AN EXPERIMENTAL INVESTIGATION OF THE EFFECT OF SELECTED FACTORS ON THE SHORT-TERM RETENTION OF PITCH SEQUENCES

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FACTORS ON THE SHORT-TERM
RETENTION OF PITCH SEQUENCES

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ABSTRACT

AN EXPERIMENTAL INVESTIGATION
OF THE EFFECT OF SELECTED
FACTORS ON THE SHORT-TERM
RETENTION OF PITCH SEQUENCES

By

Kermit Wells Holly, Jr.

The primary purpose of this study was to investigate the effect of changes of timbre in a stimulus item, length of retention interval, and performance of a task (during the retention interval) on short-term recognition memory for pitch. A secondary concern of the study was the response performance on test items in which the second sequence was different from the first.

Procedures

A 48-item pitch sequence memory test - The *Pitch-Timbre Memory Test* - was developed to collect the data for the study. Each item consisted of two pitch sequences. The second sequence was either the same or different from the first. For twenty-four of the items, the same sound quality (a sine wave) was used in both sequences. The second sequence of the remaining twenty-four items used either a sawtooth, pulse or triangle wave form. The retention intervals were *5 seconds*, *15 seconds*, and *30 seconds*. All test items were randomized.

The twenty-eight subjects used in the study were randomly assigned to one of two groups. Group I received the memory test and performed a task during each of the retention intervals. The task was one in which the subjects counted backward by three from a number specified on the memory test tape. To insure that they were counting, subjects were required to write the numbers as they counted. Group II only took the memory test.

Conclusions

On the basis of the data analysis of the results of this study, the following conclusions were drawn:

1. The sound quality of a pitch sequence tended to affect its perception and its retention in short-term memory.

2. The sawtooth sound quality had the most disruptive effect on the short-term retention of pitch sequence. The triangle sound quality appeared to be less consistent in terms of effect on short-term retention.

3. The accuracy of recognition response in short-term retention was influenced by the length of the retention interval. Response mean scores for the task group and the non-task group were considerably lower at the 15 second retention interval.

4. The interaction effect between timbre and retention interval suggested that the short-term retention of pitch is dependent upon the kind of timbre and the

length of the retention interval, at least in this study.

5. The performance of a non-musical task did not significantly affect the short-term retention of a pitch sequence.

6. The intention between retention interval and item-type suggested that the recognition of test items as the same or different was dependent on the length of the retention interval. Test items in which both pitch sequences were the same, were recognized with greater accuracy during the 5 second retention interval, than test items, in which the second sequence was different.

7. The triple interaction between timbre, retention interval, and item type (same vs. different) suggested that the short-term retention of pitch sequences is dependent upon timbre, length of the retention interval, and whether the second sequence is the same or different.

8. The true influence of the main effects of timbre and retention interval should be qualified because of the number of interactive effects.

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By

Kermit Wells Holly, Jr.

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TO MY MOTHER AND FATHER

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CHAPTER I

INTRODUCTION

Memory and learning are interrelated processes; factors that affect the former also affect the latter. An examination of current memory literature reveals that there are several theories of memory. One of these describes the human memory system as an information processing system involving the acquisition, retention, and retrieval of information. This view of memory as information processing has led to the development of a number of 'models of memory.' Of these, one that seems highly applicable to a theory of music memory is the model proposed by Atkinson and Shiffrin (1968).

This model postulates that memory is comprised of three components -- a sensory register, a short-term store, and a long-term store.[1] Initially, information from the environment is accepted and processed by the various sensory systems (sensory register) and is entered into the short-term store, where it is either maintained through rehearsal, or lost. Information is lost from the sensory register in from one to two seconds. Thedecay rate for information in

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[1]R. Atkinson and R.M. Shiffrin, "The Control of Short-Term Memory," Scientific American, 1971, Vol. 25, No. 2, p. 83.

the short-term store is approximately thirty seconds, while in short-term store, information, if rehearsed, can be transformed to long-term storage. The long-term store is assumed to be a relatively permanent memory, from which information is not lost.[2]

The central feature of the Atkinson and Shiffrin model is the control process that operates within and between each of the structural components of the memory system. In the sensory register, the first control process is a decision as to what information to attend to, and where to scan within the system. Control processes inherent in the short-term store are a choice of which information to scan and a choice of what and how to rehearse.

The short-term store is conceived of having two functions: (1) it acts as a buffer between the sensory register and long-term storage by utilizing rehearsal strategies; and (2) it acts as a processor of information in which an item passes through various stages of encoding until it is made permanent and becomes a part of long-term store. This model assumes an interaction between short-term memory and long-term memory and a system of control processes that keep information flowing through memory. Figure 1 illustrates the flow of information through the human memory system according to this model.

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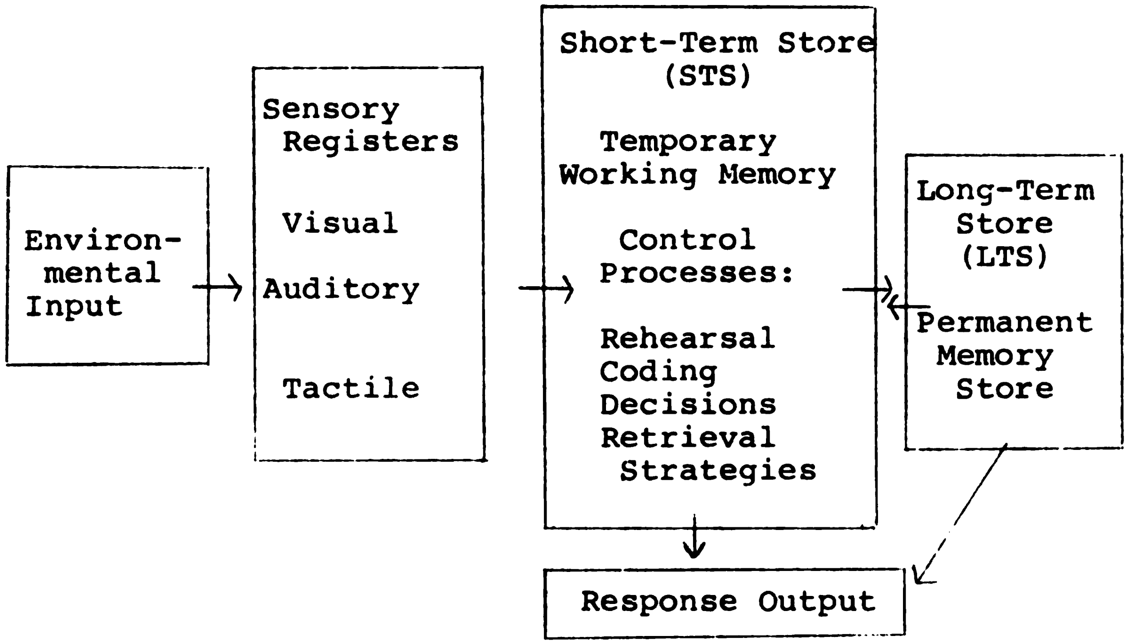
[2] *Ibid*., p. 83.

FIGURE 1



Information Flow Through the Memory System
(after Atkinson and Shiffrin, 1968)

Music Memory

Memory has been long considered an important component of music aptitude. This is evident by the number of music aptitude tests (such as those by Seashore, Drake, Wing, Bentley, and Gaston) that include a memory subtest. Shuter states that the importance of memory in musical ability is undeniable and that an appreciation of form, or qualities of performance would be virtually impossible without memory.[3]

Memory, being an essential factor in music aptitude is also an important factor in music learning. Perhaps the

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[3]Rosamunde Shuter, The Psychology of Music Ability (London: Methuen and Co., Ltd., 1968), p. 188.

role of memory in music learning has been best expressed in the following statement by Carl Seashore:

> The learning process in music involves two primary aspects; acquisition and retention of musical information and experience, and the development of musical skills. Both of these are included in the common term memory...[4]

Mursell, a theoretical and philosophical opposite of Seashore, also recognized memory to be important in the music learning process. He was also astonished at the (then) lack of research involving music memory.[5] A more recent indication of the significance of music memory is found in Richard Colwell's construction of the _Music Achievement Test_ battery. Dr. Colwell's inclusion of aural discrimination tests, and tests of pitch recognition, melodic recognition, instrument recognition, and tonal memory stress the role of music memory in music achievement. Further evidence of the awareness of the prominence of memory in music learning is the emphasis placed on memory development by Carl Orff in his _Schulewerk_. The numerous instances provided by Dr. Orff's method for rote singing, improvisation, and performing on instruments from memory illustrate an acknowledgement of the importance of music memory to musical growth.

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[4]Carl Seashore, _Psychology of Music_ (New York: McGraw-Hill, 1938, Dover Edition, 1957), p. 149.

[5]James Mursell, _Psychology of Music_ (New York: W.W. Norton and Co., 1937), p. 256.

Closely related to music memory is the factor of music or aural imagery. Imagery refers to the retention of, or the reproduction of an aural stimulus after actual stimulus has terminated. Gordon[6] postulates that imagery may be more important to music aptitude then music memory. (At present this position is not entirely dominant among music educators.) Imagery is, however, considered important in music learning. Hoffer[7] suggests that imagery is a necessary component in music reading. Sidnell and Reed[8] feel that, for the listener, aural imagery is a requisite skill in perceiving musical structure. There is little disagreement about the prominent role that aural imagery plays in music perception.

Music Memory Theory

As early as 1919, Seashore was aware that there were several kinds of music memory and stages of music memory, including an immediate (STM) memory and a longer more permanent memory.[9] Early writers on the subject

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[6]Edwin Gordon, The Psychology of Music (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1971), pp. 22-29.

[7]Charles Huffer, Teaching Music in the Secondary Schools (Belmont, California: Wadsworth Publishing Company, 1973), p. 16.

[8]Owen Reed and Robert G. Sidnell, The Materials of Music Composition (Reading, Mass.: Addison-Wesley Publishers, in press, 1977), p. 164.

[9]Carl Seashore, The Psychology of Musical Talent (Boston: Silver Burdett and Co., 1919), p. 238.

identified three kinds of music memory: pitch memory (memory for a single pitch), tonal memory (memory for a sequence of tones, implying tonal relationships), and memory for musical phrases. Today they are considered different types of an overall memory. According to Williams, current research indicates insufficient data to construct a complete model of music memory.[10]

It can be postulated, however, that the processing of music information through the memory system does involve three stages similar to those in the model suggested by Atkinson and Shiffrin. It can also be postulated that those stages are subject to the same control processes. Most researchers and writers generally agree on a three-stage model of music memory. Williams (1973) has theorized that one could control the input of musical stimuli in short-term memory and its subsequent transfer of information to long-term memory.[11] Deutsch (1965), a prolific researcher on the topic, subscribes to a multiprocess concept, but

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[10]David B. Williams, "Short-Term Retention of Pitch Sequence," Journal of Research in Music Education, Vol. 23 (1975), p. 54.

[11]David B. Williams, "The Short-Term Retention of Pitch Sequence." Ph.D. Dissertation. Seattle: University of Washington (1973), p. 169.

believes that evidence points to a highly specialized system for pitch retention different from the verbal memory system.[12]

The Problem

Many learning theorists have turned to the study of short-term memory in an effort to investigate the causes of forgetting (loss of information).[13] Mohs states that the contents of short-term memory affect the retrieval of information in long-term store.[14] According to Atkinson and Shiffrin:

> . . .the short-term memory system has been given a position of pivotal importance. That is because the processes carried out in the short-term store are under the immediate control of the subject and govern the flow of information in the memory system.[15]

Most of the research pertaining to short-term memory has been concerned with verbal memory. Many of the findings, how-

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[12]Diana Deutsch, Short-Term Memory (New York: Academic Press, 1975), p. 122.

[13]Michael Posner and Andrew Konick, "On the Role of Interference in Short-Term Memory," Journal of Experimental Psychology, Vol. 72 (1966), pp. 221-231.

[14]R.C. Mohs, "The Effect of Short-Term Contents on Long-Term Memory Search," Memory and Cognition, No. 4 (1973), p. 443.

[15]Atkinson and Shiffrin, p. 82.

ever, seem applicable to memory for music or sound stimuli. Studies of short-term memory for music have dealt primarily with pitch discrimination. Most of the early studies concentrated on theories of absolute pitch, the improvement of pitch discrimination, and memory as a component of music aptitude. Recent research has dealt with melodic perception and more recently with the loss of information in short-term memory. Studies by Wickelgren (1966), Massard (1970), Deutsch (1969, 1972), and Williams (1973) indicate that factors affecting retention in verbal memory (i.e., serial effect, similarity of interpolated material and storage capacity) also have similar effects on short-term memory for pitch.

A review of short-term pitch memory research reveals that there has been very little research on the influence of timbre on retention. One explanation for this is the assumption that timbre has little or no effect on recognition or recall of music. This may be true for long-term store, but not necessarily so for short-term store. A study by Mull found that subjects felt that some timbres were an aid to the improvement of pitch discrimination.[16] Greer states that a number of researchers believed that timbre has an influence on perception and retention.[17]

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[16]Helen K. Mull, "The Acquisition of Absolute Pitch," The American Journal of Psychology, Vol. 26 (1925).

[17]Douglas Greer, "The Effect of Timbre on Brass Wind Intonation," Experimental Research in the Psychology of Music.

The studies of Mainwaring[18] and Petzold,[19] however, found that different timbres did not significantly affect the recall of tonal patterns. Petzold, although accepting the conclusions of his study, felt that further research was needed.

Recent timbre research has resulted in the formulation of new theories concerning the relationship between timbre and pitch. Where timbre was once a carrier of sound, it is now thought to be a sound object as well.[20]

Current theories concerning the importance of short-term memory, and new developments in timbre research indicated a need to investigate the effect of timbre on short-term retention. Other factors of interest were rehearsal processes and the effect of the length of the retention interval on recognition memory for pitch sequences.

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[18] James Mainwaring, "Kinesthetic Factors in the Recall of Musical Experience," British Journal of Psychology, Vol. 23 (1933), pp. 284-307.

[19] Robert G. Petzold, Auditory Perception of Musical Sounds by Children in the First Six Grades, Cooperative Research Project, No. 1051 (Madison: University of Wisconsin, 1966).

[20] Robert Erickson, Sound Structures in Music (Berkeley: University of California Press, 1975), p. 18.

PURPOSE

The primary purpose of this study was to investigate the effect of selected factors on short-term retention of pitch. Specifically this study sought to answer the following questions:

1. Does timbre affect perception and retention in short-term memory?
2. Does the length of the retention interval affect the cognition in short-term memory?
3. Does the performance of a cognitive-motor task affect retention in short-term memory?

The possibility that the type of test item could have an influence on retention led to the inclusion of the following question:

4. Does the type of test item, i.e., one in which the second pitch sequence is the same as the first, and one in which the second sequence is different from the first have any affect on perception and retention in short-term memory?

On the basis of the research questions, the following hypotheses were advanced for this study.

H_1: Recognition response mean scores will show a difference among the four types of timbre used in the second sequence of each item on the pitch-timbre memory test.

H_2: Recognition response mean scores on the pitch-timbre memory test will show a difference when the length of the retention interval is increased.

H_3: Recognition response mean scores will show a difference between the task group and the non-task group (p. 15).

H_4: Recognition response mean scores will show a difference between test items in which the second pitch sequence was the same and test items in which the second sequence was different. (This hypothesis was not of experimental interest).

H_5: An interaction (A B) in memory performance will be shown between timbre (A) and retention interval (B).

H_6: An interaction effect (A C) in memory performance will be shown between timbre (A) and task (C).

H_7: An interaction effect (A D) in memory performance will be shown between timbre (A) and same and different responses (D).

H_8: An interaction effect (B C) in memory performance will be shown between retention interval (B) and task (C).

H_9: An interaction effect (B D) in memory performance will be shown between retention inteval (B) and same and different responses (D).

H_{10}: An interaction effect (C D) in memory performance will be shown between task (C) and same-different responses (D).

H_{11}: An interaction effect (A B C) in memory performance will be shown between timber (A), retention interval (B), and task (C).

H_{12}: An interaction effect (A B D) in memory performance will be shown between timbre (A), retention interval (B) and same and different responses (D).

H_{13}: An interaction effect (A C D) in memory performance will be shown between timbre (A), task (C) and same and different items (D).

H_{14}: An interaction effect (B C D) in memory performance will be shown between retention interval (B), task (C) and same and different items (D).

H_{15}: An interaction effect (A B C D) in memory performance will be shown between timbre (A), retention interval (B), task (C), and same and different items (D).

SIGNIFICANCE OF THE STUDY

Contributions to a theory of memory are significant when it is realized that a theory of memory is a portion of the domain of a theory of learning. By analogy, contributions to a theory of music memory are also contributions to a theory of music learning. The primary importance of this study lies in the information that it may provide concerning pitch perception and short-term retention (recognition) as components of a music memory system.

That memory is important to music listening is undeniable. Without a system that retained music information it would be virtually impossible to comprehend, appreciate, enjoy or respond to a musical experience. Paul Haack[21] has written that:

> One cannot be a very sensitive perceiver of music, or any type of effective musician for that matter, without the basic ability to retain and recall timbres and tonal-rhythmic patterns...

On a much broader level of consideration Reimer[22] notes that an important change in the new conception of general education in music, is the realization that listening is the primary music activity of our culture and is also the foundation for all other music involvements.

Given the prominence of listening in the music experience, and the role of memory in the listening process, an investigation of factors that may affect retention would seem to be of significance.

Finally, if the assumption that timbre perception is important in music learning, is valid, the assumption that timbre is important in perception may also be valid. The significance of this study also lies in the information that it may provide concerning timbre and perception.

DEFINITION OF TERMS

Definitions for the following terms are provided to assist the reader in understanding some of the concepts

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[21] Paul A. Haack, "Thanks for the Memory," Music Educators Journal, 1975, March, p. 46

[22] Bennet Reimer, "Patterns for the Future," Music Educators Journal, 1976, December, p. 22.

discussed in this study. These definitions are thought to be adequate for the purposes of this study.

Buffer - A block of memory set aside for the processing of input/output data.

Short-term Memory (STM) - The part of the memory system that has a limited capacity and is of short duration, lasting only seconds. Other designations for STM are immediate memory, primary memory, and short-term store.

Long-term Memory (LTM) - The part of the memory system that is relatively permanent and generally unlimited in capacity. Other designations for LTM are secondary memory and long-term store.

Retention - The persistence of an item over time after one presentation.

Information processing - The input, processing, storage, and retrieval of information. The concept has been borrowed by psychologists from computer technology to describe the human memory system.

Forgetting - The loss of information in memory. This definition also implies the inability to identify or recall an item or an event. There are two competing theories of forgetting: decay (time) and interference. These will be discussed in Chapter II.

Encoding - The process of modifying information so that it is in a usable form for the memory system.

Memory Trace - A hypothetical modification of the neural system, which is postulated to account for memory.

Model of Memory - A theoretical representation of the memory process.

Retention Interval - The time span between the presentation of pitch sequence B in an A-B presentation. For this study, the RI will be 5 sec, 30 sec, and 55 seconds.

Timbre - As used in this study, refers to the sound quality of a particular wave form.

Music Memory - As used in this study, refers to the input, storage and retrieval of musical information (a composite of the parameters of music - rhythm, melody, harmony, structure, and color).

Pitch Memory (tonal memory) - As used in this study refers to the input, storage, and retrieval of pitch information only.

Task group - refers to the group of subjects that perform a cognitive-motor task while taking the music memory test.

Non-task group refers to the group of subjects that take the music memory test.

ASSUMPTIONS

1. The basic premise of this study is that one of the primary goals of music instruction is the facilitation of music learning.
2. It is assumed that the model of memory presented here is valid and can be adapted to a theory of music memory.

ORGANIZATION OF THE STUDY

Chapter I has presented a statement of the problem, it's background, and it's significance. The remainder of the study is organized as follows:

Chapter II contains a review of the literature considered relevant to the topic. Included is discussion of general theories of memory, and pertinent studies of short-term retention of pitch.

Chapter III contains a presentation of the research design used in the study and a discussion of the data gathering instrument.

Chapter IV contains an analysis of the data.

Chapter V contains a summary, conclusions, a discussion of the findings, and implications for further research.

CHAPTER II

REVIEW OF RELATED LITERATURE

The purpose of this chapter is to review selectively the literature relevant to this study. The following topics are discussed: a) general theories of memory, and b) short-term memory for pitch.

General Theories of Memory

The process of memory has been of interest to man since the period of the ancient Greek philosophers. However, it was not until the beginning of psychology that quantified study could be applied to the processes of memory. Since the latter part of the nineteenth century, a number of theories have evolved to explain memory and the reasons for its failure.[1]

William James[2] was one of the first psychologists to propose more than one kind of memory. He made a distinction

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[1]Donald A. Norman, Memory and Attention (New York: John Wiley and Sons, Inc., 1969), pp. 1-3.

[2]William James, The Principles of Psychology, Volume I (New York: Henry Holt and Company, 1880), p. 420.

between a rather temporary memory, which he labeled primary, and a more latent memory, identified as secondary. These observations, however (with the exception of Carl Seashore), were not considered by psychologists until the 1950's.[3]

Beginning with Ebbinghaus in 1885, early approaches to memory and forgetting have involved two basic theories: trace-decay theory, and interference-theory. Ebbinghaus suggested that events in memory weaken over time if they are not maintained by rehersal.[4]

Trace-Decay Theory

The trace-decay theory contends that when something is learned, a memory trace is formed. If the learned information is not practiced, it will decay over time, causing forgetting. The emphasis is on changes in memory storage as a result of time.[5] Two hypotheses associated with the trace-decay theory are the consolidation hypotheses, and the spontaneous decay hypothesis. Consolidation assumes that if a memory trace is allowed to strengthen, or "set,"

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[3]Norman, op. cit., p. 81

[4]H. Ebbinghaus, Memory, Trans. by H. A. Rogers and C. E. Bussenivs (New York: Teachers College, 1913. Paperback ed., 1964).

[5]David Horton and Thomas Tornage, Human Learning (Englewood Cliffs, N.J.: Prentice-Hall, 1976), p. 122.

little forgetting will occur.[6] Spontaneous decay hypothesis proposes that information that is presented briefly is forgotten quickly if not rehersed. This aspect of trace theory is important in theoretical distinctions between temporary and relatively permanent memory systems.[7]

Interference Theory

Interference theory maintains that a memory trace is a permanent entity, and not influenced by time decay. Forgetting is explained as a difficulty of retrieval rather than storage.[8] Stronger memories block retrieval of the information being recalled. The retrieval process is hampered due to the similarity of the information being recalled and other information stored in memory.[9]

In an attempt to describe the processes that characterize forgetting, interference theorists have examined two sources of interference: retroactive inhibition and proactive inhibition. Retroactive inhibition occurs when new memories displace older memories. Proactive inhibition occurs when new memories are displaced by older memories .

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[6] Ibid.

[7] Ibid.

[8] Laird S. Cermak, Human Memory: Research and Theory (New York: The Ronald Press, 1972), P. 6.

[9] Horton and Turner, op. cit., p. 73.

theories had been abandoned as explanations of memory and forgetting until the mid-1950's when new research findings began to indicate that there may be more than one kind of memory process and several possible causes for forgetting, taking into account both interference and decay theory.[10]

Both trace-decay and interference theories of memory assumed that all events in memory were acquired, stored, and retrieved according to a single, all-encompassing set of principles, i.e., memory involved a unitary process.[11] As various facts about memory began to accumulate from clinical, biological, and experimental sources, it became increasingly difficult for psychologists to maintain a single process theory of memory.

The collected data indicated that human memory might involve:[12]

1. At least two qualitatively different systems, one operating according to trace theory, the other according to associationist (interference) theory.
2. Distinct storage and retrieval processes at both the physiological and the psychological level.

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[10]*Ibid*., p. 147.

[11]*Ibid*., pp. 151-152.

[12]*Ibid*.

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3. Complex coding of events in terms of both physical attributes (e.g., visual and auditory) and psychological attributes.

As a result, psychologists began to develop complex models of memory based on the explicit assumption that memory was not a unitary process.

Information Processing

Whereas the earlier theories of memory had been placed in a stimulus-response framework, the newer models (theories) were and are based on a cognitive approach--that of information theory and processing.

Information theory is based on a mathematical theory of communication that offered a means of measuring information in abstract units called bits. A bit is defined as the amount of information that distinguishes between two equally likely alternatives.[13] In 1949, the theory was presented by Shannon and Weaver[14] in a form accessible to psychologists. It had implications for the interpretation of cognitive processes ranging from perception to language.

The information processing approach is derived from information theory and assumes that perception, memory, and

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[13]Geoffrey R. Loftus and E. Loftus, Human Memory: The Processing of Information (New York: John Wiley and Sons, 1976), p. 3.

[14]C. E. Shannon and W. Weaver, The Mathematical Theory of Communication (Urbana, Ill.: University of Illinois Press, 1949).

the other by Peterson and Peterson,[20] inaugurated intensive research activity which has continued to the present.

As stated in Chapter I (page 6), most of the research pertaining to memory and to short-term memory in particular has dealt with verbal memory. Non-verbal auditory memory research has only recently begun to garner similar interest. A review of the literature involving experimental research in music memory reveals three primary areas of investigation: a) studies of absolute pitch and the development of pitch discrimination; b) studies of tonal memory as a component of musical aptitude; and c) specific studies of the short-term retention of pitch. The distinction between (a) and (c) is that the latter studies are investigations of pitch retention as it is related to specific theories of short-term memory, and the former studies were primarily interested in the development of pitch discrimination.

Short-term memory for pitch

Most of the studies of absolute pitch and pitch discrimination or pitch improvement have been reviewed elsewhere (New, 1957; Shuter, 1968); consequently, they will not be discussed here, except in instances where they relate specifically to the present study. Although they have not been classified as such, many of the early studies of music

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[20]Lloyd R. Peterson and E. Peterson, "Short Term Retentions of Individual Verbal Items," Journal of Experimental Psychology, 1959, Vol. 58, pp. 193-198.

memory and pitch discrimination are actually studies of short-term retention, in that they involved the presentations of brief tonal stimuli and responses to those stimuli within a brief time span, i.e., a few seconds.

One of the earliest studies of pitch retention was by Wolfe,[21] who investigated the effect of time on pitch retention. Using retention intervals up to 180 seconds, he found that there was very little loss of retention from one to five seconds. However, as the retention interval was lengthened, a gradual decline was noted. Subsequent studies by Angell and Harwood,[22] and Whipple[23] confirmed Wolfe's findings.

Anderson[24] studied interstimulus intervals of 1/16 1/8, 1/4, 1/2, 1, 2, 3, and 4 seconds to determine the most effective time interval for pitch discrimination. He reported all of the time spans as satisfactory interstimulus intervals.

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[21] H. K. Wolfe, "Untersuchungen über das Tongedächtniss," Philosophy Studies, 1886, Vol. 3, pp. 534-571.

[22] F. Angell and H. Harwood, "Experiments on Discrimination of Clangs for Different Intervals of Time," American Journal of Psychology, 1899, Vol. 10, pp. 67-71.

[23] G. M. Whipple, "An Analytic Study of the Memory Image and the Process of Judgement in the Discrimination of Clangs and Tones,: American Journal of Psychology, 1901, Vol. 12, pp. 409-457.

[24] D. A. Anderson, "The Duration of Tones, the Time Interval, The Direction of Sound, Darkness, and Quiet, and the order of Stimuli in Pitch Discrimination," Psychological Monographs, 1914, Vol. 16, pp. 150-156.

In 1945, Koester,[25] using various retention intervals from one to ten seconds, found no loss in pitch retention due to time. In a later experiment, however, using retention intervals of 0, 5, 15, and 47 seconds, he reported no significant loss of retention of to 15 seconds, but with the 47 second interval, there was a significant retention loss.

Harris,[26] reviewing the literature for pitch discrimination and interstimulus time intervals concluded that:

> The effect on pitch discrimination of elapsed time between stimuli has been shown . . . to depend to a considerable extent on whether the standard sequence is always the same frequency. When it is, subjects can quickly build up from the preceding stimuli a subjective standard upon which he bases his judgement of succeeding stimuli. This subjective standard remains stable for many seconds. Consequently, discrimination with a single standard stimulus is relatively little affected by the time between standard and comparison stimuli. If, on the other hand, the standard stimulus is changed in frequency for every judgement, then the range of the standard and variable stimuli is considerably greater, the preceding sequence of stimuli furnishes only a relatively coarse anchor for judging, and the subject is forced to consider only the two particular stimuli of a comparison pair.[27]

Accordingly, Harris proceeded with an experiment using both a fixed standard pitch and a varying standard pitch (from 950 Hz to 1050 Hz). Using two groups, he

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[25]Thomas Koester, "The time Error in Pitch and Loudness Discrimination as a Function of Time Interval and Stimulus Level," Archives of Psychology, 1945, No. 297.

[26]J. Donald Harris, "The Decline of Pitch Discrimination with Time," Journal of Experimental Psychology, 1952, Vol. 43, pp. 96-99.

[27]Ibid., p. 98.

tested one group with a fixed standard pitch at intervals of 3, 7, 15, and 25 seconds. For the second group, the standard tone was varied. The interstimulus intervals were .1, 1, 3, 7, and 15 seconds. Harris reported that with the fixed standard stimulus, no decline in discrimination occurred up to 25 seconds; a decline of 8 cps occurred after 15 seconds; a decline of 3 cps occurred after 25 seconds. On the other hand, there was a retention loss at delays of 3, 7, and 15 seconds with the group having the standard pitch.[28]

In 1954, Bachem[29] investigated the effect of time lapse between standard and comparison tones utilizing a two group design in which one group's subjects possessed absolute pitch and the other group's subjects, relative pitch. The time-lapse intervals were 1 second, 3 seconds, 15 seconds, 60 seconds, 1 hour, 1 day and 1 week. Results showed that there was no observable difference in pitch retention between the two groups. However, errors increased with the longer time intervals, with few errors being reported by the subjects possessing absolute pitch.[30]

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[28]*Ibid.*, p. 99.

[29]A. Bachem, "Time factors in Relative and Absolute Pitch Determination," *Journal of the Acoustical Society of America*, 1954, Vol. 26, pp. 751-753.

[30]*Ibid.*, p. 753.

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The studies that have been cited are important because they show that retention for a single pitch is subject to decay over time. The alternative hypothesis for loss of information in short-term memory is that of interference from competing stimuli. Wickelgren[31] designed an experiment to determine whether pitch retention was also subject to interference from material interpolated during the retention interval.

In this experiment, subjects listened to a standard tone of either 2, 4, or 8 seconds in duration, followed by an interference tone (a tone sounded during the retention interval) of 2, 4, or 8 seconds duration. A comparison tone of 2 seconds was then played, followed by a 4-second response interval. Subjects rated their confidence of response using a scale from 1 to 5. Standard tones used in the experiment were either 800 Hz, 820 Hz, or 840 Hz. The comparison tones differed by either 0 Hz, +10 Hz, or +15 Hz-- all difference conditions occurred equally. Wickelgren found that:[32]

> 1. Interpolating a tone between the standard and comparison tones does affect pitch recognition; the longer the duration of the interpolated tone, the poorer the pitch recognition.
>
> 2. Increasing the duration of the standard tone facilitated pitch retention.

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[31] Wayne A. Wickelgren, "Consolidation and Retroactive Interference in Short-Term Recognition Memory for Pitch," Journal of Experimental Psychology, Vol. 72, No. 2, 1966, pp. 250-259.

[32] Ibid.

3. Trace strengths for the standard tone increased during presentations of the standard pitch that were over 4 seconds.

He also reported that the higher pitched tones were remembered better than lower pitched tones.[33]

In a subsequent study, Wickelgren[34] examined the interference tone to determine what effect its frequency and intensity similarity to the standard tone had on pitch retention. The tones for this experiment were randomly selected in 10 Hz steps over the interval from 400 Hz to 590 Hz. Interference tones were ±15 Hz, ±20 Hz, ±40 Hz, ±100 Hz, ±200 Hz, +300 Hz, or +800 Hz from the standard (S) tone. The comparison (C) tone differed by 0 Hz or +10 Hz. Two groups were used for the study. One group was instructed to attend to the interpolated tone, and not to reherse during the retention interval. The second group was instructed to ignore the interpolated tone and to reherse the S tone. Wickelgren reported that:[35]

1) The similarity of the interpolated tone to the standard tone appeared to have no effect on recognition performance (beyond a difference of 40 Hz between the standard and interference tone) regardless of the instructional condition.

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[33] Ibid.

[34] Wayne A. Wickelgren, "Associative Strength Theory of Recognition Memory for Pitch," Journal of Mathematical Psychology, 1969, Vol. 6, pp. 13-61.

[35] Ibid., p. 38.

2) There seemed to be a facilitory effect on performance when the interpolated tone differed by 15 Hz or 20 Hz, and the comparison tone was on the same side as the standard and interference tones.

The results of the intensity experiment indicated that the interpolated tones' intensity did not affect pitch recognition (at least within the levels used in the study).

It was concluded by Wickelgren[36] that the duration of the interpolated tone was the primary cause of interference, since neither similarity nor the intensity of the interpolated tone had any significant effert on the recognition performance.

In 1970, Massaro,[37] employing various kinds of interpolated material, also reported that interference was a factor in the deterioration of short-term memory for pitch. He used tones, Gaussian noise and a blank time interval as the interpolated material; the retention intervals were 1 second, 2 seconds, and 4 seconds. An analysis of the data from the experiment indicated that the retention of pitch decreased as the retention interval increased, and that the decrease in retention over time is highly dependent on the interpolated material.[38]

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[36] *Ibid*., p. 15.

[37] Dominic W. Massaro, "Retroactive Interference in Short-Term Recognition Memory for Pitch," *Journal of Experimental Psychology*, 1970, Vol. 83, pp. 32-39.

[38] *Ibid*., p. 39.

It was also found, as in the Wickelgren study, that interpolated tones nearer in Hz to the standard tone had a facilitory effect on retention.

In a series of experiments, Massaro[39] sought to determine the effect of a masking tone, presented retroactively (after the standard tone) and proactively (before the standard tone) on short-term pitch retention. Subjects in the first experiment were asked to identify two 20 millisecond tones as high (870 Hz) or low (770 Hz). A masking tone of 820 Hz and 500 Milliseconds followed after a varying time interval of 0, 20, 40, 80, 160, 250, 350 or 500 milliseconds. All conditions were randomized within a given session (two per day during a four-day period). Results of the experiment indicated that pitch identification performance increased as the time interval between the test tone and the masking tone increased, up to approximately 250 milliseconds when the masking tone was presented immediately after the test tone, it interfered with the processing of the test tone.[40]

The procedures for the second experiment were the same as in the first experiment except that the masking tone was presented proactively. It was found that the test tone was

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[39] Dominic W. Massaro, "Preperceptual Auditory Images," Journal of Experimental Psychology, 1970, Vol. 85, pp. 411-417.

[40] Ibid., p. 412.

identified at a minimum performance level of 94 percent at each time level.[41] Experiments III and IV were replications of the first experiment except that the masking was presented dichotically i.e. the test tone was presented to one ear, and the masking tone was presented to the other ear. In experiment III, the test tone was always presented to the same ear. The masking tone was always presented to the opposite ear. In experiment IV, the test tone was presented to either ear randomly. The masking tone was presented to ear contralateral (opposite) to the test tone presentation. The results obtained were similar to those obtained in the first experiment. Massaro theorized that these results provided evidence for a central auditory store, since a dichotic masking tone was as effective as one presented binaurally.[42]

A fifth experiment was undertaken to determine whether the similarity of the masking tone to the test tone had any effect on the processing of pitch information. The data revealed no significant difference in identification or performance as a function of the frequency of the masking tone.[43]

Massaro interpreted the findings of this series of experiments as evidence for a sensory storage system that retains an auditory image (retention of a stimulus presentation after the stimulus has terminated) of a tone for about

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[41] Ibid., p. 413

[42] Ibid., p. 415

[43] Ibid., p. 416

250 milliseconds. He also concluded that the image could be processed while it lasts.[44] This study is also important because it provides the first quantitative evidence for pitch imagery. Prior studies such as those by Whipple (1901) were based on introspective reports of subjects.

In 1972, Massaro [45] sought to determine the effect of stimulus information and processing time in making absolute pitch judgements. He was also interested in determining whether perceptual processing during a silent interstimulus interval was as effecient as in processing a continuous tone. Two test tones, an 800 Hz sine wave tone and an 800 Hz sawtooth wave tone, were to be identified as sharp (sawtooth wave) or dull (sine wave). The two conditions of the study were (1) silent processing, and (2) continuous processing. In the silent processing condition, the test tone was followed by a silent time interval of 30 milliseconds, 50, 80, 130, 190, 250, 340 or 440 milliseconds. The continuous condition had the test presented at durations of 40, 60, 90, 140, 200, 260, 350 or 440 milliseconds, followed by a 10 millisecond silent interval, which was followed by a masking tone.

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[44] Ibid., p. 416

[45] Dominic W. Massaro, "Stimulus Information Vs. Processing Time in Auditory Pattern Recognition," Perception and Psychophysics, 1972, Vol. 12, pp. 50-59.

Massaro reported that processing time seemed to be more important than stimulus duration; and that the rate of processing was almost equal for the silent and the continuous conditions. Performance was near chance with 50 milliseconds processing time; however, it improved to 70 percent with processing time of 270 millisedonds.[46]

Massaro considered these findings as further support for a Preperceptual Auditory Store (PAS). The PAS, he suggests, contains information about the acoustic characteristics of the stimulus (tone), which decays at a very rapid rate. In a review of literature of auditory memory, Horton and Turnage[47] notes that Massaro's findings are contradictory to most of the research reported. To account for this discrepancy, Massaro proposed an intermediary stage between the PAS and short-term memory, which he identifies as the Synthesized Auditory Memory (SAM). Accordingly, the recognition process involves the transformation of preperceptual information into a synthesized percept via the SAM, which then channels it into short-term memory.[48]

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[46] Ibid., p. 52.

[47] Horton and Turnage, Human Learning, p. 200.

[48] Dominic W. Massaro, "Auditory Information Processing," in Handbook of Learning and Cognitive Processes Volume 4 -- Attention and Memory. Edited by W.K. Estes (Hillsdale, N.J.: Lawrence Erlbaum Assoc., Publishers, 1976), pp. 276-277.

Research in verbal memory, particularly that by Crowder and Morton,[49] tend to support Massaro's theory of a preperceptual auditory memory. They, however, identify their preperceptual store as a Precategorical Acoustic Store.

Deutsch[50] investigated the effects of spoken numbers vs. tones interpolated during the retention. She found that the interpolated numbers had little effect on pitch retention while the tones were highly disruptive.[51]

The studies of interference in short-term memory for pitch cited thus far have involved interpolation of single tones only. In 1972, Deutsch[52] investigated the effect of interpolating a sequence of four tones (which included the standard tone, or the comparison tone, both or neither) in the retention interval. In this experiment the subjects listened to a standard tone which was followed by a sequence of four interpolated tones (300 milliseconds apart), a 2 second pause, and then a

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[49] R.G. Crowder and J. Morton, "Precategorical Acoustic Storage," Perception and Psychophysics, 1969, Vol. 5, pp. 365-373.

[50] Diana Deutsch, "Tone and Numbers Specificity in Short Term Memory," Science, 1970, Vol. 168, pp. 1604-1615.

[51] Ibid., p. 1604.

[52] Diana Deutsch, "The Effect of Repetition of Standard and Comparison Tones on Recognition Memory for Pitch," Journal of Experimental Psychology, 1972, Vol. 93, pp. 156-162.

comparison tone. The subjects were instructed to remember the standard tone, ignore the 4 interpolated tones, and then judge whether the comparison tone was the same as or different than the standard tone. There were ten conditions. They were:

1. Neither standard nor comparison tone were present in the interpolated tones.

2. The standard tone was present as the second interpolated tone.

3. The standard tone was present as the third interpolated tone.

4. Neither the standard or comparison tones were present. The comparison was different than the standard.

5. The standard tone was the second interpolated tone. The comparison tone was different.

6. The standard tone was the third interpolated tone. The comparison tone was different.

7. The comparison tone was the second interpolated tone.

8. The comparison tone was the third interpolated tone.

9. The comparison tone was the second, and the standard tone was the third interpolated tone.

10. The standard tone was the second interpolated tone and the comparison tone was the third interpolated tone.

The analysis of the data for the study indicated that inserting a tone that was the same as the S* tone reduced errors in pitch judgment; inserting a tone that was the same as or similar to the C** tone increased errors in judgement.[53]

In a more recent, but related study, Deutsch,[54] reported that including a tone that is identical in pitch to the S tone (in an interpolated sequence) has a faciliatory effect on pitch memory. This facilatory effect, however, was found to be extremely sensitive to serial position, i.e., its position relative to the S tone. The closer the identical tone was placed to the standard pitch, the better the recognition performance. In a subsequent discussion of this serial effect, Deutsch theorized that the repeated tone produces memory consolidation by trace strengthening.[55] A suggested alternate hypothesis was that the subject might have been adopting a particular strategy in which the newer tone replaces the S tone, forming a newer trace.[56] Deutsch

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*Standard tone.

**Comparison tone.

[53] Ibid., p. 156.

[54] Diana Deutsch, "Facilitation by Repetition in Recognition Memory for Tonal Pitch," Memory and Cognition, 1975, Vol. 3, pp. 263-266.

[55] Diana Deutsch and J. Anthony Deutsch, Short Term Memory (New York: Academic Press, 1975), pp. 135-136.

[56] Ibid., p. 136.

performed a second experiment to test this alternative hypothesis. She concluded from the results that her memory consolidation hypothesis was the correct one.[57]

In 1974, Deutsch[58] conducted an experiment to determine the interference effect of interpolated tones taken from octave ranges above and below that of the S and C tones. The S and C tones were taken from the octave c^4 to b^5. Neither the S nor C tones were included in the interpolated sequence. There were four conditions in the experiment:

1. Condition S - the interpolated was in the same octave as the S and C tones.
2. Condition H - the interpolated tones were taken from the octave above.
3. Condition L - the interpolated tones were from the octave below the S and C tones.
4. Condition H-L - the tones were taken from the octaves above and below the S and C tones.

An analysis of the data indicated that the greatest amount of interference occurred in condition H-L, followed by conditions S, H and L, respectively. Deutsch concluded that interference can be produced by tones from a relatively wide range.[59]

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[57] Ibid.

[58] Diana Deutsch.

[59] Ibid., p. 232.

In a discussion of the results of this experiment and the other experiments cited, Deutsch offered the following hypothesis:[60]

> When we listen to a sequence of tones, we process not only the tones themselves, but also the relationships between them, i.e., the melodic sequence of intervals...

She suggests, therefore, that the greater error rate in the condition in which the interpolated tones were drawn from both the higher and lower octave ranges (Deutsch, 1974) was due to the subjects' being less able to utilize pitch relationships as compared to the other conditions.[61]

In the early 1970's researchers began to use pitch sequences and short melodic patterns as stimuli in short-term pitch retention studies. One such study by Dowling and Fujitani[62] sought to determine whether melodic sequences are recognized by their contour, interval relationship, or as discrete pitches. Melody, in this study, was defined as a series of intervals between successive pitches.

The study consisted of two experiments. The first experiment involved short-term memory with a standard melody,

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[60] Ibid., p. 233.

[61] Ibid., p. 234.

[62] W.J. Dowling and Diane Fujitani, "Contour, Interval and Pitch Recognition in Memory for Melodies," Journal of the Acoustical Society of America, 1971, Vol. 49, No. 2, pp. 524-431.

and comparison melodies that were either untransposed or transposed from the key of the standard melody. Subjects were randomly assigned to one of six groups. The groups were divided equally between the transposed and untransposed conditions. Group 1 (untransposed condition) and Group 2 (transposed condition) determined whether the second of two melodies was the same or different from the first (task 1). Group 3 (untransposed) and Group 4 (transposed) determined whether the second of two melodies was the same or had the same contour as the first (task 2). Group 5 (untransposed) and Group 6 (transposed) compared the standard melody with a same or different contour melody (task 3). Subjects in Groups 1, 2, 3, and 4 were instructed to identify the comparison melody as same only if it were identical to the standard melody.

Dowling and Fujitani reported that the effects of transposition and task and their interaction were significant ($p < .01$). Recognition performance for tasks 1 and 2 were equal in the untransposed condition. It was somewhat more difficult for the transposed conditions. Performance on the third task was better for the transposed condition than for the untransposed condition. It was suggested by the investigators that the subjects in the untransposed condition misunderstood the task.

The conclusions drawn by Dowling and Fujitani were that:[63]

> Subjects utilize discrete pitch information when recognizing brief untransposed melodies; and melodic contour when recognizing transposed melodies, i.e., melodic contour is more important than discrete pitch.

The second experiment was categorized as long-term memory experiment since the melodies used were familiar folk songs which were considered stored in long-term memory. Subjects were instructed to listen to several melodies and then listen to distorted versions of the same melodies. The distorted versions preserved the harmonic outline, the melodic contour, or the intervallic relationships and contour. The results of the study showed that recognition performance for the undistorted version of the songs was 0.99. Recognition performances for the distorted versions were 0.66 for the version which preserved contour and interval size, 0.59 for the version with contour only preserved, and 0.28 for the version that preserved the harmonic outline.

Dowling and Fujitani concluded that: (a) melodic contour was important in the recognition of familiar melodies, and (b) recognition memory (long-term) appears to involve more than just storing melodic contour and relative

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[63] Ibid., p. 531.

interval size. Specific pitch relationships seem to be stored as well.[64]

Serial Effects

A review of literature for short-term pitch retention yields two experimental studies that dealt with special serial effects. Ortmann,[65] in an often cited study, alluded to serial effect in tonal memory when he listed 'order of pitch in a sequence' as a miscellaneous variable in melodic perception. Deutsch (1972)[66] noted a possible serial effect with interpolated tones.

Taylor[67] examined serial effect in an investigation of 25 melodic intervals within melodic contexts (4 and 6 pitch, melodic sequences). One of the questions asked by Taylor was: Is each melodic interval perceived differently as a function of that interval within its melodic context?

Four- and six-pitch melodies with test intervals imbedded in the first, center or last position of the

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[64] Ibid., pp. 530-532.

[65] Otto Ortmann, "Some Tonal Determinants of Melodic Memory," Journal of Educational Psychology, 1933, Vol. 24, pp. 454-467.

[66] Deutsch, "Effects of Repetition," p. 161.

[67] James Taylor, "Perception of Melodic Intervals within Melodic Context" (Doctoral dissertation, University of Washington, 1972).

melody, were presented to the subjects. After each presentation subjects were instructed as to which interval to identify. Two numbers were given to indicate the location of the target interval, i.e., 1-2 indicated the interval between the first and second tones of the melody. A 7-second interval followed in which the name of the target interval was written down. Taylor reported that:[68]

> Each interval was perceived differently as a function of its position within its melodic context. 17 intervals were perceived less accurately in the center position than in first and last position. 15 intervals were perceived less accurately in first position than in the last position.

A significant interaction ($p < .05$) was found for the length of melody, and serial positions of the test interval. Taylor concluded that:[69]

> The position of an interval, i.e., first, center or last...within a pitch sequence is a strong variable that significantly influences the perception of all the intervals used in the study.

In 1973, Williams,[70] using a three-factor repeated measures paradigm, made a more intensive investigation of of the effect of sequence length and serial position on

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[68] *Ibid.*, p. 168.

[69] *Ibid.*, p. 154.

[70] David B. Williams, "Short-Term Retention of Pitch Sequence" (Seattle: Ph.D. dissertation, University of Washington, 1973).

short-term pitch retention. The pitch sequences were 3, 5, and 7 pitches in length. There were three serial positions: primary (first), center, and last. The third factor, delay time, had six levels: 0, .5, 1, 3, 5, 7.5, and 15 seconds. Serial position and delay time were randomly ordered across the three sequence lengths, giving a total of 630 trials.[71] Each of the 13 subjects were exposed to all treatment combinations.

The memory task involved a forced-choice procedure (the subject is required to recall or recognize a designated item). A pitch sequence was presented, followed by a delay time, followed by a visual response cue (lighted number), which indicated the position of the pitch that was to be recalled. The subject responded by singing the designated pitch. A judgment was then made (by the experimenter) as to whether the response matched the designated pitch. Because the six replications of a treatment combination were pooled, a subject's score could range from 0 to 6.

An analysis of the data indicated a significant difference ($p < .01$) for the main effects of sequence length, serial position, and delay time. All two-factor

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[71] _Ibid_., p. 31.

interactions were noted to be significant ($p < .05$). There was no significant three-factor interaction.[72]

On the basis of the results of his study, Williams concluded that:[73]

> 1. Loss of retention in short-term memory occurs as a result of increased delay time before recall, the position of a pitch within a sequence (recency primacy center), and the increased length of a sequence.
>
> 2. Retention of a pitch sequence is a function of delay time before recall, serial position and sequence length, and their combined effects.

In regard to the specific effects of serial position, Williams asserted that:[74]

> The loss of information in the recency and primacy positions of a pitch sequence is dependent upon both time and item decay, and their combined effects. Loss of information in the center position, on the other hand, is a function of item decay, not time decay. Furthermore, the behavior of the recency and primacy positions in not the same. Loss of information in the recency position is equally one of time and item decay, whereas, loss of information in the primacy position is more one of item decay rather than time decay.

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[72] Ibid., pp. 142-143.

[73] Ibid., p. 144.

[74] Ibid., p. 144.

In a most recent study of short-term pitch memory, Long[75] examined the effect of melody length, tonal structure, melodic contour, and music perception ability on memory for pitch. She also investigated the relationship between melodic memory and the amount of tonal information contained in a melody. Melody lengths were 7, 11, and 15 pitches.

Subjects were placed in one of three groups according to their perceptual ability. Group 1 consisted of graduate music majors; Group 2 was composed of undergraduate music majors; and Group 3 were non-music majors. Subjects in each group listened to 12 specially composed melodies. Each melody was heard twice. On the first hearing, each melody was followed by two seconds of silence, and a one-second test tone. The instructions were to remember the melody and determine if the test tone had occurred in the melody. Each melody was presented once followed by a test tone (correct one) that had been heard in the melody. On the second hearing the melody was followed by a test tone that deviated by a half-step (above or below) the first tone. This tone had not occurred in the melody. Subjects responded, indicating the confidence of their decision on

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[75]Peggy Ann Long, "Pitch Recognition in Short Melodies" (Tallahassee: Unpublished Ph.D. dissertation, The Florida State University, 1975). In Dissertation Abstracts, 1976, No. 4083).

a six-point rating scale (+3 very sure, yes, -3 very sure, no).

Long reported that the results of the analysis of variance showed the factors of groups and tonal structure to be significant ($p < .01$). Memory performance by the groups composed of music majors was better than that of the non-music major group. Tonal melodies were remembered better by all three groups. As the length of melodies increased, memory performance decreased. All other tests were found to be not significant ($p < .01.$).

The findings of Long tend to support Taylor (1972) and Williams (1973) in regards to pitch length. Shorter melodies are remembered better than melodies of longer duration.

Timbre Perception

According to the literature, there has been little study of the influence of timbre on perception and retention. Mainwaring,[76] in an early study of recall memory, decided that the performance medium of a melody was unimportant in its recall. Using the introspective report of subjects to the question" "Whether it was easier to recall

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[76]James Mainwaring, "Kinesthetic F-ctros in Recall of Musical Experience," British Journal of Psychology, 1933, Vol. 23, p. 295.

a tune that had been presented on one instrument rather than another," Mainwaring found that subjects responded indecisively both times that question was asked. He concluded that the subjects' indecision provided evidence that the medium of tone is forgotten or completely ignored.[77]

The five-year longitudinal study of auditory perception by Petzold[78] is one of the most extensive investigations of music memory undertaken. The major purpose of the study was to determine the differences between children at each of the first six grade levels, in the manner in which they perceive and respond to the auditory presentation of musical sounds.

A secondary aspect of the study dealt with the influence that combinations of the basic music elements, i.e., rhythm, timbre, and harmony, might have upon the auditory perceptions of melodic sequences.[79]

Since the findings of Dr. Petzold's study are well known and are frequently reported in the literature, only the timbre study will be discussed.

Although the timbre study was a pilot project within the overall longitudinal study, it is perhaps the

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[77] Ibid.

[78] Robert G. Petzold, Auditory Perception of Musical Sounds by Children in the First Six Grades (Madison: University of Wisconsin Press, 1966).

[79] Ibid., p. 253.

most extensive investigation of the effects of timbre on auditory perception to date. Petzold stated that the purpose of the timbre study was to seek answers to the following question: What kinds of relationships exist between the type of performance medium utilized for the aural presentation of melodic items, and the accuracy with which children perceive and reprodue these items? Subsidiary questions were concerned with determining whether any single performance medium seemed to be most appropriate for use at a given grade level, and whether one medium of performance led to error responses that were markedly different from those of other performance media.

Originally eight timbre qualities were to be used in the study: piano, soprano voice, flute, violin, tenor voice, French horn, trombone, and cello, representing soprano, tenor and bass ranges. An exploratory study found that the children were unable to make octave transpositions with their voices; therefore, the tenor and bass range timbres were elimianted in the actual study. Four forms of the Timbre Test were recorded, utilizing the piano, soprano voice, flute, and violin.

The results of the study indicated that all three main effects (timbre treatment, grade, and sex) were significant ($p < .01$). Thus, the use of different performance media for presenting melodic items produced significant differences in test scores, regardless of grade level or sex.[80] There was, however, no interaction between the main variables. The data also showed that melodic items performed on the violin were responded to with greater accuracy, followed by the voice and then the piano and flute, in that order. Petzold could not account for this result.[81]

In summarizing the results of this study, Petzold suggested that the four tests did not cover as broad a range of possibilities as they should have and that further research should be undertaken.[82]

Recently, Williams[83] found that changes from a 'bland' to a 'rich' timbre affected children's perception of melodic motion. Thirty-two second-grade and thirty-two fifth-grade students took part in an experiment in which the task consisted of identifying the unidirectional motion of two-pitch melodic patterns (unisons, ascending-descending minor seconds, thirds, and perfect fourths). The timbre of the initial tone of each pattern was varied either as a rich timbre (strong in harmonics) or a bland timbre

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[80] Petzold, p. 129.

[81] _Ibid_., p. 134.

[82] _Ibid_., p. 144.

[83] David B. Williams, "An Interim Report of a Programmatic Series of Music Inquiry Designed to Investigate Melodic Pattern Identification Ability in Children," _Council for Research in Music Education_, 1976, pp. 78-83.

(deficient in harmonics). The second tone of all the patterns was a rich timbre. After listening to a pattern, the child, by pushing one of three buttons, indicated whether the pattern ascended, descended or remained stationary.

Williams reported that changes from the rich timbre to the bland timbre were perceived as ascending motion. The effect was particularly dominant with descending minor seconds.[84]

SUMMARY

The review of literature supports evidence for _time decay_ and _interference_ as causative factors for loss of information in short-term pitch retention. The studies of Solf (1896), Angell (1899), Whipple (1901), Anderson (1914), Koester (1945), Harris (1952), Pollack (1952), and Bachem (1954) have shown that memory for pitch gradually deteteiorates over time. The research of Wickelgren (1966, 1969), Massaro (1970, 1971, and 1972), and Deutsch (1970-1974) has shown that short-term memory for pitch is also subject to interference.

In addition, the research of Massaro has provided evidence for a sensory storage system -- the Preperceptual Auditory Store (PAS) which holds auditory information for

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[84] _Ibid_.

a short time (about 250 msec) after a stimulus has been presented. And, what is perhaps more important, Massaro's studies have provided a quantitative measurement of auditory imagery.

Serial effects in pitch memory were implied by Ortmann (1933) and reported by Taylor (1972) and Williams (1973). Dowling and Fujitani indicate that contour is important in the preservation of transposed melodies. Taylor, Williams (1973) and Long (1975) have shown that the length of a melody or pitch sequence also affects the short-term retention of that melody, longer melodies being less well remembered.

The review of literature for timbre perception reveals inconclusive results, particularly for timbral effects on immediate perception and retention. The findings of Mainwaring, Petzold and Williams (1975) suggest, however, that timbre may affect perception.

Finally, the review of literature has shown that there are similarities between pitch memory and verbal memory. Shuter[85] suggests that memory for music is analogous to verbal memory. The research literature does provide evidence that pitch memory and verbal memory are subject to the same effects, i.e., decay over time, interference, and serial position.

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[85]Rosamund Shuter, Psychology of Musical Ability (London: Methuen and Co., Ltd., 1968), p. 202.

Deutsch, on the other hand, interprets the findings of her research to indicate that memory for pitch and verbal memory are different. She asserts that the two are distinct systems.[86] Bower supports this contention, stating that:[87]

> We can remember something about nonverbal events even though we can't describe them ...They seem to be represented in terms of analogical structures that are not necessarily connected to the verbal system.

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[86] Diana Deutsch, "Short-Term Memory," pp. 145-146.

[87] Gordon H. Bower, "Introduction to Concepts and Issues," in Handbook of Learning and Cognitive Processes. Edited by W.K. Estes (New York: John W. Wiley and Sons, 1975), p. 57.

CHAPTER III

DESIGN OF THE STUDY

Sample

The sample for this study consisted of twenty-eight Michigan State University undergraduate students enrolled in Music 271, a fundamentals of music class for non-music majors. The subjects were from various schools and departments within the university. There were 11 female students and 17 male students. All academic classifications (freshman, sophomore, junior and senior) were represented in the class structure. Data obtained from student information cards (completed during the first week of the term) indicated that the members of the class possessed varying degress of experience with music, ranging from little or no experience to several years of prior study.

Instrumentation

An investigation designed pitch-memory test - the Pitch-Timbre Memory Test (P-TMT) was used to collect the data for this study. For several reasons it was deemed necessary to construct a test rather than use one of the existing published tests. One reason was to provide a control for prior experience with music memory tests. Another reason was to control for other variables such as tonality, rhythm, and the number of pitches used in each sequence.

The actual development of the test took approximately a year and a half. At the outset of the study, the investigator had planned on using acoustic instruments (Flute, clarinet, trumpet, French horn, cello, and voice) as the sound sources for the test items. These instruments were used in the preparation of the initial version of the test. The test itself contained 20 items. Each item consisted of two, six-pitch sequences composed by the investigator. Six Michigan State University undergraduate music students performed and recorded the test. It was discovered during the playback of the recorded test that the items were not performed equally, i.e., there were differences in articulation, intonation, dynamics, and attacks and releases, between the items. After several subsequent recordings it was concluded that the problem of controlling for performer differences was of such magnitude as to make the use of acoustic instruments implausible. It was also determined that the pitch sequences were tonally biased because of the investigator's unconscious preference for certain intervallic combinations.

The decision therefore, was made to (a) have the test items programmed by a computer and (b) use a synthesizer as the sound source for the test items. The revised version of the test was completed during the Winter term of 1977.

In its final form, the Pitch-Timbre Memory Test contained 48 items. Each item consisted of two, four-pitch sequences. The atonal pitch sequences were developed by the CDC-6500 computer system located in the Computer Center at Michigan State University from a program written especially for this study. The pitch sequences were generated by an Arp 2600 synthesizer and recorded on a TEAC 33440-S tape recorder. The automatic trigger of attack and release was accomplished by the internal clock of the sample and hold. The four-pitch sequences were played at a rate of four sixteenth notes in a quarter note, m.m. ♩ = 60.

The four wave forms (sine, sawtooth, pulse and triangle), which constituted the timbres of the pitch sequences, came out of voltage control oscillator No. 2 of the envelope generator. The sine wave was used as the standard timbre. All four timbre qualities were randomly assigned as comparison timbres. The test tapes were prepared and edited (under the supervision of the investigator) by professional recording engineers at a professional recording studio in East Lansing, Michigan. Two members of the Michigan State University music faculty listened to the pitch sequences in order to certify their suitability as atonal pitch sequences. The

Table 3.1

Pitch-Timbre Memory Test Format

Item No.	Sequence A	Retention Interval	Timbre	Sequence B
1	sine	5 sec.	sine	same
2	sine	30 sec.	sine	different
3	sine	15 sec.	sawtooth	different
4	sine	15 sec.	sine	different
5	sine	5 sec.	sine	different
6	sine	15 sec.	sine	same
7	sine	5 sec.	pulse	same
8	sine	15 sec.	sawtooth	different
9	sine	15 sec.	sine	same
10	sine	15 sec.	triangle	same
11	sine	5 sec.	pulse	different
12	sine	30 sec.	pulse	same
13	sine	5 sec.	sine	different
14	sine	15 sec.	sine	different
15	sine	5 sec.	sine	different
16	sine	30 sec.	sine	same
17	sine	15 sec.	triangle	different
18	sine	15 sec.	pulse	different
19	sine	5 sec.	sine	same
20	sine	15 sec.	triangle	same
21	sine	5 sec.	sawtooth	different
22	sine	5 sec.	triangle	same
23	sine	30 sec.	sine	same
24	sine	5 sec.	sine	different
25	sine	30 sec.	pulse	different
26	sine	30 sec.	sawtooth	different
27	sine	15 sec.	sine	same
28	sine	15 sec.	sine	different
29	sine	15 sec.	sawtooth	same
30	sine	30 sec.	triangle	different

Table 3.1 (continued)

Item No.	Sequence A	Retention Interval	Timbre	Sequence B
31	sine	30 sec.	triangle	same
32	sine	15 sec.	pulse	same
33	sine	5 sec.	sine	same
34	sine	5 sec.	sine	same
35	sine	30 sec.	sawtooth	different
36	sine	5 sec.	triangle	same
37	sine	30 sec.	sine	different
38	sine	30 sec.	sine	different
39	sine	30 sec.	sine	same
40	sine	5 sec.	pulse	different
41	sine	15 sec.	sine	different
42	sine	30 sec.	sawtooth	same
43	sine	5 sec.	triangle	different
44	sine	30 sec.	sine	different
45	sine	30 sec.	sine	same
46	sine	30 sec.	pulse	same
47	sine	15 sec.	sine	same
48	sine	5 sec.	sawtooth	same

pitch sequences were also judged atonal by a class of non-music major undergraduate students enrolled in Music 271. (The distinction between tonal and atonal had been explained to the class.)

One of the three retention intervals (5 seconds, 15 seconds, or 30 seconds) was used between the first and second pitch sequences of each item. There was a 5 second response interval between each item. Two test tapes were used in the study. Both tapes contained the memory test; however, there were differing sets of instructions at the beginning of each tape. Test-retest reliability was established with $r = .92$, using the Pearson Product Moment Correlation formula. Table 3.1 shows the test format.

Design

A $2 \times 2 \times 3 \times 4$ split-plot factorial design (Winer, 1971)[1] was selected as the basic research design for the study. The independent variables were Timbre, Retention Interval, Task and Same/Different Items. Factor A, Timbre had 4 levels (sine wave, sawtooth wave, pulse wave, and triangle wave). Factor B, retention interval, had three levels: 5 seconds, 15 seconds and 30 seconds. Factor C, task, had two levels, same and different. Factor D, item-type had two levels, same sequence and different

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[1]B.J. Winer, Statistical Principles in Experimental Design, 2nd Edition (New York: McGraw-Hill, 1971, pp. 367-371).

sequence. The dependent variable was response performance (test score), as measured by the Pitch-Timbre Memory Test.

Procedures

Subjects were randomly assigned to one of two groups. Each group contained 14 subjects. Group I, took the Pitch-Timbre Memory Test, and performed a task during the retention interval of each item. The task consisted of counting backwards by threes from a specified number announced immediately after the first pitch sequence. The task is an interference procedure developed by Peterson and Peterson,[2] to study forgetting in short-term memory. To insure that they were really counting, subjects were instructed to write the numbers as they counted. Group II, the no-task group, simply took the test. Figure 3.1 shows the structure of the test tapes.

Although the instructions and practice items were recorded, the procedures were also explained and diagrammed on the blackboard prior to the playing of the test tape. Both test tapes were played on a Sony TC 155 tape recorder connected to a Scott Solid State Amplifier Model 299-1, and two large Jensen Speakers. The amplifiers and speakers were part of the classroom's audio system.

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[2]Lloyd Peterson and M.J. Peterson, "Short-Term Retention of Individual Verbal Items," Journal of Experimental Psychology, 1959, Vol. 58, pp. 193-198.

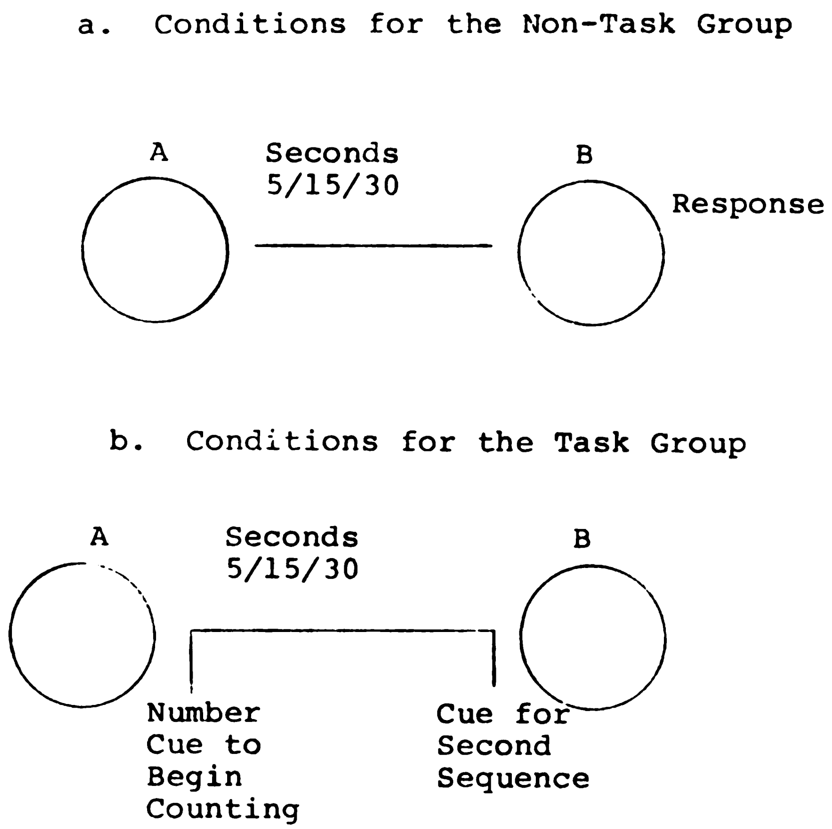

Figure 3.1

<u>The Pilot Study</u>

A pilot study was undertaken during the term prior to the actual testing to determine procedural efficacy. The sample size and the conditions were the same as in the actual study. All procedures were found to be generally satisfactory. It was found, however, that some subjects in the <u>task</u> group did not understand the procedures. It was also discovered that once the test had begun that several of the students did not always perform the task. Therefore, during the study itself, a careful but unobtrusive observation was maintained for the entire testing period.

Treatment of Data

The tests were scored by the Michigan State University Testing Service, whose services included transferring the scores to data cards. The actual data analysis was done by a CDC 6500 computer system housed in the Computer Center at Michigan State University. ANOVAH, a special analysis of variance program that treats nested classifications, was used to examine the main effects and interactions.

Testable Hypotheses

For experimental purposes the hypotheses advanced in this study were stated in their null form.

$H_0 1$: No difference will be found in the recognition response mean scores among the four types of timbre (wave forms) used in the second sequence or each item of the pitch-timbre memory test.

$H_0 2$: No difference will be found in recognition response mean scores as a result of change in the length of the retention interval.

$H_0 3$: No difference will be found in the recognition response mean scores between the task group and the non-task group.

$H_0 4$: No difference will be found in recognition response mean scores between test items in which the second pitch sequence is the same and test items in which the second sequence is different.

$H_0 5$: No significant interaction (AB) will be found between timbre (A) and retention interval (B).

$H_0 6$: No significant interaction (AC) will be found between timbre (A) and task (C).

$H_0 7$: No significant interaction (AD) will be found between timbre (A) and same sequence items vs. different sequence items (D).

$H_0 8$: No significant interaction (BC) will be found between retention interval (B) and task (C).

$H_0 9$: No significant interaction (BD) will be found between retention interval and same sequence items vs. different sequence items.

$H_0 10$: No significant interaction (CD) will be found between task (C) and same sequence item vs. different sequence item (D).

$H_0 11$: No significant interaction (ABC) will be found between timbre (A), retention interval (B) and task (C).

$H_0 12$: No significant interaction will be found between timbre (A), retention interval (B), and same sequence items vs. different sequence items (D).

$H_0 13$: No significant interaction (ACD) will be found between timbre (A), task (C), and same sequence item vs. different sequence item (D).

$H_0 14$: No significant interaction (BCD) will be found between retention interval (B), task (C) and same sequence items vs. different sequence items (D).

$H_0 15$: No significant interaction (ABCD) will be found between timbre (A), retention interval (B), task (C) and same sequence items vs. different sequence items (D).

CHAPTER IV

ANALYSIS OF THE DATA

The data for this study were processed and analyzed by the computer system located at Michigan State University. An SPSS (Statistical Package for the Social Sciences) program was utilized to determine the means for the 24 types of test items for each subject. These were coded into a special format and instrumented through the ANOVAH program which examined the main effects and interactions by analysis of variance techniques. The ANOVAH[1] program is a FORTRAN IV Program designed to perform N-way analysis of variance. It was revised for use (by the Office of Research Consultation, College of Education) on the CDC 6500 computer at Michigan State University. The routine will perform the calculations necessary for balanced, fully replicated or nested factorial designs and can handle any design up to 9 factors (counting replications).

Table 4.1 illustrates the split-plot factorial designed data matrix with descriptive statistics for the 24 types of question.

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[1]ANOVAH was originally programmed by Tom Houston in FORTRAN-63 for the CDC 1604 at the Laboratory of Experimental of the Wisconsin Research and Development Center for Cognitive Learning.

Table 4.1 Data Matrix for the Split Plot Factorial Design*

		Task C_1 (counting backwards)				Non-Task C_2			
	Retention Interval	Same		Different		Same		Different	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
A_1 sine	B_1 5 sec.	.7321	.2292	.4143	.1657	.7676	.2493	.4429	.1950
	B_2 15 sec.	.6071	.2541	.5714	.2673	.5357	.2161	.5714	.3457
	B_3 30 sec.	.5893	.2877	.6429	.2129	.4107	.2705	.6964	.2231
A_2 sawtooth	B_1 5 sec.	.8571	.3631	.2857	.4688	.7857	.4258	.4286	.5136
	B_2 15 sec.	.1424	.3631	.3214	.3167	.3243	.4258	.2857	.3231
	B_3 30 sec.	.8571	.3631	.3571	.2344	.4286	.5136	.7500	.3252
A_3 pulse	B_1 5 sec.	.7143	.4688	.3571	.4972	1.0000	.0000	.5000	.5189
	B_2 15 sec.	.3571	.4972	.6429	.4972	.2857	.4688	.5000	.5189
	B_3 30 sec.	.6429	.3631	.7143	.4688	.4286	.4322	.5714	.5136
A_4 Triangle	B_1 5 sec.	.8214	.2486	.7143	.4688	.7500	.3252	.4286	.5136
	B_2 15 sec.	.7857	.2568	.8571	.3631	.5357	.3650	.6429	.4972
	B_3 30 sec.	.6429	.4972	.1429	.3631	.4286	.5136	.5000	.5189

*N = 14 in each cell.

Table 4.2

ANOVA Summary for Main Effects and Interactions

(Timbre = A Time = B Task = C Item = D)

Source of Variation	Sum of Squares	df	Mean Squares	F
Timbre (A)	1.574	3	.524647	3.76*
within	10.863	78	.139270	
Retention Interval(B)	2.018	2	1.009022	7.97*
within	6.582	52	.126579	
Task-Groups (C)	.227	1	.226968	2.73
within	2.155	26	.082868	
Items (D)	1.146	1	1.145926	4.03
within	7.387	26	.284104	
A x B	6.402	6	1.067057	7.74*
within	21.511	156	.137892	
A x C	.360	2	.120123	.86
within	10.863	78	.138270	
A x D	.380	3	.126581	.745
within	13.236	78	.169689	
B x C	.380	2	.190026	1.50
within	6.582	52	.126574	
B x D	6.754	2	3.376953	17.63**
within	9.960	52	.191543	
C x D	.635	1	.634557	2.23
within	7.387	26	.284104	
A x B x C	1.669	6	.278121	2.01
within	21.511	156	.137892	
A x B x D	1.922	6	.320406	2.19*
within	22.787	156	.146072	
A x C x D	.678	3	.225426	1.33
within	13.236	78	.169689	
B x C x D	1.908	2	.953865	4.97*
within	9.960	52	.191543	
A x B x C x D	.964	6	.160711	1.10
within	22.787	156	.146072	

*$p < .05$

**$p < .01$

Results

Table 4.2 shows a summary of the ANOVA results for the main effects and interactions.

The presentation of data will continue with a consideration of the results of the tests of the individual null hypotheses.

$H_0 1$: No difference will be found in the recognition response mean scores between the four types of timbre (wave forms) used in the second sequence of each item of the pitch-timbre memory test.

A primary concern of this study was the effect of changes in timbre on perceptions and retention. The results of the ANOVA tests on this main effect show that $F = 3.76$ is significant beyond the .05 level (Table 4.3). Therefore null hypothesis 1 was rejected.

Table 4.3

ANOVA for Timbre Effect (Factor A)

Source of Variation	Sum of Squares	df	Mean Square	F
Timbre (A)	1.574	3	.524647	3.76*
within	10.863	78	.139270	

*$p < .05$

A <u>Neuman-Kuels</u> test was performed to determine the difference between the means found that the mean score at the sawtooth wave differed significantly ($p < .05$) from those of the other wave forms, i.e., sine, pulse, and triangle (Table 4.4).

Table 4.4

Results of Neuman-Kuels Test of Timbre Means

means	.640 (triangle)	.582 (sine)	.560 (pulse)	.426 (sawtooth)
.640	-	.022	.044	1.28*
.582		-	.022	1.06*
.560			-	.084*
.472				

*significant at the .05 level

$H_0 2$: No difference will be found in recognition mean response scores as a result of change in the length of the retention interval.

Table 4.5 shows the results of the ANOVA tests for null hypothesis two. The F ratio 7.97 was significant at the .05 level. Null hypothesis two was therefore rejected.

Table 4.5

ANOVA for Retention Interval Effect Factor (B)

Source of Variation	Sum of Squares	df	Mean Squares	F
Retention Interval (B)	2.018	2	1.009022	7.97*
within	6.582	52	.126529	

*$p < .05$

A post-hoc test (Neuman-Kuels) performed to determine the difference between the means for the main effect of retention interval found that the 15 second retention interval and the 30 second interval mean scores differed significantly ($p < .05$) from that of the 5 second interval (Table 4.6).

Table 4.6

Results of the Neuman-Kuels Test of Retention Interval Means

	0.625 (5 sec.)	0.550 (30 sec.)	0.491 (15 sec.)
0.625	-	0.075*	0.134*
0.550		-	0.059
0.491			-

*significant at the .05 level

$H_0$3: No difference will be found in the recognition response mean scores between the task group and the non-task group.

$H_0$4: No difference will be found in the recognition response mean scores between test items in which the second pitch sequence is the same and test items in which the second pitch sequence is different.

The results of the ANOVA tests for the main effects of task and item-type are shown in Table 4.7. The $F = 2.73$ for task effect and the $F = 4.03$ for the item-type effect were found to be non-significant at the .05 level. Null hypotheses 3 and 4, there, failed to be rejected.

Table 4.7

ANOVA for Task and Item-Type Effect (Factors C and D)

Source of Variation	Sum of Squares	df	Mean Square	F
Task (C)	.227	1	.226968	2.73
within	2.155	26	.082868	
Item-type (D)	1.146	1	1.145926	4.03
within	7.387	26	.284104	

$H_0 5$: No significant interaction (AB) will be found between timbre (A) and retention interval (B).

Interaction effects between timbre and retention were found to be significant $F = 7.74$ at the .05 level. The ANOVA results are shown in Table 4.8. Null hypothesis 5 was rejected.

Table 4.8

ANOVA for the Interaction (AB) of Timbre (A) and Retention Interval (B)

Source of Variation	Sum of Squares	df	Mean Square	F
Timbre x TI (A x B)	6.402	6	1.067057	7.74*
within	21.511	156	.137892	

*$p < .05$

Figure 4.1 shows the interaction (AB) of timbre (A) and retention interval (B).

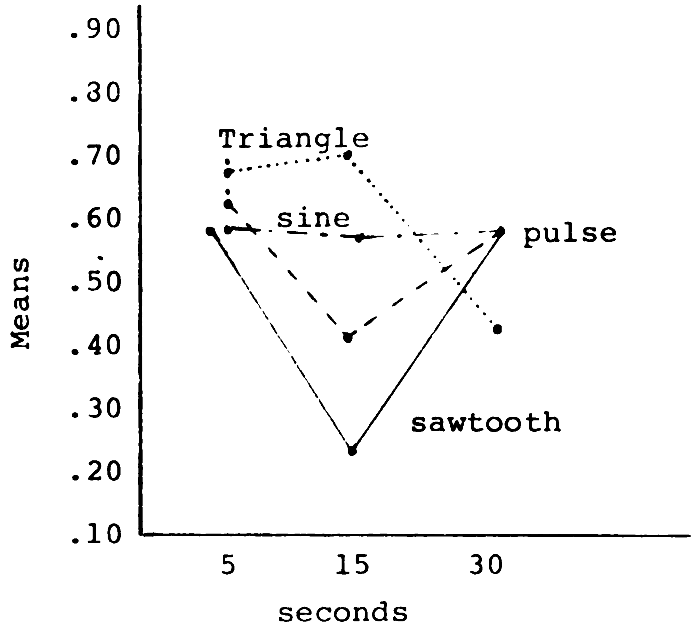


Figure 4.1

Timbre/Retention Interval Interaction (AB)

$H_0$6: No significant interaction (AC) will be found between timbre (A) and task (C)

$H_0$7: No significant interaction (AD) will be found between timbre (A) and item-type (D).

The ANOVA tests for interaction effects between timbre and task, and timbre and item type indicated non-significance for both interactions (Table 4.9). Null hypotheses 6 and 7 failed to be rejected - $p < .05$.

Table 4.9

ANOVA for the Interaction Effect of Timbre/Task (AC) and Timbre/Item (AD)

Source of Variation	Sum of Squares	df	Mean Square	F
Timbre/Task (AC)	.360	3	.120163	.86
within	10.863	78	.139270	
Timbre/Item (AD)	.380	3	.126581	.75
within	13.236	78	.169689	

$H_0 8$: No significant interaction (BC) will be found between retention interval (B) and task (C).

The results of the ANOVA indicated no significant interaction between retention and task (Table 4.7). Therefore the null hypothesis failed to be rejected.

$H_0 9$: No significant interaction (BD) will be found between retention interval (B) and item-type (D).

A significant interaction, $F = 17.63$ at the .05 level, was found between retention interval and item-type (Table 4.10). Figure 4.2 graphs the (BD) interaction.

$H_0 10$: No significant interaction (CD) will be found between task (C) and item type (D).

As indicated by Table 4.10 the interaction between task and item type were found to be non-significant. Null hypothesis 10 failed to be rejected.

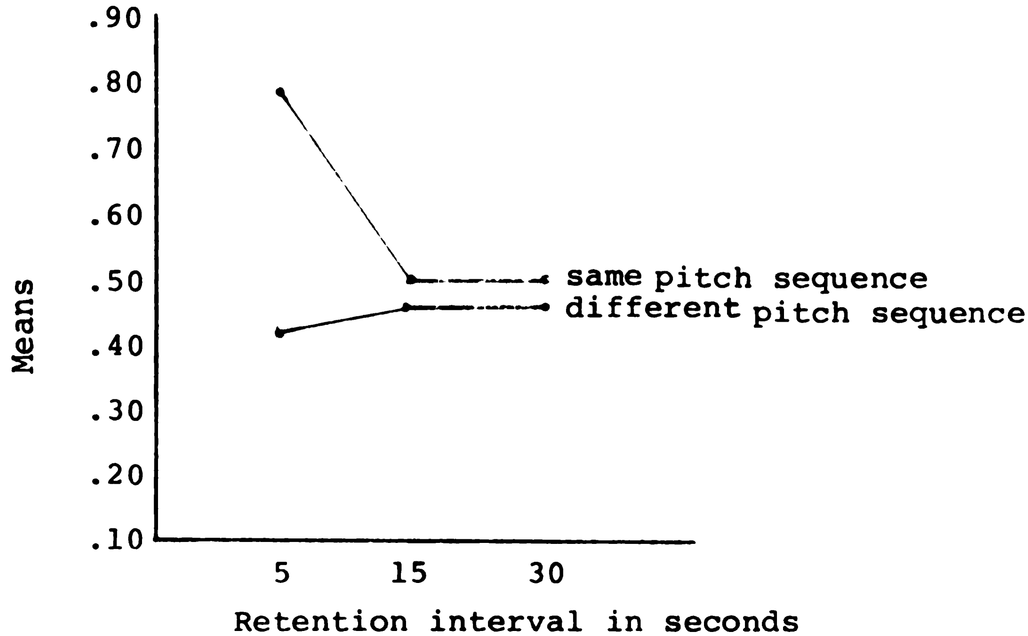


Figure 4.2

The Interaction (BD) between
Retention Interval (B) and Item Type (D)

Table 4.10

The ANOVA for the Interaction
Effects between Retention Interval
and Task (BC), Retention Interval
and Item Type (BD) and Task and
Item Type (CD)

Source of Variation	Sum of Squares	df	Mean Square	F
RI - Task (BC)	.380	2	.190026	1.50
within	6.582	52	.126579	
RI - Item (BD)	6.754	2	3.376953	17.63*
within	9.960	52	.191543	
Task - Item (CD)	.635	1	.634557	2.23
within	7.387	26	.284104	

*$p < .05$

$H_0 11$: No significant interaction (ABC) will be found between timbre (A) retention interval (B) and task (C).

The ANOVA indicated that no significant interaction occurred between timbre, retention interval and task. Table 4.11 shows that the obtained F ratio was not significant. Null hypothesis 10 failed to be rejected.

$H_0 12$: No significant interaction (ABD) will be found between timbre (A) retention interval (B) and item type (D).

The triple interaction (ABD) between timbre, retention interval and item type was shown to be significant $F = 2.19$ (Table 4.11) at the .05 level. Null hypothesis 12 was rejected.

Table 4.11

ANOVA for Interaction Effects (ABC) between Timbre (A), Retention Interval (B) and Task (C), and the Interaction Effects (ABD) between Timbre (A), Retention Interval (B) and Item Type (C)

Source of Variation	Sum of Squares	df	Mean Square	F
Timbre - RI - Task (ABC)	1.669	6	.278121	2.01
within	21.511	156	.137892	
Timbre - RI - Item (ABD)	1.922	6	.320406	2.19*
within	22.787	156	.146072	

*$p < .05$

Figure 4.3 shows a line plot of the triple interaction (ABD) between timbre, retention interval and item type.

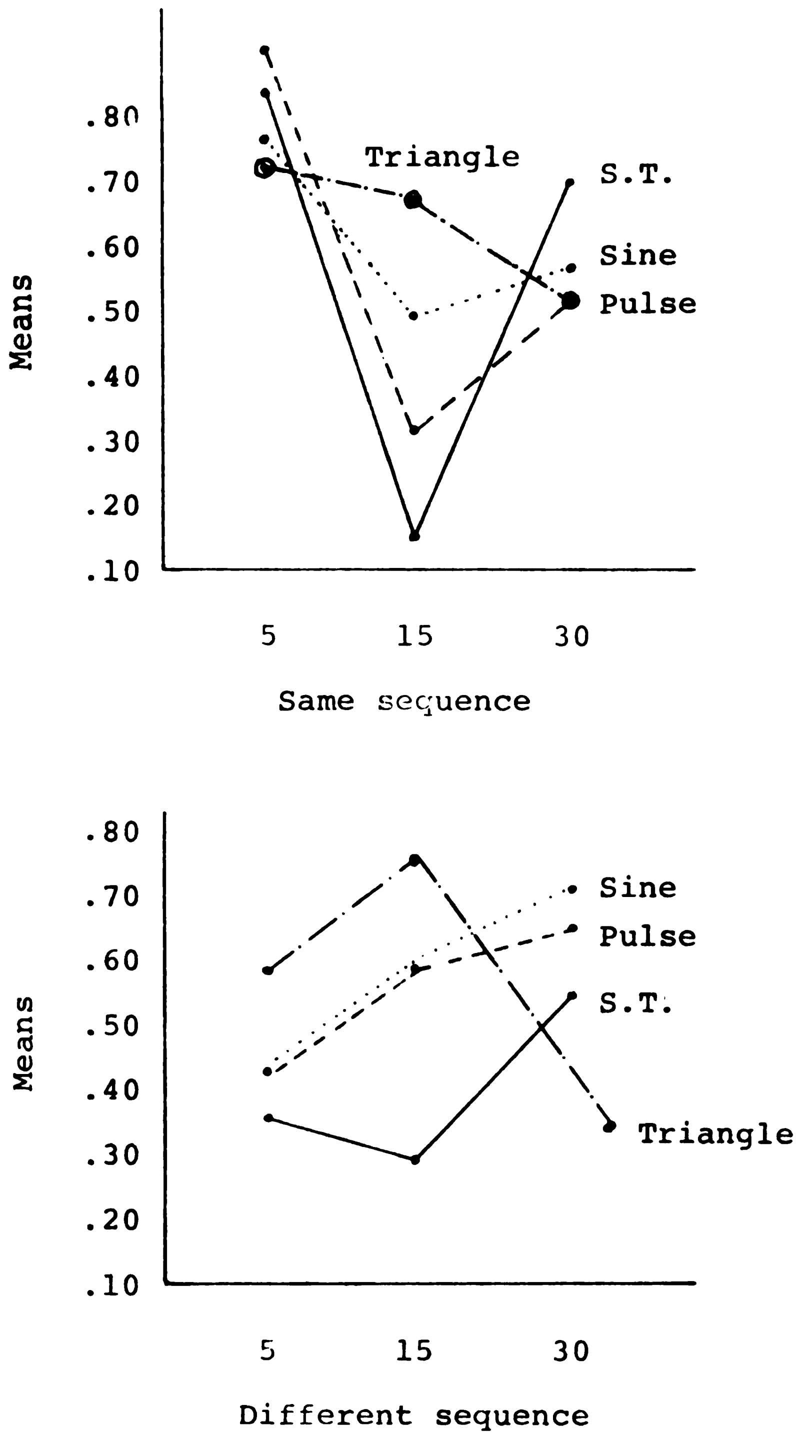


Figure 4.3

$H_0 13$: No significant interaction (ACD) will be found between timbre (A), task (C) and item type (D).

The results of the ANOVA indicated a non-significant interaction effect between timbre, task and item type (Table 4.12). Null hypothesis 13 failed to be rejected.

$H_0 14$: No significant interaction (BCD) will be found between retention interval (B), task (C), and item type (D).

The interaction effect between retention interval, task, and item-type was found to be significant ($F = 4.97$) at the .05 level. Null hypothesis 14 was rejected. Table 4.12 shows both (ACD) and (BCD) ANOVA results.

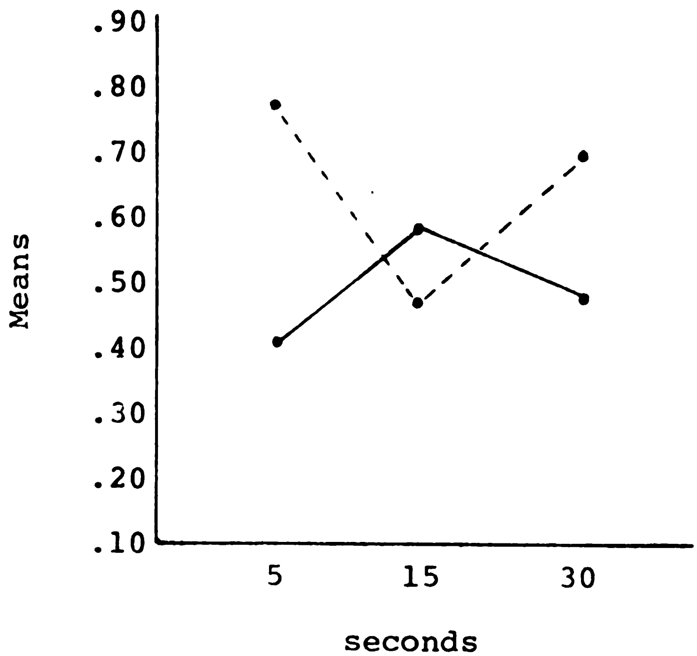
Table 4.12

ANOVA for the Interaction Effects (ACD) between Timbre, Task, and Item, and Interaction Effects (BCD) between Retention Interval, Task and Item

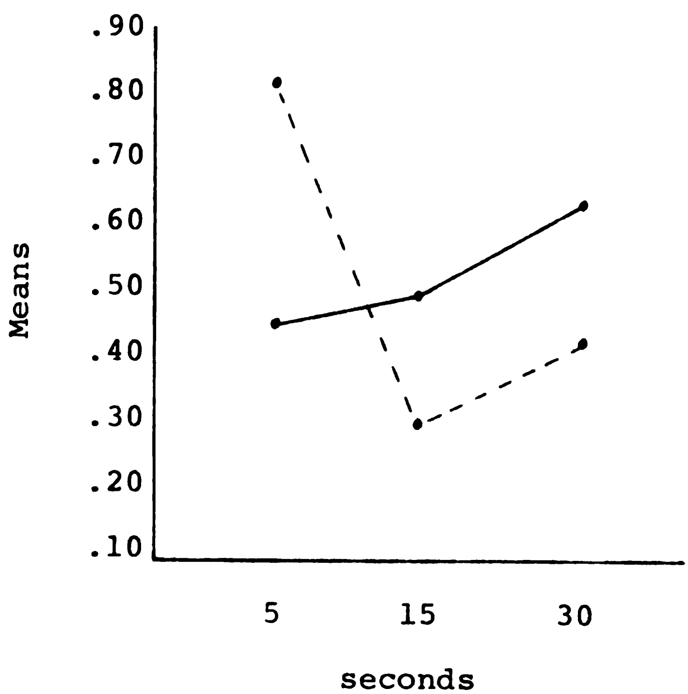
Source of Variation	Sum of Squares	df	Mean Square	F
Timbre × Task × Item (ACD)	.678	3	.225926	1.33
within	13.236	78	.169689	
RI × T × I (BCD)	1.908	2	.953865	4.97*
within	9.960	52	.160711	

*$p < .05$

Figure 4.4 shows a graph of the interaction between retention interval, task and item type.



Gp 1 (task)



Gp 2 (non-task)

Figure 4.4

$H_0$15: No significant interaction (ABCD) will be found between timbre (A), retention interval (B), task (C) and item type (D).

The interaction between timbre (A), retention interval (B), task (C), and item type (D) was found to be non-significant. Null hypothesis 15 was, therefore failed to be rejected.

Summary

As a result of the analysis of data null hypotheses 1, 2, 5, 9, 12, and 14 were rejected. The remaining null hypotheses failed to be rejected.

The main effects of timbre (A) and retention interval (B) were found to be significant at the .05 level Interaction effects of timbre and retention interval (AB), retention interval and item type (BD); timbre, retention interval and item (ABD); and retention interval, task and item type (BCD) were also found to be significant ($p < .05$).

CHAPTER V

SUMMARY AND CONCLUSIONS

The primary purpose of this study was the investigation of the effect of changes of timbre, length of retention interval (time) and performance of a task (during the retention interval) on short-term recognition memory for pitch. A secondary concern was the response performance on test items in which the second sequence was the same as the first, and those test items in which the second sequence was different from the first.

A review of short-term memory for pitch reveals that there has been little research on the influence of timbre on perception and retention. Research by Mull,[1] Mainwaring,[2] Petzold,[3] and Williams,[4] indicate a possible

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[1]Helen K. Mull, "The Acquisition of Absolute Pitch," The American Journal of Psychology, 1925, p. 489.

[2]James Mainwaring, "Kinesthetic Factors in Recall of Musical Experience," British Journal of Psychology, 1933, Vol. 23, p. 295.

[3]Robert G. Petzold, Auditory Perception of Musical Sounds by Children in the First Six Grades (Madison: University of Wisconsin Press, 1966).

[4]David B. Williams, An Interim Reprot of a Programmatic Series of Music Inquiry Designed to Investigate Melodic Pattern Identification Ability in Children," Council for Research in Music Education, 1976, pp. 78-83.

timbre effect. Petzold,[5] whose research involved a more direct investigation of timbre influence, concluded that timbre did not significantly affect the recall of tonal patterns, suggested, however, that further research was needed.

The literature on short-term memory for pitch is replete with investigations of the effect of time decay, and interference on the retention of a single pitch. Studies by Anderson,[6] Harris,[7] and Bachem,[8] show that short term memory for pitch deteriorates over time. Later research by Wickelgren,[9] Massaro,[10] and Deutsch,[11] indicated that short-term memory for pitch is also subject to interference of these effects on the retention of pitch sequences.

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[5]Petzold, p. 129.

[6]D.A. Anderson, "The Duration of Tones, the Time Interval, the Direction of Sound, Darkness, and Quiet, and the Order of Stimuli in Pitch Discrimination," Psychological Monographs, 1914, Vol. 16, pp. 150-156.

[7]J. Donald Harris, "The Decline of Pitch Discrimination with Time," Journal of Experimental Psychology, 1952, Vol. 43, pp. 96-99.

[8]A. Bachem, "Time Factors in Relative and Absolute Pitch Determination," Journal of the Acoustical Society of America, 1954, Vol. 26, pp. 751-753.

[9]Wayne A. Wickelgren, "Consolidation and Retroactive Interference in Short-Term Recognition for Pitch," Journal of Experimental Psychology, 1966, Vol. 72, No. 2, pp. 250-259.

[10]Dominic W. Massaro, "Retroactive Interference in Short-Term Recognition Memory for Pitch," Journal of Experimental Psychology, 1970, Vol. 83, pp. 32-39.

[11]Diana Deutsch, "The Effect of Repetition of Standard and Comparison Tones on Recognition Memory for Pitch," Memory and Cognition, 1975, Vol. 3, pp. 263-266.

A four factor split-plot design (Winer, 1971, p. 367-371; Kirk, 1968, p. 308-311) was adopted for this study. The independent variables were timbre (Factor A), retention interval (Factor B), task (Factor C) and item type (Factor D). The dependent variable was accuracy of recognition response measured by performance on a pitch-sequence memory test.

The data gathering instrument was a 48 item pitch-sequence memory test. The *Pitch-Timbre Memory Test* was designed by the investigator especially for this study. Each item consisted of two pitch sequences. The second sequence was either the same or different from the first. For twenty-four of the items, the same sound quality (a sine wave) was used for both pitch sequences of the item. The second sequence of the remaining twenty four items was either a sawtooth pulse or triangle wave form. The retention intervals were either *5 seconds*, *15 seconds*, or *30 seconds*. All items were randomized.

The twenty-eight subjects used in the study were randomly assigned to one of the two groups. Group I received the memory test and performed a task during each of the retention intervals. The task consisted of counting backwards by three from a number specified on the memory test tape. To insure that they were counting subjects wrote the numbers as they counted. Group II only took the memory test.

Findings

Four primary hypotheses and eleven secondary hypotheses were examined in their null form. ANOVAH, an analysis of variance computer program which handles vested factorial and repeated measure designs, was used to analyze the data.

According to the data analysis, the following reresults are reported.

$H_0 1$: No difference will be found in the recognition response mean scores among the four types of timbre (wave forms) used in the second sequence of each item of the pitch-timbre memory test.

A significant difference was found between the mean socre of the sawtooth wave and the mean scores of each of the other wave forms ($p < .05$). Null hypothesis one was rejected with an F ratio of 3.76 which is significant beyond the .05 level.

$H_0 2$: No difference will be found in recognition response mean scores as a result of change in the length of the retention interval.

A significant difference was found between the mean scores of the 16 second and 5 second retention intervals, and between the mean scores of the 30 second and 5 second retention interval ($p < .05$). Null hypothesis two was rejected $F = 7.97$ which is significant beyond the .05 level.

$H_0 3$: No difference will be found in the recognition response mean scores between the task group and the non-task group.

Null hypothesis three failed to be rejected. There was no significant difference between the means of the task group and the non-task group.

$H_0 4$: No difference will be found in recognition response mean scores between test items in which the second pitch sequence is the same and test items in which the second sequence is different.

Null hypothesis four failed to be rejected. There was no significant difference between the means of the two types of items.

$H_0 5$: No significant interaction (AB) will be found between timbre (A) and retention interval (B).

Interaction effects between timbre and retention interval were found to be significant $F = 7.74$ at the .05 level. Null hypothesis five was rejected.

$H_0 6$: No significant interaction (AC) will be found between timbre (A) and task (C).

There was no significant interaction effect between timbre and task. Null hypothesis six failed to be rejected.

$H_0 7$: No significant interaction (AD) will be found between timbre (A) and same sequence items vs. different sequence items (D).

There was no significant interaction between timbre and items. Null hypothesis seven failed to be rejected.

$H_0 8$: No significant interaction (BC) will be found between retention interval (B) and task (C).

Null hypothesis eight failed to be rejected. There was no significant interaction between retention interval and task.

$H_0 9$: No significant interaction (BD) will be found between retention interval and same sequence items vs. different sequence items.

A significant interaction was found between retention interval and items. The F ratio of 17.63 was found to be significant at the .05 level. Null hypothesis nine was rejected.

$H_0 10$: No significant interaction (CD) will be found between task (C) and same sequence item vs. different sequence item (D).

Null hypothesis ten failed to be rejected. There was no significant interaction between task and item.

$H_0 11$: No significant interaction (ABC) will be found between timbre (A), retention interval (B) and task (C).

Null hypothesis eleven failed to be rejected. There was no significant interaction between timbre, retention interval, and task.

$H_0 12$: No significant interaction will be found between timbre (A), retention interval (B) and same sequence items vs. different sequence items (D).

The triple interaction (ABD) between timbre retention interval, and task was found to be significant $F = 2.19$ at the .05 level. Null hypothesis twelve was rejected.

$H_0 13$: No significant interaction (ACD) will be found between timbre (A), task (C), and same sequence item vs. different sequence item (D).

There were no significant interactions between timbre, task, and item. Null hypothesis thirteen failed to be rejected.

$H_0 14$: No significant interaction (BCD) will be found between retention interval (B), task (C) and same sequence items vs. different sequence items (D).

A significant interaction effect $F = 4.97$ ($p < .05$) was found between retention interval, task and items. Null hypothesis fourteen was rejected.

$H_0 15$: No significant (ABCD) will be found between timbre (A), retention interval (B), task (C) and same sequence items vs. different sequence items (D).

There was no significant quadruple interaction between timbre, retention interval, task, and items. Null hypothesis fifteen failed to be rejected.

Conclusions

An examination of the findings of this study suggest the following conclusions:

1. The sound quality of a pitch sequence tended to affect its perception and its retention in short-term memory.

2. The sawtooth sound quality had the most disruptive effect on the short-term retention of pitch sequence. The triangle sound quality appeared to be less consistent in terms of effect on short-term retention.

3. The accuracy of recognition response in short-term retention was influenced by the length of the retention interval. Response mean scores for the task group and the non-task group were considerably lower at the 15 second retention interval.

4. The interaction effect between timbre and retention interval suggested that the short-term retention of pitch is dependent upon the kind of timbre and the length of the retention interval, at least in this study.

5. The performance of a non-musical task did not significantly affect the short-term retention of a pitch sequence.

6. The intention between retention interval and item-type suggested that the recognition of test items as the same or different was dependent on the length of the retention interval. Test items in which both pitch

sequences were the same, were recognized with greater accuracy during the 5 second retention interval, than test items, in which the second sequence was different.

7. The triple interaction between timbre, retention interval, and item type (same vs. different) suggested that the short-term retention of pitch sequences is dependent upon timbre, length of the retention interval, and whether the second sequence is the same or different.

8. The true influence of the main effects of timbre and retention interval should be qualified because of the number of interactive effects.

Discussion

Taylor[12] has proposed a list of perceptual determinants in melodic recognition. Included in the list are:

1. Gestalt of melody
2. Rhythm
3. Tempo
4. Dynamics
5. Timbre
6. Transposition
7. Melodic contour
8. Interval (size, direction, etc.)

He suggests that it is possible that an interval, for instance a p5, may be perceived and remembered differently

[12] James Taylor, "Perception of Melodic Intervals Within Melodic Context," (Doctoral dissertation, University of Washington, 1972), p. 6.

when played on a trumpet, as compared to a piano.[13] The results of this study would seem to give some support to that hypothesis. This may be particularly true in the case of non-music majors, who, for the most part, have not been exposed to the specialized training of the musician. Furthermore, the findings of this study appear to agree with those of Williams[14], who noted that children tended to musjudge intervals when presented by rich timbre as compared to presentation by a bland timbre. With reference to this investigation the sawtooth wave (rich timbre) had a detrimental influence on perception and retention.

The findings in respect to retention interval were somewhat contrary to expectation. The investigator had theorized a greater retention loss with the 30 second retention interval rather than the 15 second retention interval. These results, however, may be explained by the possibility that by the 15 second time interval the limits of short-term retention; and the improved performance during the 30 second interval was due to the transferral of pitch information into long term memory.

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[13] Ibid., p. 11.

[14] David B. Williams, "An Interim Report of a Programmatic Series of Music Inquiry Designed to Investigate Melodic Pattern Identification Ability in Children," Council for Research in Music Education," 1976, pp. 78-83.

though this explanation is somewhat inconsistent with other findings, it is plausible. Furthermore, the research literature on short-term retention seems to be inconsistent in regards to the length of the short-term memory; report ing time-spans from 15 seconds to 60 seconds.

Another puzzling finding of this investigation was the lack of difference in performance between the task group and the non-task group. One explanation for the lack of difference is that the task of counting backwards (while writing) was not difficult enough to interfere with the processing of the pitch information. An alternative possibility is that two different kinds of information processing systems were operating simultaneously - one processing pitch information, the other mathematical - verbal information. The counting procedures did not interfere with the pitch rehersal procedures. The research of Deutsch[15] would seem to support such a thesis. Her theory that pitch information retains its characteristics in short-term memory without being recoded seems to be operable in this instance.

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[15] Diana Deutsch and J. Anthony Deutsch, Short Term Memory (New York: Academic Press, 1975), pp. 141-146.

Implications of the Study

One of the implications of this study is that some consideration should be given to the kind of timbre used in a music learning situation. The richness or blandness of a particular timbre might affect the perception of the sound stimuli. Petzold[16] found a difference between mean scores of items that were presented on the violin as compared to those presented on the flute. He also noted mean differences between test items presented on the piano and those presented by voice. Both of these mean comparisons were between relatively rich timbres (violin and voice) and relatively bland timbres (flute and piano). He found no difference between the mean scores of the two rich timbres, or between the means of the two bland timbres. The greatest number of correct responses occurred when the violin was the presenting timbre. The findings of Petzold's study and those of this study imply that certain timbres have facilatory effects in memory. What this means to music teaching is that the music educator in both learning situations or using echo type exercises might improve student response by using a particular timbre.

The findings of this study would seem to have a direct implications for music testing. In light of the

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[16]Petzold, *op. cit.*, p. 144.

results, the assumption that timbre does not affect memory, does not seem to hold true for short-term memory. Since most published music tests are tests of short-term memory, it might be well to re-evaluate such tests for possible timbre effects. A test battery such as Gordon's Music Aptitude Profile[17] might be highly susceptible to timbre effect. Authors of new tests should experiment with various timbre before their selection of a sound source for test items.

On a much broader level the findings of this study point to a theory of music memory that is more inclusive. Earlier concepts of music memory are based on a tonal system of music, i.e., tonality, and do not account for atonality. During the first half of the twentieth century, when most of the research in music memory took place, those involved did not understand or recognize atonality. Atonal music was considered by many of these researchers to be nonsense music and invalid as a means of expression. Therefore, music organized on atonal principles was not included in a theory of music memory. This has been found to be an erroneous conclusion, since atonality is a dominant principle in organizing pitch today.

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[17]Edwin Gordon, Musical Aptitude Profile (Boston: Houghton Miflin Company, 1965).

The theory of music memory based primarily on tonality, however, has had enormous consequences for music learning. Music teaching on all academic levels, the elementary grade through senior college, has been <u>relatively</u> successful in getting students to perceive, respond to, and in many instances understand music embracing a tonal system. This has not been true for twentieth century music, especially that utilizing atonal organization.

One of the problems is the difference in the principles of organization between tonal and atonal music. Tonal music is based on repetition; melodic, harmonic, rhythmic and structural repetition. In many instances this repetition is quite obvious. A hierarchy of tonal relations is another feature of tonal music. This hierarchy leads to both expectation and anticipation in the perception of tonal music. Essentially, what this means in terms of music memory is that rehearsal mechanisms are inherent in the music itself, providing a maximum retention of such music.

Atonal music, on the other hand, involves less repettion, or a much more subtle kind of repetition which provides a minimum amount of rehearsal in the music itself. Therefore it is less easily perceived or retained. Since it is now acknowledged that music organized according to principles other than those of tonality represents a valid form of expression, it would seem prudent to re-examine a music memory theory based primarily on tonal hierarchies. For, in essence, such a theory has had the consequence on music learning of maximizing the amount of information available in tonal music; and minimizing the information available in atonal music.

Teachers of music theory, and some music educators have come to realize that any linear or vertical combination of two or more tones has information potential. This realization, however, has not yet filtered into music education for the general student. Given the increasing recognition that listening is the principal music activity or means of involvemnt for the non-musican, perhaps a theory of music learning that is evolved from a music information theory of memory would achieve greater success with the teaching of all kinds of music. Such a theory of music memory would be inclusive of all compositional practices; and the information available would be relative to the particular compositional style. For instance, a composition by Webern could convey the same amount of information as a composition by Mozart. This is not implicit in current memory theory.

Implications for Further Research

The findings of this investigation suggests replications of this study with subjects at lower academic levels (elementary, junior high school or senior high school students). In addition the following research is recommended.

1. A more direct investigation of timbre effect in which descriptive responses are possible. For instance, same - higher - lower.

2. A study similar to this one except that three groups are utilized. The third group would have conditions in which timbre and retention interval are held constant.

3. A replication of this study using music majors as well as non-music majors.

4. A replication of this study using a different task during the retention interval. For instance, writing a musical phrase.

5. A replication using a larger sample.

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APPENDICES

APPENDIX A

THE PITCH-TIMBRE MEMORY TEST

Appendix A
The Pitch-Timbre Memory Test

The Pitch-Timbre Memory Test

APPENDIX B

THE TWENTY FOUR TEST QUESTIONS

Appendix B

Description of Test Questions

1. Sine Wave - 5 seconds - same sequence
2. Sawtooth Wave - 5 seconds - same sequence
3. Pulse Wave - 5 seconds - same sequence
4. Triangle Wave - 5 seconds - same sequence
5. Sine Wave - 15 seconds - same sequence
6. Sawtooth Wave - 15 seconds - same sequence
7. Pulse Wave - 15 seconds - same sequence
8. Triangle Wave - 15 seconds - same sequence
9. Sine Wave - 30 seconds - same sequence
10. Sawtooth Wave - 30 seconds - same sequence
11. Pulse Wave - 30 seconds - same sequence
12. Triangle Wave - 30 seconds - same sequence
13. Sine Wave - 5 seconds - different sequence
14. Sawtooth Wave - 5 seconds - different sequence
15. Pulse Wave - 5 seconds - different sequence
16. Triangle Wave - 5 seconds - different sequence
17. Sine Wave - 15 seconds - different sequence
18. Sawtooth Wave - 15 seconds - different sequence
19. Pulse Wave - 15 seconds - different sequence
20. Triangle Wave - 15 seconds - different sequence
21. Sine Wave - 30 seconds - different sequence

22. Pulse Wave - 30 seconds - different sequence

23. Pulse Wave - 30 seconds - different sequence

24. Triangle Wave - 30 seconds - different sequence

APPENDIX C

RAW DATA FOR THE 24 QUESTIONS

Appendix C

Raw Data for the 24 Questions

Student		Questions 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
*	1	.25	1.00	.00	1.00	.50	.00	.00	.50	.25	1.00	.50	1.00	.40	.00	1.00	1.00	.50	.50	1.00	1.00	.75	.50	1.00	1.00
*	2	.50	1.00	.00	.50	.75	1.00	1.00	1.00	.75	1.00	.50	1.00	.60	.00	.00	1.00	.25	.50	.00	1.00	.50	.00	1.00	.00
*	3	1.00	.00	1.00	.00	.00	.00	.00	1.00	.25	1.00	1.00	1.00	.40	.00	1.00	1.00	.25	.00	1.00	1.00	.75	.50	1.00	.00
*	4	.75	1.00	1.00	1.00	.75	1.00	.00	1.00	.75	1.00	1.00	1.00	.20	.00	.00	1.00	.75	.00	.00	1.00	.50	.00	1.00	.00
*	5	1.00	1.00	1.00	1.00	.50	.00	.00	.50	.75	1.00	1.00	1.00	.20	.00	.00	.00	.75	.00	1.00	.00	.25	.50	.00	.00
*	6	1.00	.00	.00	.00	.25	.00	1.00	.50	.75	1.00	.50	1.00	.40	1.00	.00	.00	.50	.50	1.00	1.00	.75	.00	1.00	.00
*	7	1.00	1.00	1.00	.50	.50	.00	1.00	1.00	.75	1.00	1.00	1.00	.40	1.00	.00	1.00	1.00	.50	1.00	1.00	.50	.50	.00	.00
*	8	.75	1.00	1.00	1.00	.75	.00	.00	1.00	.50	1.00	1.00	.00	.80	.00	.00	.00	.75	.00	1.00	.00	.75	.50	.00	.00
*	9	.75	1.00	1.00	1.00	.75	.00	1.00	.50	1.00	.00	.00	1.00	.40	.00	1.00	1.00	.25	.50	.00	1.00	.75	.50	1.00	.00
*	10	.75	1.00	1.00	1.00	.75	.00	.00	1.00	.75	.00	.50	1.00	.40	1.00	1.00	.00	.50	.00	.00	1.00	.75	.50	.00	.00
*	11	.50	1.00	1.00	1.00	.75	.00	1.00	1.00	.25	1.00	1.00	.00	.60	.00	.00	1.00	.75	.00	1.00	1.00	1.00	.00	1.00	1.00
*	12	.50	1.00	1.00	1.00	.50	.00	.00	1.00	1.00	1.00	.00	.00	.40	1.00	.00	1.00	1.00	.50	1.00	1.00	.75	.50	1.00	.00
*	13	.75	1.00	1.00	1.00	.75	.00	.00	.50	.25	1.00	.50	.00	.40	.00	.00	1.00	.50	.50	.00	1.00	.75	.50	1.00	.00
*	14	.75	1.00	.00	1.00	1.00	.00	.00	.50	.25	1.00	.50	.00	.20	.00	1.00	1.00	.25	1.00	1.00	1.00	.25	.50	1.00	.00
**	15	.50	.00	1.00	.00	.50	1.00	1.00	1.00	.75	.00	1.00	.00	.00	1.00	1.00	.00	1.00	.50	1.00	.00	.50	.50	1.00	.00
**	16	.50	.00	1.00	1.00	.25	1.00	1.00	.50	.25	1.00	.50	1.00	.60	.00	.00	1.00	.25	.00	.00	1.00	.50	1.00	1.00	.00
**	17	1.00	1.00	1.00	1.00	1.00	.00	1.00	.50	.50	1.00	1.00	1.00	60	.00	.00	.00	.25	.00	1.00	1.00	.75	1.00	1.00	.00
**	18	1.00	1.00	1.00	.50	.50	.00	.00	.00	.25	1.00	.50	.00	.40	.00	1.00	1.00	1.00	.00	.00	1.00	.75	.00	.00	1.00
**	19	.75	1.00	1.00	.50	.50	.00	1.00	1.00	.75	.00	.00	1.00	.40	1.00	.00	.00	.50	.00	.00	1.00	.75	1.00	.00	.00
**	20	.75	1.00	1.00	1.00	.25	1.00	.00	.50	.25	.00	.00	1.00	.20	1.00	.00	.00	.25	.50	1.00	.00	.75	.50	.00	1.00
**	21	.50	1.00	1.00	.50	.75	.00	.00	.50	.00	.00	.00	.00	.40	1.00	1.00	1.00	.25	.00	1.00	1.00	.25	1.00	1.00	1.00
**	22	1.00	1.00	1.00	1.00	.50	.00	.00	.50	.25	.00	.00	.00	.60	1.00	1.00	.00	1.00	.50	1.00	.00	.50	1.00	1.00	1.00
**	23	1.00	1.00	1.00	1.00	.75	.00	.00	.00	.75	.00	.00	.00	.40	.00	1.00	1.00	.75	.50	.00	1.00	1.00	1.00	1.00	.00
**	24	1.00	1.00	1.00	1.00	1.00	.00	.00	1.00	.00	.00	.00	.00	.40	.00	.00	.00	.75	.00	.00	.00	1.00	.50	1.00	1.00
**	25	1.00	1.00	1.00	1.00	1.00	.00	.00	1.00	.75	.00	1.00	1.00	.40	.00	.00	.00	1.00	.50	.00	1.00	.50	1.00	.00	.00
**	26	.75	1.00	1.00	.50	.50	.00	.00	.00	.50	1.00	1.00	.00	.80	.00	1.00	.00	.50	.50	1.00	1.00	1.00	.50	.00	1.00
**	27	.75	.00	1.00	.50	.75	.00	.00	.50	.25	1.00	.50	.00	.40	.00	1.00	1.00	.00	1.00	.00	.00	.75	1.00	1.00	1.00
**	28	.25	1.00	1.00	1.00	.50	.00	.00	.50	.50	1.00	.50	1.00	.60	1.00	.00	1.00	.50	.00	1.00	1.00	.75	.50	.00	.00

* Task Group

** Non-Task Group

APPENDIX D

TEST RETEST SCORES

Test-Retest Scores

Student	Test 1	Retest
1	33	34
2	31	30
3	31	33
4	29	30
5	29	29
6	28	30
7	28	27
8	27	28
9	27	27
10	26	27
11	26	25
12	26	28
13	25	24
14	24	26
15	32	33
16	32	30
17	32	32
18	29	29
19	28	29
20	26	28
21	26	27
22	26	26
23	25	25
24	25	24
25	24	25
26	24	27
27	22	23
28	22	22

$r = .92$