>9.61</td>
<td>--</td>
<td>55.26</td>
</tr>
<tr>
<td></td>
<td>High School Concert Band Experience</td>
<td>0.36</td>
<td>12.96</td>
<td>3.35</td>
<td>18.29</td>
</tr>
<tr>
<td></td>
<td>High School Mixed Chorus Experience</td>
<td>0.38</td>
<td>14.44</td>
<td>1.48</td>
<td>8.52</td>
</tr>
<tr>
<td></td>
<td>String Player</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Years of Private Applied Lessons</td>
<td>0.18</td>
<td>3.24</td>
<td>1.28</td>
<td>6.83</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Retrograde Scores</th>
<th>Biographical Variables</th>
<th>R</th>
<th>R^2</th>
<th>F</th>
<th>Per cent Increase in R^2</th>
</tr>
</thead>
<tbody>
<tr>
<td>DF 1</td>
<td>String Player</td>
<td>0.14</td>
<td>1.96</td>
<td>--</td>
<td>9.46</td>
</tr>
</tbody>
</table>

* Significance is indicated by an F value of at least 6.00 at the one per cent level.
Table 21

Relationships Between the Total Test Scores (128 Test Pairs) for Inversion and Retrograde Inversion Melodic Shapes and the Biographical Variables of 510 Subjects

<table>
<thead>
<tr>
<th>Biographical Variables</th>
<th>Inversion Scores</th>
<th>Retrograde Inversion Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R</td>
<td>R²</td>
</tr>
<tr>
<td>DF</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Music Major</td>
<td>0.25</td>
<td>6.25</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>College Dance Band Experience</td>
<td>0.30</td>
<td>9.00</td>
</tr>
<tr>
<td>High School Glee Club Experience</td>
<td>0.31</td>
<td>9.61</td>
</tr>
<tr>
<td>Grade Point Average</td>
<td>0.33</td>
<td>10.89</td>
</tr>
</tbody>
</table>

* Significance is indicated by an F value of at least 6.00 at the one per cent level.
accounting for 10.89% of the variance in the Inversion scores. The variable Music major contributed the most with 6.25%, followed in turn by College Dance Band experience with 2.75%, High School Glee Club experience with 0.61%, and GPA with 1.28%.

Retrograde Inversion Scores Versus Biographical Variables. Table 21 shows that four biographical variables made significant contribution to R, accounting for 10.89% of the variance in Retrograde Inversion scores. The variable Music major contributed most with 5.76%, followed in turn by GPA with 2.65%, Years of Private Applied Lessons with 1.20%, and College Dance Band experience with 1.28%.

Of the eight different biographical variables which made significant contribution to R, two were nonmusic variables, the ACT Composite scores and GPA. Of the six music variables which contributed significantly to R two reflected high school level experience, two reflected college level experience and two reflected possible experience at both levels.

The highest accountable variance in test scores for the four melodic shapes was in the Original results, with 15.21%, which is in contrast to the accountable variance in total test scores, which was 23.04%.

Relationships of the Total Test Scores for the Four Treatments to the Biographical Variables

Tables 22 and 23 contain the results of the regression analysis tests of total test scores for the four treatments and the biographical variables.
<table>
<thead>
<tr>
<th>DF</th>
<th>Biographical Variables</th>
<th>Treatment I Scores</th>
<th>Treatment II Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R</td>
<td>R²</td>
<td>Per Cent Increase in R²</td>
</tr>
<tr>
<td>1</td>
<td>0.32</td>
<td>10.24</td>
<td>--</td>
</tr>
<tr>
<td>2</td>
<td>0.38</td>
<td>14.44</td>
<td>4.20</td>
</tr>
<tr>
<td>3</td>
<td>0.41</td>
<td>16.81</td>
<td>2.37</td>
</tr>
</tbody>
</table>

* Significance is indicated by an F value of at least 6.00 at the one per cent level.
Table 23

Relationships Between the Total Test Scores (128 Test Pairs) for Treatments III and IV and the Biographical Variables of 510 Subjects

<table>
<thead>
<tr>
<th>DF</th>
<th>Treatment III Scores</th>
<th>Treatment IV Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Biographical Variables</td>
<td>R</td>
</tr>
<tr>
<td>1</td>
<td>ACT English Scores</td>
<td>0.23</td>
</tr>
<tr>
<td>2</td>
<td>Music Major</td>
<td>0.28</td>
</tr>
<tr>
<td>3</td>
<td>College Dance Band Experience</td>
<td>0.29</td>
</tr>
<tr>
<td>4</td>
<td>High School Mixed Chorus Experience</td>
<td>0.32</td>
</tr>
</tbody>
</table>

* Significance is indicated by an F value of at least 6.00 at the one per cent level.
Treatment I Scores Versus Biographical Variables. From Table 22 it can be seen that three biographical variables contributed significantly to the multiple correlation coefficient (R), accounting for 16.81% of the variance in the Treatment I test scores. Years of Private Applied Lessons contributed 10.24%, followed in turn by ACT English Scores with 4.20% and College Dance Band experience with 2.37%.

Treatment II Scores Versus Biographical Variables. Table 22 shows that three biographical variables contributed significantly to R, accounting for 8.41% of the variance in Treatment II scores. High School Concert Band experience contributed 4.41%, followed by ACT Natural Science Scores with 2.35% and High School Mixed Chorus experience with 1.65%.

Treatment III Scores Versus Biographical Variables. Table 23 shows that four biographical variables contributed significantly to R and accounted for 10.24% of the variance in Treatment III scores. ACT English scores contributed 5.29%, followed by Music majors with 2.55%, College Dance Band experience with 0.57%, and High School Mixed Chorus experience with 1.83%.

Treatment IV Scores Versus Biographical Variables. Table 23 shows that four biographical variables contributed significantly to R accounting for 10.89% of the variance in Treatment IV test scores. GPA contributed most with 5.29%, followed by College Dance Band experience with 2.55%, ACT Mathematics scores with 1.77%, and experience as a Brass player with 1.28%.
Of the ten different variables which made significant contributions to R, six were music background variables and four were nonmusic variables. Of the four nonmusic variables three reflected academic attainment in high school and one at the college level. Of the six music variables, two reflected experience at the high school level, two at the college level and two reflected possible experience at both levels. The variable College Dance Band experience contributed to the variance in test scores in three of the four treatments, and ACT English scores contributed to the variance in test scores in two treatment phases.

Of the 43 variables isolated for use in the regression analysis only fourteen of them appeared at least once as a significant contributor to R in some phase of the analysis. Those music variables which did appear were:

- Experience in High School Concert Band, Mixed Chorus, Glee Club and Other Ensemble;
- College level experience in Dance Band;
- Experience as a Brass player or a String player;
- Years of Instruction on Instrument or Voice (Private Applied Lessons);
- Experience as a Music major in college.

The nonmusic variables which appeared were:

- Grade Point Average (GPA);
- Standard ACT Scores in English, Mathematics, and Natural Sciences and the ACT Composite Scores.

Relationships of the Total Test Scores to Combined Biographical Variables

There was no apparent consistency in appearance of the
biographical variables in the regression analysis results to this point, with the possible exception of appearance of College Dance Band experience, GPA and ACT English scores. The highest percentage in variance in scores was only 23.04% leaving 76.96% of the variance unaccounted for. A tentative conclusion is that combined measures of general musical background and general academic achievement should contribute significantly to a multiple correlation coefficient and that these combined variables may account for a greater percentage of the variance in test scores. In order to test this, an additional regression analysis was made with certain biographical variables combined. The new set of biographical variables were:

- Sex, Age, Rank, GPA, ACT Composite Score;
- Accounting Major;
- Agriculture Major;
- Business Administration Major;
- Elementary Education Major;
- English Major;
- History Major;
- Music Major;
- Physical Education Major;
- Undecided Major;
- Perfect Pitch;
- Experience playing:
  - Woodwind instrument
  - Brass instrument
  - Percussion instrument
  - Keyboard instrument
  - String instrument
- Experience as a vocalist;
- Experience playing other instrument(s);
- Years of private instruction on instrument or voice;
- Instrumental ensemble experiences (high school and college);
- Vocal ensemble experience (high school and college);
- Other ensemble experience (high school and college);
- Total ensemble experience (all ensembles at both levels).

Table 24 contains the results of the regression analysis with the
combined set of biographical variables. The variables reported have significant F values at the one per cent level.

Table 24

<table>
<thead>
<tr>
<th>Total Test Scores</th>
<th>Per Cent Increase in R²</th>
<th>F *</th>
</tr>
</thead>
<tbody>
<tr>
<td>DF</td>
<td>Biographical Variables</td>
<td>R</td>
</tr>
<tr>
<td>1</td>
<td>Total Ensemble Experience</td>
<td>0.36</td>
</tr>
<tr>
<td>2</td>
<td>ACT Composite Scores</td>
<td>0.43</td>
</tr>
<tr>
<td>3</td>
<td>Grade Point Average</td>
<td>0.45</td>
</tr>
<tr>
<td>4</td>
<td>Woodwind Player</td>
<td>0.46</td>
</tr>
</tbody>
</table>

* Significance is indicated by an F value of at least 6.00 at the one per cent level.

Of the new group of twenty-seven biographical variables only four contributed significantly to the multiple correlation coefficient, and they accounted for only 21.16% of the variance in the total test scores. Total Ensemble experience made the largest contribution of 12.96%, followed in turn by ACT Composite scores with 4.53% contribution, GPA with 2.76% contribution and experience as a Woodwind player with 0.91% contribution.

The tentative conclusion has been partially substantiated, in that a part of the general musical background and of the general academic achievement contributed to the variance in the total test scores.
scores, but the percentage of variance accounted for is no higher than the highest cumulative contribution as found in analysis of total test scores versus all biographical variables. Of importance is the fact that total musical ensemble experience contributed most to the multiple correlation coefficient.

Summary

A series of four stepwise linear regression analyses were performed on the test data in order to estimate the relationships between the test scores and certain background factors. The first test sought relationships between the scores in the two test halves and the total test scores with the forty-three biographical variables. College Dance Band experience, ACT English scores, GPA, Years of Private Applied Lessons, ACT Mathematics scores and experience in High School Mixed Chorus were significant contributors to the multiple correlation coefficient. The variables that contributed significantly to R on the second test half scores nearly approximate those which contributed significantly on the total test scores. The highest per cent of variance accounted for in the test scores was 23.04% in the total test scores.

The second analysis, seeking the relationships between the total test scores for the twelve-tone row and derivative melodic shapes and the biographical variables, showed that four variables appeared at least twice as significant contributors to R, these variables being experience as a String player, Years of Private Applied Lessons, experience in College Dance Band, and experience as a Music major.
The highest per cent of variance of melodic shape test scores which was accounted for was 15.21%, found in the Original scores.

The third analysis sought the relationships between the total test scores for the four treatments and the biographical variables. The variable College Dance Band experience appeared three times as a significant contributor to R. ACT English scores and experience in High School Mixed Chorus appeared twice as significant contributors to R. The highest per cent of variance in the test scores accounted for in the treatments test scores was 16.81% in Treatment I scores.

Because of the lack of evident consistency in the results and because of the low percentage of accountable variance in test scores, a fourth regression analysis was made using combined biographical variables and total test scores. The variables which contributed significantly to R were Total Ensemble experience, ACT Composite scores, GPA, and experience as a Woodwind player.

The highest cumulative variance found was only 23.04%, which left 76.96% of the variance unaccounted for. This remaining variance is due to unknown factors.
CHAPTER VI
RESULTS OF THE INFORMATION THEORY ANALYSIS

A Resume of the Development of Information or Communication Theory

Information or communication theory is not new to the various disciplines which engage in scientific research, and information theory concepts and methods have been employed in psychology and in music for over twenty years. The initial work in information theory was done by Hartley (1928) who published a paper which dealt with the sending of messages within certain defined communication systems, and which dealt with the basic mathematical aspects of sending and receiving messages. He proposed the first quantitative expression of information measurement. Hartley's paper went unnoticed until the late 1940's when Shannon (1948) published a paper which developed the logic and mathematics which serve as the basis for contemporary applications of information theory analysis. Weaver (1949) wrote a paper which explained Shannon's work, and the two articles, Shannon's and Weaver's, were subsequently combined in a single work, The Mathematical Theory of Communication, which was published in 1949. This bipartite publication has remained the prime source for information theory investigation.

Attneave (1959) wrote the book Applications of Information Theory to Psychology in which the concepts of information theory
are applied to hypothetical situations applicable to research in psychology. The method of applying information theory analysis is described in some detail.

The Terminology of Information Theory

Of most importance is an understanding of the term information. According to Attneave (1959):

Information is something which we gain by reading, or listening, or by directly observing the world about us ... we can gain information only about matters in which we are to some degree ignorant, or uncertain: indeed information may be defined as that which removes or reduced uncertainty (p. 1).

Weaver (1949) has defined information by projecting what it isn't:

The word information ... is used in a special sense that must not be confused with its ordinary usage. In particular, information must not be confused with meaning (p. 8).

Weaver continued:

To be sure, this word information in communication theory relates not so much to what you do say, as to what you could say. That is, information is a measure of one's freedom of choice when one selects a message (p. 8-9).

Moles (1966) says simply that information is quantitative (p. 19).

Coons and Kraehenbuehl (1958) defined information as "the technical term for a measure of the degree of randomness exhibited by a pattern of events" (p. 129), and these same authors later (1959) defined information "as the nonconfirmation of a prediction" (p. 511).

From these explanations we can derive the following:

Information a) removes or reduces uncertainty;
     b) should not be confused with meaning;
     c) is a measure of choice in selecting a message;
     d) is quantitative;
     e) is a measure of randomness in a pattern of events;
f) is the nonconfirmation of a prediction.

The unit of measure in information is the binary digit or bit. The derivation of the term stems from the use of logarithms to the base 2. According to Hiller and Bean (1966):

The binary number system, consisting only of the digits 0 and 1, is employed because it is postulated that all questions of information content can be reduced ultimately to the binary choice of 'yes-no' type decisions (p. 100).

Miller (1956) defined the bit as "the amount of information that we need to make a decision between two equally likely alternatives" (p. 83).

The amount of information transmitted from a source to a receptor, or the amount of information present in a communication system, is always referred to as the number of bits. For computations of information transmittal or content the capital letter "H" is used as a symbol to represent the quality measured and the bits or amount are the quantity measured. Thus, when the equation

\[ H = 2.32 \]

is encountered we say that there are 2.32 bits of information.

Another term in information theory is redundancy. Most authors explain or define redundancy by presenting its representative mathematical expression. Moles (1966) however, has provided us with an explicit definition of redundancy:

It is a measure of the relative 'wastage' of symbols in transmitting a given message (p. 42).

Hiller and Fuller (1967) have provided another interesting definition of redundancy:

Redundancy is an indication of the degree of order present in a message; the lower the redundancy, the nearer the message is to the random state (p. 76).
Perhaps one way of defining redundancy is to call it the measure of efficiency in a communication system.

Two other terms used in information theory contexts which are closely related are stochasticity and ergodicity. Attneave (1959) wrote:

A fundamental idea in information theory is that of the stochastic process. A stochastic process is any system which gives rise to a sequence of symbols to which probability laws apply (p. 13).

Cohen (1962) supports Attneave's definition:

In information theory, the output of any information source .... is considered a stochastic process, i.e., a random source emitting signs according to probabilities (p. 140).

It may be said simply that stochasticity is the predictability of a message. Ergodicity is created from a stochastic situation.

According to Attneave (1959):

A stochastic process is said to be ergodic if the probability laws which characterize it remain constant for all parts of the sequence (p. 13).

In other words, if one has a communication process which is stochastic, and if one analyzes segments of the total process individually, the communication process is said to be ergodic if the individual segments of the process are equally probable or predictable.

Information Theory and Music

Ward (1953) investigated the ability of people to identify isolated sine wave frequencies. By subjecting the results of testing to information theory analysis, he discovered that people with perfect pitch performed very well on the test whereas people without
perfect pitch fared poorly. Ward also found that the smaller the interval the greater the transfer of information. Pinkerton (1956) reported the results of a study of an informational analysis of melodies. He concluded:

... we have been able to calculate an entropy or average information per note, for certain kinds of elementary melody. This gives us an indication of the amount of meaning or information that can be expressed by such melodies. We have demonstrated that a certain amount of redundancy or repetition is necessary in order to have tuneful melodies. It is possible to give a quantitative measure of this redundancy (p. 86).

Pinkerton's remark about the need for redundancy in a "tuneful" melody could be inverted to the effect that in order to obtain a good twelve-tone melody there must be little or no redundancy.

Meyer (1957) explored the definitions "meaning" can have in an information theory-musical context and created the following definition:

Musical meaning arises when an antecedent situation, requiring an estimate as to the probable modes of pattern continuation, produces uncertainty as to the temporal-tonal nature of the expected consequent .... Both meaning and information are thus related through probability to uncertainty (p. 416).

By applying the intent of the above definition, it could be said that one reason there is little meaning for most people in twelve-tone music is because it is extremely difficult to predict future events ("modes of pattern continuation") if there is little transfer of information.

Meyer (1959), in a discussion of what makes music "great", included an application of information concepts to his research and dealt with the antecedent versus consequent tendencies in music and
how information measurement can help in predicting the consequents.

Meyer drew parallels between music and language since both are communication systems that have "an ordered probability system .... which serves to make the .... stimuli or events mutually relevant to one another" (p. 490). He examined the nature of the tendency of humans to seek a goal in a musical experience and related this tendency to a probability system which, Meyer said, was relatable to the information content in the music. Meyer summed this by quoting Wiener (1954):

".... the more probable the message, the less its information. Cliches, for example, are less illuminating than great poems (p. 490).

Meyer contended that events which upset the goal seeking tendencies lower the probability of consequent events, and, as such, they "create or increase information" (p. 490). It could be that the tendency of goal seeking is thwarted in twelve-tone music because of high information content, and conversely, because of a lack of associative redundancy.

The paper by Cohen (1962) is important to the development of information theory applications in music in that he a) attempted to explain the assumptions for information theory analyses done in music, b) provided a resume of the results of this research and c) criticized the research results (p. 137). Cohen reviewed information theory in terms of the application to musical contexts and reported three divisions into which the applications of information theory to music could be placed: a) analytic-synthetic, b) synthetic,
and c) analytic. The analytic-synthetic application involved the analysis of a musical composition, which analysis then served as the basis for synthetically generated musical samples; the synthetic application used a random source, the product from which was manipulated selectively; the analytic application was the use of information theory processes to determine style in music (p. 142).

Lewin (1968) reported the results of an informational approach to twelve-tone analysis. He assumed that:

... a listener's expectation of hearing any given interval of a twelve-tone row at a given moment is conditioned by the structure of the row, and also by the interval, and intervals, he has just heard previously (p. 50).

In the first of two conclusions, Lewin projected that perception of a row could be extremely good if a listener can recall at least three intervals back and can estimate the probability of a following interval (p. 51).

**Information Theory Application to this Investigation**

Since information and the transmittal of information are measurable, it was considered appropriate to measure the information contained in the communication system created by the aural discrimination test reported in this dissertation; and to measure the amount of information transmitted from the stimulus or source (the twelve-tone pairs) to the response or receptor (the responses to the aural discrimination tasks). If some pattern of information content and transmittal could be found in the test results, conclusions based on the results of such analysis could be helpful in creating generalizations about the perceptual qualities of the twelve-tone rows used
in the test.

The source used to construct the informational analyses was Attneave's (1959) *Applications of Information Theory to Psychology*. The logic and mathematical expressions which must be computed for such an analysis were taken from Chapter 3, "Man's Ability to Transmit Information," and a computer program, in FORTRAN IV-G language, was created using the contingency tables as input.

**Measures Calculated in this Investigation.**

Of prime interest in this investigation is the knowledge of the amount of information that is transmitted from stimulus to response, or from the aural source, the twelve-tone rows, to the receptor, as measured by the subjects' responses to the aural discrimination tasks. In order to calculate the amount of information transmitted, three other measures had to be calculated first. The formulae were taken from Attneave (1959), and without involving the derivation of the formulae, may be described as follows. The explanation of each measure includes the mathematical symbol as well as the equation used in the calculation.

The first two measures calculated were the amount of information per stimulus, $H(y)$, and the amount of information per response, $H(x)$. The "y" and "x" represent the axes of a Cartesian system, which is approximated in a contingency table. In the contingency tables presented in Chapter IV the stimulus sets are identified at the left side of each table while the possible responses are identified across the top of each table. The left
side is the "y" axis, and the top is the "x" axis, and the subscripts
"y" and "x" refer to the stimuli and responses respectively. The
formulae used in calculating the information per stimulus and
response are:

\[ H(y) = \log_2 N - \frac{1}{N} \sum N_i \log_2 N_i \]
\[ H(x) = \log_2 N - \frac{1}{N} \sum N_j \log_2 N_j \]

Where \( N \) is the total number of responses, \( i \) is any stimulus value
and \( j \) is any response value. The verbalization of the first formula
can be:

The information per stimulus, \( H(y) \), is equal to the log
of the total number of stimuli minus one over the total
number of stimuli times the sum of the stimulus values
times their logarithms.

The next value calculated was the amount of information contained
in the joint occurrence of a stimulus and a response, labelled
\( H(y,x) \). The formula for this calculation is:

\[ H(y,x) = \log_2 N - \frac{1}{N} \sum N_i, j \log_2 N_i, j \]

With these three values calculated, \( H(y) \), \( H(x) \), and \( H(y,x) \),
we can now calculate the transmittal of information from source
to receptor by simple mathematical manipulation of the three values.
Transmittal, or \( T(y,x) \) is obtained by adding the values of \( H(y) \)
and \( H(x) \) and subtracting from this sum the value of \( H(y,x) \).

\[ T(y,x) = H(y) + H(x) - H(y,x) \]

Two other measures derivable from the basic set of three are now
calculatable. The first is called the equivocation of transmission
or that amount of stimulus information lost by the subject. This
value, labelled $H_x(y)$, is obtained by subtracting the amount of information transmitted, $T(y,x)$, from the amount of information per stimulus, $H(y)$.

$$H_x(y) = H(y) - T(y,x)$$

The other value we can now calculate is the ambiguity or the amount of irrelevant information contained in the response. We can say more simply that ambiguity is a measure of the guess work done by the receptor or test subject in creating a response or test answer. This measure, $H_y(x)$, is computed by subtracting the amount of information transmitted, $T(y,x)$, from the amount of information per response, $H(x)$.

$$H_y(x) = H(x) - T(y,x)$$

Condensing the above explanations we see the six measures calculated and their mathematical symbols.

| Amount of information per stimulus | $H(y)$ |
| Amount of information per response | $H(x)$ |
| Information contained in the joint occurrence of a stimulus or response | $-H(y,x)$ |
| Information transmitted | $-T(y,x)$ |
| Equivocation | $-H_x(y)$ |
| Ambiguity | $-H_y(x)$ |

Information Theory Analysis Part I: Analysis of All 621 Subjects Responses Reported by Treatment

Table 25 shows the results of the information theory analysis results of all subjects' responses to the aural discrimination tasks. The left side of the table identifies the information measures calculated for each treatment, and the top of the table identifies the rows. The amount of stimulus information, $H(y)$, for each of the rows is 2.00 bits of information. This pattern follows what
Table 25

Information Measures of All 621 Subjects*  
Responses Grouped By Treatment

<table>
<thead>
<tr>
<th>Measure</th>
<th>Row 1</th>
<th>Row 2</th>
<th>Row 3</th>
<th>Row 4</th>
<th>Mean Measure</th>
<th>All Rows</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Mean</td>
<td></td>
</tr>
<tr>
<td>H(y)</td>
<td>2.00</td>
<td>2.00</td>
<td></td>
<td></td>
<td>2.00</td>
<td></td>
</tr>
<tr>
<td>H(x)</td>
<td>1.90</td>
<td>1.93</td>
<td></td>
<td></td>
<td>1.90</td>
<td></td>
</tr>
<tr>
<td>H(y,x)</td>
<td>3.59</td>
<td>3.55</td>
<td>3.45</td>
<td>3.53</td>
<td>3.54</td>
<td></td>
</tr>
<tr>
<td>T(y,x)</td>
<td>0.31</td>
<td>0.38</td>
<td>0.42</td>
<td>0.35</td>
<td>0.37</td>
<td>Transmittal</td>
</tr>
<tr>
<td>Hx(y)</td>
<td>1.69</td>
<td>1.62</td>
<td>1.58</td>
<td>1.65</td>
<td>1.64</td>
<td>Equivocation</td>
</tr>
<tr>
<td>Hy(x)</td>
<td>1.59</td>
<td>1.55</td>
<td>1.45</td>
<td>1.53</td>
<td>1.53</td>
<td>Ambiguity</td>
</tr>
<tr>
<td>H(y)</td>
<td>2.00</td>
<td>2.00</td>
<td></td>
<td></td>
<td>2.00</td>
<td></td>
</tr>
<tr>
<td>H(x)</td>
<td>1.92</td>
<td>1.89</td>
<td>1.95</td>
<td>1.88</td>
<td>1.91</td>
<td></td>
</tr>
<tr>
<td>H(y,x)</td>
<td>3.88</td>
<td>3.82</td>
<td>3.78</td>
<td>3.85</td>
<td>3.84</td>
<td></td>
</tr>
<tr>
<td>T(y,x)</td>
<td>0.04</td>
<td>0.07</td>
<td>0.17</td>
<td>0.04</td>
<td>0.08</td>
<td>Transmittal</td>
</tr>
<tr>
<td>Hx(y)</td>
<td>1.96</td>
<td>1.93</td>
<td>1.83</td>
<td>1.96</td>
<td>1.92</td>
<td></td>
</tr>
<tr>
<td>Hy(x)</td>
<td>1.88</td>
<td>1.83</td>
<td>1.78</td>
<td>1.85</td>
<td>1.83</td>
<td></td>
</tr>
<tr>
<td>H(y)</td>
<td>2.00</td>
<td>2.00</td>
<td></td>
<td></td>
<td>2.00</td>
<td></td>
</tr>
<tr>
<td>H(x)</td>
<td>1.94</td>
<td>1.91</td>
<td>1.95</td>
<td>1.94</td>
<td>1.93</td>
<td></td>
</tr>
<tr>
<td>H(y,x)</td>
<td>3.80</td>
<td>3.79</td>
<td>3.73</td>
<td>3.74</td>
<td>3.78</td>
<td></td>
</tr>
<tr>
<td>T(y,x)</td>
<td>0.14</td>
<td>0.12</td>
<td>0.23</td>
<td>0.19</td>
<td>0.17</td>
<td>Transmittal</td>
</tr>
<tr>
<td>Hx(y)</td>
<td>1.86</td>
<td>1.88</td>
<td>1.77</td>
<td>1.81</td>
<td>1.83</td>
<td></td>
</tr>
<tr>
<td>Hy(x)</td>
<td>1.80</td>
<td>1.79</td>
<td>1.73</td>
<td>1.74</td>
<td>1.76</td>
<td></td>
</tr>
<tr>
<td>H(y)</td>
<td>2.00</td>
<td>2.00</td>
<td></td>
<td></td>
<td>2.00</td>
<td></td>
</tr>
<tr>
<td>H(x)</td>
<td>1.83</td>
<td>1.87</td>
<td>1.87</td>
<td>1.90</td>
<td>1.87</td>
<td></td>
</tr>
<tr>
<td>H(y,x)</td>
<td>3.77</td>
<td>3.81</td>
<td>3.82</td>
<td>3.88</td>
<td>3.82</td>
<td></td>
</tr>
<tr>
<td>T(y,x)</td>
<td>0.07</td>
<td>0.05</td>
<td>0.05</td>
<td>0.02</td>
<td>0.05</td>
<td>Transmittal</td>
</tr>
<tr>
<td>Hx(y)</td>
<td>1.94</td>
<td>1.95</td>
<td>1.95</td>
<td>1.98</td>
<td>1.96</td>
<td></td>
</tr>
<tr>
<td>Hy(x)</td>
<td>1.77</td>
<td>1.81</td>
<td>1.82</td>
<td>1.88</td>
<td>1.82</td>
<td></td>
</tr>
</tbody>
</table>
Attneave (1959) predicted in his discussion of the stimulus information. In order for an information theory analysis to be appropriate to this investigation, the stimuli have to be stochastic, that is equiprobable. Since there are four stimuli, that is, four basic aural pairs which were used in the test, and since they appeared an equal number of times and were randomized, the probability that any one of the pairs would occur is the same for any other pair; or they all are equiprobable. Thus, the amount of information per stimulus is simply the \( \log_2 4 \), which is 2.00. It will be seen that in all of the information theory results tables presented, the amount of information per stimulus is the same, that is, \( H(y) = 2.00 \) in all cases.

**Treatment I.** In Treatment I no alteration was made in the second twelve-tone row of each test pair. The amount of information contained per response for the four rows in treatment phase I ranged from 1.93 down to 1.87 bits. Since the values of information per response do not equal the amount of information per stimulus, and they should not since, if \( H(y) = H(x) \) the information or communication system is suspect, we may assume that some of the stimulus information was lost. However, when looking at the transmittal values ranging from 0.42 down to 0.31 bits we can see that very little information was actually transmitted from the row pairs to the test answers. The explanation for this becomes obvious when we look at the equivocation and ambiguity values.

Both the equivocation and ambiguity values are high. The
equivocation values range from 1.69 down to 1.58 bits and the ambiguity values range from 1.59 to 1.45 bits. With a value of only 2.00 bits of information present per stimulus, equivocation and ambiguity appear to be of some consequence in explaining the poor transmittal of the information from stimulus to response. All this is to say that a) there was a great deal of stimulus information lost by the test subjects, amounting to about 1.6 bits per stimulus, and b) there was a great deal of guessing being done by the test subjects amounting to about 1.5 bits per response. Another important result is shown by the differences in the equivocation and ambiguity results. It can be seen that the equivocation values are consistently higher than the ambiguity values, indicating that there was more stimulus information lost than information created by guessing. This data is representative of the difficulty the subjects encountered in correctly identifying the shape of the second item of each test pair.

**Treatment II.** Treatment II involved the transposition of the second twelve-tone row of each test pair. By reviewing the Treatment II portion of Table 25 we can see that the amount of information per response is slightly higher than in Treatment I results, and we see that the values for the transmittal of information are much lower than in Treatment I. The values for equivocation and ambiguity are much higher than reported for Treatment I. It would appear that introducing transposition in the test complicated the matter for the test subjects.
Specifically, the amounts of information per response range from 1.95 down to 1.88 bits with an average of 1.91 bits. The amounts of information transmitted range from 0.17 down to 0.04 bits with an average transmittal of 0.08 bits. The explanation for the low transmittal values again can be found in the equivocation and ambiguity values. The equivocation values range from 1.96 to 1.83 bits, which indicates a great deal of loss in stimulus information and the ambiguity values range from 1.88 to 1.78 bits indicating a high degree of guessing by the test subjects. With 2.00 bits of information per stimulus in this treatment phase there was an average loss of 1.92 bits of information per stimulus, and with an average of 1.91 bits per response, the test subjects provided or guessed an average of 1.83 bits per response.

Treatment III. Treatment III involved octave displacement of a note within the second twelve-tone row of each test pair. The values for information per response are higher in Treatment III than in Treatment II, and the values for information transmittal are also higher than in Treatment II. The values for equivocation and ambiguity are lower than in Treatment II. Specifically, the values for information per response range from 1.95 bits down to 1.91 bits with a mean of 1.93 bits. The amounts of information transmitted range from 0.23 to 0.12 bits with an average of 0.17 bits. The amount of information transferred is quite low, although higher on the average than in Treatment II, as the equivocation and ambiguity values show. The equivocation values range from 1.88 down to 1.77...
bits, with an average loss of 1.83 bits of information for every 2.00 bits of information in each stimulus. The ambiguity values range from 1.80 down to 1.73 bits with an average of about 1.76 bits provided or guessed by the subjects for an average of 1.93 bits per response. Again, there was quite a bit of stimulus information lost and extra information created or guessed by the subjects, although, as has been stated, the values are higher than those in Treatment II.

Treatment IV. Treatment IV involved transposition of the second twelve-tone row of each test pair in conjunction with octave displacement of a note within the row. Results from Table 25 show Treatment IV to have the lowest average transmittal values for all subjects, and the highest average equivocation values for all subjects. The values for information per response range from 1.90 to 1.83 bits, with an average of 1.87 bits. The values for the information transmitted range from 0.07 down to 0.02 bits, with an average of 0.05 bits, which is the lowest of the four treatments. These extremely low transmittal values show that a very small amount of information was transmitted from the stimulus to response. The values for equivocation range from 1.98 down to 1.94 bits with an average stimulus loss of 1.96 bits of every 2.00 bits of stimulus information. The ambiguity values range from 1.88 down to 1.77 bits with an average guess of 1.82 bits for approximately 1.87 bits of information per response.

Table 26 contains the mean or average values for information
per response, information transmitted, equivocation or stimulus information lost, and ambiguity or the amount of guessing for the four treatments. The bar above each symbol, i.e., $\bar{H}$, is the mathematical symbol for the mean or average value.

**Table 26**

Mean Information Values for All 621 Subjects Grouped by Treatments

<table>
<thead>
<tr>
<th>Measures</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\bar{H}(x)$</td>
<td>1.90</td>
<td>1.91</td>
<td>1.93</td>
<td>1.87</td>
</tr>
<tr>
<td>$H(y,x)$</td>
<td>0.37</td>
<td>0.08</td>
<td>0.17</td>
<td>0.05</td>
</tr>
<tr>
<td>$H_x(y)$</td>
<td>1.64</td>
<td>1.92</td>
<td>1.83</td>
<td>1.96</td>
</tr>
<tr>
<td>$H_y(x)$</td>
<td>1.53</td>
<td>1.83</td>
<td>1.76</td>
<td>1.82</td>
</tr>
</tbody>
</table>

It can be seen that Treatment I gave the best results, in that Treatment I had the highest information transmittal, the lowest equivocation or stimulus loss, and the lowest ambiguity or guessing. This means that when no alteration was made in the second twelve-tone row of each test pair the amount of information that was transmitted from the test pairs to the listeners, as measured by their responses to the test pairs, was highest of the four treatments, the amount of stimulus information lost was lowest of the four treatments and the amount of information created or guessed by the subjects was lowest of the four treatments.

**Information Theory Analysis Part II; Results of All 621 Subjects' Responses Reported by Row**

Table 27 contains the information theory analysis results for all subjects' responses to the aural discrimination tasks, presented by row. The left side of the table identifies the information
<table>
<thead>
<tr>
<th>Measure</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>Treatments</th>
<th>Mean Measure</th>
<th>All Treatments</th>
</tr>
</thead>
<tbody>
<tr>
<td>$H(y)$</td>
<td>2.00</td>
<td>2.00</td>
<td>2.00</td>
<td>2.00</td>
<td>$H(y)$</td>
<td>2.00</td>
<td>Stimulus</td>
</tr>
<tr>
<td>$H(x)$</td>
<td>1.90</td>
<td>1.92</td>
<td>1.94</td>
<td>1.83</td>
<td>$H(x)$</td>
<td>1.90</td>
<td>Response</td>
</tr>
<tr>
<td>$H(y,x)$</td>
<td>3.59</td>
<td>3.88</td>
<td>3.80</td>
<td>3.77</td>
<td>$H(y,x)$</td>
<td>3.76</td>
<td>Joint S-R</td>
</tr>
<tr>
<td>$T(y,x)$</td>
<td>0.31</td>
<td>0.04</td>
<td>0.14</td>
<td>0.07</td>
<td>$T(y,x)$</td>
<td>0.14</td>
<td>Transmittal</td>
</tr>
<tr>
<td>$H(x,y)$</td>
<td>1.69</td>
<td>1.96</td>
<td>1.80</td>
<td>1.77</td>
<td>$H(x,y)$</td>
<td>1.86</td>
<td>Equivocation</td>
</tr>
<tr>
<td>$H(y,x)$</td>
<td>1.59</td>
<td>1.88</td>
<td>1.80</td>
<td>1.77</td>
<td>$H(y,x)$</td>
<td>1.76</td>
<td>Ambiguity</td>
</tr>
<tr>
<td>$H(y)$</td>
<td>2.00</td>
<td>2.00</td>
<td>2.00</td>
<td>2.00</td>
<td>$H(y)$</td>
<td>2.00</td>
<td>Stimulus</td>
</tr>
<tr>
<td>$H(x)$</td>
<td>1.93</td>
<td>1.89</td>
<td>1.91</td>
<td>1.87</td>
<td>$H(x)$</td>
<td>1.90</td>
<td>Response</td>
</tr>
<tr>
<td>$H(y,x)$</td>
<td>3.55</td>
<td>3.83</td>
<td>3.79</td>
<td>3.81</td>
<td>$H(y,x)$</td>
<td>3.75</td>
<td>Joint S-R</td>
</tr>
<tr>
<td>$T(y,x)$</td>
<td>0.38</td>
<td>0.07</td>
<td>0.12</td>
<td>0.05</td>
<td>$T(y,x)$</td>
<td>0.16</td>
<td>Transmittal</td>
</tr>
<tr>
<td>$H(x,y)$</td>
<td>1.62</td>
<td>1.93</td>
<td>1.88</td>
<td>1.95</td>
<td>$H(x,y)$</td>
<td>1.85</td>
<td>Equivocation</td>
</tr>
<tr>
<td>$H(y,x)$</td>
<td>1.55</td>
<td>1.83</td>
<td>1.79</td>
<td>1.81</td>
<td>$H(y,x)$</td>
<td>1.75</td>
<td>Ambiguity</td>
</tr>
<tr>
<td>$H(y)$</td>
<td>2.00</td>
<td>2.00</td>
<td>2.00</td>
<td>2.00</td>
<td>$H(y)$</td>
<td>2.00</td>
<td>Stimulus</td>
</tr>
<tr>
<td>$H(x)$</td>
<td>1.87</td>
<td>1.95</td>
<td>1.95</td>
<td>1.87</td>
<td>$H(x)$</td>
<td>1.91</td>
<td>Response</td>
</tr>
<tr>
<td>$H(y,x)$</td>
<td>3.45</td>
<td>3.78</td>
<td>3.73</td>
<td>3.82</td>
<td>$H(y,x)$</td>
<td>3.70</td>
<td>Joint S-R</td>
</tr>
<tr>
<td>$T(y,x)$</td>
<td>0.42</td>
<td>0.17</td>
<td>0.23</td>
<td>0.05</td>
<td>$T(y,x)$</td>
<td>0.22</td>
<td>Transmittal</td>
</tr>
<tr>
<td>$H(x,y)$</td>
<td>1.58</td>
<td>1.83</td>
<td>1.77</td>
<td>1.95</td>
<td>$H(x,y)$</td>
<td>1.78</td>
<td>Equivocation</td>
</tr>
<tr>
<td>$H(y,x)$</td>
<td>1.45</td>
<td>1.78</td>
<td>1.73</td>
<td>1.82</td>
<td>$H(y,x)$</td>
<td>1.70</td>
<td>Ambiguity</td>
</tr>
<tr>
<td>$H(y)$</td>
<td>2.00</td>
<td>2.00</td>
<td>2.00</td>
<td>2.00</td>
<td>$H(y)$</td>
<td>2.00</td>
<td>Stimulus</td>
</tr>
<tr>
<td>$H(x)$</td>
<td>1.88</td>
<td>1.88</td>
<td>1.94</td>
<td>1.90</td>
<td>$H(x)$</td>
<td>1.90</td>
<td>Response</td>
</tr>
<tr>
<td>$H(y,x)$</td>
<td>3.53</td>
<td>3.85</td>
<td>3.74</td>
<td>3.88</td>
<td>$H(y,x)$</td>
<td>3.75</td>
<td>Joint S-R</td>
</tr>
<tr>
<td>$T(y,x)$</td>
<td>0.35</td>
<td>0.04</td>
<td>0.19</td>
<td>0.02</td>
<td>$T(y,x)$</td>
<td>0.15</td>
<td>Transmittal</td>
</tr>
<tr>
<td>$H(x,y)$</td>
<td>1.65</td>
<td>1.96</td>
<td>1.81</td>
<td>1.98</td>
<td>$H(x,y)$</td>
<td>1.85</td>
<td>Equivocation</td>
</tr>
<tr>
<td>$H(y,x)$</td>
<td>1.53</td>
<td>1.85</td>
<td>1.74</td>
<td>1.88</td>
<td>$H(y,x)$</td>
<td>1.75</td>
<td>Ambiguity</td>
</tr>
</tbody>
</table>
measures calculated and the rows, and the top of the table identifies the treatments.

**Row 1.** The values for information per response for Row 1 results range from 1.94 to 1.83 bits with an average value of 1.90 bits. The values for information transmitted range from 0.31 to 0.04 bits, which range is greater than those found in Table 13. The average value for information transmitted is 0.14 bits. The amount of information transmitted is low, with the equivocation and ambiguity values high. The equivocation values range from 1.96 to 1.69 bits, with a mean value of 1.86 bits. The ambiguity values range from 1.88 to 1.59 bits with a mean value of 1.76 bits. Of particular interest are the values for Treatment I. In the Row 1 results from Table 27, the Treatment I results show the highest transmittal values, and the lowest stimulus lost and guess values. The treatment with the next best transmittal is Treatment III. Treatment II shows the lowest transmittal values as well as the highest values for equivocation and ambiguity.

**Row 2.** As can be seen in Table 27 the Row 2 transmittal values approximate those for Row 1, with a range from 0.38 to 0.05 bits and an average of 0.16 bits. The values for information per response for Row 2 range from 1.93 to 1.87 bits with an average of 1.90 bits, the same for Row 1 results. The values for equivocation and ambiguity, ranging from 1.95 to 1.62 bits and 1.83 to 1.55 bits respectively, approximate the values for Row 1 results, and the means for both measures are 1.85 bits for equivocation and 1.75 bits for ambiguity.
each only 1/100th of a bit different from the comparable values for Row 1 results. As was the case in the Row 1 results, Treatment I had the best transmittal results, Treatment III next best, and Treatment IV the worst results.

Row 3. The Row 3 results do not approximate those of Row 1 as nearly as those of Row 2, as can be seen by comparing the respective means. The Row 3 values for information per response range from 1.95 to 1.87 bits with a mean value of 1.91 bits. The transmittal values range from 0.42 to 0.05 bits with a mean value of 0.22 bits, the highest yet encountered in this phase of the report. The values for equivocation range from 1.95 to 1.58 bits with a mean value of 1.78 bits, and the ambiguity values range from 1.82 to 1.45 bits with a mean value of 1.70 bits. The results for Treatment I show the highest transmittal and the lowest stimulus information and guessing values for this table. Treatment III results are next best, based on the transmittal value, and Treatment II is the third and Treatment IV last, again based on the transmittal values. This matches the pattern for Row 2 results, although the Row 3 results are a bit better, which is to say, Row 3 showed higher transmittal values and lower equivocation and ambiguity values than Row 2 results.

Row 4. The Row 4 results of information per response range from 1.94 to 1.88 bits with mean value of 1.90 bits. The transmittal values range from 0.35 to 0.02 bits with a mean value of 0.15 bits. The values for equivocation range from 1.98 to 1.65 bits with a mean value of 1.85 bits and the ambiguity values range from 1.88 to
1.53 bits with a mean value of 1.75 bits. Treatment I results are the best in this table, with the highest transmittal value and lowest equivocation and ambiguity values. Treatment III results are second best, and Treatment II results are third best, based on transmittal values. Treatment IV results show the lowest transmittal values and the highest equivocation and ambiguity values.

Table 28 contains the mean values for information per response, transmittal, equivocation and ambiguity for each row with the treatments collapsed. The mean response values for all four rows is nearly the same, while the mean values for transmittal vary. Row 3 showed the best mean transmittal value, followed in turn by Rows 4, 2, then Row 1. Row 3 showed the lowest mean equivocation value, and the lowest mean ambiguity value.

Table 28

<table>
<thead>
<tr>
<th>Measure</th>
<th>Row 1</th>
<th>Row 2</th>
<th>Row 3</th>
<th>Row 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>$H(x)$</td>
<td>1.90</td>
<td>1.90</td>
<td>1.91</td>
<td>1.90</td>
</tr>
<tr>
<td>$T(y,x)$</td>
<td>0.14</td>
<td>0.16</td>
<td>0.22</td>
<td>0.15</td>
</tr>
<tr>
<td>$H_x(y)$</td>
<td>1.86</td>
<td>1.85</td>
<td>1.78</td>
<td>1.85</td>
</tr>
<tr>
<td>$H_y(x)$</td>
<td>1.76</td>
<td>1.75</td>
<td>1.70</td>
<td>1.75</td>
</tr>
</tbody>
</table>

These results support hypothesis two, that a Schoenbergian twelve-tone row and derivatives would be harder to identify than non-Schoenbergian rows, as was demonstrated by the analysis of variance results reported in Chapter III. Row 1, the Schoenberg row, showed the lowest mean transmittal value as well as high
equivocation and ambiguity values.

Table 29 shows the ranking of each treatment on a row by row basis as derived from the information theory analysis results. The numbers in the cells indicate the rank, with 1 being the best ranking, indicating the best transmittal values, and 4 being the lowest ranking indicating the worst transmittal.

### Table 29

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Row 1</th>
<th>Row 2</th>
<th>Row 3</th>
<th>Row 4</th>
<th>Mean</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3.25</td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2.0</td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>3.75</td>
<td></td>
</tr>
</tbody>
</table>

The best transmittal values appeared in Treatment I, where there was no serial treatment of the row or derivatives in the second item of each test pair. The next best transmittal values appeared in Treatment III, in which a note was displaced within the rows and derivatives. Treatment II, in which transposition of the row and derivatives was introduced, was next best in ranking. The lowest ranking was for Treatment IV in which transposition was combined with displacement of a note within a row or derivatives.

This ranking pattern is supported by the contingency table analysis results which, based on the number of correct responses to the aural discrimination tasks, showed Treatment I with the highest level of correct responses, Treatment III next best, followed by
Treatments II and IV.

Summary

An information theory analysis was performed on the contingency tables in order to determine the amounts of information transmittal from the stimulus (the twelve-tone pairs) to the receptors (as measured by the subjects' responses to the aural discrimination tasks). The results were arranged by treatments and by twelve-tone row. The results arranged by twelve-tone row showed that Row 1, the Schoenberg row, had the lowest transmittal values, while Row 3 had the best transmittal value. A ranking of all four rows, based on the transmittal values, shows Row 3 to have the best transmittal, followed by Rows 2, 4, and 1. The results arranged by treatment showed that in all cases the amount of information per stimulus was 2.00 bits, while the amount of information per response ranged from 1.95 bits to 1.87 bits. At first glance these figures would appear to be feasible in that it can be expected that there may be some stimulus information lost in communication and therefore the amount of information per response would be lower than the amount of information per stimulus. However, when reviewing the figures for transmittal, equivocation and ambiguity, which is to say, how much stimulus information actually was received, how much stimulus information was lost, and how much guessing was done, we see that there was very low transmittal, considerable stimulus information lost, and a great deal of guessing done by the subjects. Of interest is the fact that there was more stimulus information lost than ambiguous information.
created by the subjects. The composite mean for equivocation was 1.84 bits of stimulus information lost, while the composite mean for ambiguity was 1.74 bits of information created by the subjects.

Treatment I showed the best results of the four treatments, having the highest mean transmittal, $T(y,x) = 0.37$ bits, the lowest mean equivocation, $H_x(y) = 1.64$ bits, and the lowest mean ambiguity, $H_y(x) = 1.53$ bits of the four treatments. Treatment III had the next best results with mean transmittal of 0.17 bits, mean equivocation of 1.83 bits and mean ambiguity of 1.83 bits. Treatment II is next best with mean transmittal of 0.08 bits, mean equivocation of 1.92 bits and mean ambiguity of 1.83 bits. Treatment IV had the lowest mean transmittal value, 0.05 bits, the highest mean equivocation value, 1.96 bits, and the next to highest ambiguity value, 1.82 bits. These results reinforce the contingency table analysis and analysis of variance results which supported hypotheses 3, 4, and 5, to the effect that octave displacement of a note in a row, transposition of a row, and the combination of octave displacement and transposition makes rows and derivatives so treated harder to identify than rows and derivatives not treated.

These results also support the ranking of influence of the treatments as developed from the contingency table analysis results. The information theory analysis results show that Treatment I results were best, followed in turn by Treatments III, II, and IV.
CHAPTER VII

CONCLUSIONS AND SUGGESTIONS FOR ADDITIONAL RESEARCH

Conclusions Regarding the Hypotheses

The first hypothesis was:

The order of difficulty in identifying a row and its derivatives is as follows: the easiest to identify is the original row itself, followed in order by retrograde, inversion, and retrograde inversion.

The results of the analyses of variance test supported the hypothesis to the extent that the original was shown easiest to identify, the retrograde inversion was shown hardest to identify, and the retrograde and inversion were shown harder to identify than the original but easier to identify than the retrograde inversion. The error term reported in the analysis of variance test results was large, indicating variation in the overall pattern. This variation was identified in the results of the contingency tables analysis, which showed that the order of difficulty changed when the row and derivatives were transposed or when the row and derivatives were transposed in combination with octave displacement of a note within the row.

The second hypothesis was:

A Schoenbergian row and derivatives are harder to identify than a symmetrical row and derivatives not composed by Schoenberg.

The results of the analysis of variance test support this
hypothesis. The Schoenberg twelve-tone row (Row 1) received the lowest mean score of the four twelve-tone rows used in the test. The information theory analysis results also support this hypothesis, in that the Schoenberg twelve-tone row received the lowest mean transmittal value, a high mean equivocation value (that is, information lost), and a high ambiguity value (that is, information created or guessed by the subjects).

Hypothesis three was:

The octave displacement of a note within a row makes it harder to identify a row and its derivatives with such displacement than a row and derivatives without displacement.

The results of the analysis of variance test support this hypothesis. In Treatment III octave displacement of a note within the twelve-tone row was introduced, and the mean correct score for Treatment III was significantly lower than the mean correct score for Treatment I in which the second twelve-tone row of each test pair was left unaltered. The information theory analysis results also support the hypothesis. Treatment III had a mean transmittal value that was lower than that for Treatment I, and Treatment III had mean equivocation and mean ambiguity values that were higher than in Treatment I. This indicates that in Treatment III more information was lost and more information created by guessing than in Treatment I.

Hypothesis four was:

Transposing a row and its derivatives makes identification of a transposed row and derivatives
harder to identify than a non-transposed row and derivatives.

The analysis of variance results support this hypothesis. Treatment II introduced transposition of the second twelve-tone row of each test pair, and the mean correct score for Treatment II was significantly lower than the mean correct score for Treatment I. The hypothesis was also supported by the information theory analysis results. Treatment II had a mean transmittal value that was lower than that for Treatment I, and Treatment II had mean equivocation and mean ambiguity values that were higher than in Treatment I. This indicates that in Treatment II more information was lost and more information created by guessing than in Treatment I.

Hypothesis five was:

The transposition of a row and its derivatives in conjunction with octave displacement of a note within the same row and derivatives will make identification of a row and derivatives treated in this fashion harder than a row and derivatives which are untreated.

This hypothesis was supported by the analysis of variance results. Treatment IV involved transposition and octave displacement of a note within the row. The mean correct score of Treatment IV was significantly lower than the score for Treatment I. The information theory analysis also supported the hypothesis in that Treatment IV had the lowest mean transmittal value, and Treatment IV had the highest equivocation and ambiguity values of the four treatments. This means that of the four treatments, Treatment IV showed the highest amount of information lost and the highest
amount of information created by guessing.

From the foregoing it can be concluded that:

1) The order of difficulty in identifying a twelve-tone row and its derivatives is: The original is easiest to identify, the retrograde inversion is hardest to identify, and the retrograde and inversion were harder to identify than the original but easier than the retrograde inversion;

2) the Schoenberg twelve-tone row used in this test was harder to identify than any of the three symmetrical rows used;

3) identification of a twelve-tone row and derivatives is made more difficult by transposition;

4) identification of a twelve-tone row and derivatives is made more difficult by displacing a note within the row an octave; and

5) identification of a twelve-tone row and derivatives is made more difficult by transposition in conjunction with octave displacement of a note within the row.

Conclusions Beyond the Hypotheses

Ranking of the Twelve-Tone Rows. A ranking of the four twelve-tone rows used in the test appeared in the results of the analysis of variance and the information theory analysis. The analysis of variance results showed that Row 3, the symmetrical row that approximated a short peaked melody with low beginning and end, had the highest mean score, followed in turn by Rows 2, 4, and 1. However, the differences in mean scores for Rows 2 and 4 were shown not significant. The information theory analyses results, based on mean transmittal
values, showed Row 3 to have the highest transmittal value, followed in turn by Rows 2, 4, and 1. It can be concluded that:

6) Of the four twelve-tone rows used in the test, Row 3, a symmetrical twelve-tone row that approximated a short peaked melody with a low beginning and end, was the easiest to identify. This was followed in turn by either Row 2, a symmetrical twelve-tone row which had minor sevenths at the end of each hexachord or by Row 4, which was a symmetrical twelve-tone row with a tritone-perfect fourth combination of intervals at the beginning of each hexachord. Row 1, the non-symmetrical twelve-tone row composed by Schoenberg, was the hardest to identify.

**Ranking of the Treatments.** A ranking of the treatments appeared in the results of the analysis of variance, contingency tables analysis and information theory analysis tests. Treatment I, in which the second twelve-tone row of each test pair was unaltered, had the highest mean score, followed in order by Treatment III, which involved octave displacement of a note within the second twelve-tone row of each test pair, Treatment II, which involved the transposition of the second twelve-tone row of each test pair, and Treatment IV, which involved transposition of the second twelve-tone row of each test pair in conjunction with octave displacement of a note within the row. Treatment I had the highest number of correct responses to the test items, followed in turn by Treatments III, II, and IV, and Treatment I had the highest mean transmittal value, followed in turn by Treatments III, II, and IV. It can be concluded that:
7) Treatment I, in which the second twelve-tone row of each test pair was unaltered, showed the best results, followed in turn by Treatment III, involving the octave displacement of a note within the second twelve-tone row of each test pair; Treatment II, involving transposition of the second twelve-tone row of each test pair; and Treatment IV, which involved the transposition of the second twelve-tone row in each test pair in conjunction with octave displacement of a note within the row.

Conclusions Regarding Biographical Factors. The analysis of variance results showed that, of a group of six majors within the total test population, the Music majors performed best, in that they showed the highest mean score. Those factors which contributed significantly to the variance in test scores were total ensemble experience, the ACT Composite score, reflecting academic achievement in high school, GPA, reflecting academic achievement in college, and experience as a Woodwind player. These factors accounted for 21.16% of the test scores variance, leaving a variance of 78.84% due to unknown factors. It can be concluded that:

8) Music majors performed better than any other majors who took the test; and

9) experience in a musical ensemble in high school or college, the ACT Composite score, GPA, and experience as a Woodwind player are related to the variance in test scores.

Conclusion Regarding the Perceptibility of Twelve-Tone Rows

The perceptibility of the twelve-tone rows used in this
investigation depend on several factors. The type of row, that is, the configurational and intervalic properties of each row must be considered. The differences between the three symmetrical rows and the Schoenberg row, as determined by the results of the analysis of variance and information theory analysis, point to this. Identification of the symmetrical row which approximated a short melody with a low beginning and ending and a high middle (Row 3) was easier than identifying the Schoenberg row (Row 1) which had several characteristic intervals at beginning and end.

The shape of the various derivatives also was a contributing factor in determining the degree of perceptibility of a twelve-tone row. The results of the analysis of variance test and the contingency table analysis showed the ranking of the shapes to be 0, R, I, and RI, with 0 being the easiest to identify and RI the hardest to identify. The serial treatments to which the row and derivatives were subjected showed a consistent pattern of influence. Transposing a twelve-tone row, displacing a note within the twelve-tone row, and transposing the twelve-tone row and derivative in conjunction with octave displacement made its identification harder than the identification of an untreated twelve-tone row.

The listeners' academic and musical backgrounds must also be taken into consideration. Of the college majors who took the test the Music majors had better scores than any other group. Ensemble participation in high school or college, and academic attainment in high school and college had an effect on the test scores. A
conclusion concerning the perceptibility of four twelve-tone rows used in the test can be:

10) The perceptibility of the four twelve-tone rows used in the test is partially dependent upon the aural and configurational properties of the rows; the shape of the row, that is, whether the original or one of the derivatives is being heard; the serial treatment to which the row or derivative is subjected; the extent of the listeners' participation in musical ensembles; and the academic achievement of the listener.

A Comparison of the Conclusions of This Investigation and the Conclusions of Other Studies

White (1960) investigated the properties of tonal melodies which were distorted (reviewed in Chapter I, supra., pp. 16-18). He concluded that 1) turning a melody around, that is, playing its retrograde form, makes its correct identification difficult, and 2) that transposing a melody has no effect on its identifiability. The results of this investigation showed that the retrograde form of a twelve-tone row as harder to identify than the original, apparently concurring with White's results. But, transposition of a twelve-tone row made its identification difficult, which results disagree with White. I think that the difference in these results rests solely on the fact that twelve-tone rows are not tonal, thus deleting an associative factor in the identification process. Turning a tonal melody or a twelve-tone row around makes identification of both difficult, and the lack of a tonal feeling in a twelve-tone
row could be the reason for transposition making its identification harder.

Walker (1960) performed a study of the audibility of twelve-tone rows (reviewed in Chapter I, supra, pp. 18-23) and three of his conclusions can be compared with results of this investigation. First, Walker concluded that the inversion form of a row was harder to identify than the retrograde form. This is not in agreement with the results of this investigation which showed that the differences in mean scores between retrograde and inversion were not significant and therefore it cannot be said which of the two derivatives, retrograde or inversion, is harder to identify. Second, Walker concluded that the Schoenberg twelve-tone rows he used in his investigation were harder to identify than the other rows used. In this investigation the Schoenberg twelve-tone row was hardest to identify. Thirdly, Walker concluded that octave displacement of a note within a row did not produce "serial dis-unity" (1960, p. 146). Although he did not define what he meant by "serial dis-unity," I take it that he was at least referring to the identifiability of a twelve-tone row with a displaced note. The results of this investigation conflict with Walker's, in that octave displacement of a note within the twelve-tone rows used in this test resulted in fewer correct responses than rows with no treatment.

Duerksen (1967), in his study of altered and repeated orchestral themes (reviewed in Chapter I, supra, p. 18), found that participation in some musical activity was reflected in his test scores and college
Music majors had the highest scores. The results of this investigation seem to echo Duerksen's findings, in that the Music majors had the highest mean scores and ensemble experience was related to variance in test scores. Duerksen further concluded that the single most influential factor in relation to scores on his test was listening experience. Listening experience was not measured in this investigation. The single most important factor in relation to test scores in this investigation was participation in a musical ensemble.

Suggestions for Additional Research

As a means of determining the extent to which other kinds of serial treatments of twelve-tone rows affect the identifiability of these rows, investigations could be undertaken to determine the effect of fragmentation of the twelve-tone row apart from and in combination with transposition and octave displacement of a note within the row. The effect of fragmentation, transposition, displacement and other transformations of the twelve-tone row could be investigated in conjunction with the effects of different instrumental or electronic timbres as well as the effects of various rhythmic patterns.

When a twelve-tone row is fragmented, as in an orchestral composition, identifying the row and its derivatives could become impossible. This can lead to the following question: where does musical meaning exist? Does the row have enough musical meaning by itself to make up for the confusing aural situation in a composition, or is there sufficient meaning within the composition to keep the
Musical meaning arises when an antecedent situation, requiring an estimate of the probable modes of pattern continuation, produces uncertainty about the temporal-tonal nature of the expected consequent. If a [musical] situation is highly organized and the possible consequents in the pattern process have a high degree of probability, then information (or entropy) is low. If, however, the [musical] situation is characterized by a high degree of shuffledness [or randomness] so that the consequents are more or less equi-probable, then information is said to be high. Both meaning and information are thus related through probability to uncertainty (p. 11).

Investigations into meaning in twelve-tone music could first start with the determination of the "modes of pattern continuation" in the music. This could then lead to the investigation into the existence of antecedent and consequent situations in twelve-tone music, and from these the extent or existence of meaning could be determined.

In order to engage in research that deals with meaning in twelve-tone music, the information potential of a twelve-tone row must be clearly defined, and a means of measuring the informational content of a row must be established. One step in accomplishing these tasks is to determine whether a twelve-tone row is ergodic or a Markoff chain. The term ergodicity refers to the equiprobability of a segment of a message which is stochastic or predictable. A Markoff chain is another manifestation of a stochastic system.
According to Meyer (1967) a special case of a stochastic process in which the probabilities depend upon the previous events, is called a Markoff process or a Markoff chain. The fact that music, like information, is an instance of a Markoff process has important practical and theoretical ramifications (p. 15).

The question then is: to what extent are the pitches in a twelve-tone row equi-probable?

Concerning the problem of fragmentation of a row, another question can be asked: to what extent does fragmentation or breaking up a row influence the perceptibility of the row? White (1960) included fragmentation in his study of distortion in tonal melodies and concluded that fragmentation, while he actually shortened the melodies by one-third their length, had "little effect upon the overall percentage of correct identifications" (p. 104). I do not think these results are applicable to a twelve-tone situation because of the tonal-atonal implications and because White's fragmentation process involved only shortening and did not include part of the melodies other than the first one-third. However, an experiment similar to White's, using fragments of twelve-tone rows, may help to answer questions concerning perceptibility of fragmented rows.

An interesting investigation might be to determine if the entire row is too long for normal perception. According to Miller (1956):

Everybody knows that there is a finite span of immediate memory and that for a lot of different kinds of test materials this span is about seven items in length (p. 91).
Since a twelve-tone row comprises twelve different pitches it could be that there is too much information in the row for it to be recalled accurately from memory. Miller (1956) suggested a means of enhancing the results of identification tasks:

The input [the twelve-tone row] is given in a code that contains many chunks with few bits [of information] per chunk. The operator [listener] recodes the input into another code that contains fewer chunks with more bits per chunk. There are many ways to do this recoding, but probably the simplest is to group the input events, apply a new name to the groups, and then remember the new name rather than the original input events (p. 93)

To say this another way, a listener, who is confronted with an aural discrimination task involving a twelve-tone row, might remember the twelve-tone row on the basis of its over-all aural characteristics such as contour or melodic shape, and would not have to remember the entire sequence of twelve pitches.

An approach to the problem of the perceptibility of a twelve-tone row could be to perform experiments involving hexa- and tetrachords which are subjected to serial treatment. This could be especially revealing in the case of symmetrical and combinatorial rows, where the hexa- and tetrachords are very much alike. It could well be that the measure of the perceptibility of the hexa- and tetrachords is also a measure of the perceptibility of the entire row.

One of the information techniques employed by many investigators is to measure the redundancy in a communication system. Once the problem or ergodic or Markoff quality of twelve-tone rows has been solved, a redundancy study might well prove revealing. It could
be that there is very little redundancy and too much information in a twelve-tone row, the point being that a form of communication which has little or no redundancy, if this is possible, will contain too much information for normal perceptual processing.

The serial treatments used in this investigation, transposition and octave displacement, are compositional devices that are not used exclusively in twelve-tone music. The use of these devices can be found in tonal music. For example, transposition occurs when the second theme in sonata allegro form is presented in different keys in the exposition and recapitulation, and octave displacement occurs when different instruments trade parts of a theme in an orchestral composition. The use of these devices in the composition of music has been accepted by most musicians and was not questioned until they were incorporated in twelve-tone music. It is suggested that investigation of the effect of such compositional devices on tonal melodies be undertaken.
Appendix A
Biographical Data Page

Name _______________________________________________________________________

Sex: Male ________Female ______________Date of Birth _____________________

What is Your Major? ____________________________________________________

What is Your Degree Program? _________________________________________

Circle the Name of the College in which you are enrolled:

Liberal Arts                  Commerce

Science & Technology         Unassigned Departments

Education

College rank (circle one): Freshman Sophomore Junior Senior

Indicate the number of years of participation in the following musical organizations prior to your entrance into college:

Marching Band ______ Mixed Chorus ______
Concert Band ______ Glee Club ______
Dance Band ______ Church Choir ______
Orchestra ______ Chamber Ensemble ______
Other Ensemble ______

Indicate the number of years of participation in the following musical organizations since your entrance into college:

Marching Band ______ Mixed Chorus ______
Concert Band ______ Glee Club ______
Dance Band ______ Church Choir ______
Orchestra ______ Chamber Ensemble ______
Other Ensemble ______

Do You have absolute or perfect pitch? Yes _____ No_____ Don't know_____

Do you sing or play a musical instrument? If so, name the instrument or voice (Music Majors indicate only your primary instrument):

______________________________________________________________

Indicate the number of years or private instruction on your instrument or voice: __________________________

* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
DO NOT WRITE BELOW THIS LINE

GPA __________ AS OF ______________

ACT Standard Scores:
Appendix B
Code for Card Punching of Data for Analysis of Variance and Chi-Square Tests

<table>
<thead>
<tr>
<th>Column</th>
<th>Card One</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,2,3</td>
<td>Subject ID number (001 to 615)</td>
</tr>
<tr>
<td>4</td>
<td>Card number for this subject (1, 2, or 3)</td>
</tr>
</tbody>
</table>
| 5      | Date test was taken: 0 = April 30  
|        | 1 = May 1  
|        | 2 = May 5  
|        | 3 = May 6 |
| 6      | Sex of subject: 0 = Male  
|        | 1 = Female |
| 7      | Age of subject: 0 = 16 years  
|        | 1 = 17 years  
|        | 2 = 18 years  
|        | 3 = 19 years  
|        | 4 = 20 years  
|        | 5 = 21 years  
|        | 6 = 22 years  
|        | 7 = 23 years  
|        | 8 = 24 years  
|        | 9 = 25 years or older |
| 8,9    | Major of the test subject:  
|        | 00 = Accounting  
|        | 01 = Agriculture  
|        | 02 = Art  
|        | 03 = Biology  
|        | 04 = Business Administration  
|        | 05 = Business Education  
|        | 06 = Chemistry  
|        | 07 = Elementary Education  
|        | 08 = English  
|        | 09 = Foreign Languages  
|        | 10 = Geography  
|        | 11 = Government  
|        | 12 = History  
|        | 13 = Home Economics  
|        | 14 = Industrial Arts  
|        | 15 = Industrial Education  
|        | 16 = Mathematics  
|        | 17 = Mass Media  
|        | 18 = Medical Technology  
|        | 19 = Music  
|        | 20 = Nursing  
|        | 21 = Office Administration  
|        | 22 = Office Management  
|        | 23 = Physical Education  
|        | 24 = Pre-Professional  
|        | 25 = Psychology  
|        | 26 = Secondary Education  
|        | 27 = Sociology & Anthropology  
|        | 28 = Special Education  
|        | 29 = Speech & Theater  
|        | 30 = Double Major; neither is music  
|        | 31 = Double Major; one is music  
|        | 32 = Undecided  
| 10     | College of subject:  
|        | 0 = Liberal Arts  
|        | 1 = Education  
|        | 2 = Commerce  
| 11     | Rank: 0 = Freshman  
|        | 1 = Sophomore  
|        | 2 = Junior  
|        | 3 = Senior  
| 12     | Pre-College Ensemble Experience  
|        | 0 = yes; 1 = no.  
| 13     | Years experience in Marching Band:  
|        | 1 = 1 year  
|        | 2 = 2 years  
|        | 6 = 6 years  
|        | 7 = 7 years |
3 = 3 years 8 = 8 years
4 = 4 years 9 = 9 years
5 = 5 years 0 = no response

14 Concert Band experience: 0 = yes; 1 = no.
15 Years experience in Concert Band:
1 = 1 year 6 = 6 years
2 = 2 years 7 = 7 years
3 = 3 years 8 = 8 years
4 = 4 years 9 = 9 years
5 = 5 years 0 = no response

16 Dance Band experience: 0 = yes; 1 = no.
17 Years of Dance Band experience:
1 = 1 year 6 = 6 years
2 = 2 years 7 = 7 years
3 = 3 years 8 = 8 years
4 = 4 years 9 = 9 years
5 = 5 years 0 = no response

18 Orchestra experience: 0 = yes; 1 = no.
19 Years of orchestral experience:
1 = 1 year 6 = 6 years
2 = 2 years 7 = 7 years
3 = 3 years 8 = 8 years
4 = 4 years 9 = 9 years
5 = 5 years 0 = no response

20 Mixed Chorus experience: 0 = yes; 1 = no.
21 Years of Mixed Chorus experience:
1 = 1 year 6 = 6 years
2 = 2 years 7 = 7 years
3 = 3 years 8 = 8 years
4 = 4 years 9 = 9 years
5 = 5 years 0 = no response

22 Glee Club experience: 0 = yes; 1 = no.
23 Years of Glee Club experience:
1 = 1 year 6 = 6 years
2 = 2 years 7 = 7 years
3 = 3 years 8 = 8 years
4 = 4 years 9 = 9 years
5 = 5 years 0 = no response

24 Church Choir experience: 0 = yes; 1 = no.
25 Years of Church Choir experience:
1 = 1 year 6 = 6 years
2 = 2 years 7 = 7 years
3 = 3 years 8 = 8 years
4 = 4 years 9 = 9 years
5 = 5 years 0 = no response

26 Chamber ensemble experience: 0 = yes; 1 = no.
27 Years of Chamber ensemble experience:
1 = 1 year 6 = 6 years
2 = 2 years 7 = 7 years
3 = 3 years 8 = 8 years
4 = 4 years 9 = 9 years
5 = 5 years 0 = no response
Other ensemble experience: 0 = yes; 1 = no.

Years of other ensemble experience:
1 = 1 year
2 = 2 years
3 = 3 years
4 = 4 years
5 = 5 years
6 = 6 years
7 = 7 years
8 = 8 years
9 = 9 years
0 = no response

Marching Band Experience: 0 = yes; 1 = no.

Years of Marching Band experience:
1 = 1 year
2 = 2 years
3 = 3 years
4 = 4 years
5 = 5 years
6 = 6 years
7 = 7 years
8 = 8 years
9 = 9 years
0 = no response

Concert Band experience: 0 = yes; 1 = no.

Years of Concert Band experience:
1 = 1 year
2 = 2 years
3 = 3 years
4 = 4 years
5 = 5 years
6 = 6 years
7 = 7 years
8 = 8 years
9 = 9 years
0 = no response

Dance Band experience: 0 = yes; 1 = no.

Years of Dance Band experience:
1 = 1 year
2 = 2 years
3 = 3 years
4 = 4 years
5 = 5 years
6 = 6 years
7 = 7 years
8 = 8 years
9 = 9 years
0 = no response

Orchestra experience: 0 = yes; 1 = no.

Years of orchestral experience:
1 = 1 year
2 = 2 years
3 = 3 years
4 = 4 years
5 = 5 years
6 = 6 years
7 = 7 years
8 = 8 years
9 = 9 years
0 = no response

Mixed Chorus experience: 0 = yes; 1 = no.

Years of Mixed Chorus experience:
1 = 1 year
2 = 2 years
3 = 3 years
4 = 4 years
5 = 5 years
6 = 6 years
7 = 7 years
8 = 8 years
9 = 9 years
0 = no response

Glee Club experience: 0 = yes; 1 = no.

Years of Glee Club experience:
1 = 1 year
2 = 2 years
3 = 3 years
4 = 4 years
5 = 5 years
6 = 6 years
7 = 7 years
8 = 8 years
9 = 9 years
0 = no response
Church Choir experience: 0 = yes; 1 = no.

Years of Church Choir experience:
1 = 1 year
2 = 2 years
3 = 3 years
4 = 4 years
5 = 5 years
6 = 6 years
7 = 7 years
8 = 8 years
9 = 9 years
0 = no response

Chamber Ensemble experience: 0 = yes; 1 = no.

Years of Chamber Ensemble experience:
1 = 1 year
2 = 2 years
3 = 3 years
4 = 4 years
5 = 5 years
6 = 6 years
7 = 7 years
8 = 8 years
9 = 9 years
0 = no response

Other Ensemble experience: 0 = yes; 1 = no.

Years of Other Ensemble experience:
1 = 1 year
2 = 2 years
3 = 3 years
4 = 4 years
5 = 5 years
6 = 6 years
7 = 7 years
8 = 8 years
9 = 9 years
0 = no response

Do you have perfect pitch? 1 = yes; 0 = no; 0 = don't know.

Musical instrument played by subject:
00 = Flute, Piccolo
01 = Clarinets
02 = Oboe, English Horn
03 = Bassoon
04 = Saxophones
10 = Cornet, Trumpet
11 = French Horn
12 = Baritone
13 = Trombone
14 = Tuba, Sousaphone
20 = Percussion
30 = Piano, Organ
40 = Violin
41 = Viola
42 = Cello
43 = String Bass
44 = Banjo
45 = Guitar
46 = Ukelele
50 = Voice
60 = Other
99 = no response

Years of instruction on voice or instrument:
1 = 1 year
2 = 2 years
3 = 3 years
4 = 4 years
5 = 5 years
6 = 6 years
7 = 7 years
8 = 8 years or more
0 = no response

Grade point average at end of last enrolled term prior to test date; no GPA = 9999

Test score:
56, 57 Standard ACT English; no score = 99
58, 59 Standard ACT Mathematics; no score = 99
60, 61 Standard ACT Social Science; no score = 99
62, 63 Standard ACT Natural Science; no score = 99
64, 65 Standard ACT Composite; no score = 99
### Card One

<table>
<thead>
<tr>
<th>Column</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>1-3</td>
<td>Subject ID number: 001 to 615 (cases without GPA or ACT deleted)</td>
</tr>
<tr>
<td>4</td>
<td>Card number for this subject (1)</td>
</tr>
<tr>
<td>5</td>
<td>Sex of Subject: 0 = male 1 = female</td>
</tr>
<tr>
<td>6, 7</td>
<td>Age of Subject: 16-25 years old</td>
</tr>
<tr>
<td>8</td>
<td>Major: 1 = Accounting 0 = Other</td>
</tr>
<tr>
<td>9</td>
<td>Major: 1 = Agriculture 0 = other</td>
</tr>
<tr>
<td>10</td>
<td>Major: 1 = Business Administration 0 = other</td>
</tr>
<tr>
<td>11</td>
<td>Major: 1 = Elementary Education 0 = other</td>
</tr>
<tr>
<td>12</td>
<td>Major: 1 = English 0 = other</td>
</tr>
<tr>
<td>13</td>
<td>Major: 1 = History 0 = other</td>
</tr>
<tr>
<td>14</td>
<td>Major: 1 = Music 0 = other</td>
</tr>
<tr>
<td>15</td>
<td>Major: 1 = Physical Education 0 = other</td>
</tr>
<tr>
<td>16</td>
<td>Major: 1 = Undecided 0 = other</td>
</tr>
<tr>
<td>17</td>
<td>Rank: 1 = Freshman 2 = Sophomore 3 = Junior 4 = Senior</td>
</tr>
<tr>
<td>18</td>
<td>Years experience in marching band: 0-9 years</td>
</tr>
<tr>
<td>19</td>
<td>Years experience in concert band: 0-9 years</td>
</tr>
<tr>
<td>20</td>
<td>Years of dance band experience: 0-9 years</td>
</tr>
<tr>
<td>21</td>
<td>Years of orchestral experience: 0=9 years</td>
</tr>
<tr>
<td>22</td>
<td>Years of mixed chorus experience: 0-9 years</td>
</tr>
<tr>
<td>23</td>
<td>Years of glee club experience: 0-9 years</td>
</tr>
<tr>
<td>24</td>
<td>Years of church choir experience: 0-9 years</td>
</tr>
<tr>
<td>25</td>
<td>Years experience in other ensemble: 0-9 years</td>
</tr>
<tr>
<td>26</td>
<td>Ensemble Experience Since Entering College</td>
</tr>
<tr>
<td>27</td>
<td>Years of marching band experience: 0-9 years</td>
</tr>
<tr>
<td>28</td>
<td>Years of concert band experience: 0-9 years</td>
</tr>
<tr>
<td>29</td>
<td>Years of dance band experience: 0-9 years</td>
</tr>
</tbody>
</table>

### Card Two

<table>
<thead>
<tr>
<th>Column</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 2, 3</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>5 to 80</td>
</tr>
</tbody>
</table>

### Card Three

<table>
<thead>
<tr>
<th>Column</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 2, 3</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>5 to 41</td>
</tr>
</tbody>
</table>
29 Years of orchestral experience: 0–9 years
30 Years of mixed chorus experience: 0–9 years
31 Years of glee club experience: 0–9 years
32 Years of church choir experience: 0–9 years
33 Years experience in other ensemble: 0–9 years
34 Perfect pitch: 1 = subject claims to have perfect pitch
               0 = subject claims not to have perfect pitch
               or claims not to know
35 Musical instrument played: 1 = woodwind instrument
               0 = not woodwind instrument
36 Musical instrument played: 1 = brass instrument
               0 = not brass instrument
37 Musical instrument played: 1 = percussion instrument
               0 = not percussion instrument
38 Musical instrument played: 1 = keyboard instrument
               0 = not keyboard instrument
39 Musical instrument played: 1 = string instrument
               0 = not string instrument
40 Musical instrument played: 1 = voice 0 = not voice
41 Musical instrument played: 1 = other instrument
               0 = not other instrument
42 Years of instruction on instrument or voice 0–8 years
43–46 GPA (x100)
47,48 ACT English score
49,50 ACT Math score
51,52 ACT Social Sciences score
53,54 ACT Natural Sciences score
55,56 ACT Composite Score

Column Card Two
1–3 Subject ID Number
4 Card number for this subject (2)
5–80 Test answers 1 through 76 (1 = right 0 = wrong)

Column Card Three
1–3 Subject ID Number
4 Card number for this subject (3)
5–56 Test answers 77 through 128 (1 = right 0 = wrong)

Column Card Four
1–3 Subject ID Number
4 Card number for this subject (4)
5–7 Total test score: 0–128
8,9 Test 1 score: 0–64
10,11 Test 2 score: 0–64
12,13 Total test/Treatment N score: 0–32
14,15 Total test/Treatment T score: 0–32
16,17 Total test/Treatment D score: 0–32
18,19 Total test/Treatment TD score: 0–32
20,21 Total test/shape O score: 0–32
22,23 Total test/shape R score: 0–32
24,25 Total test/shape I score: 0–32
26,27 Total test/shape RI score: 0–32
28,29 Test 1/Treatment N score: 0–16
30,31  Test 2/Treatment N score: 0-16
32,33  Test 1/Treatment T score: 0-16
34,35  Test 2/Treatment T score: 0-16
36,37  Test 1/Treatment D score: 0-16
38,39  Test 2/Treatment D score: 0-16
40,41  Test 1/Treatment TD score: 0-16
42,43  Test 2/Treatment TD score: 0-16
44,45  Test 1/shape O score: 0-16
46,47  Test 1/shape O score: 0-16
48,49  Test 1/shape R score: 0-16
50,51  Test 2/shape R score: 0-16
52,53  Test 1/shape I score: 0-16
54,55  Test 2/shape I score: 0-16
56,57  Test 1/shape RI score: 0-16
58,59  Test 1/shape RI score: 0-16
REFERENCES


Glock, W. 1951. Comment. The Score, 6, 3-6.


Miller, George. 1956. The Magical Number Seven, Plus or Minus Two: Some Limits on Our Capacity for Processing Information. The Psychological Review, 63, 81-97.


