RELATIONSHIPS BETWEEN PITCH MEMORY IN SHORT MELODIES AND SELECTED FACTORS

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This study investigated relationships between memory for pitch in short melodies and melody length, tonal structure, melodic contour, and music perception ability. Results indicated that all these factors interact to some degree with memory. The factors demonstrating the greatest influence were music perception ability (a product of previous music learning), and tonal structure (the degree of relationships among the pitches of a melody, commonly described as tonality or atonality). Memory for pitch improved as the number of pitches in a melody decreased. Certain melodic contours also caused variations in pitch memory.

Key Words: acoustics, aural discrimination, memory.

Memory studies exploring elements of music such as context, contour, length, tonality, and music learning have produced results consistent with more general memory studies and current memory theories. Considerable evidence demonstrates that the Gestalt principles of context are relevant for music. Generally, information in context is perceived differently than information out of context (Taylor, 1971; Norman, 1969; Dowling and Fujitani, 1971). The contextual difference has been attributed to interactions or relationships of the elements of music. Taylor found a strong trend toward greater accuracy in recognizing intervals in isolation rather than in melodic context. Ward (1972) reviewed six studies that analyzed intervals during performances of music works and found an overall pattern of sharpness, or stretching of the intervals. Ward attributed these findings to contextual effects.

This study is based on the author's doctoral dissertation (Florida State University, 1975).

A second parameter, melodic contour, has received little attention as an experimental variable. White (1960) assured his readers that contour was important to the recognition of distorted melodies. Dowling and Fujitani demonstrated that contour was not as important in long-term memory as was the exact interval size. Deutsch (1972) concluded that interval size and preservation of the contour were more important to melodic memory than memory for pitch.

As a function of melody length, serial position effects for pitch memory have been demonstrated by both Taylor and Williams (1973). Taylor discovered that recall was more accurate for intervals near the end of a melodic phrase and least accurate near the middle of a phrase. Williams obtained the same results with pitch recognition. Deutsch (1970) showed that interference in memory increased as the number of intervening tones between the standard tone and the test tone increased. In effect, this procedure lengthened the phrase by adding tones between the tone to be remembered and the final test tone.

Tonal melodies appear to be easier to remember than atonal melodies (Frances, 1958; Zenatti, 1969), and the degree or "strength" of tonality of the melodies could be an organizational factor for memory. Using information theory, Taylor (1977) demonstrated that melodies of the same length and contour but differing tonal structure (tonal versus atonal) were perceived as containing different amounts of information concerning a tonal center. Each subject was asked to sing the pitch he believed to be the tonal center after hearing each melody. Generally, there was a high degree of agreement among the subjects as to the tonal center for the tonal melodies. More diversity of choice resulted in the selections of tonal centers for the atonal melodies. Information theorists consider the number of different choices (number of different pitches selected, in this case) as the "amount of information." Thus, atonal melodies exhibited greater amounts of information than tonal melodies in Taylor's study. Taylor called these indexes "tonal strength values."

George Miller's 1956 study illustrated the relationship between the amount of information in a perceptual unit and memory. He suggested that a simple recoding system (such as regrouping a series of numbers into groups of twos or threes) actually reduced the amount of information needed to remember the number series. He concluded that a recoding system is necessary in order to accommodate the memory's limited processing or channel capacity. Consider Miller's thesis as it might apply to music. If three pitches, forming an ascending major triad, root position, were used to initiate a melody, this pattern could be recognized and stored in memory as a major triad or perhaps identified as the tonic triad or another type of triad, depending upon the particular melodic context. Instead of encoding three pitches (for example, C, E, G), their direction (contour), and two intervals (major third, minor third), memory would be less encumbered with a single recoding system such as tonic triad, C major triad, and so on.

Taylor's findings pointed up the fact that subjects who were music majors consistently produced lower tonal strength values for tonal melodies than nonmusic majors. Using Miller's thesis, it might be conjectured that subjects who were studying music were more capable of recoding tonal information, thereby reducing the amount of information in each melody, than were nonmusic majors.

The literature thus suggests that melody length, tonality, and learning ability affect memory. Furthermore, it supplies sufficient evidence to support the thesis that the amount of information in a perceptual unit affects memory for that unit.

Purpose and Procedure

The purpose of this study was to investigate the effects of melody length, contour, tonal structure, and music perception ability on memory for certain pitches embedded in short melodies. The study investigated the possibility that the tonal strengths of the melodies were correlated with memory for pitch. A linear relationship between change in melodic memory and change in tonal strength was hypothesized.

The twelve melodies composed and tested by Taylor were selected as the stimulus variables for this study because of the systematic controls of his compositional process and because of the known tonal strength values derived from his experiment.

The melodies encompassed two contours—an M-shape and a V-shape; three lengths—7, 9, and 11 pitches; and two tonal structures—tonal and atonal (see Figure 1).

The experimental task consisted of 24 trials; each of the twelve melodies was used in two trials. A trial consisted of an identification number; a melody of 7, 11, or 15 pitches; a latency interval; a test tone; and a response interval. An identification number signaled the beginning of each trial. Two seconds were allowed for this number. The melody followed the identification number. The length of each pitch was .5 seconds, so that a melody with seven pitches required 3.5 seconds, 11 pitches required 5.5 seconds, and 15 pitches required 7.5 seconds. A one-second test tone followed a two-second latency interval. Subjects, who had an interval of six seconds in which to respond to each trial, were instructed to remember the melody, decide if the test tone presented after the melody was contained in that melody, and respond accordingly (see Figure 1). The total time for each trial was 14.5 seconds, 16.5 seconds, and 18.5 seconds for the melodies with 7, 11, and 15 pitches, respectively.

The tone selected to serve as the standard tone in each of the twelve melodies was the pitch that fell adjacent to the center pitch. In each melody, the first, last, and center pitches were the same except that the center pitch was an octave lower than the ends (see Figure 1). The tones on either side of the center pitch were identical.

The tones selected to serve as the incorrect test tones for the twelve noise trials (that is, where the test tone was not the same as the standard) were chosen so that the pitches were one semitone higher or lower than the standard tones. The subject's task was to determine if the test tone was present in the melody. All tones that occurred in a melody were eliminated from being used as an incorrect test tone for that melody.

This experiment attempted to replicate Taylor's testing situation. Precautions were taken to reproduce the same melodies by using the same

Figure 1
Melodies With Seven Pitches

Melody | Correct Test Tone

1
2
3
4

The correct test tones (CTT) were presented as notated. The incorrect test tones (ITT) for melodies 1 through 4 were E, F, D, and G-sharp, respectively. These were presented in the same manner as the correct test tones. Melodies 1 and 3 have a V-shaped contour. Melodies 2 and 4 have an M-shaped contour (disregarding the B's on either ends). Notice that melodies 1 and 2, 3 and 4 contain the same pitches; only the contours are changed. The tonal structure of melodies 1 and 2 is considered tonal while the tonal structure of melodies 3 and 4 is considered atonal.

equipment and the same procedures, whenever possible. The experimental tapes were recorded in the Moog synthesizer laboratory at Florida State University. The sine wave generator (901, Moog 3B) of the synthesizer was used to produce a sine wave. The attack and decay envelope consisted of 100 m/sec attack, 50 m/sec initial decay, 500 m/sec sustain, and a 50 m/sec final decay. Melodies were recorded on a cassette tape recorder.

Six randomly ordered tapes were used to control for order effects. Each tape consisted of 24 randomly ordered trials (12 melodies, each followed by the correct test tone and then the same 12 melodies, each followed by an incorrect test tone). Total time per tape was 6.6 minutes.

Three groups, two consisting of 31 subjects and one consisting of 28 subjects, were recruited from Florida State University music classes at the graduate and undergraduate levels. Nonmusic majors were recruited from music appreciation classes and from the university at large. A music perception test was administered to serve as a criterion measure for placing each subject in one of the three groups. The Taylor music perception ability test, designed to evaluate essential music skills, was used in this experiment to approximate the same melodic perception ability levels that Taylor established in his 1977 study.

Subjects were tested to determine if they were able to sing what they were thinking, by asking subjects to "think along" with a familiar melody as it was played. When the melody stopped, the subjects were asked to continue the melody by singing it. Subjects who could not obtain a 90 percent accuracy for this task were eliminated from the experiment. A highly discriminating task included in the test consisted of sightsinging five melodies of varying tonalities ranging from five to eleven pitches. Taylor used this procedure because his experimental task involved singing that pitch that the subject believed was the tonal center of each melody. In this study, however, the music perception ability test was used to screen respondents to ensure a population approximately the same as Taylor's.

The music perception ability test and the experimental testing were scheduled for one session. The experimental testing preceded the ability testing in order to avoid possible bias for the first task.

Testing facilities consisted of two acoustically paneled rooms, each containing two stereo loudspeakers and a cassette recorder. All speakers were connected to an amplifier and a cassette recorder in an adjoining room. Subjects were seated facing the speakers, approximately three feet away. One subject was tested in each room at a time. Care was taken to insure that all subjects were seated in the same position relative to the speakers. The subject was given an answer sheet that had been coded to specify which of the six orders of melodies had been assigned to that subject.

Instructions and three examples were recorded on high-quality cassette tape and played before the test tape was presented. Subjects were instructed to listen to the three practice examples and determine if the test tone was contained in the melody presented. Subjects were asked to rate their confidence in their decisions on a six-point scale: +3, "very sure yes"; +2, "sure yes"; +1, "maybe yes"; −1, "maybe no"; −2, "sure no"; and −3, "very sure no."

The instructions and examples were approximately four minutes long. Immediately following were the 24 trials of the experimental tape and the 13-minute music perception ability test.

Data Analysis and Statistical Design

A memory operating characteristic (MOC), a measurement from signal detection theory, was approximated for each melody within each of the three ability groups. To approximate the MOC curve, six sets of coordinates were derived. For a melody with a correct test tone, a frequency of each of the six ratings was tabulated across all subjects within each of the three groups. The same procedure was followed for the melody with an incorrect or noise test tone. A percentage of the number of times each rating occurred was calculated over the ratings from +3, "very sure yes," to −3, "very sure no." For example, if 21.4 percent of the subjects responded with rating "very sure yes" and 17.9 percent responded with "sure yes," the cumulative proportion for the two ratings was 39.3 percent. This procedure was continued across the remaining ratings, with the sixth cumulative rating always equaling 100 percent for the cumulative responses (see Table 1). To obtain an estimate of the curve, the cumulative ratings for melodies followed by incorrect test tones (ITT) were plotted on the x-axis and the cumulative ratings for melodies followed by correct test tones (CTT) were plotted on the y-axis of a two-dimensional graph. Curves (MOCs) were approximated by connecting the plotted points. Chance responses would have produced a diagonal line and perfect responses would have produced a straight line across the top of the graph (see Figure 2).

The area under the curve was estimated by the trapezoidal rule (Adams, 1963; Agnew, 1962), and represented an index of the memory strength for

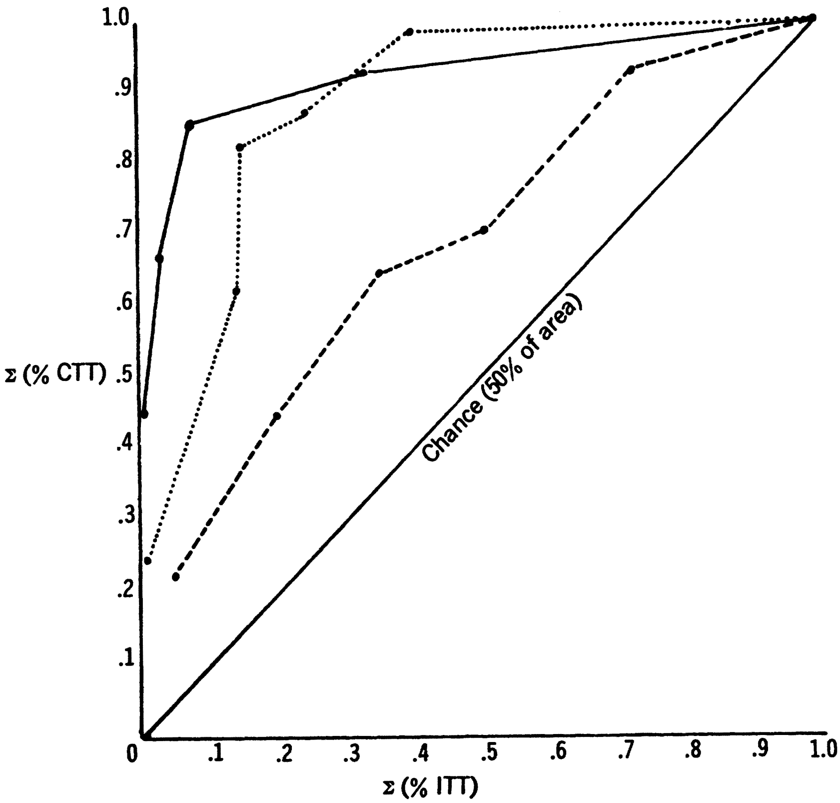
Table 1
Frequencies and Percentages for Melody Four

Group	Rating	Freq.	%CTT*	Σ (CTT)	Freq.	%ITT*	Σ (ITT)
	+3	6	.214	.214	2	.072	.072
	+2	5	.179	.393	4	.143	.215
3	+1	6	.214	.607	4	.143	.358
	−1	2	.072	.679	5	.178	.536
	−2	6	.214	.893	9	.321	.857
	−3	3	.107	1.000	4	.143	1.000

Note: Group 1 MOC = .8945865, Group 2 MOC = .857306, Group 3 MOC = .61701
*CTT = Correct Test Tone, ITT = Incorrect Test Tone.

each melody. For further explanation and examples of this procedure, see Pollack, Norman, and Galanter, 1964; Pollack and Norman, 1964; Dowling, 1973a, 1973b; Egan and Clarke, 1966.

Taylor's original tonal strength (TS) values consisted of 36 scores per group, 12 for each of three stimulus modes—the 12 melodies heard once while visually following the melodic notation. The TS values produced



*See Figure 1 for melody.

Note: Group 1 MOC ———— Area = .8945865

Group 2 MOC .... Area = .857306

Group 3 MOC ------------------ Area = .61701

Figure 2
Memory Operating Characteristics for Groups
Melody Four*

during the latter mode were discarded, and the TS scores associated with the first and second modes were averaged for comparisons with the MOCs produced by the same melodies. This procedure was considered the most conservative possible, since the visual presentation mode was not a factor in this study.

The 36 TS values, 12 for each group, were derived by the averaging procedure previously described. The Pearson product-moment correlation coefficient was used to test the linearity between the area under the curve for each melody and the corresponding TS value. A significance level of .01 was chosen for this test.

The factors of length, contour, tonal structure, and ability groups were tested by a four-factor analysis of variance design with all factors fixed. The design was a 3 (lengths) × 2 (contours) × 2 (tonal structures) × 3 (ability groups) factorial experiment with one observation per cell. A CYBER73 computer and the facilities of the Florida State University Computing Center were used to compute the analysis of variance. The four-way interaction mean square was used as the error term.

Results and Conclusions

The analysis of variance procedure indicated that two main effects, tonal structure (tonality versus atonality) and ability groupings, were significant at the .01 level. A Newman-Keuls sequential range test for pairs of means indicated that ability groups I and II (predominantly music majors) were significantly different ($p < .01$) than group III (predominantly nonmusic majors) (see Table 2).

Table 2
Analysis of Variance for MOC Values

Source of Variation	Sum of Squares	d.f.	Mean Square	F
Ability group (G)	.3341	2	.1670	64.23* (18.00)
Length (L)	.0893	2	.0447	17.19
Tonal structure (T)	.0943	1	.0943	36.27* (21.20)
Contour (C)	.0012	1	.0012	.46
Group × tonal structure	.0402	2	.0201	7.731
Tonal structure × contour	.0283	1	.0284	10.92
GLTC (Error)	.0135	4	.0026	
Total	.6962	35		

*Significant at $\alpha = .01$. Numbers in parentheses indicate F table values.
Note: Insignificant interactions deleted from table.

The Pearson product-moment correlation coefficient value ($r = -.221$) suggested that there was no significant linear relationship between areas under the MOCs and TS values.

The results of the analysis of variance revealed considerable differences among the three ability groups. It was reported that groups I and II were significantly different than group III. However, there was no significant difference between groups I and II.

These results were not surprising, insofar as both groups I and II were predominantly music majors. Groups I and II made fewer errors in detecting correct and incorrect test tones than group III (the nonmusic major group). Logically, it follows that music learning increased memory for pitch. The results of the perception ability factor support the conjecture that memory is dependent upon learned systems.

The length factor (7, 11, and 15 pitches) was not significant. However, the MOC means for the three lengths (.84, .81, and .73 respectively) decreased as length increased. If a significance level of .05 had been acceptable, this factor would have been significant. The differences in means would have been between the 7-pitch melodies and the 15-pitch melodies as well as between the 11-pitch melodies and the 15-pitch melodies. However, there would have been no significant difference between the 7-pitch melodies and the 11-pitch melodies at .05. Perhaps this indicates that the memory's channel capacity, as described by Miller, reaches its processing peak between 11 pitches and 15 pitches. Deutsch (1970) also suggested that the length factor increased interference in memory.

As predicted, pitches embedded in the tonal melodies were much easier to remember than pitches embedded in the atonal ones. It has been suggested that Western tonality, a learned system, aids memory. This position is generously supported by the results of this factor.

The relationship between tonal strength and the MOC was not found to be significant. It was expected that the test tone in the melody easiest to remember (highest memory score) would have the lowest TS value (most tonal), but this relationship did not occur. Although a relationship appeared logical between TS values and MOCs, it did not exist in this experiment. Perhaps because length was not a contributing factor to the TS values, and because the length factor appeared to be related to memory, the influence of tonality may have been overshadowed by the confusion of as many as 11 to 15 pitches in the memory process.

Although no interactions were significant at the .01 level, two interactions were worthy of closer scrutiny—the interactions of groups by tonal structure and tonal structure by contour. If the interaction of groups by tonal structures had been tested at a significance level of .05, it would have been significant. The test tones of the tonal melodies were not remembered differently among the three groups. Yet in a comparison of the MOCs of the atonal melodies, there was evidence that group I would have scored significantly different than group III ($p < .05$). The differences in group I and III seemed related to a learning process. Perhaps memory for intervals, as demonstrated on the music perception ability test, was an agent causing group I to be superior to group III in remembering the test tones in atonal melodies. Another possibility is that group I was able to employ something other than tonality to facilitate remembering the test tones. Temko (1971) demonstrated that some type of structural system producing a focal pitch or center was operating in many melodies judged to be atonal.

The interaction of tonal structures by contours was suggestive also. If this interaction had been tested at the .05 level, it, too, would have been significant. A comparison of pairs of means would have indicated that the M-shaped tonal melodies were easier to remember than the V-shaped tonal melodies. The literature offers few possible explanations for this occurrence. After studying the melodies, it was conjectured that remembering an M-shaped melody may require more attention to interval size and absolute pitch than the V-shaped contour. The V-shaped contour may elicit memory for shape instead of stressing interval size. In support of this hypothesis, Steck and Machotka (1975) suggested that attention is increased to a certain extent as the amount of information in a stimulus increases.

The preceding deductions as to the probable causes for observed trends are supported by firm statistical evidence. However, other factors and interactions did not produce the same degree of evidence. Although the effect size of these other factors and interactions was not large enough to be detected at the .01 level, these additional areas are worthy of further research. The length factor showed a definite trend in observation of the individual means as well as the group means. The interaction of the groups and tonal structures was not surprising. The most provocative finding was that contour in tonal melodies may be an important melodic memory factor. Since so little is known about the effects of melodic contour on memory for melody, the supportive evidence in this study would certainly suggest a direction for future studies in melodic contour.

All the factors tested in this experiment seem to influence memory for melody to some degree. The subject's perception ability and structure of the tonal melodies appeared to enhance memory for a pitch embedded in the melody. Longer melodies appeared to interfere with memory while the contour factor appeared to function only in tonal melodies.

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