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A study of cognitive processes of children creating music in a computer learning environment.

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A STUDY OF COGNITIVE PROCESSES
OF CHILDREN CREATING MUSIC
IN A COMPUTER LEARNING ENVIRONMENT

A Dissertation Presented

by

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ABSTRACT

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FEBRUARY 1988

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This study focuses on use of computer software -- namely, the Music Construction Set -- and its effects on children's cognitive processes. Twenty eight students at the fifth and sixth grade levels were selected; fourteen served as a control group and fourteen as an experimental group.

A pre-test and post-test consisted of questions in four categories: global-texture, melody contour, abstraction and closure.

During a two and one-half month period, each student in the experimental group had ten one-half hour sessions using the computer with music software to write their own melodies, harmonize them or develop a rhythmic accompaniment for them.

The general hypothesis was that the experimental group would show more improvement than the control group. Results showed gains in three of four categories and t test significance in one (texture).

Anecdotal data, prompted by questions, revealed certain advantages of a computer learning environment. Using a computer was regarded as easier than playing an instrument; learning music fundamentals was facilitated subliminally by the menu; hearing original compositions played back immediately encouraged revisions and new ideas; and seeing and hearing music simultaneously helped recognition of texture, melody contour and abstraction. Further student responses indicated unanimous positive reaction to the use of the computer, enjoyment in using it for creative purposes and enthusiasm to continue.

Implications for music education include its potential for enhancing creativity, and more experiential understanding of music.

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CHAPTER I

INTRODUCTION

> "As the scientific study of human development matures it is not only natural, but it is necessary to reach beyond understanding the ways humans develop capacities, to study the ways emerging capacities fit into the larger sphere of human undertakings. Music is one of the most significant of those endeavors.
>
> "Music touches the entire range of our lifespan on a daily basis. Involving children with music and music training has high market, and common sense, validity. Parents understand intuitively that children will benefit and that their lives will be enriched, if they are influenced by music and music training. Yet among both human development specialists and educators, the systematic study of how music weaves into the fabric of our progress through life is only beginning." (Webster, 1987, p. vii)

These statements in a chapter of a recently published book, Music and Child Development, capture the spirit of this dissertation. The chapter presents different approaches to conceptualizing various ways music may be considered in children's lives, and it includes discusssion of cognition, language, reading, socialization and creativity.

The subject of creativity is also central to Art, Mind, and Brain, (Gardner, 1982), in which the author writes: "The greatest psychologists - from William James to Sigmund Freud, from B. F. Skinner to Jean Piaget - have all recognized the importance and appeal of a study of the creative processes." He goes on to describe his goals: studying the creative process of children and adults, normal, gifted and brain-damaged. His approach is a cognitive one as exemplified by Piaget, Chomsky, and Levi-Strauss.

The focus of this dissertation is use of a computer learning environment to facilitate the creative process in music. Does a better quality of learning take place when the creative process is in progress? Do students learn more as they begin to construct things? Does better learning take place because of the interactive nature of a computer? Is there more motivation when students deal with music in a computer learning environment? Can good music software provide a computer learning environment that motivates creativity and, in turn, provides a more experiential understanding of music?

These questions prompted a research study involving 28 fifth and sixth grade students using a computer to learn and work with music. Fourteen students were randomly selected for the experimental group and fourteen for the control group. (A pilot study with students at the fifth to seventh grade level is described in Chapter II.) This research study was conceived to determine whether a computer learning environment is viable for encouraging the creative process in music, as well as serving as a 'motivator' for students in elementary school.

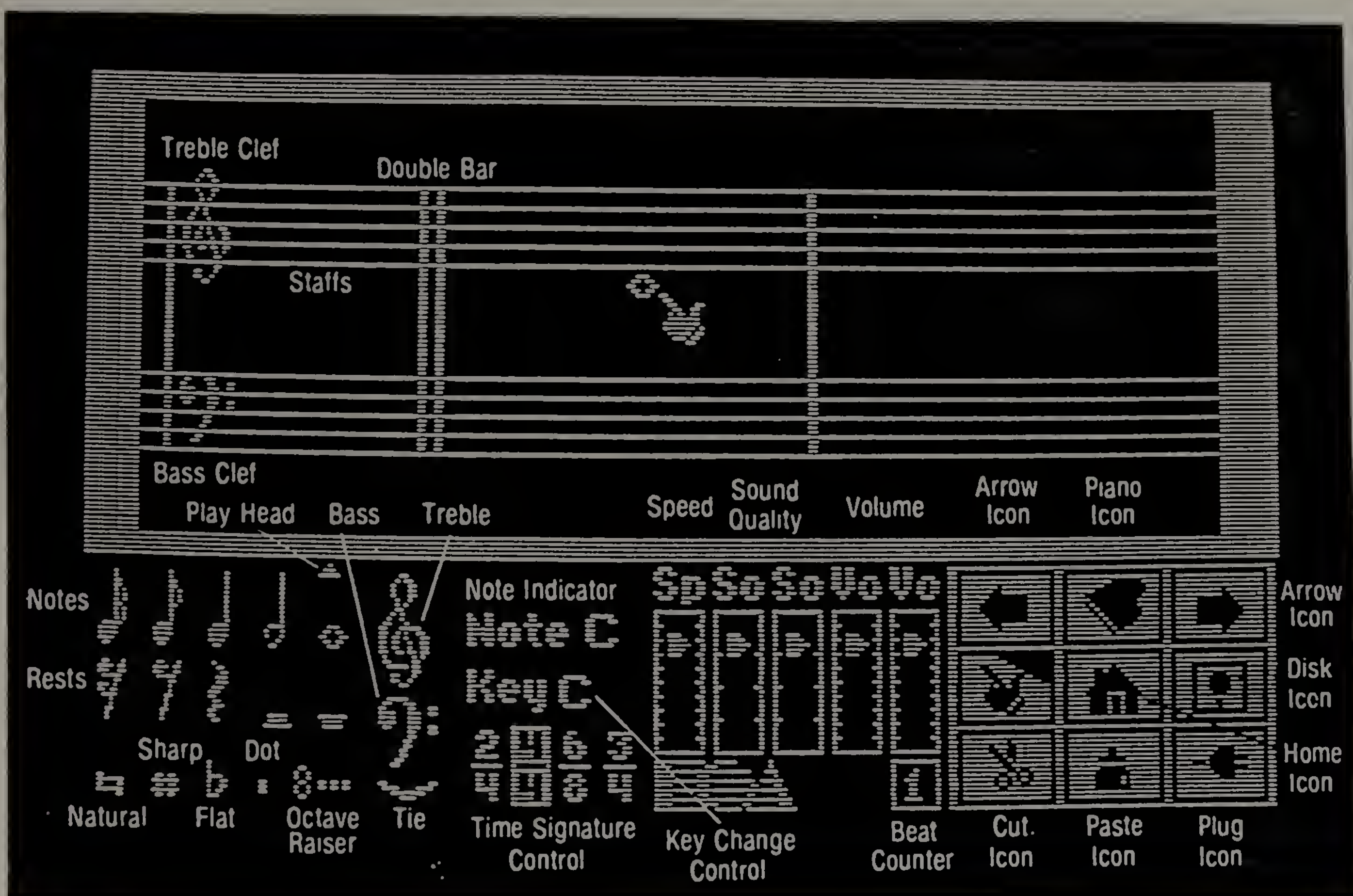
Hypothesis and Research Questions

The questions posed above provided focus for the hypothesis and research questions of this dissertation. The basic research question is: will there be differences between the experimental group using a computer music learning environment and a control group that does not?

The hypotheses are as follows: The experimental group will show more improvement that the control group on the following measures: 1. global-texture (the ability to tell whether the student is hearing one or two melodies, or one melody with chords), 2. contour-recognition (recognizing repeated melodic phrases within a composition), 3. abstraction (recognizing a familiar phrase of a melody inserted in a second melody after having heard it twice or three times in the first melody), 4. closure (determining whether a melody has been brought to a reasonable close, cadence, or is left unresolved).

During this research study it became evident that by offering students an opportunity to create their own music they were engaging in a process of problem-solving. They were called upon to use their knowledge of the fundamentals of music and were challenged to acquire more information in order to complete some tasks.

This process is highly interactive since the software they were using presented all the information they needed to write a melody with simple accompaniment. Their immediate questions could be answered by the researcher. The software, the Music Construction Set published by Electronic Arts, Inc., offers two staves, 12 key signatures, 4 different meters, all possible note values and rests up to 16th notes, several different speeds and tone qualities, several levels of volume for either bass or treble clef, an octave raiser (see Glossary A), 4 voices and a duplicating procedure in which any number of measures can be placed at different places in the composition. (See Figure 1.)



Music Construction Set
Figure 1

ELECTRONIC ARTS™

2755 Campus Drive San Mateo CA 94403 (415) 571-7171

In ten half hour sessions, 14 students who comprised the experimental group were given simple tasks: 1) to complete a given 4 measure melody, 2) to write their own 8-16 measure melody, 3) to harmonize the melody, 4) to write a second melody to go with the first, usually in the bass clef, 5) to write a rhythmic pattern played by drum beat to go with a melody, 6) to write a melody that could be used in imitation with a second voice as in a round or canon.

In order to be able to capture student reactions to the use of the computer while composing melodies, a series of general questions were asked. Many of the conversations were taped; some were recorded by video tape; and all of the compositions were put on manuscript paper so that each student had his own compositions to keep. (See Appendix 2.) The questions are given at the end of Chapter III and a summary of their responses are found at the end of Chapter IV.

Learning how to create music in a computer learning environment is treated as a process of problem-solving in this study. The process involves learning music 'from the inside out', that is, learning basic information about music as the student is constructing a melody or musical composition. A higher motivation level can be expected while the composition is in process. The need to know vital information about note values, meter and pitch at the point of writing the melody gives a purpose and impetus, as well as an immediacy to learning. It is known that computer experience helps children develop new thinking skills, and may show that it "...influences their view of themselves as problem-solvers" (Burns, 1986, p. 2).

The premise for this experiment was: given a good piece of software such as this Music Construction Set, students could have an opportunity to be creative in music just as they are in art or in writing stories. Further, it was conjectured that this experience in creativity becomes a process of problem-solving and that better learning takes place as they complete the task.

Further, given the diverse kinds of musical background the students have, they must proceed from their present points of learning to fill in gaps of information and move forward with the problem-solving process. This is an enigma that has implications for music education. It is difficult for a music specialist, or a classroom teacher to ascertain just how much a student has learned about music up to any given point.

In order to better understand what the student can be expected to do in music at each grade level, a summary of the musical activities typical of Grades 1-6 are outlined below (Raebeck & Wheeler, 1974). Note that creative tasks have been underlined.

Typical Elementary School Music Curriculum

Grade 1

Musical Activities: SINGING - by rote. Songs about home, school, community, holidays and seasons. Nonsense and fun songs. Finger plays, action songs, singing games. Original songs composed by class. New verses added to familiar songs. Songs which develop rhythmic and dramatic interpretation. RHYTHMS - Basic bodily movements (walk, run,

skip, gallop, bend push, clap etc.) Rhythmic exploration and dramatizations of music. Inprovisations. Rhythm instruments. Action songs and singing games. LISTENING - to story, mood and picture music. Listening to other people sing or play instruments. Contemporary music and music of other eras. INSTRUMENTS - Playing song bells, rhythm instruments, strumming one-chord songs on autoharp. Becoming familiar with sound of orchestral instruments. Exploration of piano and other instruments. Growth in Conceptual Understandings: Mood (happy or sad). Dynamics (loud or soft). Tempo (fast or slow). Contrasts in rhythm. Similar phrases. Bodily implication of the rhythm of music (music that walks and runs). Differences in sound qualities made by various instruments. Changes in melodic direction. Repeated rhythmic patterns. Basic beat in simple meters. Chord changes (with autoharp accompaniment). Keeping time to music through bodily movement. Associate symbols of note values with walking (quarter notes), running (eighth notes), giant steps (half notes).
Create simple, original songs, accompaniments, interpretations and rhythmic dramatizations. OBJECTIVES - Learn many songs, acquire a small repertoire of story and mood music. Use of melodic, rhythmic and accompanying instruments.

Grade 2

SINGING - by rote. Vocal exploration and improvisation. More emphasis on songs about community helpers. Introduction to the musical score thru experiences exploring song books. RHYTHMS - Rhythmic improvisation. Relating rhythmic movements to note values. Awareness of different meters, strong and weak beats. Melodic contour. Major and minor modes. Music as it progresses by step and skip. Individual ability to make music: sing, play instruments, create songs and accompaniments. LISTENING - Introduction of abstract music thru illustration of legato and staccato rhythm. OBJECTIVES - Rhythmic counting of note values associated with walking, running, giant steps.

Grade 3

SINGING - by rote. Use of books as an aid in learning a song. Folk and patriotic songs. Rounds. Original songs created by class. RHYTHMS - Basic bodily movements to step out rhythmic patterns. Clapping to internalize rhythm patterns, develop inner ear. Improvisation. Conducting. Singing games and simple folk dances. Original accompaniments with rhythm instruments created by class. LISTENING - to story, mood, picture and abstract music. INSTRUMENTS - learning to play simple melody instruments. Strumming chords on autoharp. Develop an awareness of tone quality and pitch accuracy. Form. Major scale construction. Cadences. Syncopation. Chordal progressions. Develop an ability to sing more difficult songs. Find melodic and rhythmic patterns in a musical score. Conduct simple songs. OBJECTIVES - A wider permanent song repertoire. Note values and their organization into measure of the musical score. Recognition of simple meters 2/4, 3/4, & 4/4. Musical notation as an aid in singing and playing. Creating short songs. Rhythmic accompaniments.

Grade 4

SINGING - by rote and note. Dialogue and echo songs. Songs with descants. Melodic rondo. RHYTHMS - making percussive sounds, clapping, snapping, patting as rhythmic accompaniment to singing. LISTENING - for understanding of simple musical forms (ABA) and different types of music (march, waltz, minuet). INSTRUMENTS - making chord charts for autoharp using ear approach. Learning to accompany two-chord songs. Beginning instruction on band and orchestral instruments. CREATING short instrumental compositions. Simple second parts for melody instruments to accompany songs. An awareness of chord relations. Compound meter (6/8). Triad and chord structure. Differences between harmonic and contrapuntal music. An ability to sing chants, echo songs, rounds and canonas. Play two-chord songs. OBJECTIVES - Recognize AB and ABA structure in simple songs. Rondo form. Rhythmic notation for dotted quarter and eighth notes.

Grade 5 & 6

SINGING - by rote and note. Songs with counter melodies. Songs harmonized in thirds and sixths. Harmonizing by ear. Songs created by class. Songs which correlate with other areas of study. Ethnic songs. Introduction to three-part singing. RHYTHMS - thru conducting, rhythmic dramatizations, folk and square dances, accompanying on rhythm instruments. LISTENING - to selections from operas and operettas. To children's concerts. INSTRUMENTS - lessons on different instruments. Learning to classify instruments of the band and orchestra by sight and sound into specific families. An awareness of blending and balancing of parts in singing. Tone quality and phrasing as an essential to good singing. Relatedness of tempo, dynamics, rhythm, pitch, instrumentation in creating a mood. Different musical expressions as related to culture. An ability to sing more difficult counter melodies. Accompany class singing with melody or strumming instruments. Remember rhythmic and melodic patterns, phrases and themes. Compare differences in mood, form, and instrumentation. Write in musical notation, original parts for rhythmic & melodic instruments.

OBJECTIVES - A wide variety of unison and part songs. The difference between program and abstract music. Some of the world's great musical literature and composers. Creating original songs, musical plays, rhythmic accompaniments, introductions or interludes, original instrumental compositions. Minor and pentatonic scale construction. Chordal progressions (I, IV, V, I). Other forms (rondo, theme and variations, fugue). Other types of musical expression (folk songs, art songs, ballets, symphonies, concertos, suites). Time value relationships of sixteenth notes.

A large question is: how much of this curriculum does the average public school student have an opportunity to experience during the elementary school years? However, in almost every grade level he may be given opportunities to be creative in a group. The rationale behind suggesting that students may have much more effective experiences using a computer learning environment is predicated on the belief that writing a simple melody with music software is far easier than by the pencil and paper method. This is because there is so much information at their finger tips: the formation of staffs, clefs and notes of many different values that are immediately played back on command in the correct rhythm and without concern about where the notes are located. It is also possible for them to see and hear examples of melodies to get an idea of how to manipulate notes and their sounds.

In the process of achieving the goal of completing a simple melody, the student acquires the information that is most beneficial to understanding music from the "inside out" and fills in the gaps. This is the incremental aspect of learning, the process of problem-solving. But strangely enough, it takes place during a drive toward the product, i.e. accomplishing the task. Students of this age group, (fifth and sixth graders) are often very task-oriented.

There has been a lot of research done on children's perception of music particularily at the early childhood level, (e.g. Bamberger, 1977, Gardner, 1982, Greenhoe, 1972, Gorder, 1976, Guilford, 1967, and Webster, 1977). Though they do not include use of a computer learning environment, the cognitive processes involved in creating music are put together in a conceptual model by Webster.

One article that was of particular value for the purposes of this paper was entitled "The Development of Cognition in Music", (Serafine, 1980). An opening statement made by Serafine in describing the relationship of the meaning of the words 'music perception' as opposed to 'music cognition' struck a chord:

> "For more than a century the disciplines of psychology and music have sponsored a joint attack on questions regarding the nature of music perception. More recently scholars in both fields have begun to speak of music cognition rather than perception in apparent recognition of the active, constructive processes that perhaps are not captured by the term perception. The general idea is that understanding a composition is not so much a matter of passively perceiving its features as they really are, but more a matter of actively constructing them out of what the mind already knows. Homage paying to the notion of cognitive construction is now so ubiquitous that we would do well to raise two questions: What do we mean by a constructive definition of music cognition? By what method can we test, or even demonstrate, the constructive thesis? I will address these questions by first discussing cognition in general and then cognitive development over the life span, the investigation of which, in my opinion, offers a laboratory for testing the constructive thesis. Finally the researcher describes a research program now in progress on the topic of cognitive development in music, (p. 218).

Overview of Chapters

Much has been done in the field of music perception, ear training in melodic and harmonic intervals, analysis, orchestration and applied vocal and instrumental courseware. This will be summarized in Chapter II. There is however, only a relatively small body of research in more creative applications of music in a computer learning environment

(Bamberger) which will also be covered. Chapter III will contain an outline of the study, its overall design, sample, methods, instruments and expected results.

The results of pre-tests and post-tests with experimental and control groups as well as interesting comments and revelations made by the 14 students in the experimental group will be examined in Chapter IV. Chapter V will include a discussion of the results of the study, limitations, implications, suggestions for future research, and recommendations.

It is hoped that this dissertation will add to information in the areas of creativity in music and with computers. It is also a fervent hope that some music educators will catch the excitement by recognizing the potential that microcomputer music software offers in student learning and teacher training.

The advantages offered to those who wish to learn the basics of music, melody, rhythm, and harmony include learning the names of notes, where they go on the staff, hearing the notes as they are put on the staff, and the potential offered for writing music. This can be accomplished with the Music Construction Set. There is also value in the aesthetic feeling of satisfaction that one has in having created something of one's own.

In the process of creating, one furthers knowledge of the essentials of music. Step 1, creating original music propels step 2, learning more about the fundamentals. Using a computer music learning environment is a 'motivator' toward acquiring new skills in music that has been largely limited to singing, listening and performing. In providing a new vehicle (music software), a new stimulus toward learning is available. The essence is that students learn by constructing, by constructing they discover, and by discovering they learn more concretely and open new doors through their own creativity.

References

Chapter I

Webster, Peter. (1987). Conceptual bases for creative thinking. In J. C. Peery, I. W. Peery, & T. W. Draper, (Eds.). (1987). Music and child development. (Introduction). New York: Springer-Verlag.

Gardner, Howard. (1982). Art, mind, and brain: A cognitive approach to creativity. (Introduction). New York: Basic Books.

Raebeck, Lois, & Wheeler, Lawrence. (1974). Music in the Elementary school. New approaches to music in the elementary school. (3rd ed.). Dubuque, Iowa: William C. Brown.

Serafine, Mary Louise. (1983). The development of cognition in music. Bulletin for Council for Research in Music Education. 1-14.

CHAPTER II.

PREVIOUS RESEARCH & REVIEW OF LITERATURE

The transition from interest in computer-assisted instruction (CAI) in music to new ways of using the computer to learn music came about very circuitously. It evolved from the realization that most software and courseware, at least in the early years (1967-1982) was tutorial and/or drill-and-practice. A lot of it was very pedantic, repetitious, and lacked any kind of new technique. In short, it was the same as traditional ear training drill--moving step by step--except done by the computer.

There seemed to be a frantic rush to see who could get the most music in memory, randomly selected examples, and storage of grades--all designed to help students move on according to their abilities. Sound quality was of much importance since the fidelity of early synthesizers left a great deal to be desired. Thus, a lot of time was spent in working out sound envelopes.

Typically, an author of courseware had to learn programming techniques, good pedagogical design, and to avoid what is termed 'page-turning'--an instructional sequence that did not improve at all on what could be done with a textbook. The whole issue of programmed workbooks had turned out to be merely a phase in the long line of experiments in education designed to find better methods of teaching.

As a matter of fact, there must have been a few pedants sitting on the sidelines, feeling that computer-assisted instruction (CAI) was another gimmick that wouldn't work. And truly, the earliest examples of music courseware for micros had a lot of room for improvement.

Early CAI Music

A foray into the world of CAI in music during the years between 1967 and 1980 brought forth the following programs which are described below.

The intellectual environment in the early 1960s, which was greatly influenced by programmed instruction in education, gave impetus to the first generation of CAI systems. Tremendous optimisim was generated by those interested in CAI because of the nature of education as a labor-intensive activity. Technology had already increased productivity in other labor-intensive activities and the field of education was ready for a more effective means of communication. The computer represented a means of delivering programmed instruction as a major component in teaching.

CAI, in the years between 1967 and 1980, includes courseware that is designed to be used either in conjunction with regular courses of learning and, as such, lends itself to tutorial or drill-and-practice exercises, or as enrichment to course content, and some full courses.

It is pertinent that we describe the early experiments in CAI/music. Most of it was in the above mentioned tutorial and drill-and-practice modes. There is much to be said for this method of teaching, and almost all of these experiments over a twenty-five year period showed the effectiveness of learning by computer. That particular tenet no longer needs to be proven. Computer assisted, based or managed instruction is already a fact of life today. Those schools, universities and colleges that are fortunate to have CAI in their budgets and in use testify to its effectiveness in better learning in less time. (Ames, 1977, Arenson, 1978, Rumery, 1985, Taylor, 1978). The first generation of CAI music evolved from large mainframes and minicomputers.

Sight-singing

One of the earliest experiments in CAI was begun at Stanford University in 1967 under the direction of Kuhn and Allvin. In this experiment a series of sight-singing exercises and tests were encoded in a computer language designed for use in music instruction sequences. The instructional program controlled the examples presented to the student. Musical examples were stored in an image file (a file in the computer's memory), and selected by the computer. The student requested an audible model and, when ready, sang into a microphone in time to a metronomic beat. Each note of the student's performance was sampled and the pitch extracted. The data were deposited in computer memory and analyzed.

The results determined whether a specific exercise had to be repeated, whether similar material was presented for additional practice, or whether the student was to go forward in the program. This "branching" operation is an important capability of the computer in education. (Branching is the ability of the computer to choose between alternative courses of action, pre-determined by instructions given by a programmer.)

Research done in the early days of CAI stressed the need for interaction between the student and machine, as well as the need for positive reinforcement. The computer represented a means of individualized instruction that provided immediate feedback. It could provide examples of greater or lesser difficulty, depending on student needs.

These three reasons support the use of CAI (with quality courseware). If each advantage is examined separately, it can be seen that neither a textbook, a programmed workbook, nor material on cassette can provide these unique advantages. It must be made clear from the outset, that from the beginning of CAI, no one suggested that it would in any way replace the teacher. It is merely, or more importantly, an adjunct to teaching that offers immediate feedback, positive reinforcement, and branching.

Kuhn and Allvin concluded that their program in sight-singing provided a structure for an instructional sequence for future programs at beginning, intermediate and advanced levels; offered flexibility in criteria for evaluating student responses; and recorded a complete and permanent history of student performance and progress for analysis. It is important to note that students reacted very favorably in their evaluations, particularily to the congratulatory remarks the program offered when correct answers were given.

Ear-training for instrumental musicians

Between 1967 and 1969, Diehl (1971) at Pennsylvania State University, developed a program in CAI in ear-training for instrumentalists. The program concentrated on the areas of phrasing, articulation, and rhythm for intermediate clarinetists at the secondary school level. This program was one of the first to be developed in the area of performance.

A second project developed by Diehl, this time working with Zeigler (1973) under a grant from the U. S. Office of Education, included flute, clarinet, saxaphone, trumpet, and horn. Students listened to several versions of musical examples on prerecorded tapes. They were asked to recognize discrepancies in articulation, phrasing and rhythm. They did not begin to perform the articulation exercises until they had completed the first part in aural discrimination. Twenty-five students were tested before and after the CAI program and the comparison showed a gain of between 11% to 55% between the pre-test and post-test for individual scores.

At the beginning of the two projects of ear-training for instrumental musicians, Diehl stated that little was known at that time about how students learn music fundamentals, or how they perceive performance. Both programs provided opportunities for meaningful research in the areas of aural-visual discrimination and performance.

One further study in the field of instrumental ear-training was done by Peters (1974) at the University of Illinois. The focus was on the capability of the computer to judge pitch and rhythm accuracy of student performance on the trumpet. The reason for the lack of development in this subject area was the inability (at that time) of computers to deal with the sound medium. The project was an early attempt to solve the audio interfacing of the PLATO system for judging music performance. The audio interface was limited to a 20 note range, suitable only for first and second year trumpet students.

The test, administered to eight university students, revealed that a 2% pitch tolerance was too exacting, and a 10% margin in rhythmic performance, too wide. The feedback that was available to the student performer was a valuable part of the experiment. The author included a comment in his summary that higher levels of positive reinforcement should be included in future programs.

Basic Musicianship

The subject of basic musicianship covers an area more general than ear training and includes the fundamentals of music. This is also the first program used with students at a secondary school level.

In 1971, Von Feldt (1971) of the University of Missouri-Kansas City, did a comparative study between two methods of teaching music, the traditional teacher-classroom technique and CAI. The purpose of the study was, first, to determine the effect of CAI on students with high initial achievement and low achievement scores, and second, to compare achievement and time spent in the two methods of instruction.

Thirty-seven volunteer students, from the seventh grade general music class, were divided into two groups with 17 in the CAI group and 20 in the traditional classroom group.

Selected music concepts (the staff, clefs, notation, time signatures), taught in both groups formed the basis for the development of a test instrument. Students in both groups were given pre- and post-tests. The conclusions, based on the pre- and post-test mean scores showed that, except for the top quartile of high initial achievement scorers, CAI was found to be twice as effective as teacher-classroom techniques, and in 30% less time.

In the same year, Allvin (1971) at Oakland University commented that "research in CAI is too new to have produced any definitive findings, but dramatic new opportunities in music instruction can be foreseen in some recent experiments" (p. 131).

Allvin described a program in basic musicianship which was divided into the four segments of ear-training, music notation on a staff and keyboard, elementary analysis, and rhythm discrimination. The main thrust of the program was to find ways of using aural-visual coupling for music instruction.

In an early sequence in ear-training, two pitches were played for the student as a staff was displayed on the screen; the first pitch or reference tone appeared and then 2 additional tones. The student was asked to answer whether the second pitch was lower or higher than the first by using his light pen to touch the note of his choice. (The light pen is another piece of hardware that offers immediate interaction with a computer. See Glossary B.) Then the audio system sounded the pitches shown on the screen, immediately followed by the original two pitches. The comparison of the student response to the original pitches and his own was an effort to provide reinforcement of the correct response or corrective feedback.

Rhythmic drill

A program in CAI to teach selected behaviors in the area of rhythm perception was completed by Placek (1972) at the University of Illinois-Urbana using TUTOR (a courseware authoring language) on a PLATO III system. Six students were selected from a basic music course for elementary education teachers to participate in three learning sessions of a computer-assisted lesson in rhythm. The main objectives were to teach the student to demonstrate a knowledge of basic rhythmic notation and 2) the relation of rhythmic notation to aural rhythmic patterns.

"The selection and logical ordering of behaviors, the lesson's content, alternative paths and machine reponses contingent upon student input" (p. 18) were part of the analysis. Data obtained and reported included: "1) total time spent and amount of program covered, 2) amount of time on each main routine, 3) number of tries and OK or No responses from the computer, 4) special keys pressed within an exercise or problem" (p. 13). Students were interviewed as to their opinions of this CAI in music. They felt the time spent was enjoyable and valuable. The scoring of the tests showed that 85% had learned the basic behaviors related to notation in the lessons.

Advantages of CAI/Music

The bulk of this research into the history of CAI/Music emphasizes the specific advantages of CAI for music education, the long journey from the beginnings to where it is now, and the documentation in general terms of its effectiveness. As a mode of teaching that serves only as an adjunct to classroom teaching, it has advantages never before offered that challenge programmers to exploit them to their fullest: interaction, immediate feedback, record-keeping and positive reinforcement.

In the field of music, the simultaneous use of aural and visual, sight, and sound plus documentation on the screen, cannot be duplicated by teachers or teaching assistants. A blackboard, workbook, cassette tape, or keyboard cannot rival a micro with good courseware.

Ear Training

A study by Killam, Lorton, and Schubert (1975) at Stanford University identified a primary problem: the discrepancy between the amount of skill in ear-training required by the university music major and the amount that had been acquired prior to college entrance. The minimal level of competence is, for some students, not easily attained.

Before the inception of CAI in music, ear-training sessions with drill-and-practice in interval identification had been done by paid personnel, i.e. teachers or graduate assistants. This was (and is) time consuming and costly.

There are many variables involved in ear-training: the relative difficulty of intervals, dissonant and consonant, descending and ascending intervals, timbre, duration, the sequence of instructional presentation, and prior individual experience or training on the part of the student. The authors stressed the advantages of computer-controlled administration: random selection of examples played, controlled timing of presentation, and the computer's ability to analyze and report detailed student response. Fifteen undergraduates, seven females and eight males at Stanford University took part in the study. The mean percentage correct on simultaneous (harmonic) intervals was 67%, and that of both ascending and descending intervals was 81% in a sampling of 288 intervals. The report also included a listing of what intervals proved to be more difficult. The intervals in order of their difficulty were P8, M3, m2, P4, M6, P5, M2, m3, tritone, M7, m7 and m6 (the P8 at 88% and m6 at 55%. See Glossary B.) Suggested areas for further research were: the effect of tonality and timbre on interval recognition and the effect of student familiarity with timbre from their applied music studies.

One of the most well-documented research projects in the field of CAI music was undertaken at the University of Delaware under the direction of Hofstetter (1979). Begun in 1974, it has become an ongoing research program entitled GUIDO (Graded Units for Interactive Dictation Operations). In the first experiment, GUIDO was compared to the traditional ear-training tape laboratory. Thirty-three freshmen received a traditional ear-training course with drill done at the tape laboratory. During the second semester, the group was split with 17 students assigned to an experimental group at the computer terminals, and the other 16 students were assigned to the control group at the tape laboratory. The mean scores were 86% for the GUIDO group and 75% for the tape group. Following these results, the University of Delaware replaced their tape laboratory with a computer-based laboratory.

In the years following this decision, Hofstetter and Arenson (1978, 1980, 1981, 1982) created music courseware for the PLATO installation using their GUIDO programs that covered all kinds of ear-training and melodic and harmonic dictation. It was then made available for stand-alone PLATO terminals. All of this is described in a paper entitled "The History of Computer-Assisted Instruction in Music" written in May 1983. Since that time Hofstetter and Arenson have gone on to help open up other fields in music for CAI such as orchestration. Almost all of their reports on their research is available through ADCIS publication Journal of Computer-Based Instruction, as well as that done by several other leaders in the field.

Since CAI/Music is not the main topic of this paper, but a fore-runner to other applications of the computer in music education, i.e. learning music through creativity, the next section will deal with more recent developments in brief, and then relate some of Jean Bamberger's experiments with LOGO at M.I.T., which is more closely connected to computers, music, and creativity.

Recent Developments in CAI/Music

In the years between 1978 and 1983, roughly coinciding with the advent of microcomputers, many new programs appeared. Much was written about the advantages and disadvantages of CAI. In an article entitled "CAI: Current Trends and Critical Issues", Chambers and Sprecher (1980) added to a growing list of advantages of CAI and also listed a number of the disadvantages that could be foreseen in 1980 when this article was published.

The advantages included interaction, ability to 'branch' (advance or retreat), immediate feedback, positive reinforcement, systemmatic presentation, record-keeping, and random-access (which provides a large reservoir of examples at any given level of difficulty). Most of these advantages are much more effective than in traditional methods of teaching. Of the four modes in use-- tutorial, drill-and-practice, simulation and educational games--each has its own kind of usefulness.

Simulation (a mode that models real-life or hypothetical situations that require a student to make decisions and develop problem-solving skills) permits latitude in creative decision making and allows for experimentation. As such, it's style of approach that is most compatible with composing music in a computer learning environment.

CAI as an adjunct to classroom teaching permits the computer to act as a liberator or purveyor of "quality time" for the teacher and for the student in the micro lab. In doing so, it also provides ample opportunity for developing a student's potential in creative work.

At this point in time, it is also general knowledge that the use of CAI has been an enlightened gift to bilingual (speech synthesizer) and 'disadvantaged' students. It has already taken its place as a valuable teaching tool for those with inadequate English and math skills (particularily entering college and university students), continuing education students, industrial training programs (robots) and the armed services.

The disadvantages of CAI, though minimal compared to the plus-factors, will always be with us. Costs are not stable; one micro or mainframe is not necessarily compatible to the next; "instant obsolescence" is the rule; the quality of the software is very variable; and well-trained personnel are scarce. There are more, such as student difficulty with the keyboard (perhaps because of poor motor control) but these can be offset.

The effectiveness of CAI has shown in a number of ways. It can reduce instructional time by 10-15%; it reduces attrition in education programs and courses; and it has been shown to increase reading ability from 15-20% compared to exclusively traditional methods.

It may be convincing to quote John Naisbitt's "Megatrends" (1982). "The information society is an economic reality... In a literacy-intensive society, when we need basic reading and writing skills more than ever before we are turning out an increasingly inferior product.... Seventy-five percent of all jobs by 1985 will involve computers in some way- people without basic skills and computer literacy will be moved lower on the skilled-labor totem-pole." (p. 33). While these quotes relate specifically to computer literacy, they also allude to the all-pervasive clout that high tech will have on all of our lives, and education specifically. Perhaps here is the place to look at CAI and the future of music education.

In an article entitled "Microelectronics and Music Education", Fred Hofstetter (1979) addressed this subject: "There is no other discipline for which microelectronics are better suited than music education". It individualizes instruction with a self-paced approach, focuses on the pure enjoyment of learning (de-emphasizes competition), and helps us to set up learning experiences that meet our own objectives.

A geographical geneaology of the genesis of CAI/music could be sketched by following through the university appointments of some of the luminaries and pioneers in the field. CAI/Music's origins seem to be at Stanford with Kuhn and Allvin, then Diehl at Penn State. Killam then went from Stanford to North Texas State and spawned a group which spread out from there to the University of Omaha-Nebraska, while the University of Illinois and Illinois State University as well as Ohio State University were innaugurating their own programs. This was the second generation of CAI/Music courseware, and the third could be anyplace in the world, but those best known are in Canada, Australia, England and the U. S. Prevel (1982) of the Universite Laval, Quebec, has done some very remarkable programs.

Taylor (1982) at Florida State University developed a MEDICI (Melodic Dictation Computerized Instruction) project using PLATO terminals which has now been expanded to include ear training, harmonic materials, part writing, notation, and music literature. Their basic theory program requires all undergraduate music majors to take two years of classes that meet four times a week for fifty minute classes. They report that use of the MEDICI system has helped to recapture some of the classroom time which had formerly been used for drill work in ear training and that CAI is fast, efficient and tireless.

The refinements in each program from project to project have come through a process of experimentation, statistical analyses, exchange of pertinent information between colleagues in different geographical areas (from exchange at conferences etc.).

The concerns and goals of the various universities' research into developing their own computer strategies have ranged from determining effective computer-based instructional systems to designing their programs to be as 'user-oriented' as possible. All of the previously mentioned university personnel have been members of the NCCBMI (National Consortium of Computer Based Music Instruction) a special interest group of ADCIS, which serves as a central agency of the dissemination of music courseware. This group is now known as ATMI (Association for Technology in Music Instruction).

Competency-based computer programs in music theory were undertaken by Arenson at the University of Delaware (1982). There were 14 modules that included pitch identification, note-reading, grand staff, (octave designation names), half and whole steps, beat units and divisions, meter and time signatures, intervals, scales, key signatures, triad identification, and construction and some more advanced harmony skills.

Because of the cumulative nature, students were sequenced from beginning to end, 1 through 14. Each lesson was table-driven and instructors could individualize each lesson for their own needs. This allows for a number of variables and incorporates a greater degree of flexibility, particularily for a large student population.

In the case of CBI or CAI in music, much has been recorded and analyzed between 1967 and 1983. After this time, the proliferation of programs and the small amount of information about new programs seem to indicate that the value and effectiveness of high quality courseware and software is no longer being measured, nor is much information about it being published.

Like the wheel, CAI/Music has been invented, highly touted and mostly accepted. But there was an interval of time between the inception of the wheel and the eighteen-wheeler in which a lot of growth took place. What seems now like instant success was actually a slow growth process. Discovering new applications and exploiting what the micro can do best in education is still very much in its infancy. Researching its effectiveness is the focus at the moment.

Like collapsing the 'information float', (a phrase Naisbitt (1982, p. 23) uses to describe the amount of time information spends in the communications channel), the growth process in CAI/Music is moving erratically, with spurts here and there. Where education is closely allied with high-tech industry, meaningful progress is happening.

Creativity with LOGO

Jeanne Bamberger at M.I.T. created a music learning environment with LOGO that she researched between 1972 and 1983 (1972, 1974, 1974a, 1979, 1983). Using an Apple II she set up "tuneblocks" that could be put together to make musical phrases. Some arrangements made musical "sense", others did not. This is an oversimplification that developed from a series of experiments.

This environment provided a way for the student to handle and create musical structure without first having mastered the ability to play an instrument or read music in the traditional manner. It was designed to promote the understanding of his ability to control and respond to pitch relationships, the interaction between pitch and duration, and to observe how melodies are structured in a more complex design. The computer was interfaced with a "music-box" which provided a five octave range of pitches and played up to four parts simultaneously. It was also programmed to play rhythmic patterns with percussion sounds, a tom-tom, and a brushed cymbal. By a process of experimentation, the student could discover how to reconstruct the melody out of three tuneblocks to make "Twinkle, Twinkle Little Star". The student can think of a melody as an active process that can be built by a procedure. With various manuevers, in different studies, and including using a French folk tune divided into different "tuneblocks", Bamberger developed a theory of helping students to make musical "sense" out of phrases, instruments like Montessori bells, etc. She experimented with rhythmic configurations and helped students to find ways of expressing or drawing what they heard or would like to have played.

The body of Bamberger's work is extremely important to the purpose of the present study. Why is it important to encourage the creative process at an early age (grade school level)? What are the cognitive advantages? Is there an important link between creativity and learning? Do we learn better by being creative? Do students acquire more confidence in their ability to learn once they have experienced creating something of value in art or music? Some of the answers that developed from this study are discussed in Chapter V.

Artistic Creativity in Children

In looking at the use of computers in a music learning environment, it has already been shown that accomplishments are weighted in the direction of CAI in the music fundamentals. Other experiments in programming with young children using LOGO indicate that there is much to observe.

Linking the two processes, programming and writing a melody, call for creative thinking. Both require problem-solving that is a product of experimentation. In "Art, Mind and Brain", (1982) Gardner builds a strong case for the need for creativity as a product of the growth process. He summarizes the main theories of Piaget, Levi-Strauss, and Chomsky and adds that there is "limited potential of their respective systems to handle creative thought", but that there is "a recognition that the basic unit of human thought is the symbol, and that the basic entities with which humans operate in a meaningful contest are symbol systems" (p. 39). Further, he goes on to say that "the key to an understanding of artistic creation lies in a judicious wedding of structuralist approaches to philosophical and psychological investigations of human symbolic activity."

In a section on the "Artistic Development of Children", (1982) Gardner adds to Kant's two miracles (from the "Critique of Practical Reason") of the starry heaven above and the moral law we all carry within ourselves, a third miracle, the creative activity of the young child (p. 83).

He describes the U-shaped curve in the artistic development of children. It is high, when they are pre-schoolers, shifts toward realism and an understanding of the reward of conforming at 7 or 8, and proceeds to the drive to achieve a new higher level of artistic achievement (for some adolescents).

He also remarks that the onset of formal musical training in a 'music' class often marks the beginning of the end of musical development. "The atomistic focus in most musical instruction: pitch, names, notation, runs counter to the holistic way in which most children have come to think of, react to, and live with music."

By helping children to go from stage one (the enjoyment of singing songs and playing music games) to stage three (playing and creating their own music) they may be motivated to ask for just enough of the fundamentals of stage two to act as a vehicle toward making their own music.

Howard Gardner points to the writings of Suzanne Langer, specifically "Philosophy in a New Key" in which she speaks of "a basic and pervasive human need to symbolize, to invent meanings and invest meanings in one's world." She emphasized the significance of music, and though it did not directly communicate such things as "the sound of waves" or "feelings" (a composer's feeling of happiness or anger), it presents "the forms of feelings", contrasts and conflicts that do not lend themselves to description in words or logical formulas" (p. 52).

Perhaps she has touched on the international language of music which says so much to people around the world without the need for words.

The chapter entitled "Conceptual Bases for Creative Thinking in Music" (Webster, 1987) referred to in Chapter I, is a fine source of references to writers who "... have commented in a personal sense about the creative process in music..." (p. 158). Webster's model showing the thinking processes that may be utilized in the course of moving from "product intention" to "creative product" in composition, performance or analysis are very lucid and revealing. Whether a performer, (professional musician) and occasional composer, it is easy to identify with the stages he has described in this model; both require the ability to analyze pieces of music. He lists factors in divergent thinking which incorporate steps going from preparation, incubation, illumination to verification which ultimately become part of the process of convergent thinking. He enumerates enabling skills: musical aptitudes (extensiveness, flexibility, originality, tonal and rhythmic imagery, and syntax) conceptual understanding, craftsmanship, and aesthetic sensitivity. Motivation, subconscious imagery, environment and personality are components of enabling conditions which he reports drive the creative thinking process. He uses the words 'subconscious imagery', defined as "mental activity that occurs quite apart from the conscious mind and that may help to inform the creative process during times when the creator is occupied consciously with other concerns".

The word 'imagery' in the field of music is a powerful concept. Again, tracing the cognitive processes that take place while creating is a challenge for cognitive psychologists. Webster uses 'musical imagery' to describe the sounds one pictures in one's mind (particularily tonal and rhythmic imagery) while looking at a piece of music or experimenting mentally with what would sound well in a specific piece in progress. (Refer to Chapter IV for students descriptions from this study.) Perhaps his statement in italics under the heading "Thinking Process" is a real mandate for those interested in the musical creative process in children. "What has not received much study or attention by educators is the 'process' by which these skills and conditions are connected to creative production (the skills incorporated in his model and listed above)".

Summary

The direction that music software has taken in the twenty years of its history has been described. A substantial amount has been done in the field of CAI. In a recent article in "The Computing Teacher", Steinhaus (1987) relates that 75% of the Apple II music software is for computer-integrated instruction, 15% for music composition and 10% for utility purposes, record-keeping etc.

The large percentage in the field of computer-assisted instruction is due to the fact that until the advent of micro-computers, universities and colleges have had and will continue to have a vested interest in developing music fundamental skills in students majoring in music. Creating music software for a larger segment of the market began when public schools and smaller colleges began to invest in the new teaching technology.

The last parts of this chapter have been directed toward the research and writings that have explored the nature of the creative process as viewed from a cognitive position. Both Gardner (1982) and Webster (1987) have contributed substantially to this field.

The concern with using computers in music in a more creative manner has only begun. Even the concern with the importance and practibility of being creative in music using a computer has just surfaced in recent years (notably, the work done by Bamberger, 1983).

References

Chapter II

Ames, R. G. & Carpino, S. (1977). The demand for instructional computing resources: 1976-1980. California State University and Colleges, California State University, Hayward, Calif.

Arenson, Michael A. (1978). An examination of computer-based educational hardware at 28 NCCBMI member schools. Journal of Computer-Based Instruction. 5 (1&2), 38-40.

Rumery, Kenneth R. (1985). Bringing your classroom on-line, the computer as a music processor. Music Educators Journal. Jan. 21-24.

Taylor, Jack A. & Parrish, James W. (1978). A national survey on the uses of, and attitudes toward programmed instruction and computers in public school and college music education. Journal of Computer-Based Instruction. 5 (1&2), 11-12.

Kuhn, Wolfgang E. & Allvin, Raynold. (1967). Computer-assisted teaching: A new approach to research in music education. Journal of Research in Music Education, XV, 305-315.

Diehl, Ned C. (1971). Computer-assisted instruction and instrumental music: implications for teaching and research. Journal of Research in Music Education, 19, 299-306.

Diehl, Ned C. & Zeigler, Ray H. (1973). Evaluation of a CAI program in articulation, phrasing and rhythm for instrumentalists. Council for Research in Music Education, XXXI, 1-11.

Peters, G. David. (1974). Feasibility of computer-assisted instruction for instrumental music education. (From Psychological Abstracts, 1974, p. 1478-A.

Von Feldt, James R. (1971). Computer-assisted instruction in the public school general music class: A comparative study. (From Psychological Abstracts, 1972, p. 2418-A.

Allvin, Raynold L. (1971). Computer-assisted music instruction: A look at the potential. Journal of Research in Music Education, 19 (2), 131-143.

References

Chapter II

Placek, Robert W. (1972). Design and trial of a computer-assisted lesson in rhythm. (From Psychological Abstracts,) 1972, p.1478-A.

Killam, Rosemary et al. (1975). Interval recognition: Identification of harmonic and melodic intervals. Journal of Music Theory, XIX (2), 213-233.

Hofstetter, Fred T. (1979). Evaluation of a competency-based approach in teaching aural interval identification. Journal of Research in Music Education, XXVII, 201-213.

Chambers, Jack A. & Sprecher, Jerry W. (1980). Computer-assisted instruction: Current trends and critical issues. Communication of the ACM, 23 (6), 332-342.

Naisbitt, John. (1982). From an industrial society to an information society. Megatrends: Ten new directions transforming our lives. New York: Warner Books, 23-33.

Hofstetter, Fred T. (1979). Microelectronics and music education. Music Educator's Journal, April, 39-45.

Prevel, Martin. (1982). Low-cost computer-assisted ear training. Journal of Computer Based Instruction, 9 (2), 77-78.

Taylor, Jack A. (1982). The MEDICI melodic dictation computer program: Its design, management, and effectiveness as compared to melodic dictation. Journal of Computer-Based Instruction, Fall, 9 (2), 64-73.

Arenson, Michael. (1982). The effect of a competency-based computer program on the learning of fundamental skills in a music theory course for non-majors. Journal of Computer-Based Instruction, 9 (2), 55-58.

References

Chapter II

Bamberger, Jeanne. (1972). Developing a musical ear: A new experiment (LOGO Memo 6). Massachusetts Institute of Technology, Artificial Intelligence Laboratory. July.

(1974). The luxury of necessity (LOGO Memo 12). Massachusetts Institute of Technology, Artificial Intelligence Laboratory. May.

(1974). What's in a tune (LOGO Memo 13). Massachusetts Institute of Technology, Artificial Intelligence Laboratory. July.

(1979). LOGO music projects: Experiments in musical perception and design (LOGO Memo 52). Massachusetts Institute of Technology, Artificial Intelligence Laboratory. May.

(1983). The computer as sandcastle Massachusetts Institute of Technology. April.

Gardner, Howard. (1982). Artistic Development in Children. Art, mind, and brain: A cognitive approach to creativity. New York: Basic Books. 86-88.

Webster, Peter. (1987). Conceptual bases for creative thinking. In J. C. Peery, I. W. Peery, & T. W. Draper, (Eds.). Music and child development. New York: Springer-Verlag. 158.

Steinhaus, Kurt A. (1986). Putting the music composition tool to work. The Computing Teacher. Dec./Jan.

CHAPTER III.

THE STUDY

Overall Design

This study employed a standard research design with experimental and control groups (Edwards, 1954; Sprinthall, 1982). Two groups of fifth and sixth grade students (N = 14 each) were randomly selected and were tested before and after treatment. The treatment for the experimental group was comprised of ten sessions for each student with 'hands-on' experience using the Music Construction Set software (described in Chapter I) to write short melodies. The control group received no treatment.

The study was conducted at the Media Center at the School of Education, University of Massachusetts. The students that participated were from the Marks Meadow Elementary School, a laboratory school (adjacent to the Education building). The pre and post-tests were individual interviews of one-half hour duration each, (see Appendix 1).

The students came to the Media Center on a schedule that was made out weekly by their teachers. The sessions took place three days per week over a two month period during school hours from mid-April to mid-June 1986. The pre and post-test melodies were given via tape recorder with guidance by the researcher.

Responses to a series of questions (listed at the end of this chapter) and students' comments were taped and taken down in long-hand by the researcher. These questions were asked in order to help the students verbalize their thoughts about creativity in a computer learning environment. A summary of their comments and responses to the questions appears in Chapter IV.

Hypotheses

The fact that the experimental group received ten sessions in writing their own compositions and thus had more experience listening to how musical phrases were put together and how they sounded (using a computer learning environment), led to the hypothesis that their perception of melody would be better from that experience and therefore, that test scores would be higher for the experimental group than for the control group, as well as for the combined categories.

The specific hypotheses tested were: 1) The experimental group will gain more than the control group for global-texture (TEXT); 2) The experimental group will gain more than the control group for contour-recognition (CONT); 3) The experimental group will gain more than the control group for abstraction (ABST); 4) The experimental group will gain more than the control group for closure (CLOS); 5) The experimental group will gain more than the control group for the combined TEXT, CONT, ABST, and CLOS categories.

Methods

Testing

The pre-test and post-test were the same and consisted of four categories of questions. In category 1, called global-texture (TEXT), five examples of melodies were played. The melodies were between four and eight measures in length. The students were introduced to the test by the following explanation and questions:

"You are going to hear several melodies in different ways. You may hear one melody alone, two melodies together, or a melody with chords. There will be five examples in this category. As you listen to the melodies on the tape recorder will you please answer as to whether you hear one melody, two melodies or a melody with chords?" (See Appendix 1 for examples of melodies).

In category 2, called contour-recognition (CONT), five examples of melodies were played. Students were asked to tell if they heard any repetitions of phrases within each of the melodies. In example 1, there were two phrases in the melody: the second phrase was the same as the first, except for the last three notes. In example 2, there were four phrases: phrases one and three were the same, but two and four were different. In example 3, there were two phrases, but every other measure began with the same rhythmic pattern and motive. In example 4, there were four phrases: one and three were the same, and two and four were the same. In example 5, there were four phrases: phrase one and three began the same for two measures and then changed, and phrases two and four were entirely different. (See Appendix 1 for examples).

In category 3, called <u>abstraction</u> (ABST), there were only two examples. Melody 1 and melody 2 were both part of the first example; melody 3 and melody 4 were part of the second example. Melody 1 was played three times in order for the student to become familiar with it. Then melody 2 was played, and they were asked to tell whether any part of that melody had been part of the first melody. In example 1, phrase 2 was the same in both melodies which otherwise were entirely different. Melody 3 (in quarter notes) was played three times. Then melody 4 was played; it had a similar melodic contour but was in half notes. In this example the melody was similar but much slower. (See Appendix 1 for examples).

In category 4, called <u>closure</u> (CLOS), there were four examples of melodies. Two were melodies that ended in a logical fashion (resolved on the Tonic or 'do') and two that did not resolve ('left hanging' or not conclusive). The students were asked to identify which ones resolved and which did not as well as how many more notes it might take to complete the melody.

Scoring

Each question in each of the four categories was scored on a 0 - 5 point basis.

0 - totally wrong answer

1 - some verbal indication of understanding question, but

confusion as to the answer or what was heard

2 - indication of understanding the question, but answer not correct

3 - asked to have example played again, then answer correct

4 - almost correct answer (e. g. "I think it ended, but I'm not sure")

5 - correct answer

For category 1 global-texture (TEXT): There were five melodies, each with a possible correct score of 5 or a total of 25. For category 2 contour-recognition (CONT): There were five melodies, each with a possible correct score of 5 or a total of 25. For category 3 abstraction (ABST): There were two examples (two melodies for each of two questions), each with a possible correct score of 5 or a total of 10. For category 4 closure (CLOS): There were four melodies, each with a possible correct score of 5 or a total of 20. The perfect score for all categories (TEXT, CONT, ABST and CLOS) combined was 80 (25 + 25 + 10 + 20).

Sample

The 28 students in the study were from the fifth and sixth grades of the Marks Meadow Elementary School, Amherst, Mass. The students ranged in age from ten to twelve years. Many had taken lessons on one or more instruments. All of the students in both fifth and sixth grades were invited to participate in the project. The project was described to them by the researcher, and they had an opportunity to ask questions about it. The parents of each of the students received letters describing the project; permission slips were received from 28 parents. The two resident teachers randomly selected 14 students to be in the experimental group and 14 students for the control group.

Data and Statistical Analysis

Means and standard deviations were computed for both pre- and post-test scores of the 14 students in the experimental group and the 14 in the control group (shown in Chapter IV, Tables 1 and 2). The rating scale has 4 sub-scales (TEXT, CONT, ABST, and CLOS). The scores used for the tests were computed on the basis of the average scale score for each of the sub-scales and are therefore reduced to similar scales (0-5). The two-tailed t test was used to determine whether there were significant differences between the experimental and control groups. The total scores for the first three categories and also for all four of the categories were averaged. This was done because of the ceiling effect that occurred in category 4.

Gathering Anecdotal Data.

The most advantageous data may be in the verbal answers given by the experimental group to some prompting questions asked of them during the treatment. These questions were formulated to draw out their reactions to working with the computer with music software as well as perceived advantages or disadvantages. The students were so intent upon creating their own music in this new medium and asking for immediate necessary information that it became evident that their comments on how they felt about what they were doing should be elicited. Most of their comments were recorded as well as their responses to the questions. Their comments were then categorized according to creativity in general, creativity in music, and how a computer learning environment in music was helpful toward being creative. In Chapter IV the results are summarized and percentages given for how many of the group reacted in like fashion. As an indication of the effectiveness of the treatment, it was felt that their spontaneous reactions might reveal some evidence about their cognitive processes.

The series of prompting questions that were asked of the experimental group during these ten sessions were:

1. Do you think about where to place the notes?

2. Are you concerned about whether the notes you place will sound O.K.?

3. Can you make it sound the way you want to?

4. Do you think being creative in music is like doing an art project or writing a story? How is it different?

5. Is there a difference between writing music in a music class and/or with a computer?

6. Have you learned any new things?

7. What in particular have you enjoyed about this experience and would you like to do more?

8. What other projects would you like to do with the computer in music?

9. Do you think writing music is worthwhile?

10. Do computers help you to be more creative and express yourself?

11. Do you enjoy being creative?

12. Do you learn by being creative?

13. Are there other things you'd like the computer to do for you in music?

The responses from the students to these questions can be found in Chapter IV.

References

Chapter III

Edwards, A. L. (1954). Experimental design in psychological research. New York: Rinehart Co.

Sprinthall, Richard C. (1982). Basic statistical analysis. Reading, Mass.: Addison-Wesley Publishing Company.

CHAPTER IV.

RESULTS AND ANALYSIS

This chapter reports the results and offers an analysis of case studies of 14 children using microcomputer software for learning and creating music. It contains two kinds of data. The first is measures of the pre-test and post-test for both experimental and control groups, with tests for significant differences. The second type of data is anecdotal data, including individual responses to the general questions asked of the experimental group, with a summary of student comments.

The first section of this chapter contains descriptive statistics for the experimental and control groups. The second section discusses the tests for significance of difference between the two groups. The third section describes responses to the general questions (given in Chapter III). The last section is a summary of the students responses to the general questions.

Descriptive Statistics

The means and standard deviations for the pre-test, post-test and differences for the experimental group are shown in Table 1. These measures are shown for each of the four categories of global-texture (TEXT), contour (CONT), abstraction (ABST), and closure (CLOS), and

Table 1

Means and Standard Deviations for Pre-test, Post-test, and Differences for Experimental Group (N = 14)

	PRE		POST		Difference Scores	
SUBTEST	M	SD	M	SD	M	SD
Cat. 1 TEXT	2.96	1.18	4.67	.45	1.71	1.36
Cat. 2 CONT	2.69	.74	3.64	.70	.96	.78
Cat. 3 ABST	2.66	.67	3.97	1.11	1.43	1.21
Cat. 4 CLOS	3.68	1.07	4.75	.23	1.07	1.05
Cat. 1-3*	2.73	.56	4.09	.49	1.37	.73
Cat. 1-4**	3.02	.45	4.24	.38	1.22	.49

* Average of Categories 1 through 3
** Average of Categories 1 through 4

also for the total of categories 1-3 (TEXT, CONT, and ABST) as well as all four categories (TEXT, CONT, ABST and CLOS). The reasons for showing the results for categories 1-3 will be discussed in Chapter V, although it may be self-evident when the differences with and without category 4 are examined.

Of the four sub-tests, the highest pre-test mean for the experimental group was for CLOS at 3.68 and the lowest pre-test mean was for ABST at 2.66. In the post-test, the experimental group mean for CLOS was 4.75 which was quite a high mean considering that the highest possible score of 5 suggests a possible 'ceiling effect'. This could also be true for TEXT since that mean for the post-test was 4.67. The largest difference between the pre- and post-test for the experimental group was for TEXT with a gain of 1.71. The smallest gain was for CONT at .96.

With regard to variability, in the pre-test for the experimental group the standard deviation for CLOS was 1.07 while the standard deviation for TEXT was 1.18. The standard deviations tended to be larger in general in the pre-test than in the post-test. The fact that CLOS showed a mean of 3.68 with a standard deviation of 1.07 in the pre-test and a mean of 4.75 with a standard deviation of .23 in the post-test indicates that these means are both relatively high and both pre- and post- sets of means were relatively homogeneous, once again suggesting a possible ceiling effect. There were gains in each of the mean scores in all of the four categories (TEXT, CONT, ABST, and CLOS) between pre-test and post-test.

The totals of categories 1-3 and 1-4 for the experimental group show fairly high gains between pre-test and post-test means at 1.37 and 1.22 respectively and the standard deviations are low, .73 and .49.

Table 2 shows the means and standard deviations for the pre-test, post-test and differences for the control group. The highest mean for the pre-test was in TEXT at 2.87 while the lowest was in CONT at 2.24. The highest means for the post-test was in CLOS at 4.57 and again the lowest in CONT at 2.89 with a gain of only .65 between pre and post-test. However, the difference in gains for means of the control group in all four categories ranged from a low of .56 in TEXT to a high of 1.75 in CLOS. In three of the four categories, TEXT, ABST, and CONT, the control group mean gain ranged only from .56 to .65. This serves to indicate that category 4, CLOS, with a mean gain for the control group of 1.75 was clearly different from the other three small gains on categories 1, 2 and 3. This will be discussed in more detail in Chapter V.

The standard deviations for the control group in the pre-test were low at .62 to .92 and had a slightly wider range in the post-test, .36 to 1.29. The standard deviations ranged over all categories from .86 to 1.29.

It is interesting to note that while the pre-test mean score for CLOS for the control group was 2.82, for the experimental group the pre-test mean was 3.68. This relatively high mean may have prevented the experimental group from making much gain in the post-test because they were already closer to the top. A more complete discussion on the

Table 2

Means and Standard Deviations for Pre-test, Post-test, and Differences for Control Group (N = 14)

SUBTEST	PRE M	PRE SD	POST M	POST SD	Difference Scores M	Difference Scores SD
CAT. 1 TEXT	2.87	.91	3.43	.99	.56	1.29
Cat. 2 CONT	2.24	.62	2.89	.90	.65	1.14
Cat. 3 ABST	2.75	.92	3.32	1.29	.57	1.21
Cat. 4 CLOS	2.82	.91	4.57	.36	1.75	.86
Cat. 1-3*	2.61	.39	3.89	.87	.59	.79
Cat. 1-4**	2.67	.44	3.55	.56	.87	.74

* Average of Categories 1 through 3

** Average of Categories 1 through 4

ramifications of this may be found in Chapter V. Table 3 shows the gains in the mean differences as being substantially larger for the experimental group than for the control group except for category 4, CLOS. The standard deviations are generally larger for the experimental group. The highest mean gain for the experimental group was for TEXT, 1.71, and the highest mean gain for the control group was for CLOS, 1.07.

Analysis

A t-test of the CLOS category between experimental and control in the pre-test showed that the experimental group was significantly higher to begin with ($t=2.21$, $df=26$ and $p<.05$). There were no other pre-test significant differences. The implication is that the control group gain was greater than the experimental group gain because the control group scored significantly lower than the experimental group in the pre-test. This could explain the -1.80 t test score in Table 4 under CLOS.

Table 3 shows the means and standard deviations for difference scores for the experimental and control groups. The average gains are greater for the experimental group in all of the individual categories, TEXT, CONT, ABST, and in the total of categories 1-3 and categories 1-4, except for CLOS which was explained in the preceding paragraph.

Table 4 shows that there is a significant difference in the t test for TEXT, $t = 2.16$ $df = 26$ $\underline{p} <.05$ $E > C$. It also shows that there is a significant difference in averaged categories 1-3, $t = 2.62$

Table 3

Means and Standard Deviations for Difference Scores for Experimental and Control Groups

(N = 14)

	E		C	
SUBTEST	M	SD	M	SD
Cat. 1 TEXT	1.71	1.36	.56	1.29
Cat. 2 CONT	.96	.78	.65	1.14
Cat. 3 ABST	1.43	1.21	.57	1.21
Cat. 4 CLOS	1.07	1.05	1.75	.86
Cat. 1-3*	1.37	.73	.59	.79
Cat. 1-4**	1.22	.49	.87	.74

* Average of Categories 1 through 3

** Average of Categories 1 through 4

Table 4

Analysis of Difference Scores for Experimental and Control Groups

t test Results for Specific Comparisons

SUBTEST	t***	p	Direction
E vs. C Cat. 1 TEXT	2.16	<.05	E > C
E vs. C Cat. 2 CONT	1.13	n.s.	------
E vs. C Cat. 3 ABST	1.79	n.s.	------
E vs. C Cat. 4 CLOS	- 1.80	n.s.	------
Cat. 1-3*	2.62	<.05	E > C
Cat. 1-4**	1.43	n.s.	------

* Average of Categories 1 through 3
** Average of Categories 1 through 4
*** All tests have 26 degrees of freedom

df = 26 p <.05 E > C using the 2 tail table, t = 2.06. The t test for CLOS was the only comparison in which the control group had a higher gain than the experimental, thus the negative (but nonsignificant) t of -1.80. A possibility is that the control group gain was greater than the experimental gain because the control group scored significantly lower than the experimental group in the pre-test.

Anecdotal Data

Students' answers to the general questions (listed at the end of Chapter III) follow. Such anecdotal data serves to elucidate attitudes of these students toward musical creativity in a computer learning environment. In order to ensure anonymity, each of the 14 members of the experimental group are hereby known by letters A through N.

A. A was an 11 year old fifth grade student who had played the recorder for a year and was in her 2nd year playing the clarinet. She had a Commodore 64 microcomputer with cassette player at home. She was very interested in the project and showed her delight at being able to hear her melodies as soon as she had completed a phrase. She was eager to harmonize her first melody while others did not ask to do the same until they had written at least two melodies. She felt that she could make her music sound the way she wanted it to "most of the time" but that occasionally she was "surprised" that it sounded differently than she expected. Her spontaneous comments included, "I didn't think you could be creative with a computer." "It is much easier writing with a computer because it doesn't take as much time." "In the future people will be more creative in shorter periods of time".

She was most confident in saying she had learned more about music (the basics) and about how to put melodies together. She thought that being creative was fun and had never realized she would be able to accomplish what she had: three melodies, one with chords, one with rolled chords and another in imitation. She hoped that future generations of computers and software would offer more varieties of instrumental sounds, and sound like real instruments. Her total score was one of the highest, and she mentioned that she would like to teach elementary school instrumental music.

B. B was a 10 year old fifth grader who had some recorder and clarinet experience. She was concerned about the rhythm and making it sound like 'a melody I have heard before'. She liked the freedom of writing the notes she wanted to, unlike in music class where she felt she was assigned certain projects to do. She felt that a good project would be to have everyone write a song for a play.

She said the computer offered her more freedom to express herself, that there wasn't just one way to write a melody. She especially liked the opportunity to experiment, to be able to listen after a couple of measures and change what she didn't like. When finished she felt she had something different from everybody else.

C. C was a 12 year old sixth grader, an energetic youngster who had played recorder, trumpet for a year, baritone for a year and saxophone during this year. Occasionally when he came, he was a bit restless. But, like the rest of the boys, he especially enjoyed setting up a drum beat (non-pitched sound in the software) for one of his melodies.

He was concerned about the sound of the melodies he was composing ("I don't want it to sound awful") and had a tendency to work slowly as though it took a lot of effort and patience. He thought that writing music would make a great hobby or relaxation after "going to work".

D. For the most shy individuals, and D was one of them, the interviewer's questions served to draw them out. D was a very retiring 10 year old in the fifth grade. He had played recorder, trumpet and baritone for two years. It took him a long time to complete just two melodies because he did a lot of pondering and deleting. He experimented with drum beats but didn't like the sound. He felt he learned by being creative but felt there was much to be desired in the variety of sounds offered by the software.

He made the comment that there was self-satisfaction in being creative and that having the computer draw the notes was much easier than the traditional method with pencil and eraser.

E. E was a very verbal, happy 12 year old sixth grader. He had a Commodore 64 at home. Not having played an instrument, he felt that writing music on the computer was much easier than playing an instrument, (a major advantage for students who do not have the opportunity to play an instrument).

He said that he planned his melodies a measure ahead from looking at and hearing the previous measure. He liked the idea of being creative because of the opportunity "to use your own imagination".

As to whether it was worthwhile being creative in music, he felt it was, even if you were not going to be a musician, because it was like "making a beginning". He spoke about "keeping your feelings in" and about how this was a way to express them and get them outside.

In his comments he asked for a lot of information about rhythms, note values and notes on which to end. He felt one real disadvantage of the computer was forgetting to save something on disk, and that you really needed to know the keyboard to work effectively. He wrote four completed melodies, one with chords, two with drum beats, one with two melodies and another in imitation. "The computer makes writing music easier because you can hear it over and over again."

F. If E sounded as though he did a lot of planning, F verbalized very well as to how he went about it. "Often I think about where to place the notes, or I just wait until I get to the end of a note and then try to think of the next note and see whether it will sound OK and what would sound good with the last note". He allowed that "sometimes the notes did other things" than he expected, "but I really like them".

F was a very alert 10 yr. old fifth grader with a computer at home, and who had played violin for 3 years. In response to whether he liked being creative in art, music and writing he said, "Yes, because in all of them you have to think about what you're doing and how you're going to do it; and you have to think, too, about things that match."

He said it was much more fun writing music with a computer because it plays the music for you; he added that he didn't "perform much music". He thought computers might be able to help tune instruments and serve as instrumental guides, (there are a number of pieces of software that do serve as instructional and tuning guides for some instruments).

When asked if he thought writing music was worthwhile, he replied that "if you know how to do it, you enjoy doing it". He said that being creative "shows other people how I feel, and shows my way of doing it." "It feels good. My way is 1 out of 1,000. You can learn to express yourself more freely and thoroughly."

He described how much more fun writing music by computer was than with the laborious pencil, paper and eraser method: write it, then play it on the violin, then erase and play it again "and then see how that sounds". He wrote six short pieces with chords, drum beat, two melodies and imitation. He also had the largest improvement in score from pre-test to post-test (26 points).

G. G was an 11 year old sixth grader who had played violin for almost 4 years and had 3 months piano lessons. He had an Apple II at home and was familiar with the keyboard, consequently he worked very fast. He said that he planned the notes he was going to put down "a measure at a time, or two". He felt that writing music was much different than an art project or writing an essay because there were strict rules and you were limited as to the things you might do. He mentioned that someday he hoped to be a cartoonist or a scientist.

In one of his first compositions using two melodies simultaneously he actually drew a circle using sixteenth notes, to outline the circle. (See Appendix 2, p. 104). Later in the 10 measure melody, he repeated this figure and circumscribed an arrow and then finished with two scale passages in contrary motion. When asked if he was doing this for the visual or sound effect, he replied, "for sound". He talked about seeing and hearing music simultaneously and how much it would help people in learning music.

He quickly absorbed the principle of the scissors (being able to remove with the press of a key a measure at a time) and the pastepot (which allows you to juxtapose the measure or measures in another place in the composition.) By using these devices, he was able to put together an ABA form quickly (See Appendix 2, p. 106). He was familiar also with rondo form (ABACA) and wrote 'A Short Rondo' utilizing the scissors and pastepot devices (See Appendix 2, p. 105). In several of his attempts he said the music sounded "cacophonic" and then would change it. He said he felt that computers could help you to be more creative if you had the right software. "If you don't, you're limited. With certain software, everything has to be in a certain syntax. If you don't know much about music, you can only make basic plans. You learn things by experience or by doing rather than with a textbook".

H. This 10 year old fifth grade student was very shy, and therefore not very vocal. He had played trumpet for 2 years. He liked writing 'fast' notes and enjoyed putting together groups of sixteenth notes. He enjoyed writing music with the computer because "I just put down what and when I want, and when I play it over I can change it". He said this was a big improvement over trying to write a melody in class with pencil. He mentioned learning more about beats and what kind of notes (values) to use. He experimented with using simple triads to harmonize his melody, a drum beat with simple rhythm and two melodies. At the last session he asked to hear all of his melodies again.

I. This student was a 12 year old girl in the sixth grade who had had 3 months' experience with the recorder and three months with the clarinet. During our sessions she expressed regret at not being able to continue the clarinet, but said that she was unable to practice because she had too much homework (she said she had no choice).

When asked whether she could make her melodies sound the way she wanted them to, she said, "Yes, because once you get started, you know what to do." She said that sometimes she just took a guess as to what to put down, but then she could change it easily. She liked the idea of being creative and related it to art projects where she could choose whatever color crayons and mentioned the fact that her art teacher encouraged her to try different things.

She mentioned wondering about whether she would enjoy this computer-music project, "I said to myself, 'Yes, I want to do it'." Then she followed that with ..."for one thing, you get to get out of class for awhile" and later added that in music class, things were assigned and you "had to do them". This kind of experience was very worthwhile, and fun. "You can write low notes if you're angry or high notes when you're happy." "You learn how to make it better if you don't like it."

J. This 11 year old sixth grade girl had studied piano for a year and clarinet for a year. She was a bit lethargic and moved very cautiously about the microcomputer even though there was one at home, a MacIntosh. She liked thinking up melodies and thought it was much easier than writing stories. "Like in a melody, you can start and end it where you want to." "When you're writing a melody with a computer, it doesn't make a foul-up. It plays it right off. When you make a melody that's too hard, you can't play it, but the computer can."

When asked if she had learned any new things she replied, "Yes, I've learned sometimes it sounds better when you use faster notes. When you're writing music without a computer you just write one note at a time."

At one session, she began humming to herself and said, "I have it kind of pictured in my head, I have it figured out; it's just that I don't know if the notes will work out, let me think it out, it's sposed to go (humming and putting notes on monitor), it sounds better than I thought!"

K. Having taken lessons on three instruments in three years, this 10 year old fifth grader finally wrote his great opus, "Mexican Jumping Bean Concerto". He had studied the violin in 3rd grade, the trumpet in 4th grade and the baritone in fifth grade. His melodies were very pointillistic (instrumental with jagged leaps) and very atonal. Whether these traits came from boredom or the search for shock value, when he found he could set the tempo of his melodies to presto he quickly captured the admiration of the students who came after his sessions.

On thinking about where to place the notes: "Sometimes I just put them on the screen wherever I want to; I just do what I do". On whether it will sound O.K.: "not really!" Can you make it sound the way you want to? "Yes, when I write what I want to write, I just do it loosely." Do you think being creative in music is like art projects or writing a story? "There's information here that you could get out of a music book, but you're seeing it all right here on the screen, changing keys with key signatures."

The difference between music with the computer and in music class was: "In class you have an assignment, and here with the computer you can hear it, see it and print it out." On learning new things, he felt he had learned a lot about rhythm, rest and harmonizing melodies. He enjoyed the experience "...a lot. I like writing music and hearing it." He said he would like to do more projects with computer and music writing a "real, long melody with drum beats". Is writing music worthwhile? "Yes, because they have things that I don't know about, like 8va (raising the pitch an octave) and other symbols that I don't know about that make more things possible."

Do you enjoy being creative? "Yes, a lot. I like it because you aren't always on one subject the whole time. You can use your imagination. Like in art, you can think up something in your mind, like a closed shape or an open shape, you can wander around in it. It's a freer way of learning something. You don't have a lot of parameters."

Do you learn by being creative? "Sometimes. If you're experimenting, it leads you to find out things. Like in long division, you have to know how many times 6 will go into 36. You learn step by step. With music, if you happen to be talking about rhythm, you learn something about that; if it's melody, then you learn as you go." When asked about things he would like the computer to do he mentioned a voice synthesizer that would write music on the screen and then print out. (Instant music!)

L. This student, 11 years old and in the sixth grade had only played a recorder for a few months in the third grade. He said he'd "never been very great in music", that he didn't plan out the notes and that he usually couldn't get them to sound the way he'd like them to. "At home or in class I wouldn't be able to hear how it sounds because I don't play any instruments. But with the computer it gives you an idea of what you want to do next." He did end with the statement that "it's fun making music on the computer".

M. This fifth grade 11 year old student had played the violin for two years. He too, said he did not plan the notes, and that he wouldn't know if it sounded "neat or not". He said he had learned a lot of new things about where the notes were and he enjoyed it because "I didn't really know a lot about music till I came down here". He liked doing the drum beats with the music software, and felt that "if you have to compose, it's easier on a computer than with a pencil".

N. The last student was 12 and in the sixth grade. He was really 'into' rock music, had lots of rhythm and often moved to 'the beat'. He said he didn't really plan out the notes, but that they came out almost the way he wanted them to. He didn't feel that writing music was like being creative in art or in writing stories because "if you write a story it takes a lot more thinking- but music takes a lot of thinking for me. Music is harder that art projects, it's like getting on a bike, you never forget".

He felt writing music was easier with the computer, and that he had learned a lot about different notes, placing notes on the staff and how many beats in a measure. He said the experience was "a lot of fun". Do computers help you to be more creative? "Yes, you learn how to write music. I never knew how to write music before; it's fun, interesting. It can make you sad, happy, mad. I learned while I was writing music. I'm being creative! How easy it is!"

Summary of student comments

Based on the ten sessions with the 14 students in the experimental group, the responses to the interviewer's general questions are tallied and summarized below.

1). Prior computer experience at school and at home: 5 of the 14 (35%) students had computers at home. All had taken part in a few sessions instructed by the school computer specialist with 3-5 students at a terminal.

2). Formal music training: 9 of the 14 (65%) students had played or taken lessons on a variety of wind, string and keyboard instruments for from 1-3 years, beginning at the 3rd grade level.

3)a. Positive reactions: 11 out of 14 (78%) used the word "fun" and clearly enjoyed the experience. All 14 (100%) mentioned specifically their amazement at how much easier using the computer was than the traditional pencil and paper method, what a valuable and enjoyable experience it was, the tremendous advantage in being able to see and hear the music simultaneously, the accuracy and legibility of notes, as well as the freedom to write what notes occurred to them.

3)b. Advantages of the computer: All 14 (100%) mentioned advantages such as: working on the computer was easier than playing an instrument; they learned more about the fundamentals of music with the continual subliminal message of the menu page (See Figure 1); being able to hear the melodies replayed on demand; and the quick deletion and addition of a note, a measure, or a whole section of the music (which is a feature of the Music Construction Set).

4). Disadvantages: 5 (28%) participants mentioned certain disadvantages: the quality of sound generated by the computer; not being familiar with the keyboard; and failing to save on disk and losing their compositions.

5). Would like to do more with computer music software: All 14 (100%) were unanimously affirmative on this. Several asked if it could be continued in the fall.

6). Enjoy being creative in music: All 14 (100%) expressed their enjoyment of being creative in a number of different ways: it was easier than writing stories; they derived pleasure in expressing themselves in music; they liked being able to hear what they had written without the hazards of playing it incorrectly on an instrument; they used the melody lines in a visual manner; they had fun experimenting with music; and when finished had something different from everyone else.

7). Do you learn by being creative*?: 10 (71%) answered essentially yes and said that there was a lot of self-satisfaction in being creative, that it was fun, it made you think about what you were doing, how you were going to do it, made you use your imagination, think about things that matched, you learn while you experiment, much more freedom, and more could be accomplished in shorter periods of time.

8). Do you learn more about music?: 9 (64%) replied that they had learned more in this situation with the opportunity to find out information about rhythm and meter as they started the first measure, learned about melody and how their notes sounded in relation to one another in a phrase, learned how to place notes on the staff where they wanted them to sound, and learned the meaning of more symbols, which gave them more options.

9). Other things you would like the computer to do: 6 (43%) suggested that computers might be used to help tune instruments, teach fingerings for instruments, offer more varieties of instrumental sounds, reproduce the actual sound ('real-time') of instruments rather than a synthesized sound, have a voice synthesizer that would write music on the screen and print it out; and do homework! These comments reinforce the belief that there is a lot of creative thinking taking place at a time that is ripe for new ways of using the computer.

This summary has been helpful to see the students' viewpoints on the potential of creating music in a computer learning environment. Their responses to the general questions also provided a marvelous opportunity to observe some of their cognitive processes. One contrast in cognitive styles that should be noted is that of 'negotiators' versus 'planners'. D spent a lot of time in making up his mind as to what sounded pleasing to him and deleting what he didn't like. E planned his melodies a measure ahead after hearing the previous measure and F mentioned how he had to think about what he was doing while writing music and about what things would match. G demonstrated his ability at planning by using ABA and Rondo forms as well as writing the music phrases to circumscribe the shape of a circle and arrow. K was the negotiator in saying that when he wrote what he wanted to, he did it loosely.

The experimental group was anxious to get to each of the tasks and seemed to have some conversations with one another outside of the sessions as to who had tried a canon, or harmonizing a melody with chords. News of the potential of the rhythmic drum beat on the software travelled fast and the boys in particular were intrigued with it. They were interested in the ability of the software to delete, place measures and phrases in different positions, speed up tempos, produce different sounds, transpose to different keys, raise octaves, produce instantaneous key signatures, and then sit back and watch their music scroll by as played by the computer.

A great deal of conversation centered around pragmatic questions (e.g. how many more beats were needed to complete this measure, how to locate C, or how to use the various icons that acted as commands for the various accessories that were available on the software). They seemed to want to exploit the entire range of possibilities offered by the Music Construction Set and wanted to know all the parameters (e.g. the highest and lowest notes, how long the composition could be and how many measures the buffer would hold. Thus, pertinent information was needed in three vital areas: music fundamentals, computers and the parameters of this software.

The thinking processes that are involved in creating a piece of music include such aptitudes as flexibility, originality and the ability to perceive sound in relation to change. Divergent thinking which generates many possible solutions to a given problem help to put into motion the steps of preparation, incubation, illumination and the actual creation effort. Motivation, subconscious imagery and personality (risk-taking, spontaniety, openness, humor, and a preference for complexity). The final process of convergent thinking (weighing several possible solutions and converging on the best possible answer) brings about the product, the musical composition, (Webster, 1987). In each of the students varying amounts of the above attributes were evident. Results of the study infer that better learning may take place while students are in the process of being creative.

References

Chapter IV

Webster, Peter. (1987). Conceptual bases for creative thinking. In J. C. Peery, I. W. Peery, & T. W. Draper, (Eds.). Music and child development. New York: Springer-Verlag. 158.

CHAPTER V.

DISCUSSION

The Study

This research study accomplished its purpose by exploring the basic research question: Will there be differences between the experimental group using a computer music learning environment and a control group that does not? Yes, there were marked gains in the post-test scores for the experimental group for three categories of 1.15 in TEXT, .31 in CONT, and .86 in ABST. Specifically, in category 1, texture (TEXT, the ability to recognize whether the example played by tape recorder was one melody, two melodies played together or a melody with chords) there was a mean gain of 1.71 from mean pre-test 2.96 to post test 4.67. The control group went from 2.87 to 3.43 with a mean gain of only .56. This result was significant. The mean gain in contour (CONT, recognizing similar melodic contours within a melody of two to four phrases), for the experimental group was .96, compared to .65 for the control group. The mean gain in abstraction (ABST, identifying a phrase of a melody first heard in one melody and then repeated as a phrase in a new melody), for the experimental group was 1.43, but for the control group, a mean gain of only .57. In each of the first three categories, the experimental group was above the control group.

In category 4, closure (CLOS, recognizing whether a melody came to a complete cadence, ending, or was 'unresolved') the experimental group mean difference was only 1.07 compared to the control group's 1.75. The high pre-test score for the experimental group of 3.68 suggests the possibility of a ceiling effect and that possibility is reinforced even more by the high score of 4.75 in the post-test. In fact, the CLOS experimental group post-test mean of 4.75 was the highest of all the pre- and post-test means for both groups. Further, the pre-test means for the two groups were significantly different to begin with, a fact which further supports a ceiling effect and possibly explains why the control group had a greater gain for CLOS.

The implication for category 4, CLOS, is that the task was not difficult enough. Therefore, the mean change scores are shown for the combined categories 1-3 (TEXT, CONT, and ABST) as well as for the combined categories 1-4, including CLOS. Using only categories 1-3, there is a significant difference favoring the experimental group; whereas not for categories 1-4.

Inasmuch as the experimental group showed gains over the control group and the range of standard deviations were consistent in both groups, .49 to 1.36 for the experimental group and .74 to 1.29 in the control group, the general hypothesis that the experimental group will show more improvement than the control group was at least partially confirmed, showing significance in category 1, TEXT, and categories 1-3, TEXT, CONT and ABST. The independent variable -- the ten sessions for the experimental group creating music in a computer learning environment -- made a difference. The largest gain for the experimental group in category 1, TEXT, can be explained by the fact that during the treatment this group was working with one melody, two melodies played together and a melody with chords. Thus they had a better understanding of what different textures in music sound and look like on the staff.

The anecdotal data confirms the conviction that better learning takes place through problem-solving, negotiating with the computer and sound, learning while experimenting, using one strategy to build others, learning through simulation (using the process of creating music to learn valuable information about music), being exposed to the value of music, experiencing the freedom of creating, the value of constructing a composition that is entirely different from anyone else's, working in a computer learning environment is an 'enabler'. It prods young minds to do things they never imagined were possible. It is a powerful tool for motivating ideas and intellect as well as creativity.

The word 'creativity' is central to the focus of this study. The meaning of the word 'create' in the dictionary is "to cause to come into existence, originate"; the word 'creative' is described as 1. "having the power or ability to create, 2. characterized by originality of thought and execution". Gardner refers to his observations of normal and gifted children as well as adults in studying the components of artistic production and mastery from several vantage points. He says there is doubt on how to measure talent, how to define it and how to prove its existence. It is known that some students possess a natural aptitude for accomplishment in the arts, showing an early fascination and ability to progress rapidly. Inborn talent is of prime importance of course. But he believes the environment that the student is exposed to is of equal significance, (Gardner, 1982). The central theme of this study has been to explore ways of exposing students at the pre-adolescent stage of learning to ways of being creative in music, not mastery of a subject; but to show that in being assigned a task to write a melody (create or originate it) and harmonize it his ability to accomplish that task is dependent on learning basic musical facts to make this possible. The product is a result of the process of problem-solving or working out a method for performing the skill.

The stages in this process of necessity have been accurately outlined by Webster in his section called "Modes of thought" where he describes four stages: (1) the preparatory phase, in which "the creator first becomes aware of the problems at hand and the dimension of the total work that lie ahead"; (2) the incubation phase, using subconscious image that thinks up musical phrases; (3) the illumination stage, in which solutions to the problems envisoned produce a "flood of energyy that drives thinkng ahead of the final stages of completion"; and (4) the "final plateau of verification" where the music itself melds with the ideas of the creator and propels itself to conclusion, (Webster, 1987).

Implications

The results from the pre- and post-tests comparing the improvement of the experimental group to the control group suggest that the ten sessions in composing melodies and the other tasks that were assigned sensitized and added to the knowledge of music fundamentals of the experimental group. Their responses to the general questions indicate that they learned more in the process of being creative, in part because of the interaction with the computer as well as the advantages offerred by this music software.

Apparently, there is a positive effect on students when they create music in a computer learning environment. It was a new experience for all 14 students to use music software. Therefore it had a certain aura of mystery and appeal. Both the experimental and control groups were self-selected, but only in the sense that they could participate only if they had a permission sheet signed by their parents. After being oriented to the music software and asking occasional informational questions, they were allowed to proceed by themselves. This means that there was a fairly high level of motivation often found in doing projects which they invented and carried out themselves. The pride and self-satisfaction of creating something of their own gave an impetus to learning and also a feeling of independence from the teacher, who could thereby be freed to do other things.

One of the implications of this study is that by tackling a project such as writing a composition of one's own making; one embarks on an uncharted course. In using a computer with music software, a new vehicle is employed, so new skills are acquired at a primary level. The learning that takes place has more significance since the student must understand the basics of music in order to write their own melodies.

The information that they acquire is immediately put to use. This relates to the declarative knowledge, the facts we know, and the procedural knowledge, the skills we know how to perform. The skill learning which occurs in three steps: the cognitive stage (learning a description of the procedure), the associative stage (working out a method for performing the skill), and the autonomous stage (where the skill becomes automatic), is set in motion. (Anderson, 1980.)

A learning of better quality can take place since the computer enables the student to see and hear the music simultaneously. The student sees a melody as a series of intervals (steps or leaps from one note to another) while hearing the actual pitch as the notes scroll by. He relates the notes he hears to what he sees on the screen. This is a two-dimensional kind of 'implantation' that takes place. Following the pre-test during the first session of beginning to write their own melodies, the students were shown a melody on the screen and heard it. In response to the same kind of questions that were asked on the pre-test about texture, contour etc. their 100% correct answers support this theory.

The opportunity to learn more about music is also afforded to the student who does not play an instrument. The computer becomes his instrument to make music. It also includes the student with poor dexterity since it requires less motor ability, such as using both hands to play an instrument. Thus, it is a more inclusive mode of learning.

The facility the computer offers for students to rewrite and revise their compositions easily was an advantage over the traditional pencil and paper method. Upon hearing a part of the melody they wanted to change, the deletion process was quick and encouraged editing of the notes where needed.

The freedom that is a an integral part of creating one's own piece of music is a motivator that also necessitates a mastery of a certain amount of delarative knowledge that can be acquired as one proceeds with the task at hand. Learning where to place a note that one hears in his head is part of the associative stage which eventually becomes automatic should he pursue this avenue of creativity. Many people do not understand the ability to hear in one's mind and then place the note on the staff so that it will sound as it had been 'heard' silently. But this is a skill that can only be developed when being challenged to make the melody 'sound the way' it had been 'heard in one's mind'.

The ability to perform this particular skill (hearing in one's mind prior to hearing the actual sound) is most apparent in sight-reading music. If a student is able to hear it before singing or playing it he can tell whether it is right or not. The enjoyment of listening to music is in direct proportion to one's ability to hear and discern texture, contour, abstraction and closure.

This is also directly related to the many facets of the harmonic progressions and rhythmic patterns we hear as well as tone color (the sound characteristics of different instruments and combination of instruments) and dynamics (getting louder and softer). Melody, harmony, rhythm, tone color and dynamics are all elements of music which the student in elementary school is exposed to and expected to know or at least be aware of in music.

The U-shaped curve in artistic development mentioned in Chapter II refers to the wonderful profusion of drawings and paintings produced by the pre-school child who then arrives at the stage of concrete operations around the age of seven, and seems to limit his graphic efforts to copying and conforming, a so-called 'literal' stage; then he moves into the pre-adolescent stage at age eleven and twelve of formal operations where he begins to show a sensitivity to the arts, expressiveness and composition. Therefore, it is evident that as educators we must provide more opportunities for them to be creative. The potential offered in this area of linking hi-tech to the creative process in music is a 'natural' and should be explored and developed.

The reaction of the fifth and sixth graders in the experimental and control groups to this research project was virtually 100% positive. Their attitude revealed that they felt good about being creative; several students described how they planned ahead what direction their melody would take; and several took delight in finding out how to utilize the fastest possible notes (analogous to shaping wings of a paper plane for greater speed). It is a fertile field in music education; the students themselves provided a long list of reasons why they enjoyed it and learned from it. To insure the integrity of the pre-test and post-test categories and questions, two members of the music faculty at two different universities reviewed and validated the musical material for the tests.

Limitations

In setting up the research project with the principal of the Marks Meadow school and the teachers that would be involved, it was found in January when the schedule for the pre-tests and post-tests was set up, that there would only be time to work with the students between April 1 and June 15. This allowed just one half hour for each test, and with various holidays and vacations, school activities, and absences, only 10 half hour sessions with each of the students in the experimental group could be conducted.

The population and socio-economic profile of the students at Marks Meadow are not that of an average public school since it is an 'arm' of the School of Education at the University of Massachusetts.

The tasks assigned, in particular CLOS, should have been constructed differently and at a higher level of difficulty. Further, the gains noted may only be a function of the specific software used in the study. There are a number of other music software products such as the Bank Street Musicwriter, Music Composer, and Music Maestro which have a great deal of variation in the features offered. At this writing the Music Construction Set is considered the best on the market and is available for Apple IIc and IIe, Atari, Commodore 64 and Macintosh computers.

Suggestions for improvements in future software and hardware features should include a larger screen in order to see more of a composition and interfacing a synthesizer with the computer.

It is implicit in the limitations that such conditions as being in a hallway with only artificial light during the pre-tests, where university instructors and students were passing by was a difficult situation. Midway through the ten sessions for the experimental group, the study area was placed in a media viewing cubicle with no windows. On occasion the students were offered fruit or fruit punch. In their weekly routine they also had other enrichment opportunities provided by the school such as: concerts put on by visiting groups, their chance to join in ensemble music and drama groups and a variety of extra-curricular offerings.

Suggestions for Future Research

A larger sample of the normal population of both urban and suburban schools should be used for testing. It would produce more accurate results. A pilot study should be done trying out the test questions asked in order to prevent the ceiling effect that occurred in category 4, CLOS. More time should be allotted to both the experimental and control groups. More background material should be made available on each student.

The goal of this project did not include determining whether any of the students in the experimental group showed signs of talent in their compositions. A panel of qualified judges in some future research study might be a way to determine those students who might enjoy and benefit from more concentrated study in music.

It would be interesting to test more grade levels in both elementary and junior and senior high schools. More studies exploring the possibilities of creativity with students at this and older age levels would lend credence to the implications of this study that giving students an opportunity to be creative musically with microcomputers motivates learning of music fundamentals and in turn increases their aptitude in singing and playing instruments.

Conclusions

Earlier in the article by Webster (1987), he had collected a number of similar viewpoints about creating music from philosophers (Whitehead, Dewey, Maritain) psychologists (Freud, Maslow and Koestler), and composers (Schoenberg, Stravinsky, Sessions, Copland, and Hindemith). Some of the revealing information follows:

> "1. Some relationship exists between creativity and cognitive intelligence, and definite groups of cognitive abilities are involved in creative thinking.
> 2. Factors guiding the creative process spring largely from rational choice under the guidance of a pervading creative idea rather than from some form of inspiration.
> 3. The form of the final creative expression is communicable in a material result.
> 4. Stages of creative process are characterized by the recognition of the problem, accumulation of facts and materials, and the development of the problem through manipulation.
> 5. In terms of mental activity during creation, the process is an interaction between conscious and nonconscious states."

Item number 4 is a restatement of the first three stages of modes of thought -- preparatory, incubation, illumination -- and may also run parallel to the cognitive, associative and autonomous stages as outlined by Anderson (p. 222, 1980).

One of the by-products of doing research projects such as this, is in exposing more people to the fact that there is some excellent music software available now. The Wenger Corporation and Electronic Courseware Systems are leaders in software and courseware in the field of music, (see Appendix 3). Much of what they offer provides an excellent way of learning more about music. These include sight-reading, recognizing intervals (ear-training), taking rhythmic, melodic and harmonic dictation, composing music, orchestrating, learning fingering, phrasing and articulation for different instruments, and analyzing chord structures and forms of music. Actually there are many more applications, but those listed are among the most popular applications. References in the Appendix section include the addresses of leaders in the field of music software where you may write for a software catalogue.

This project has confirmed the author's early enthusiasm and conviction that teachers and students alike who have not been exposed to the music software available, would be genuinely surprised to know of the vast potential offered by a computer learning environment in music. It is strongly recommended that any classroom teacher who is involved in music in any way make good quality music software, comparable to the Music Construction Set, available to their students.

It is much more effective when a certain amount of time, weekly, is required. It is conceivable that this may be workable only at the college level because of the hardware requirements discussed earlier in Chapter II, CAI/Music. The intent of a study by Humphries (1980) was to determine if there was an optimum amount of time spent in computer-assisted drill that would result in maximum achievement; his study showed that three 25 minute sessions weekly produced the best results. That in itself underscores the importance of it as an enrichment tool. To music specialists, it is recommended that creative music software and courseware be examined, and included in the curriculum at the earliest possible opportunity.

With reference to the music curriculum summarized in Chapter I, p. 6-8, creating songs is suggested for Grades 1 through 6 where it includes musical plays, rhythmic accompaniments, introductions, interludes and original instrumental compositions, (Raebeck & Wheeler, 1974). It may be presumed that the teacher is writing the notes on manuscript paper. However, the ideal process would be to have a class put them on disk with several students assigned to selecting the notes and rhythmic patterns on music software and listening to make sure they are musically accurate.

Using both declarative (the facts we know) and procedural knowledge (the skills we know how to perform), the student is invited to move through the three steps in skill learning, i.e. the cognitive stage, the associative stage, and the autonomous stage. The expectation is that in this manner a deeper level of learning can take place. It is also more fun and requires imagination.

A new stimulus for creativity, the microcomputer, serves as a databank for learning specifically with music software for writing a composition. This is a step in a different direction from CAI using a largely drill-and-practice mode. The students in this study enjoyed working to complete the various tasks and felt rewarded by the product of their creativity.

The study revealed that in 3 categories out of 4, the experimental group did better than the control group perhaps because of their ten individual sessions working on their melodies. This suggests that better learning can take place while the product is in process. The final product, music created by students, has a special magic of its own which provides a sense of real accomplishment both educationally and musically.

References

Chapter V

Webster, Peter. (1987). Conceptual bases for creative thinking. In J. C. Peery, I. W. Peery, & T. W. Draper, (Eds.). Music and child development. New York: Springer-Verlag. 158.

Anderson, John R. (1980). Cognitive skills. Cognitive Psychology and its implications. San Francisco: W. H. Freeman and Co. 8, 222.

Humphries, James A. (1980). The effects of computer-assisted drill time on achievement in musical interval identification. Journal of Computer-Based Instruction, 6#3, 91-98.

Raebeck, Lois & Wheeler, Lawrence. (1974). Music in the elementary school. New approaches to music in the elementary school. (3rd ed.) Dubuque, Iowa: William C. Brown

Glossary A

(Music)

Dynamics - the gradations of volume in music

Imitation - repetition by one voice of a phrase previously stated by another voice

Interval - the distance between two notes (A P8 is a Perfect octave, a M3 is a major 3rd, an m3 is a minor 3rd.)

Key signature - the sharps and flats written at the beginning of each staff to indicate the key of a composition.

Meter - the basic grouping of beats and accents found in each measure as indicated by the time signature.

Rondo form - a form in which one section intermittently recurs. A frequent patterns is ABACA, A being the recurring theme and B and C the contrasting episodes.

Binary and ternary forms - forms in two or three sections such as AB or ABA.

Glossary B

(Computer terms)

light pen - an electrical device that resembles a pen and can be used to write or sketch on the screen

buffer - a temporary storage area in memory

terminal - an input/output perpheral device (keyboard of the computer)

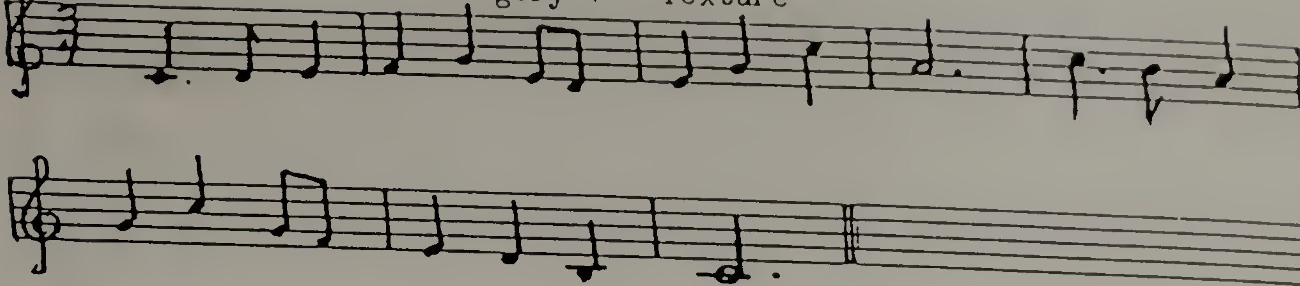
tutorial - instructional format

drill and practice- question and answer format

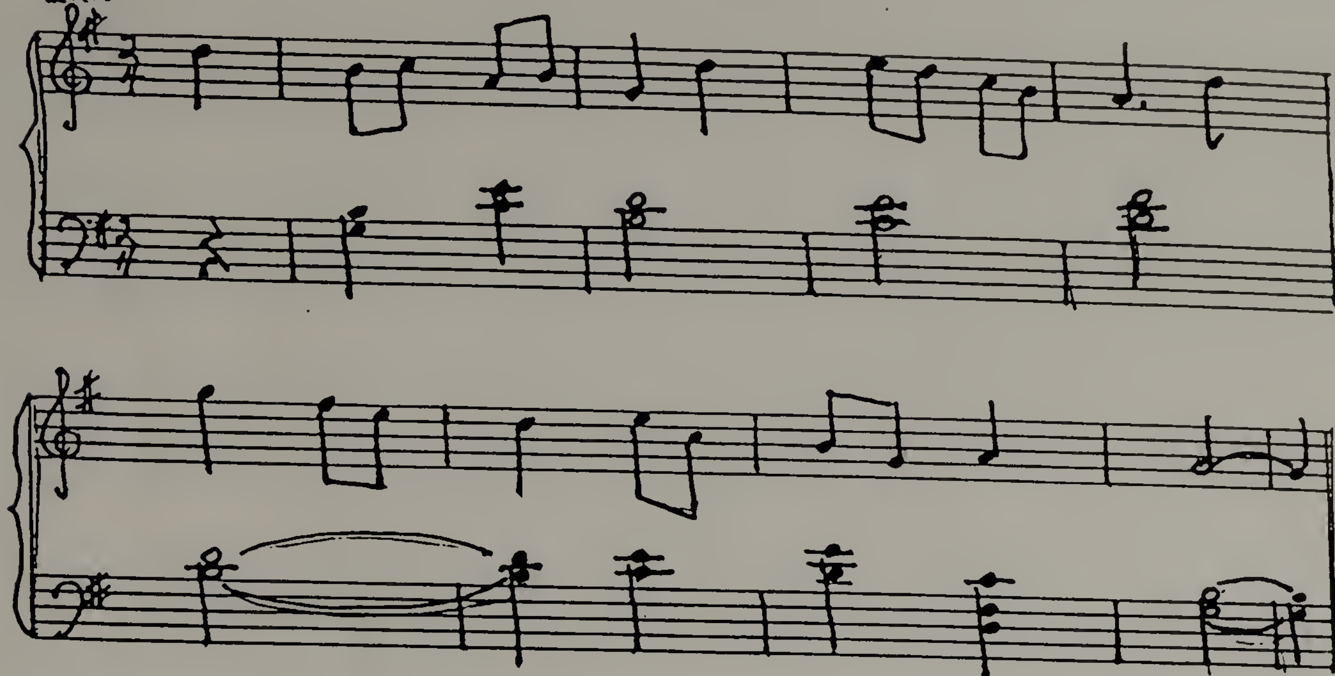
table-driven - gets its instructions from a previously specified list of instructions

Appendix 1
Category 1 - Texture

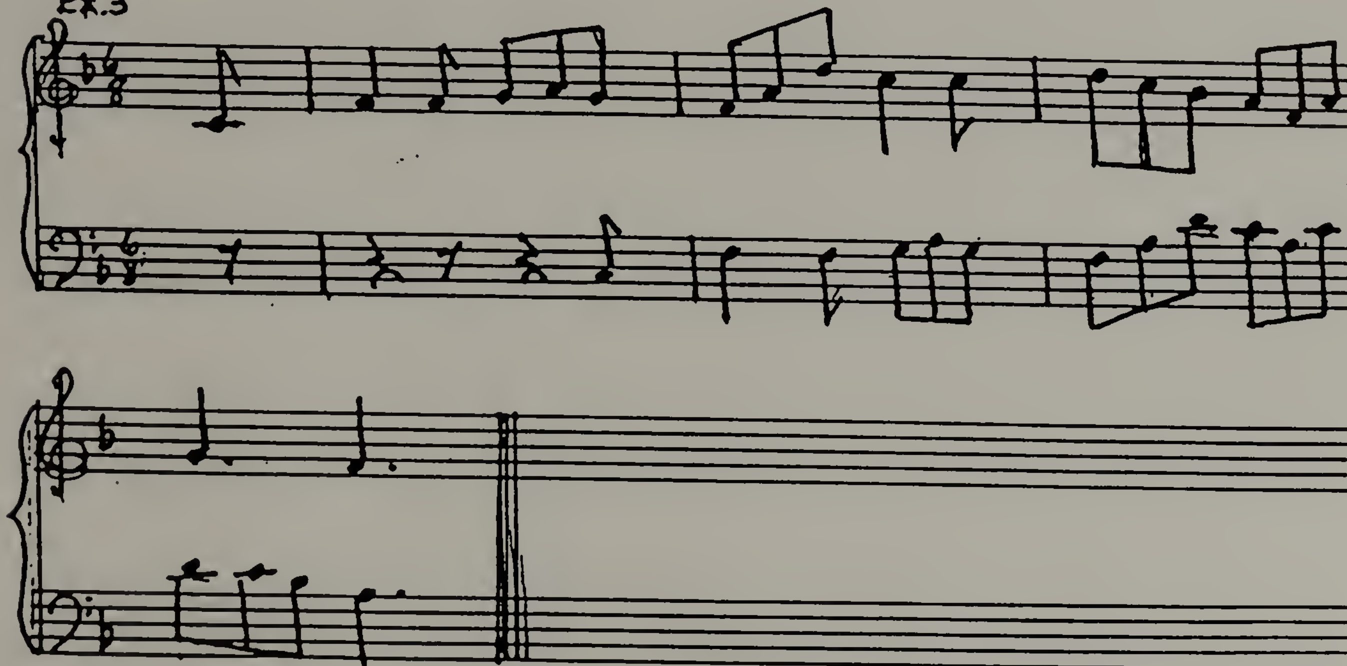
Ex.1



Ex.2

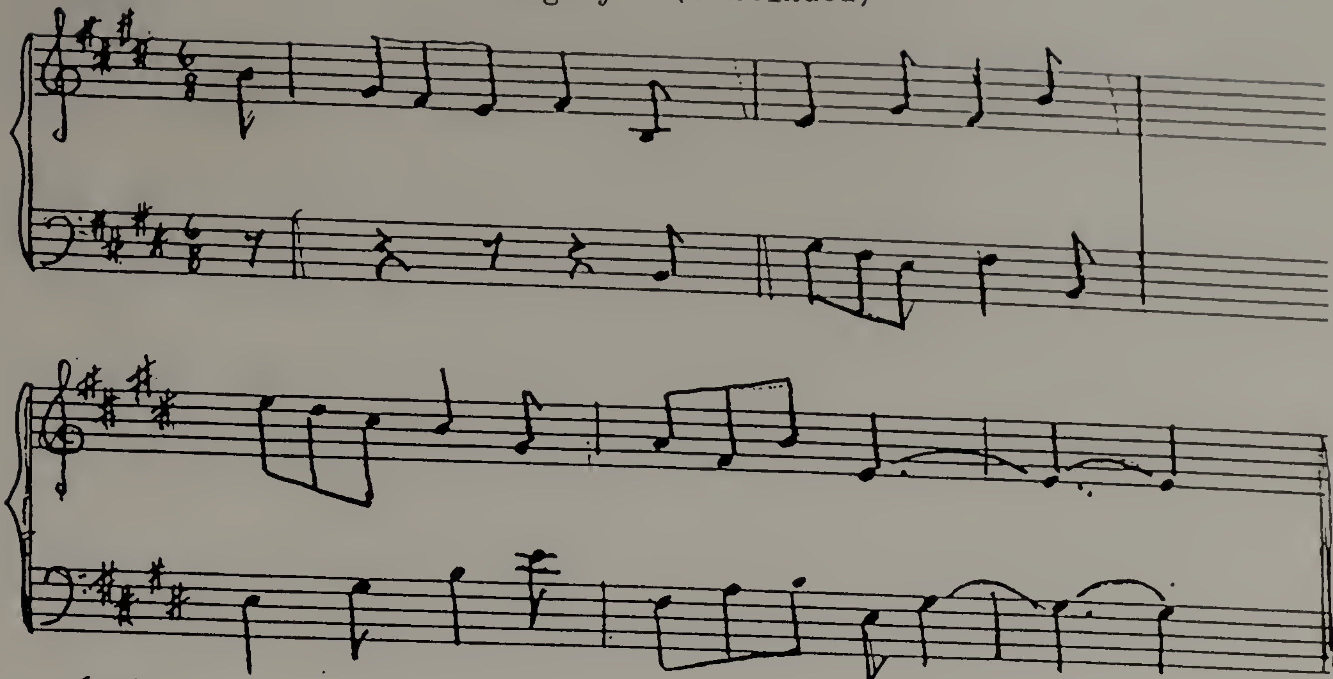


Ex.3

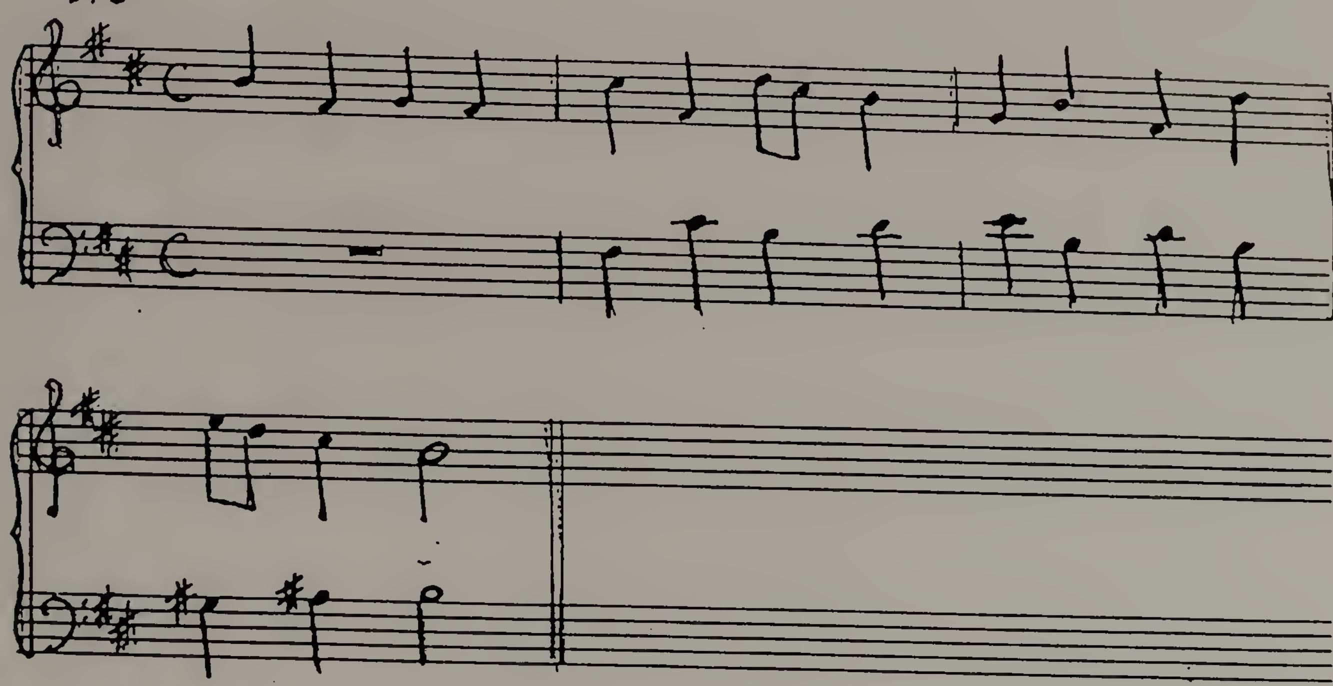


Ex. 4

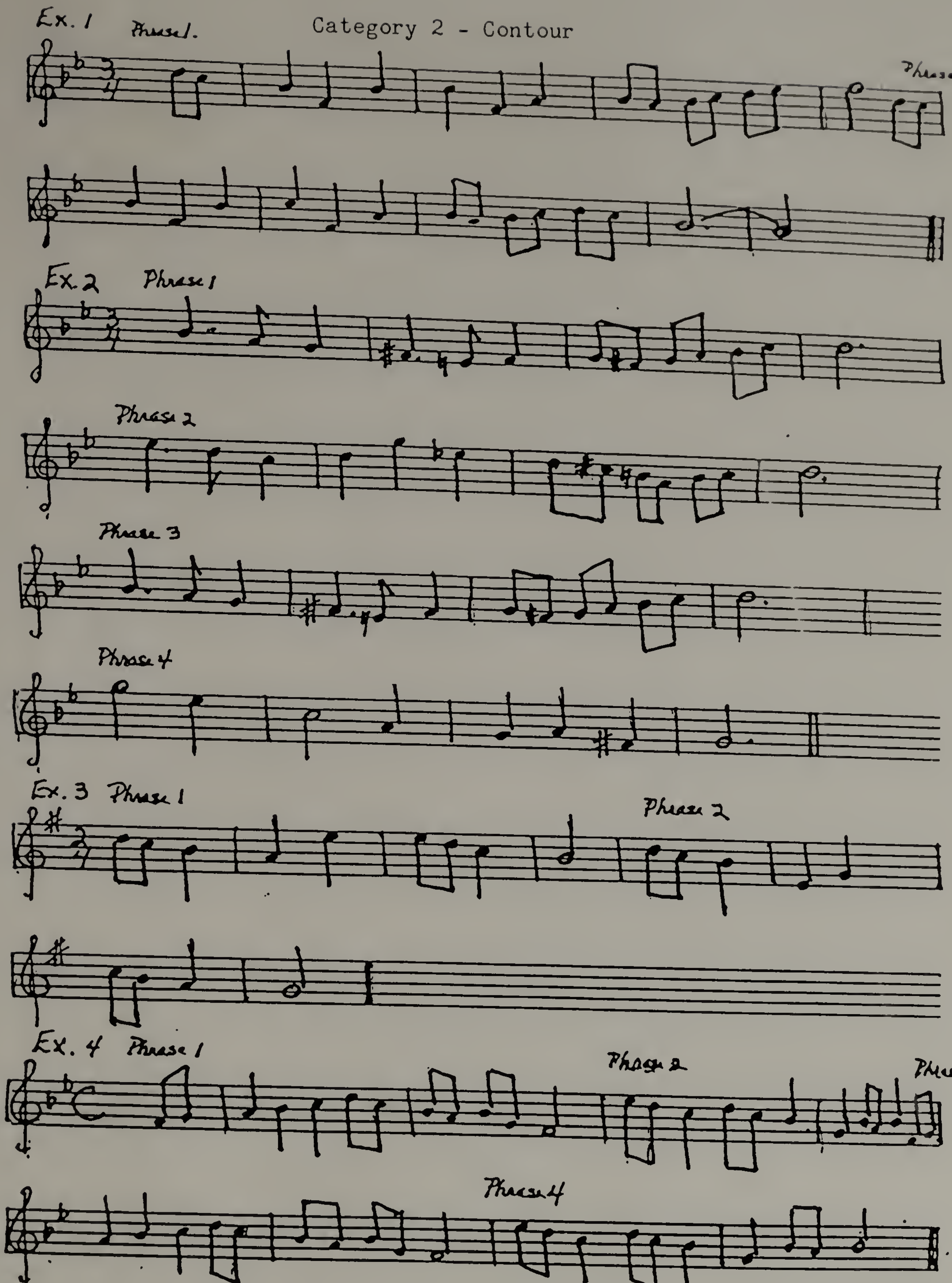
Category 1 (continued)



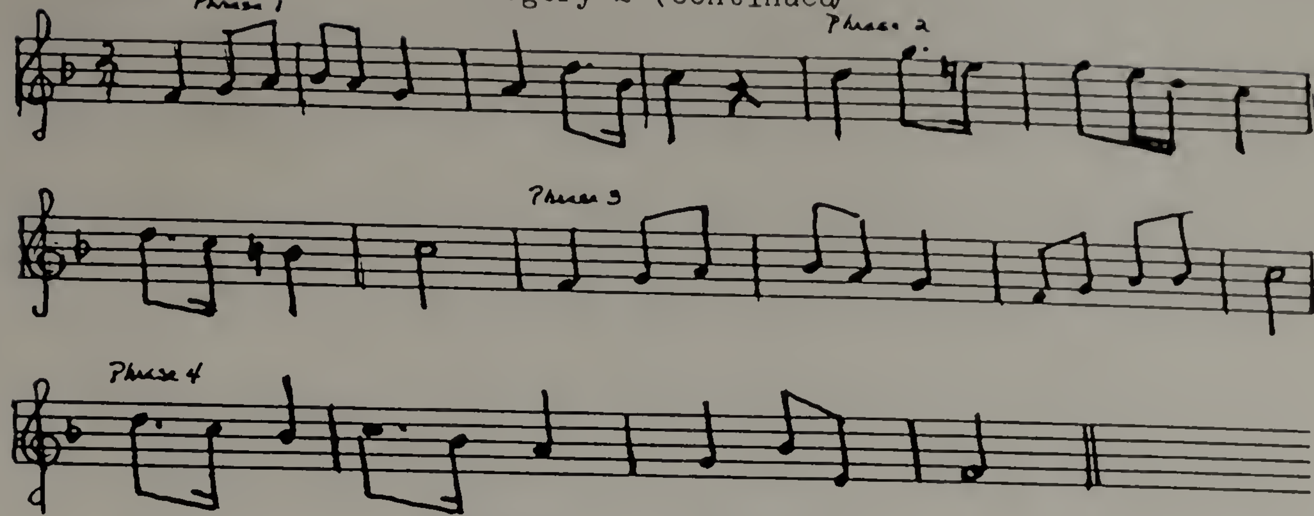
Ex 5



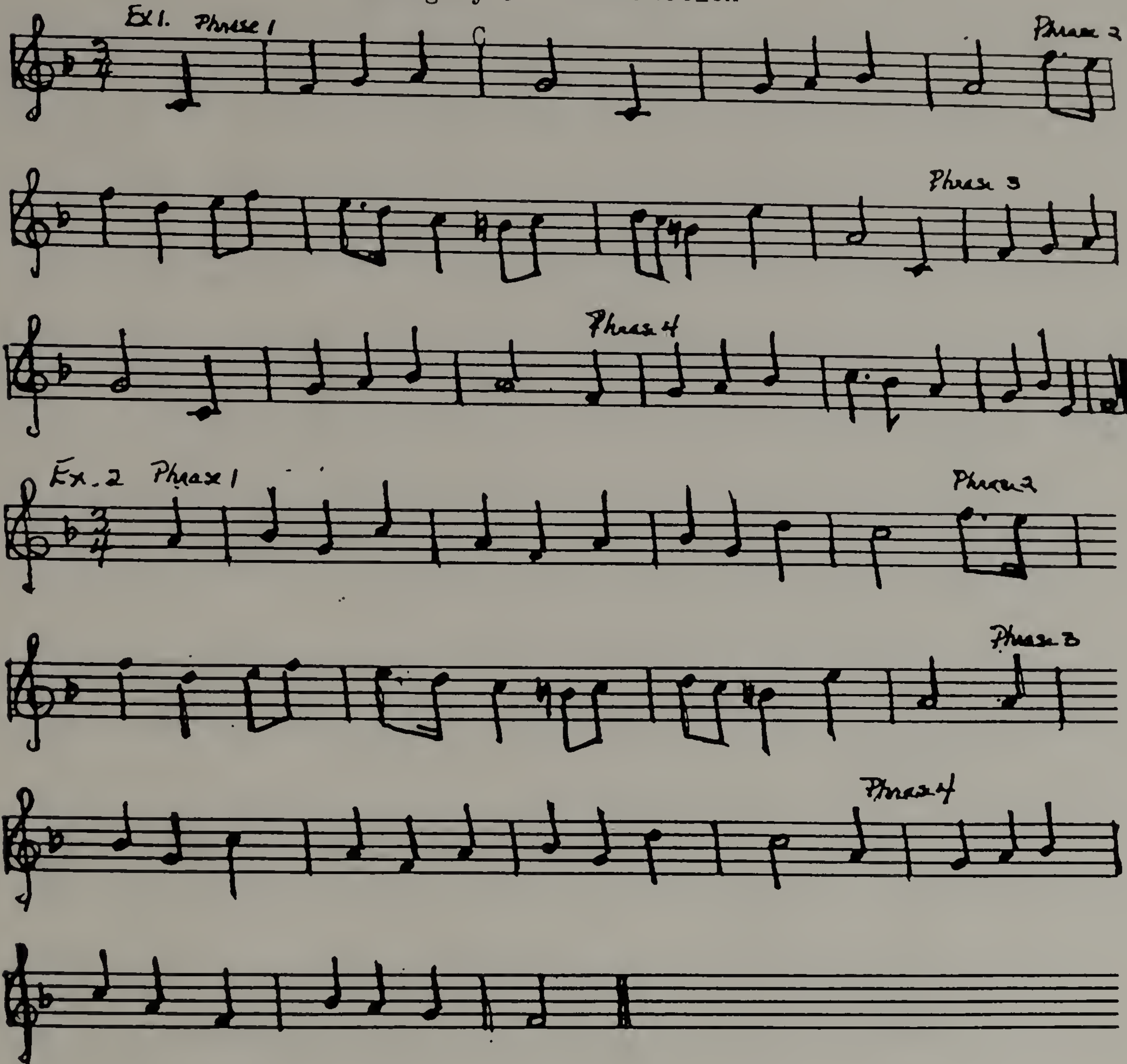
Category 2 - Contour



Ex. 5 Category 2 (continued)

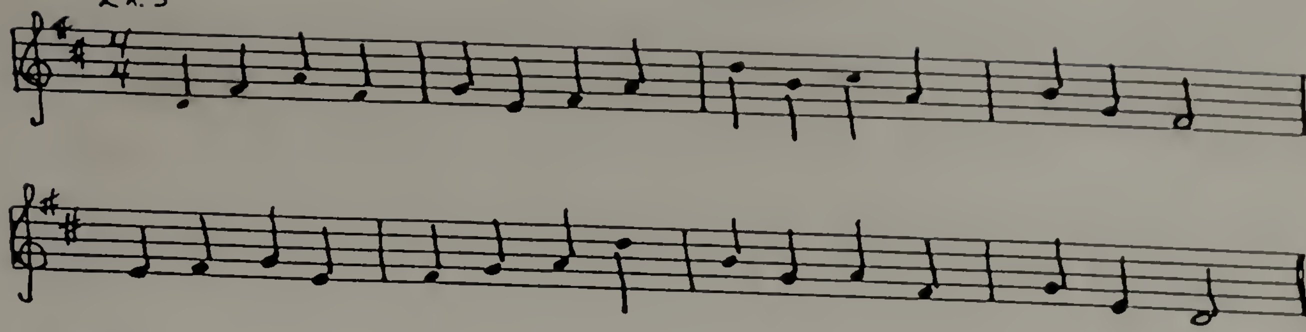


Category 3 - Abstraction

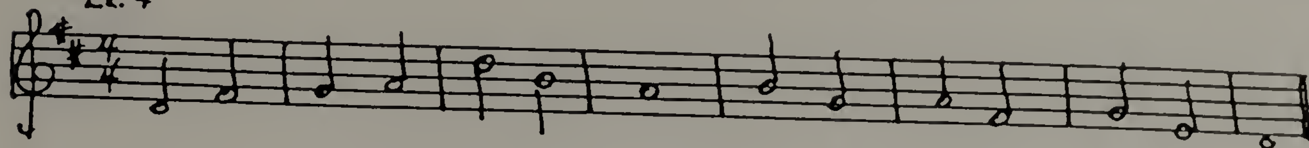


Category 3 (continued)

Ex. 3



Ex. 4



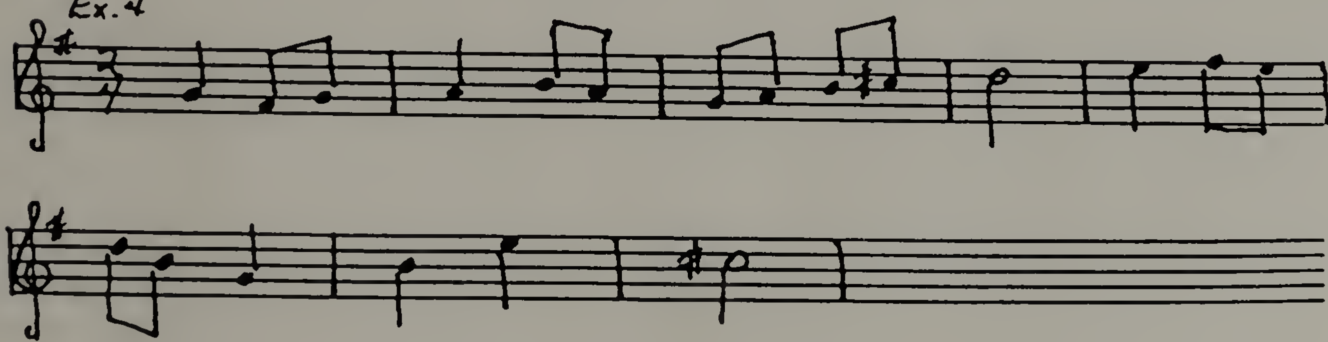
Category 4 - Closure

Ex. 1

Ex. 2

Ex. 3

Ex. 4



Appendix 2 - Students' Compositions

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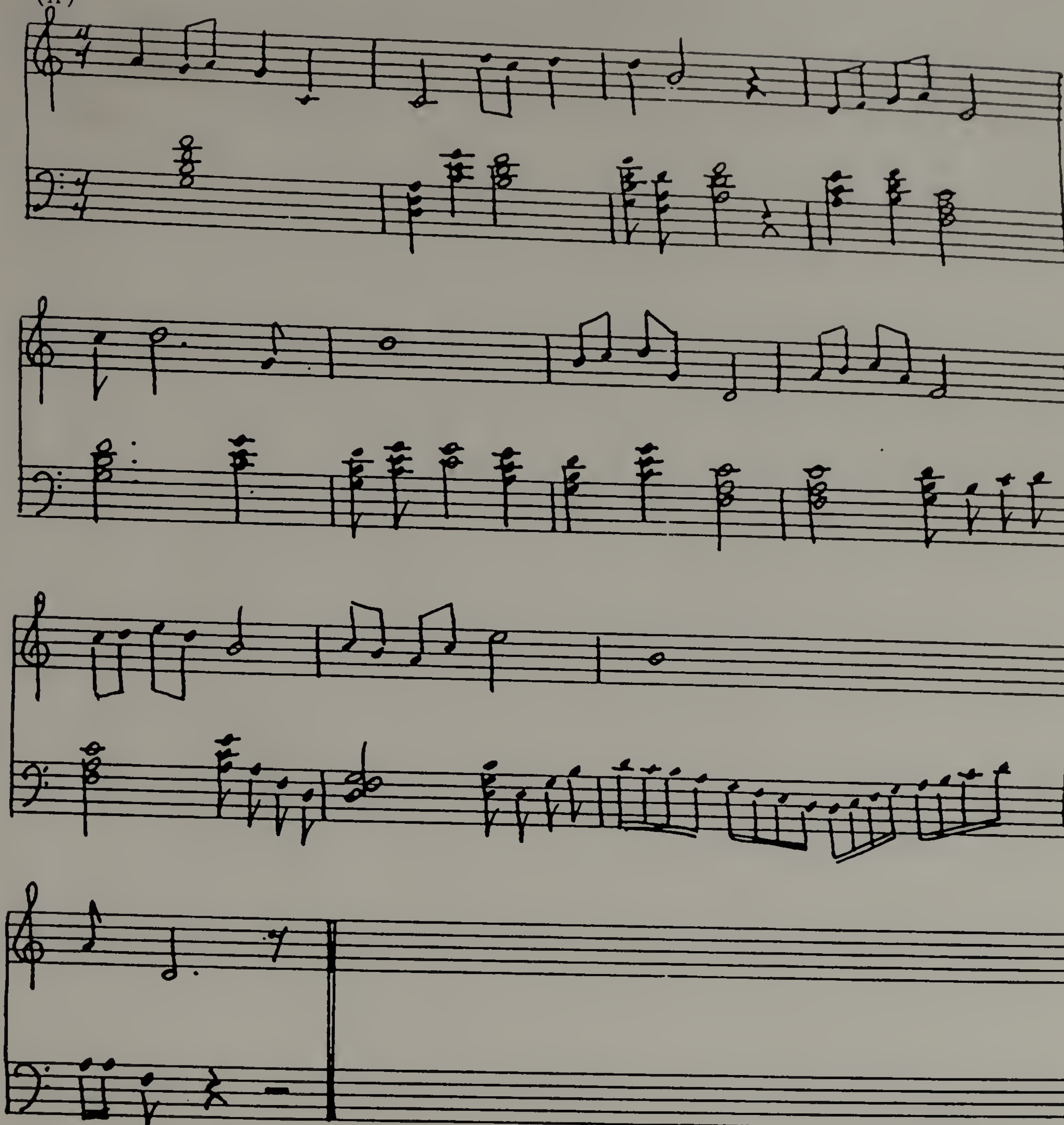

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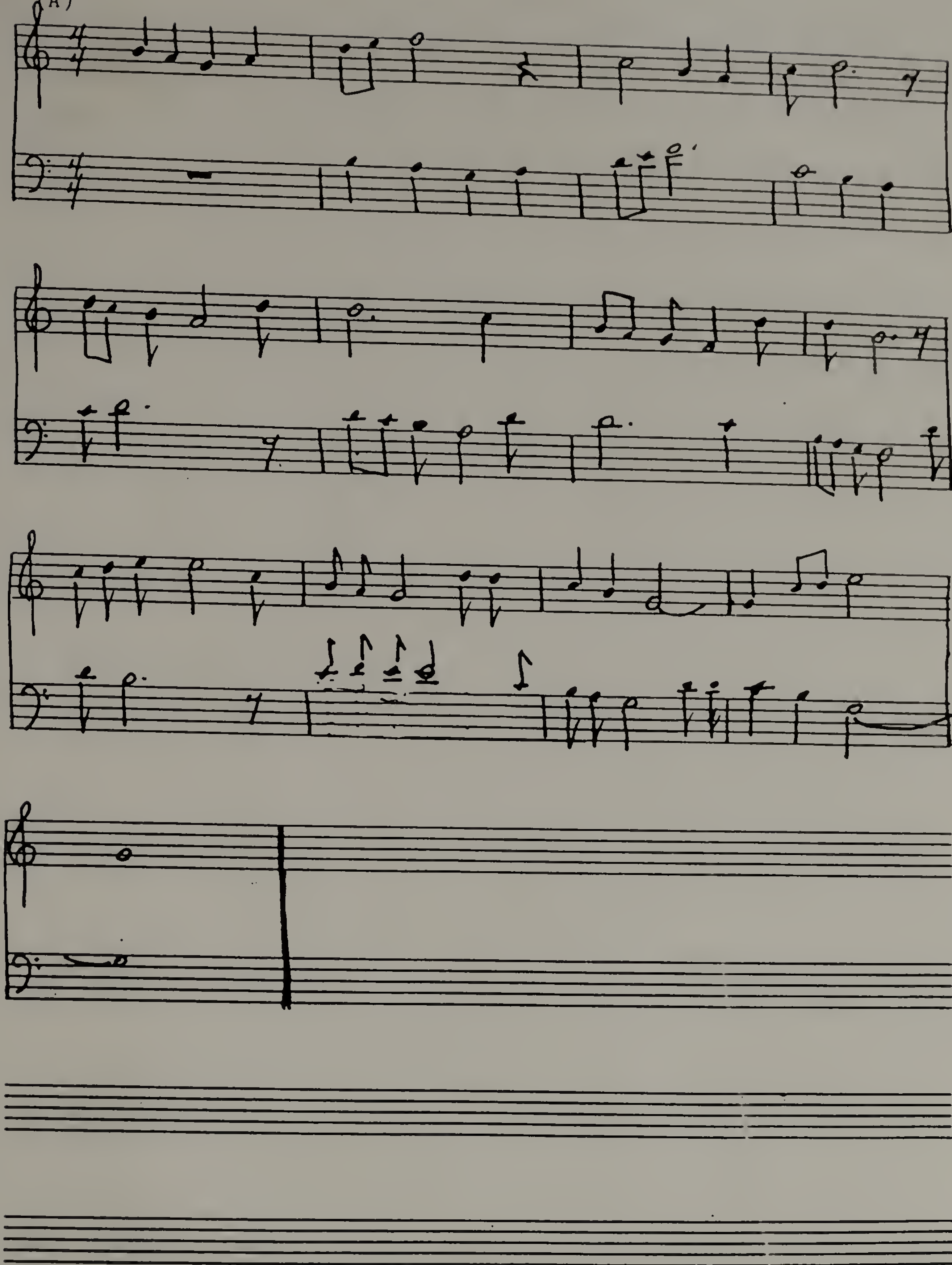
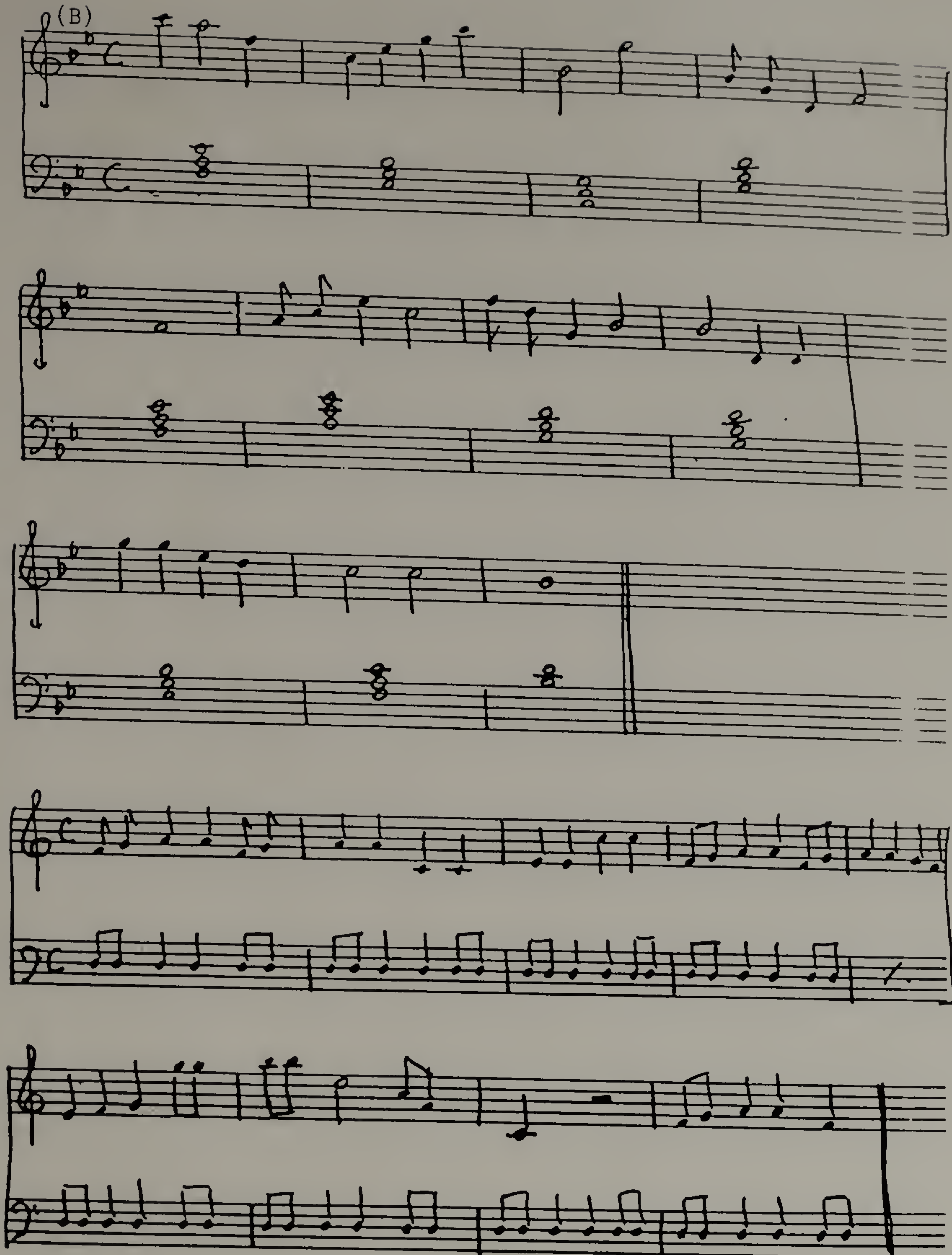
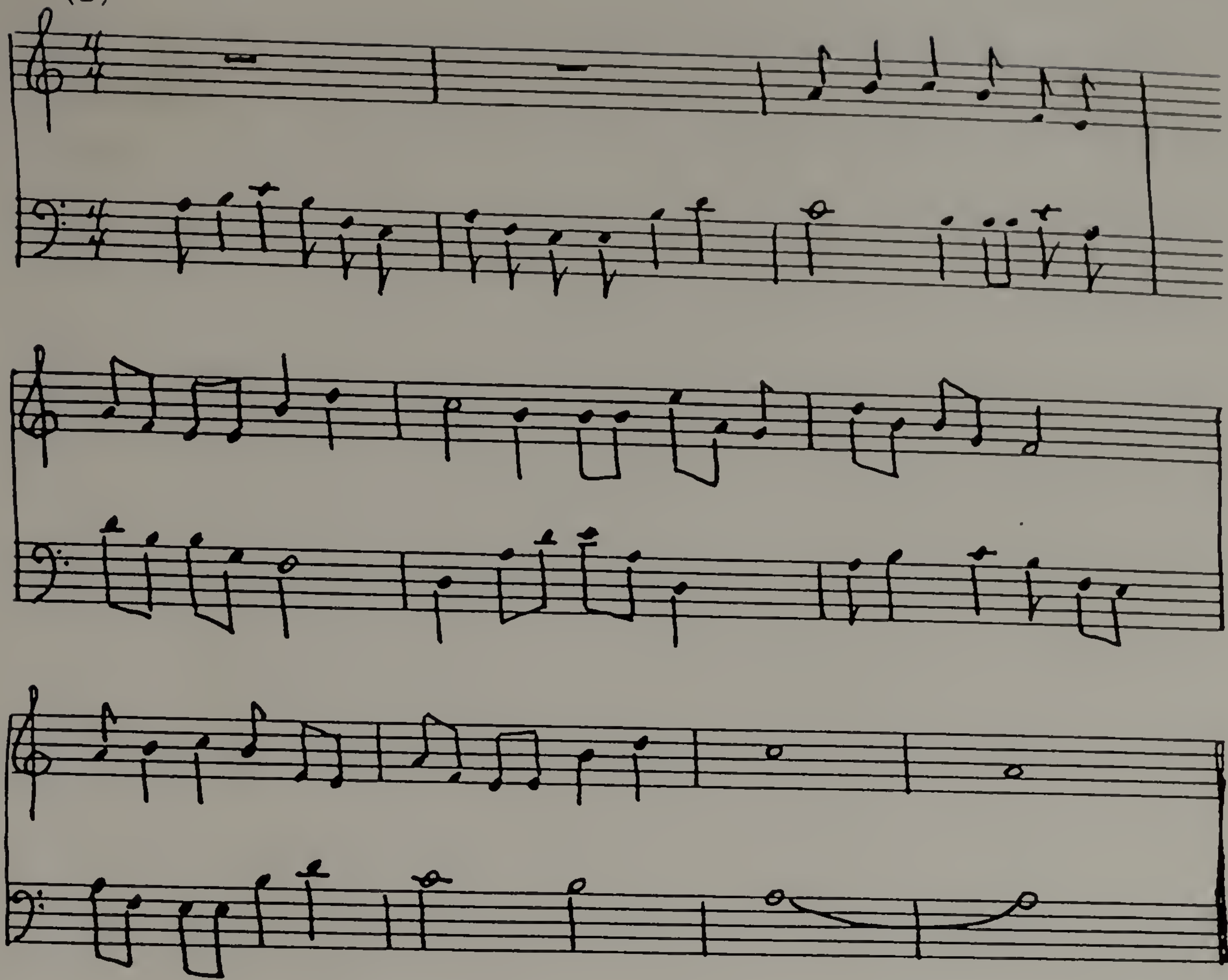
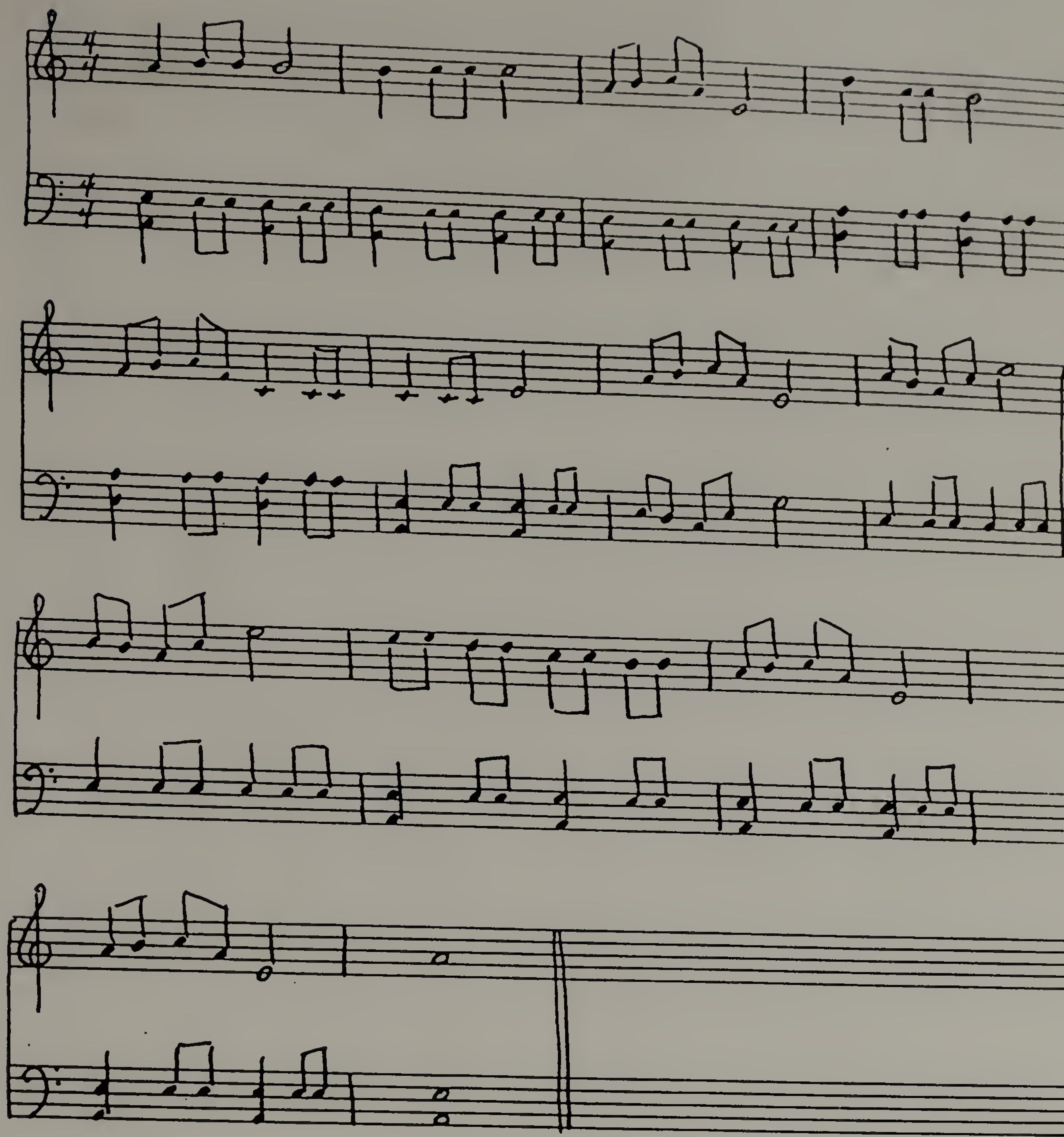



(B)

(B)



(C)



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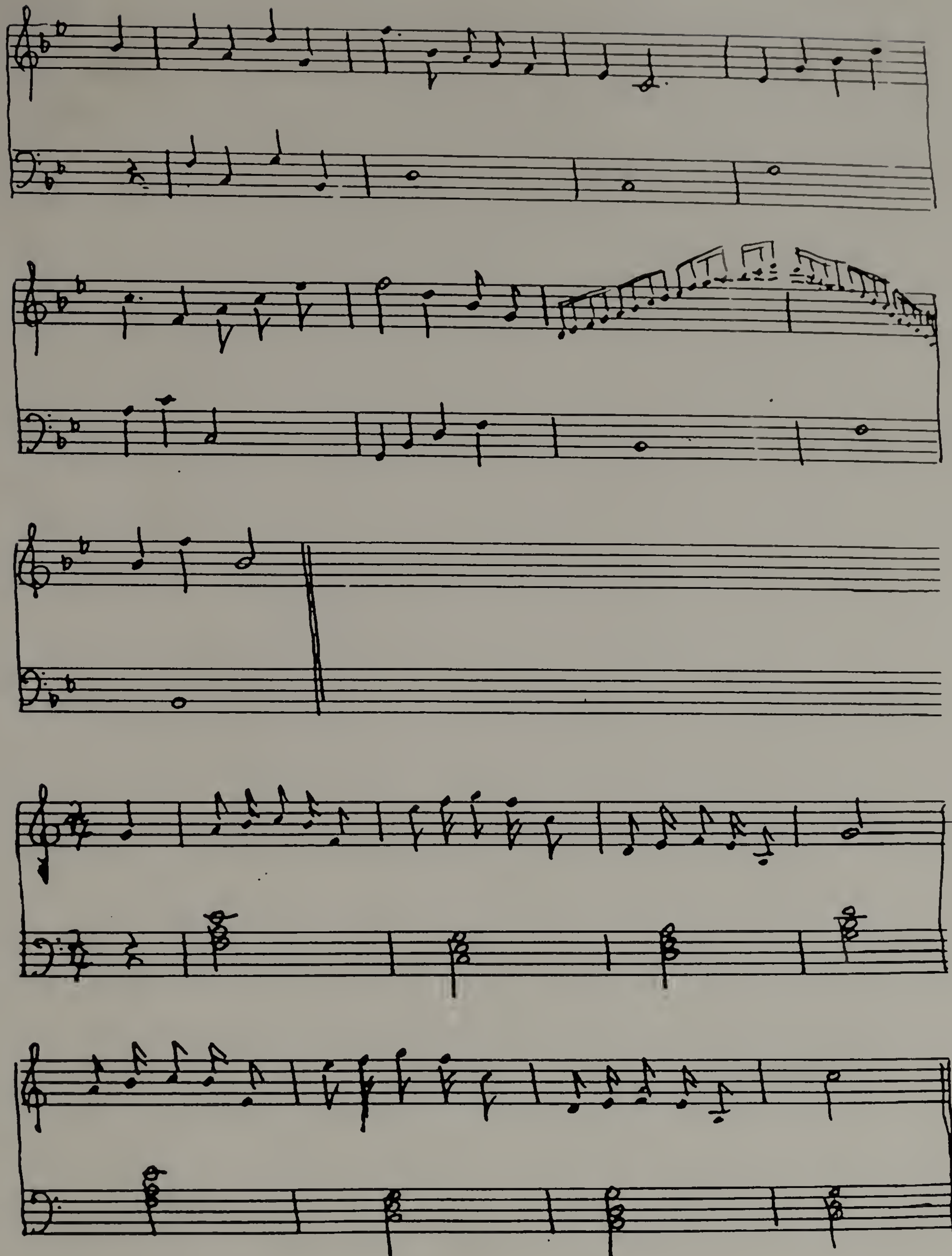
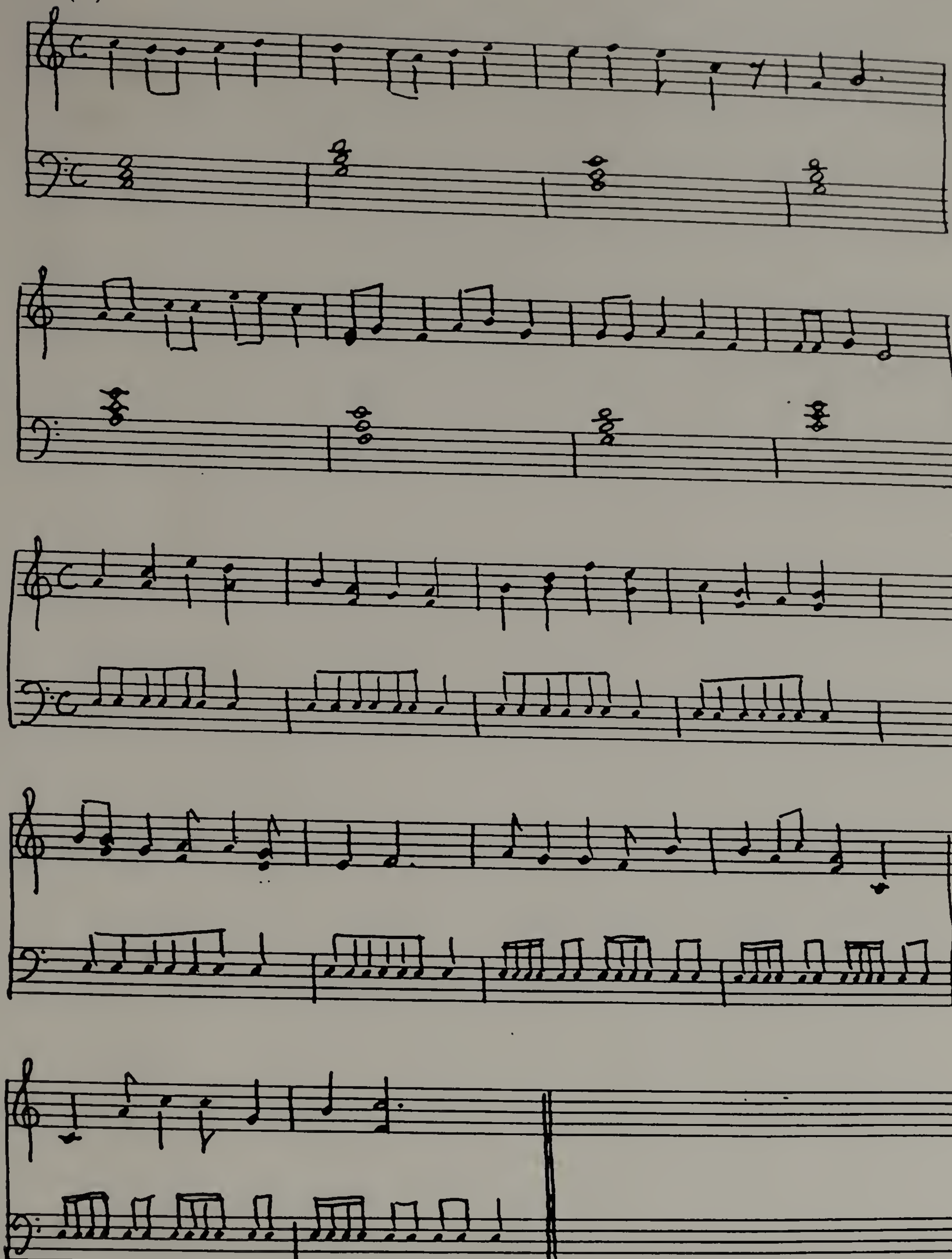


(E)



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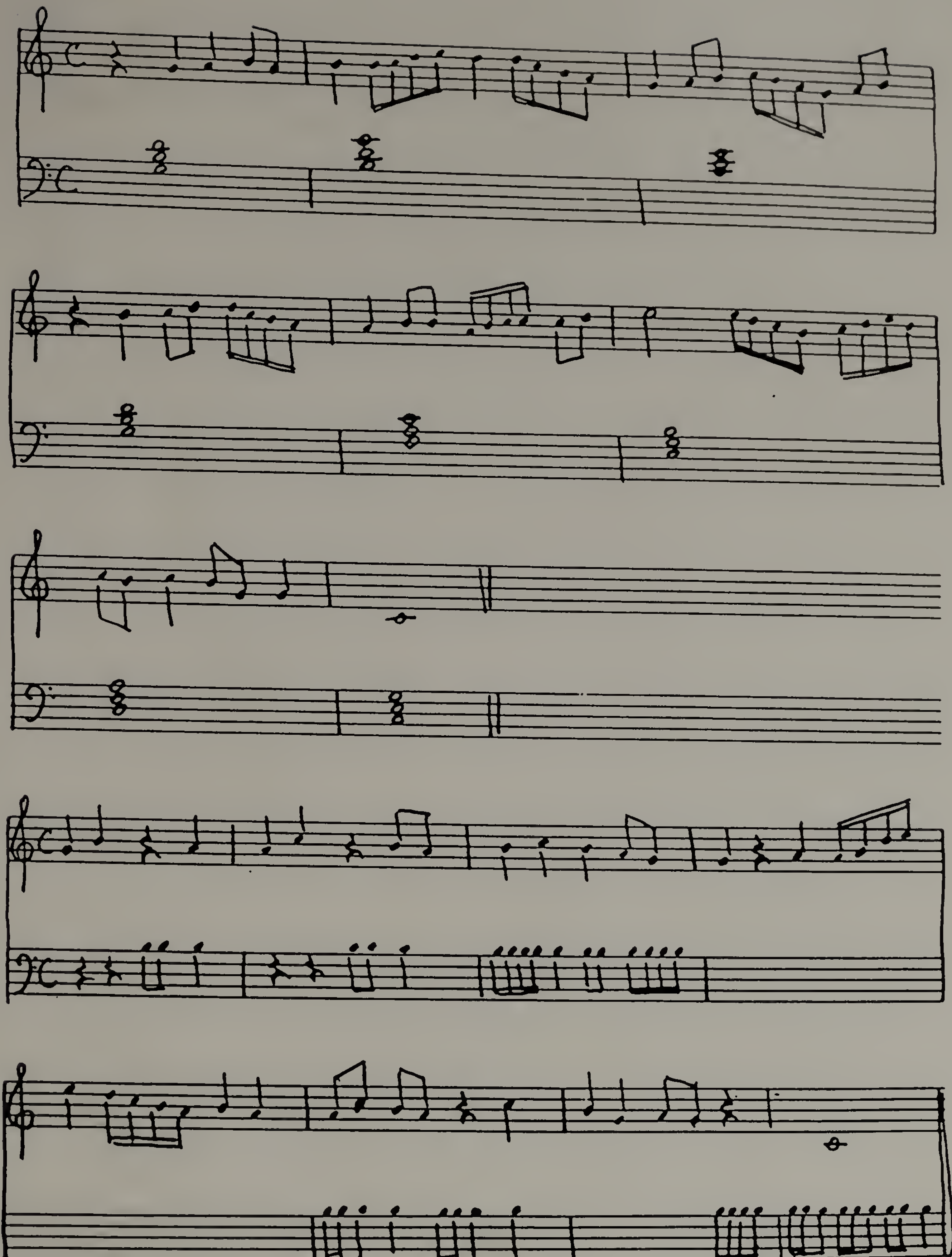
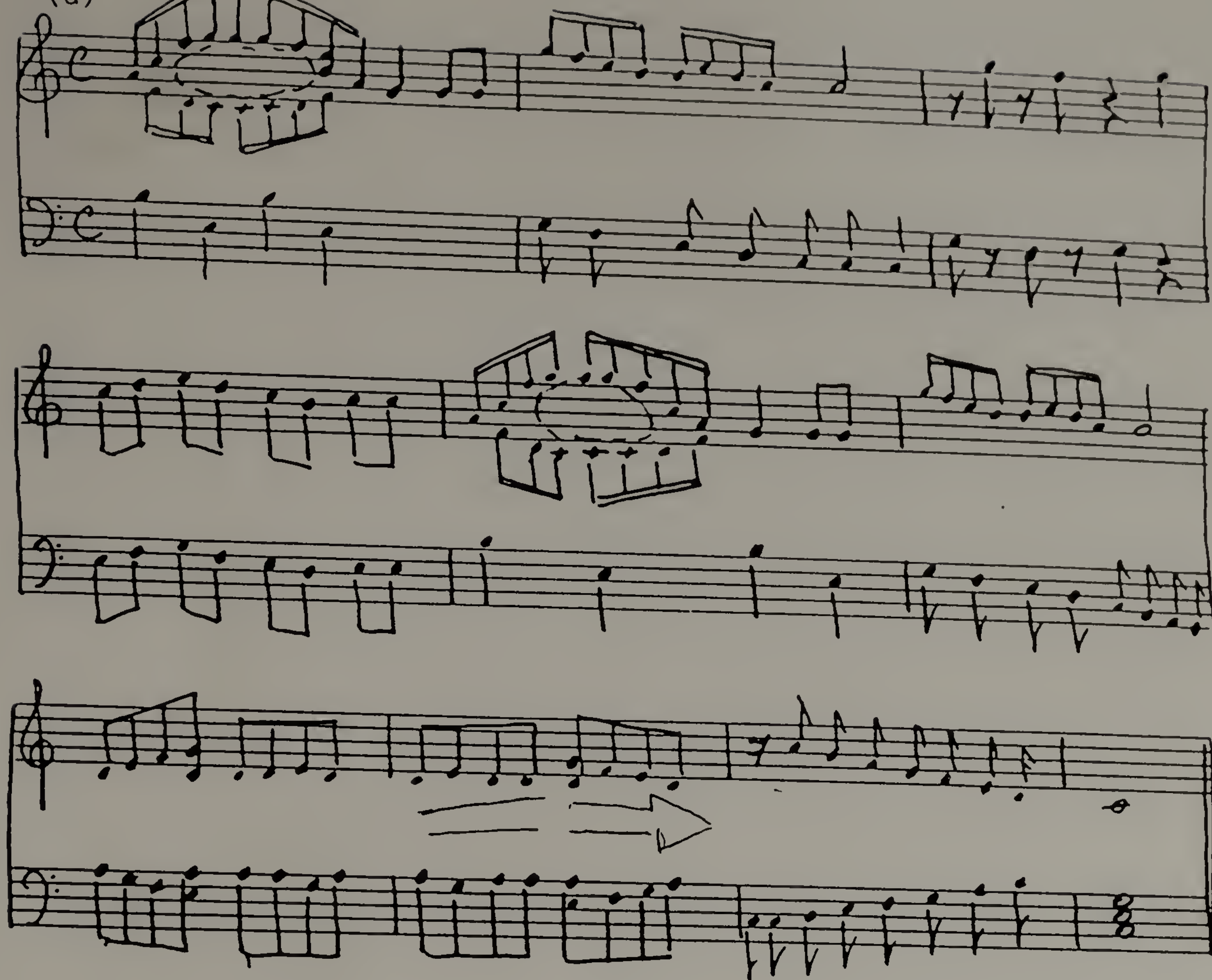
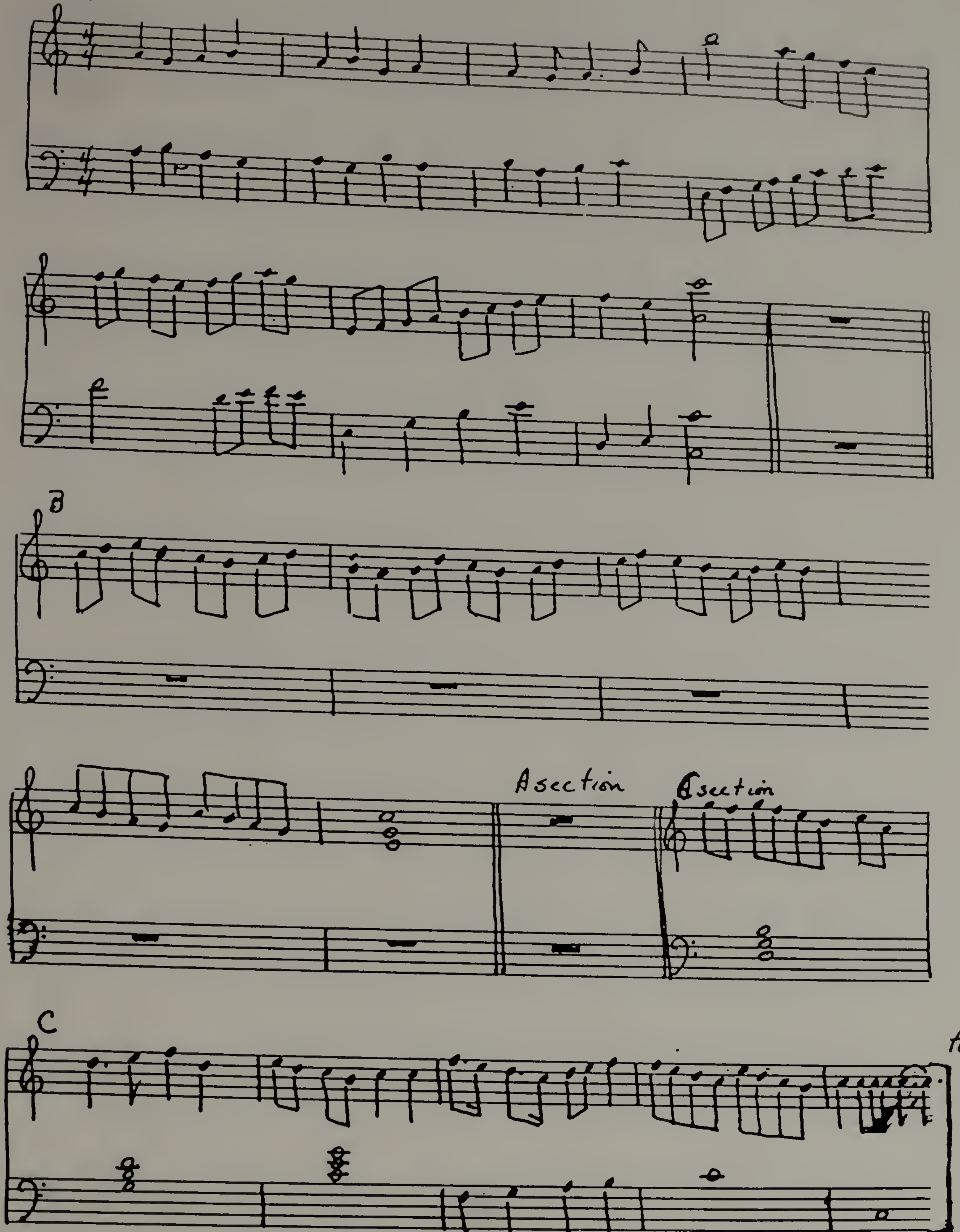


(G)

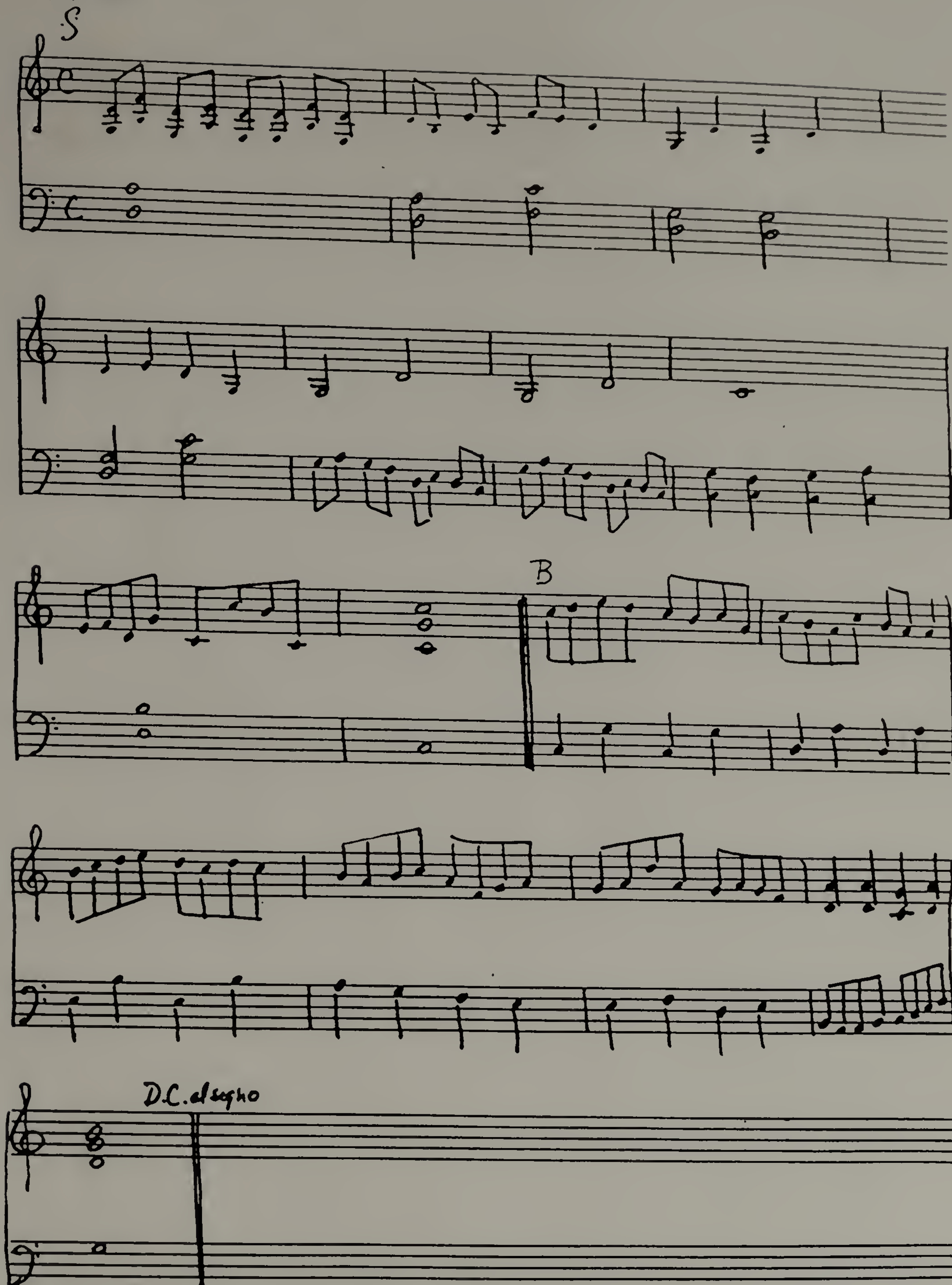


A Short Rondo

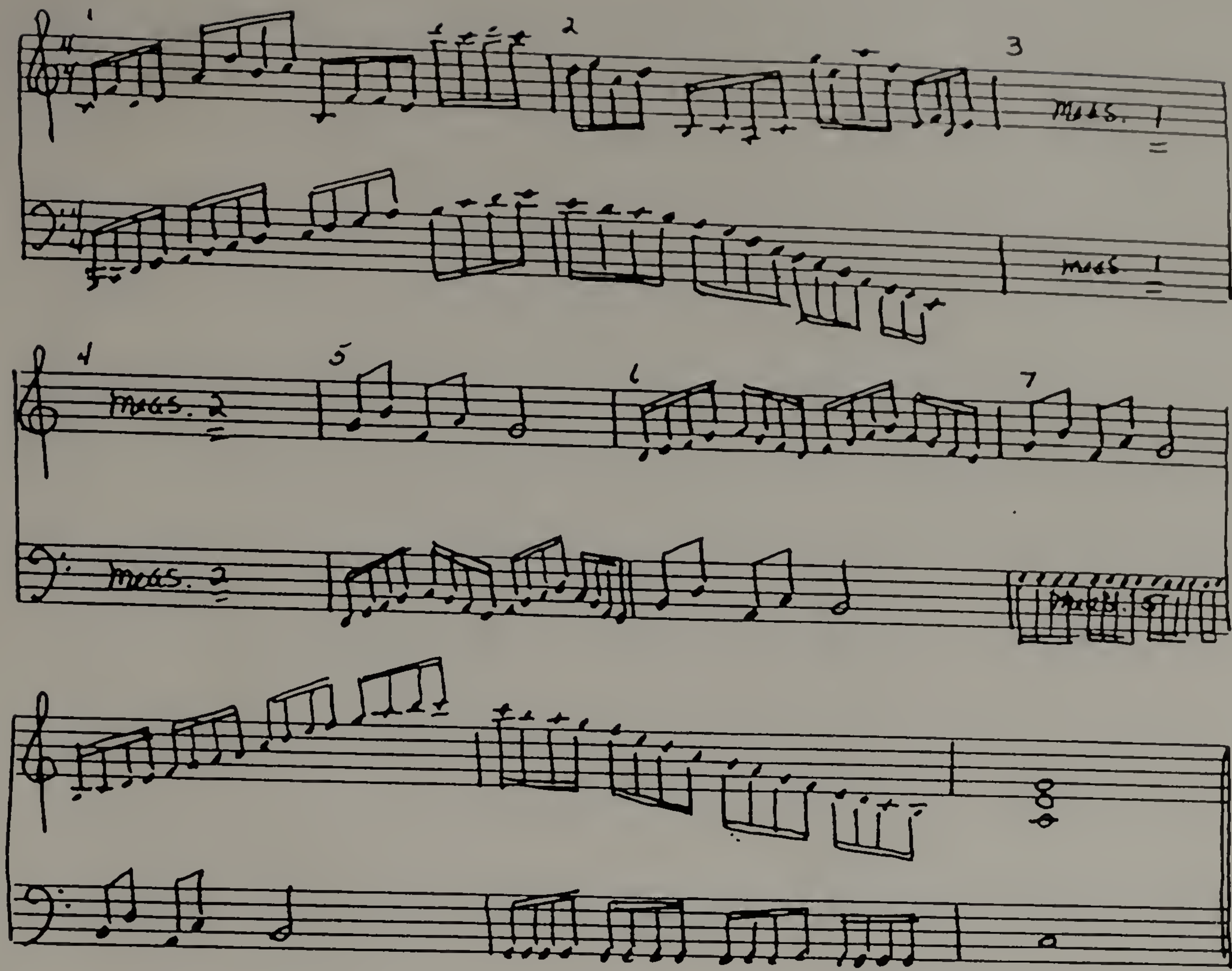
(G)



(G) ABA



(H)



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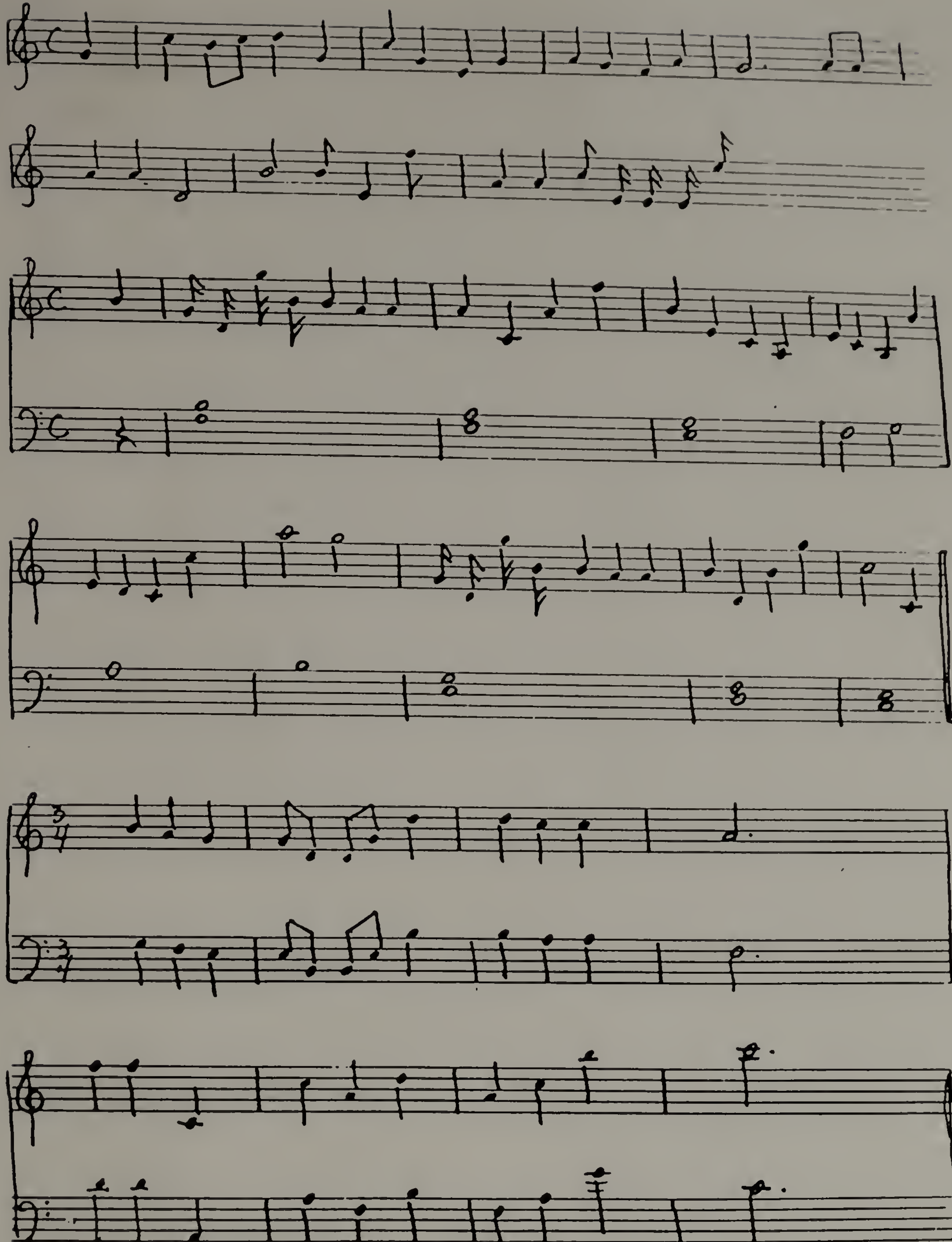

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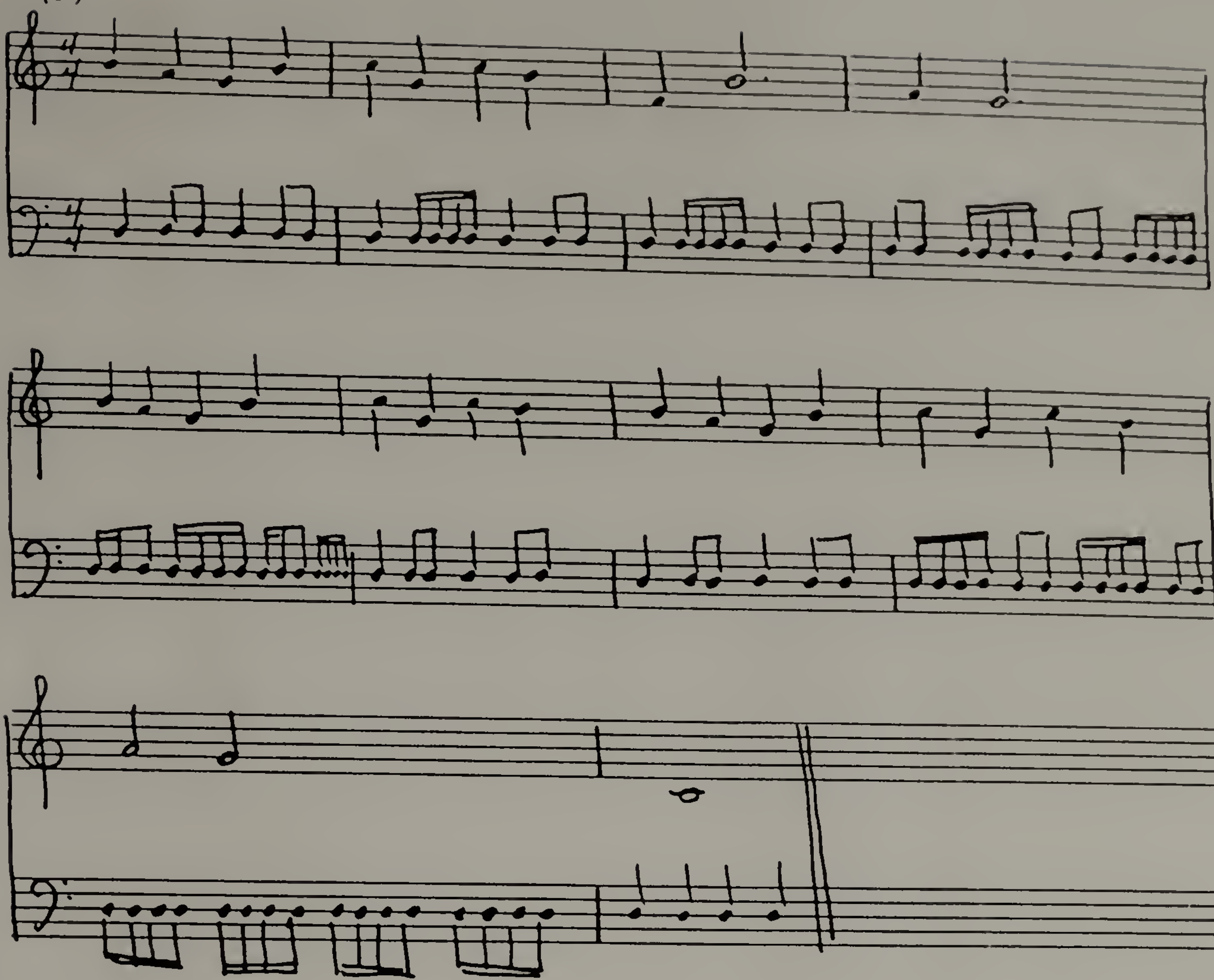

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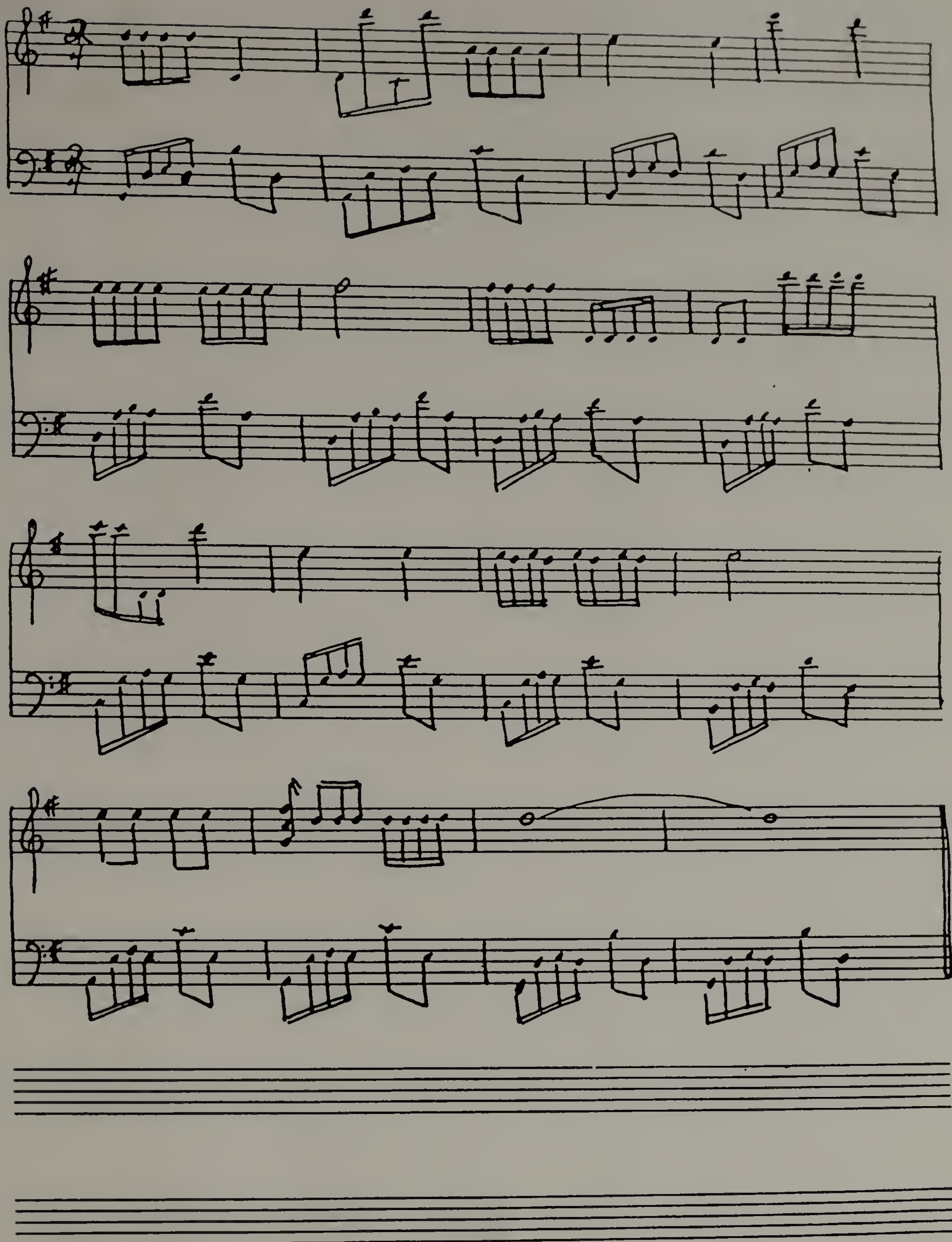

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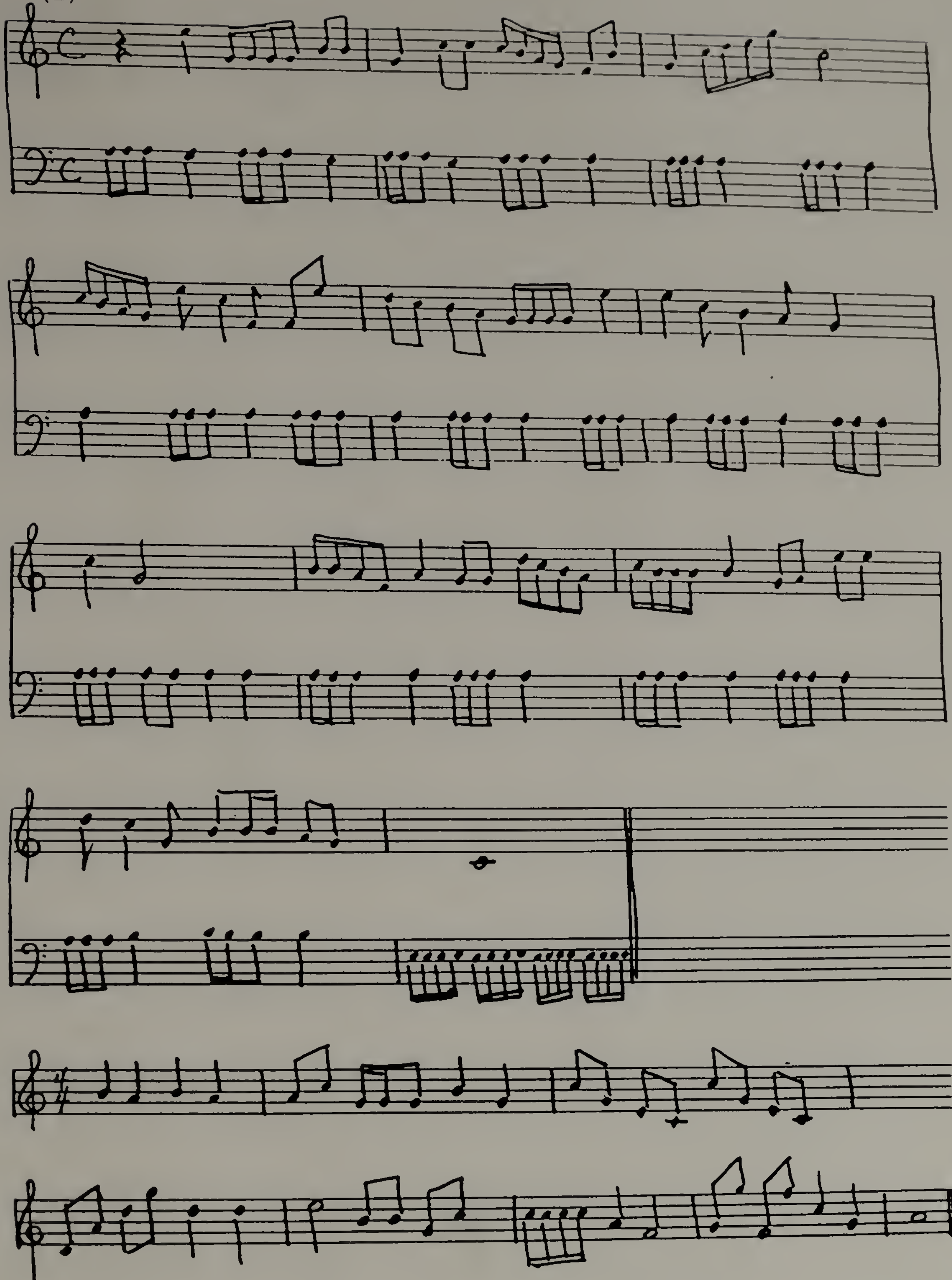

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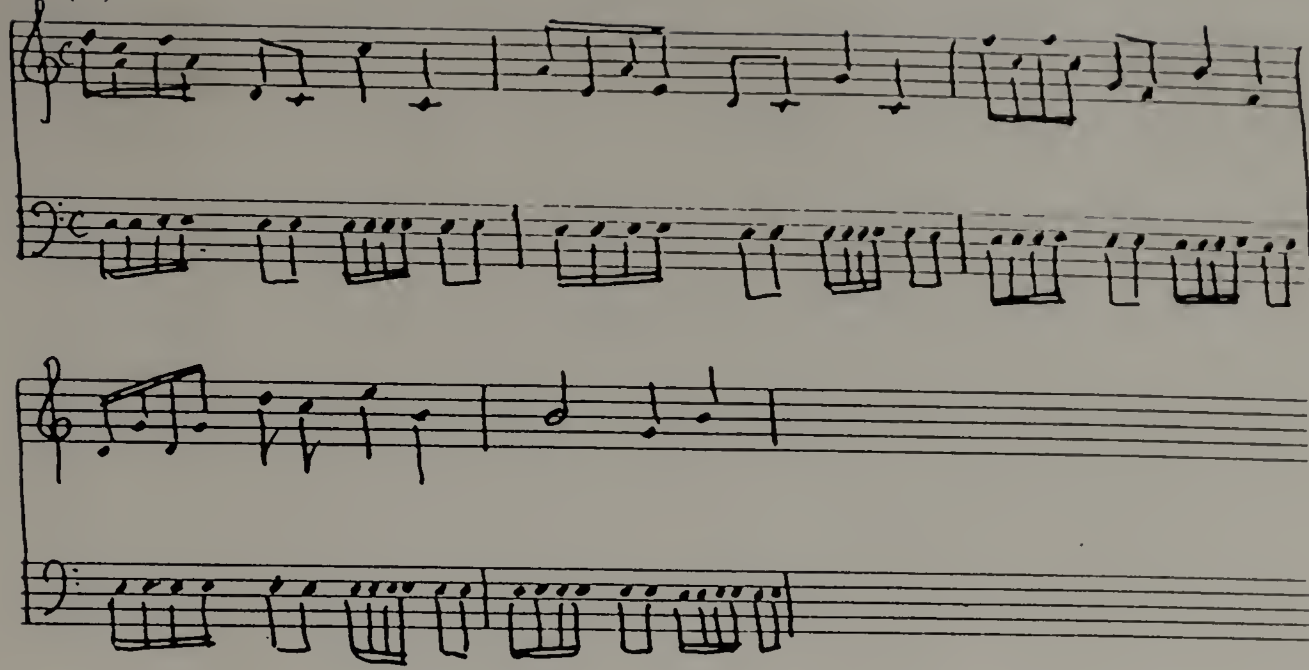
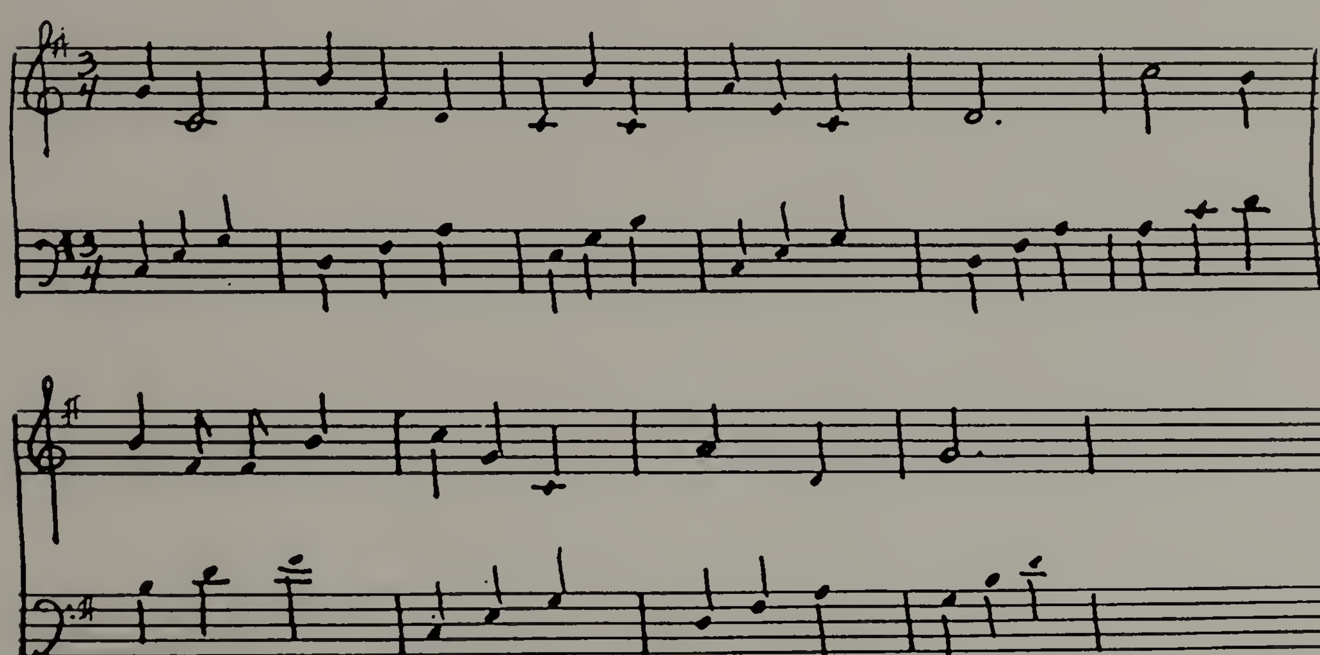
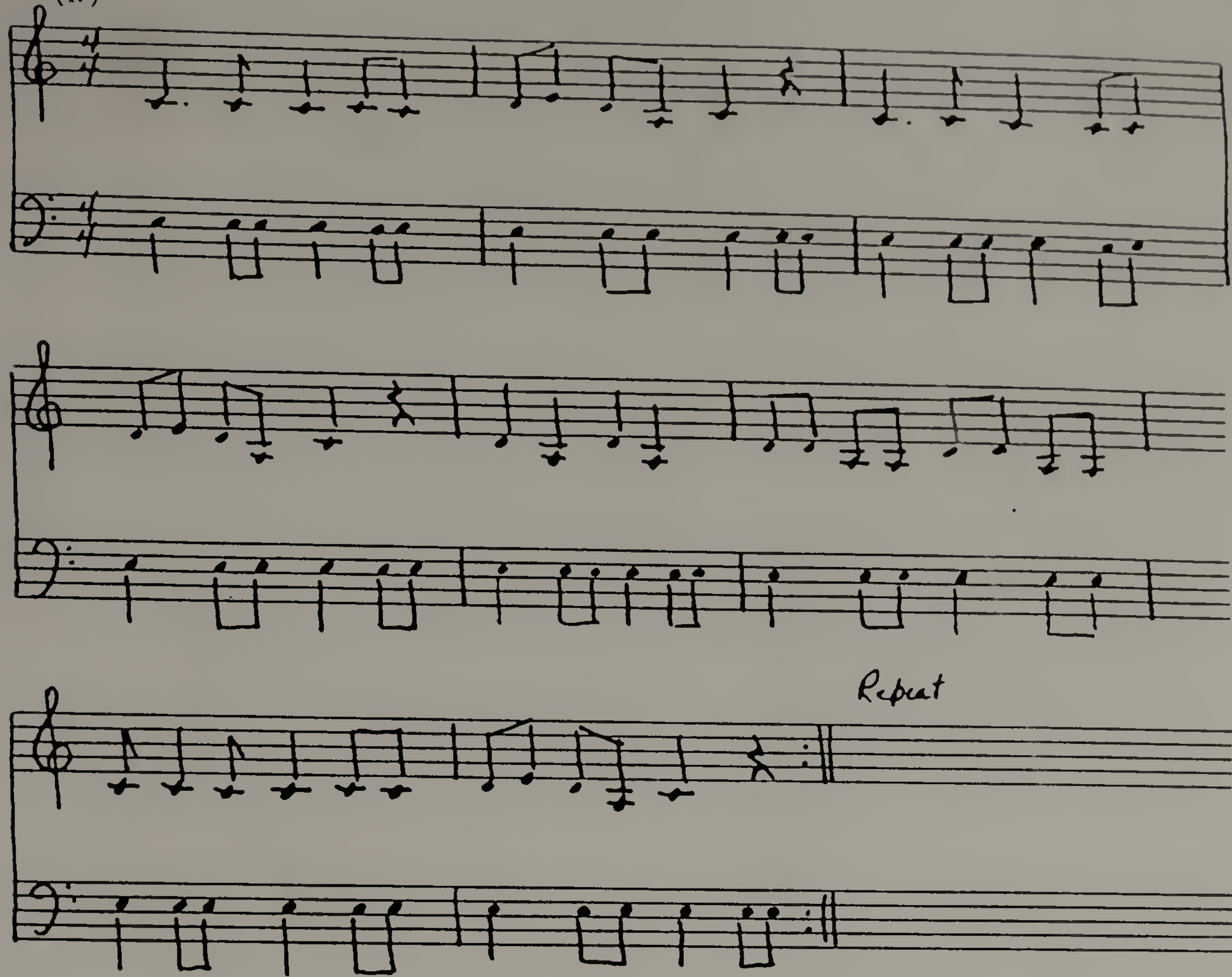




(N)



Appendix 3
Music Software Companies

Electronic Arts, Inc.
2755 Campus Drive
San Mateo, California 94403
(Apple II, Commodore, Atari)

Electronic Courseware Systems, Inc.
1210 Lancaster Drive
Champaign, Illinois 61821
(Apple II, Commodore 64 & 128,
Tandy 1000, 1200 & 3000,
IBM-PC & PC-Jr.)

Wenger Corp.
555 Park Drive
Owatonna, Minnesota 55060
(Apple, Commodore, Macintosh, IBM,
Atari, Amiga)

BIBLIOGRAPHY

Allvin, Raynold. (1984). Microcomputers in music instruction. College Music Society, Fall.

Allvin, Raynold. (1971). Computer-assisted music instruction: A look at the potential. Journal of Research in Music Education, 19 (2), 131-143.

Ames, R. G., & Carpino, S. (1977). The demand for instructional computing resources: 1976-1980. California State University and Colleges, California State University, Hayward, Calif.

Anderson, John R. (1980). Cognitive skills. Cognitive Psychology and its implications. San Francisco: W. H. Freeman and Co. 8, 222.

Arenson, Michael. (1982). The effect of a competency-based program on the learning of fundamental skills in a music theory course for non-majors. Journal of Computer-Based Instruction, 55-58.

Arenson, Michael A. (1978). An examination of computer-based educational hardware at 28 NCCBMI member schools. Journal of Computer-Based Instruction, 5 (1&2), 38-40.

Bales, Kenton. (1984), Computer-based music reading and performance assessment. College Music Society, Fall.

Bamberger, Jeanne. (1983). The computer as sandcastle Massachusetts Institute of Technology. April.

(1979). LOGO music projects: Experiments in musical perception and design (LOGO Memo 52). Massachusetts Institute of Technology, Artificial Intelligence Laboratory. May.

(1974). What's in a tune, (LOGO Memo 13). Massachusetts Institute of Technology, Artificial Laboratory. July.

(1974). The luxury of necessity (LOGO Memo 12). Massachusetts Institute of Technology, Artificial Intelligence Laboratory. May.

(1972). Developing a musical ear: A new experiment (LOGO Memo 6). Massachusetts Institute of Technology, Artificial Intelligence Laboratory. July.

BIBLIOGRAPHY

Burns, Barbara. (1986). The effects of computer experience on children's cognitive and social development. (Grant application to Department of Health and Human Services, Public Health Service,) abstract of research plan.

Carnegie Commission on Higher Education. (1977). The fourth revolution: Instructional technology in higher education. New York: McGraw-Hill.

Chambers, Jack A., & Sprecher, Jerry W. (1980). Computer-assisted instruction: Current trends and critical issues. Communications of the ACM, June. 23 (6), 332-342.

Deutsch, Diana. (1982). The processing of pitch combinations. The psychology of music. New York: Academic Press, 6, 278-281.

Diehl, Ned C. (1971). Computer-assisted instruction and instrumental music: Implications for teaching and research. Journal of Research in Music Education, Summer, 19, 299-306.

Diehl, Ned C., & Zeigler, Ray H. (1973). Evaluation of a CAI program in articulation, phrasing and rhythm for intermediate instrumentalists. Council for Research in Music Education, XXX, 1-11.

Eddins, John M. (1981). A brief history of computer-assisted instruction in music. College Music Society, Fall, 46-53.

Fiske, Harold E. (1984). Music cognition: Serial process or parallel process. Journal of Research in Music Education, 32 (1),Spring.

Foltz, Roger,& Gross, Dorothy. (1981). Ideas on implementation and evaluation of a music CAI project. College Music Symposium, Fall, 22-26.

Gardner, Howard, (1983). Music intelligence. Frames of mind: The theory of multiple intelligences. New York: Basic Books. 6, 99-127.

BIBLIOGRAPHY

Gardner, Howard, (1982), Art, mind, and brain, A cognitive approach to creativity. New York: Basic Books.

Graham, Richard M., & Beer, Alice S. Teaching music to the exceptional child: A handbook for mainstreaming. Englewood Cliffs, N. J.: Prentice-Hall.

Hofstetter, Fred T. (1976). Foundation, organization, and National Consortium for Computer-Based Musical Instruction. Journal of Computer-Based Instruction, 3 (1), 30.

(1979). Evaluation of a competency-based approach to teaching aural interval identification. Journal of Research in Music Education, XXVII, 201-213.

(1979). Microelectronics and music education. Music Educators Journal, April, 39-45.

(1981). Application of the GUIDO system to aural skills research, 1975-80. College Music Society, Fall, 46-53.

(1983). The design and manufacture of the University of Delaware sound synthesizer. Proceedings of the 1983 ADCIS Conference.

Killam, Rosemary et al. (1975). Interval recognition: Identification of harmonic and melodic intervals. Journal of Music Theory, XIX (2), 212-233.

Killam, Rosemary et al. (1981). Research applications in music CAI. College Music Society, Fall 1981, 35-37.

Krumhansl, C. (1979). The psychological representation of musical pitch in a tonal context. Cognitive Psychology, 11, 364-74.

Kuhn, Wolfgang E., & Allvin, Raynold. Computer-assisted teaching: A new approach to research in music. Journal of Reseach in Music Education, XV, 305-315.

BIBLIOGRAPHY

Matter, Darryl E. (1982). Musical development in young children. Childhood Education, May/June. 306.

Naisbitt, John. (1982). Megatrends: Ten new directions transforming our lives. New York: Warner Books. 33-37.

Peters, G. David. (1983). Computer technology in instrumental music instruction. The Instrumentalist, Feb. 35-37.

Piaget, Jean. (1964). Development and learning. Journal of Research in Science Teaching, 2, 176-186.

Placek, Robert W. (1972). Design and trial of a computer-assisted lesson in rhythm. (Ed. D. dissertation, University of Illinois.) 813-A.

Raebeck, Lois, & Wheeler, Lawrence. (1974). Music in the elementary school. New Approaches to Music in the Elementary School, (3rd ed.), 9-14.

Rumery, Kenneth R. (1985). Computer applications in music education, a survey. (Mini-grant awarded by Center for Excellence in Music Education), Northern Arizona University, May.

Rumery, Kenneth R. (1985). Bringing your classroom on-line, the computer as a music processor. Music Educators Journal, Jan. 21-24.

Serafine, Mary Louise. (1983). The Development of Cognition in music. Bulletin for Council for Research in Music Education, 1-14.

Shehan, Patricia. (1985). To educate is to activate. Music Educators Journal, April,41-43.

BIBLIOGRAPHY

Shrader, David L. (1981). Microcomputers come to music. _The Instrumentalist,_ Feb. 24-25.

Steinhaus, Kurt A. (1986). Putting the music composition tool to work. _The Computing Teacher._ Dec./Jan. 16-18.

Taylor, Jack A. (1982). The MEDICI melodic dictation computer program: its design, management, and effectiveness as compared to melodic dictation. _Journal of Computer-Based Instruction,_ _9_ (2), 64-73.

Von Feldt, James R. (1971). Computer-assisted instruction in the public school general music class: A comparative study. (D.M.A. dissertation, University of Missouri) 2418-A.

Webster, Peter. (1987). Conceptual bases for creative thinking. In J. C. Peery, I W. Peery, & T. W. Draper, (Eds.). _Music and Child Development._ New York: Springer-Verlag.

Winner, Ellen. (1982). Music. _Invented Worlds: The psychology of the arts._ Cambridge: Harvard University Press, _3,_ 195-243.

Wittlich, Gary E. (1980). Developments in computer-based music research at Indiana University. _Journal of Computer-Based_ Feb. _6_ (3), 62-71.

Wolf, Dennie, & Gardner, Howard. (1978). Beyond playing or polishing: A developmental view of artistry. (Harvard Project Zero and Boston Veteran's Administration Hospital) Oct. _3_ 1-31.

Zimmerman, Marilyn. (1970). Percept and concept: Implications _Music Educators Journal,_ Feb. 49-50, 147-148.