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> To what extent is the mind capable of attending to both tonal and rhythm dimensions when listening and giving meaning to music? Or must the mind attend to both tonal and rhythm dimensions concurrently in order to give sophisticated meaning to music? (Gordon, 1981, p. 65)

Music theorists and musical psychologists have spent considerable effort investigating the ways in which pitch is organized in music. Theorists have focused on principles assumed to underlie "good" composition while psychologists have concentrated on music's effects on the listener, but the majority of both these groups of scholars have isolated pitch as the main element to be investigated. Early theorists based their speculations on division of the string (Shirlaw, 1955); Schenker (1935/1979) saw all good music as elaboration of an underlying simple pitch structure; Reti (1951) heard combinations and permutations of a few simple melodic elements unifying large compositions; but seldom was the focus on anything but pitch. Similarly, psychologists studying the structure of musical memory have dealt with pitch as the stuff of music. Dowling (1978) discussed the importance

of scale (mode) and contour to memory, Shepard (1982) and Balzano (1980) have derived elegant structural models for scales, and Deutsch (1982) dealt with grouping of pitch in memory.

Only a few theorists (Cooper and Meyer, 1960; Yeston, 1976) or psychologists (Longuet-Higgens and Lee, 1982; Fraisse, 1982) have even approached the topic of rhythm and its purpose in music. Several possible reasons could be advanced. To begin with, there is no handy framework, like the scale, to which we can refer. What should be the unit of analysis--the beat, the measure or milliseconds? For psychologists, so little is known about the psychophysics of human timing that a cognitive theory of rhythm would be speculative at best. Intuitively, we know rhythm is important to memory, but in what way?

The concept of grouping or "chunking" (Miller, 1956) drawn from cognitive psychology provides a possible role for rhythm. In list-learning tasks, it has been found that if items are organized in temporal groups (e.g. 1,3,8...7,2), they are more easily recognized in those groupings than if re-grouped (1,3...8,7,2) (Bower and Winzenz, 1969). Dowling (1973) showed that temporal groupings had a similar effect in memory for pitch sequences. Excerpts crossing temporal boundaries (i. e., rests) were not recognized nearly as easily as were the original groupings. Deutsch (1982) extended this finding by showing that temporal grouping by fours in a passage where pitch contour naturally grouped in threes could make memory for that passage much more difficult. She further showed that segmenting a melody with no inherent pitch groupings into groups of three or four notes resulted in these groups being perceived as subjective chunks. These experiments both suggest that rhythm may serve as a mechanism for grouping pitch into memory. If this is true, memory for

pitch sequence should be aided substantially by rhythmic context, but memory for rhythm would depend very little on presence of pitches.

A study by Fiske (1982), however, suggests that memory for both rhythm and pitch sequence is assisted by the presence of the other. Reaction time to errors in either rhythm or pitch was lower when they were presented in a tonal-rhythmic context than when either was presented in the abstract. Studies in cognitive psychology have suggested that meaningful context is important to memory. For instance, deGroot (1966) found that chess masters performed no better than novices at memorizing a chess position if pieces were placed on the board at random, but they were much better at memorizing actual positions from games. If meaningful context in music involves both rhythm and pitch patterns, we would expect memory to be affected in nearly equal amounts by addition of rhythm to a series of pitches or by addition of pitches to a rhythmic pattern.

The study which follows is the first of an ongoing series intended to investigate the interactive roles of rhythm and pitch sequence in human musical memory. Its primary purpose was to investigate the effects of tonal-rhythmic context on memory for rhythmic and pitch sequences. If melodic memory were assisted more by rhythmic context than by pitch context, a grouping function could be assigned to rhythm. If context assisted both equally, as Fiske's study suggests, a more complex interaction of the two is suggested. A secondary purpose of this study was to investigate whether musical training alters the effects of context in any way. To this end, a group of music majors was compared to a group of nonmajors.

Method

The Test

Twelve simple four-measure phrases were selected from volumes IV and V of the Oxford University Press Folk Song Sight Singing Series (Crowe, Lawton & Whittaker, 1933). Each phrase was presented four different ways:

a. the abstract pitch sequence of the melody (each note one beat long) was played followed by the melody in rhythm. Subjects indicated whether the note order of the two was the same or different.

b. the complete melody in rhythm was played twice. Any change that had been present in condition (a) above was duplicated here. Subjects were asked to indicate "same" or "different" then, if different, whether the change was a pitch or a rhythmic one.

c. the abstract rhythm including metric accent (played on the tonic of the phrase) was followed by the melody in rhythm. Subjects indicated whether the rhythm was same or different.

d. the complete melody in rhythm was played twice. Any change which had been present in condition (c) above was duplicated here. Subjects were asked to indicate "same" or "different", then, if different, whether the change was a pitch or rhythmic one.

Order of all test items was counterbalanced so that items in conditions (a) and (c) preceded their counterparts in (b) and(d) half the time, with

presentations (b) and(d) preceding (a) and (c) the other half. To prevent familiarity with the phrases, the test was administered in four sittings over three days. Each sitting contained one item based on each of the twelve phrases.

The sound source for all items was an Apple-II computer using the Micro-music "Music Composer" program. Numbers of errors under each condition were recorded as the dependent variable.

Subjects

The musician group consisted of 57 freshman music majors. The nonmusician group contained 57 university students from three different classes catering to the musically inexperienced. The test was administered at the beginning and end of class periods for both groups.

Analysis

An analysis of variance was conducted using the following design: A x B x G x S/G where A is the parameter varied (pitch or rhythm), B the context (abstract vs. tonal-rhythmic), G the group (music majors vs. nonmajors), and S/G the subjects nested within groups. Magnitude of effect was estimated using Rankin's tables (Note 1) for each of the A x B interactions and the B main effect in order to determine the relative strength of support for hypotheses of "rhythm as a grouping mechanism" and "need for meaningful context" respectively. Finally, the percentage of correct identification of the changed parameter (melody or rhythm) was tabulated for items correctly identified as different under conditions (b) and (d).

Results and Conclusions

Results

Means and standard deviations for each group and each condition appear in Table 1. No interaction involving the G variable (groups) was significant, but the main effect G was (F [1, 112] = 13.192, $p < .001$). That is, nonmajors made more errors overall than did music majors, but the pattern of those errors was not significantly different. The A x B interaction was significant (F [1, 112] = 4.076, $p < .05$). That is, the effect of tonal-rhythmic context was significantly higher for pitch than for rhythmic sequences. Although this interaction was statistically significant, it accounted for only some 0.6 percent of the variance. The main effect of context (B) was much stronger (F [1, 112] = 121.927, $p < .0001$), accounting for 19 percent of the total variance. This shows that memory for both pitch and rhythm were significantly aided by putting them in a tonal-rhythmic context. Finally, a significant F-ratio for variable A (F [1, 112] = 22.492, $p < .001$) showed that the rhythmic examples were more difficult overall than the pitch ones, a common problem when trying to equate difficulty on two different parameters.

The tabulation of correct responses under the conditions with tonal-rhythmic context showed that in the vast majority of cases (87.8%), subjects in both groups could identify correctly which of the parameters had been changed. The difference between the groups in this analysis was not significant.

Table 1: Means and Standard Deviations for Error Scores by Groups and Conditions

Abstract			In Context		Both Conditions	
Music Majors						
Pitch	3.82	(1.38)	1.98	(1.23)	5.81	(1.72)
Rhythm	4.21	(1.83)	2.56	(1.63)	6.77	(1.72)
Overall	8.03	(2.43)	4.54	(2.20)	12.58	(3.62)
Non-Majors						
Pitch	4.32	(1.14)	2.46	(1.52)	6.77	(2.24)
Rhythm	4.63	(1.81)	3.66	(1.56)	8.30	(2.35)
Overall	8.95	(2.46)	6.12	(2.43)	15.07	(3.70)
Both Groups						
Pitch	4.07	(1.41)	2.22	(1.96)	6.29	(2.05)
Rhythm	4.42	(1.82)	3.11	(1.68)	7.54	(2.65)
Overall	8.49	(2.48)	5.33	(2.44)	13.82	(3.85)

Conclusions and Implications

Whereas this study showed a slight advantage for rhythm as a grouping mechanism for melody, this effect was far outweighed by the overwhelming effect of tonal-rhythmic context on memory for both parameters. A theory which sees rhythm primarily as a grouping mechanism for pitch is thus too simplistic to explain the results of this study. A theory which uses both rhythm and pitch sequence in a definition of meaningful musical context is thus more appropriate. A further characteristic of such a context was shown by Fiske (1982). Items in familiar modes and in metered rhythms showed an advantage for tonal-rhythmic context, whereas atonal and nonmetric items did not. Thus, we can say that familiarity with a style is a further element in meaningful context.

This study has strong implications for music teaching, especially in ear training, imitation through modeling, and rote-teaching of songs. Complete context--rhythm and melody--makes a passage easier to learn. Practicing rhythm alone or pitch sequence alone, at least in the early stages of learning a piece, may not be a simplification at all. In removing one of these parameters, meaningful context is severely weakened. Teachers who frequently demonstrate (or model) correct performance for students should also be aware of the importance of context. For instance, if rhythmic accuracy is to be improved, the teacher might well draw the student's attention to that parameter first then demonstrate a correct performance with complete passage, pitches, and rhythm.

This study dealt only with short-term memory for new materials. A further study, now under way, will teach complete songs to subjects, then test their speed of error detection in examples of abstract rhythm, abstract pitch sequences, and complete tonal-rhythmic context. It is quite likely that

the relative importance of pitch and rhythm will change in the process of committing a tune to long-term memory. If this proves to be the case it might be possible to develop instructional strategies that identify key parameters at different stages of learning and emphasize those parameters.

More research is needed before an adequate theory of the function of rhythm and pitch sequence can be advanced. This study has shown that both rhythm and pitch sequence are important to our short-term memory processes for melody and that each is enhanced by the presence of the other. Psychologists, theorists and music educators would do well to look less on rhythm and pitch sequence as separate entities and more as two aspects of an interactive system. The rules governing this interaction are what seem to give meaningful context to music.

Reference Note

1. Rankin, Richard J. Magnitude of experimental effect. Unpublished manuscript, University of Oregan, 1980.

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Contents