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Recognition of Novel Melodies after Brief Delays

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Three experiments on the recognition of short melodies investigated the influence of contour and interval information (respectively, the pattern of changes in pitch direction and the ordered sequence of pitch distances in a melody). Subjects rated pairs of melodies as "same" or "different" on a five-point scale. Six conditions were defined by two delays (short, 1 sec; and long, 30 sec) and three item types (target, related, and lure). In Target pairs, the second melody retained the contour and interval information of the first melody, being an exact transposition to another key. In Related pairs, only the contour information was retained, while in the Lure pairs neither contour nor interval information was retained. In conformity with the reports of Dowling and Bartlett (1981), the results indicated that contour information had a larger influence on recognition at short delays, whereas interval information had a relatively larger influence at long delays. The results are also consistent with an alternative interpretation stressing the importance of tonality/modality information in melody recognition at long delays.

Introduction

Most people can recognize a melody, whether a "pop tune" on the radio or a theme as it reappears throughout a symphony. What features of melodies do we use for memory, and how are these features processed to aid recognition? Melodies could theoretically be heard as just a series of individual pitches, but there are some more global features of melodies that seem to allow (or compel) us to group these individual pitches together and recognize the melody as a unit. Two of these more general features are (1) contour, the binary pattern of ups and downs of pitch direction, and (2) interval information, the ordered sequence of pitch distances, along a logarithmic scale of frequency, between any two adjacent pitches in the melody. Together these two types of information define the melody. They could also be used in recognition. The question is which information, contour, interval, or both, is used in recognition of melodies.

If only contour information were used, then melodies having the same contour but different interval information would be perceived as the same

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melody. However, if both contour and interval information were used in recognition, the same pair of melodies would be recognized as different. Figure 1 shows a musical example of a familiar melody (1a) and two variations of it. The first variation (1b) is an exact transposition retaining both the contour and interval information of the original. The second variation (1c) retains the contour information of the original but not its interval information. (Musically, two melodies that have the same pattern of interval information must have identical contours because interval information is assumed to contain an indication of direction.)

Melodies with the same contour but different interval information are often treated as "the same" melody. In listening to a fugue, one hears the fugue theme enter in different voices which may not be exact (interval) transpositions of the original statement. Generally, these entrances *do* retain the contour of the original. The fugue would not make much sense if one perceived these theme entrances as truly different melodies. Therefore, in this instance the exact interval information should not be the recognition criterion, only the contour is needed. Also, in a Theme and Variations form, the theme may be heard in a major mode in one variation and in a minor mode in another. This change alters the interval information of the theme but not necessarily the contour information. Yet, one would hope that the "new version" would not sound totally dissimilar.

On the other hand, interval information is not totally ignored in melody recognition. When a *familiar* melody is played with only a small change in the interval structure it is recognized as being different from the "correct" melody (Attneave & Olson, 1971; Bartlett & Dowling, 1980).

Previous studies of melody recognition have used octave-scrambled familiar melodies to isolate the relative influence of contour and interval information (Idson & Massaro, 1978; Kallman & Massaro, 1979; Massaro, Kallman & Kelly, 1980; Dowling, 1978). In these studies, recognition was generally good when both contour and pitch (specifically, chroma, pitch name independent of octave) information were present even though the pitches were scattered over octaves. When only contour information was present recognition was somewhat worse, although better than when only pitch information was present. Unfortunately, the use of a limited set of familiar, overlearned melodies in the octave-scrambling studies may favor the

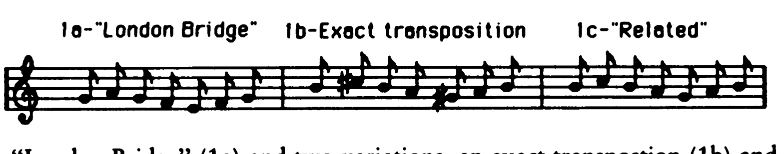

Fig. 1. "London Bridge" (1a) and two variations, an exact transpostion (1b) and a same contour–different interval "related" variation (1c).

use of contour information in a way that use of novel melodies would not. Subjects may be able to match the melody, on the basis of contour alone, to a "template" of the familiar melody. In fact, when subjects do not know the set of possible melodies, only knowing that they are familiar, contour information alone is not very useful (Kallman & Massaro, 1979).

To avoid some of the problems involved in research using octave-scrambled familiar melodies (see Deutsch, 1982), other studies of melody recognition have examined the interplay of contour and interval information by using novel melodies. Subjects perform very well when tested immediately for contour information on these novel melodies, but are easily confused about interval information in immediate test (Dowling & Fujitani, 1971; Dowling, 1978; Bartlett & Dowling, 1980). That is, they do not discriminate between related melodies (same contour–different interval) (Figure 1c) and exact transpositions (Figure 1b) when comparing them to a standard melody. These results seem to indicate that contour information is more easily encoded in immediate memory than is interval information (Dowling, 1982, p. 426).

Tests of *delayed* melodic memory present a rather more confusing picture. Experiments showing good long-term retention using familiar melodies, such as the NBC chime (Attneave & Olson, 1971), are not relevant to an investigation into the differential retention of contour and interval information over varying delays because they confound degree of learning with retention interval. Therefore, a direct comparison of the retention of *novel* melodies over short and long delays was needed.

Dowling and Bartlett (1981, Exp. 4) used a procedure designed to investigate melody recognition over both short and long delays. Pairs of novel seven-note melodies were nested together so that on each trial subjects made both a short-delay (5 sec) and a long-delay (25 sec) comparison. The short (inside) delay condition replicated the usual dominance of contour information with related melodies (same contour–different interval) confused with exact transpositions. Retrieval of both contour and interval information was more difficult after a long (outside) delay. Furthermore, a trend toward an interaction of item type and delay suggested "a loss of contour information, but not interval information, in the outside [long-delay] condition" (Dowling & Bartlett, 1981, p. 44). The results indicated that in the short-delay condition subjects responded "same" equally often to both exact transpositions and related (same contour–different interval) melodies (Figure 1c), but in the long-delay condition they were less likely falsely to respond "same" to a related melody than they were likely to correctly respond "same" to an exact transposition. In other words, their ability to discriminate related melodies from exact transpositions *increased* in the long-delay condition. In verbal memory, this would be comparable to remembering only the "gist" at a short interval and the exact wording at a longer one! Aside from being inconsistent with what is known about verbal memory, in which the exact wording of a sentence would be forgotten before its general meaning (Sachs, 1967), this finding is counterintuitive for another reason. By definition, interval information contains, at least implicitly, the contour information. So, if the pattern of interval information is retrievable, then contour information should also be retrievable.

Dowling and Bartlett proposed two explanations for their finding even though it was not reliable statistically. One of these appealed to memory representation and the other to the retrieval process. The representational explanation posited two memory traces: a short-term trace and a long-term trace. The short-term trace would explicitly represent contour information along with pitch height and (perhaps) key. The long-term trace, however, would represent contour information only implicitly while explicitly representing precise interval information (Dowling & Bartlett, 1981, p. 46–47). In other words, at the longer retention interval, the contour information would have to be derived from the interval information rather than being directly accessible. The retrieval process explanation proposed a qualitative difference in retrieval operations in a short-term situation as opposed to a long-term situation. Dowling and Bartlett emphasized that in the short delay situation, since the subject does not need to be "reminded" of the original melody and since interval information is relatively difficult to encode, the subject may allow other information, such as contour, to govern his or her response. In the long-delay situation the subjects must first decide if the test melody "reminds" them of the original melody. Since many melodies may contain similar contours, contour information may not be very useful after a long delay whereas interval information may be much better.

The following experiments were designed to investigate further the role of contour and interval information is melody recognition. Because the trend inspiring the above discussion was nonsignificant, we sought to replicate it first and then to refine some of the methodological aspects of the Dowling and Bartlett (1981) study. The main problem with the outside/inside design was a 10-sec "rehearsal" period in the outside (long-delay) condition. By allowing subjects to rehearse the first melody on each trial but not the second, degree of learning was confounded with retention interval. Also, because the design of the trials was explained to the subjects, they could have developed different strategies for the long- and short-delay conditions. For these reasons, we felt new experiments were required to clarify the empirical facts of the matter before becoming concerned about interpretation of the counterintuitive trend obtained by Dowling and Bartlett (1981).

Experiment 1

The first experiment was an attempt to replicate the Dowling and Bartlett (1981) experiment using the outside/inside (nested long/short) procedure. We though this should be our first piority because the "trend" for an interaction in their outside/inside experiment was not statistically reliable, and the entire case for differential retention of contour and interval information rests on this single experiment with ambiguous results. The second purpose was to verify that our experimental materials were comparable enough to the melodies used by Dowling and Bartlett (1981) to justify additional experiments designed to evaluate their findings.

Method

Materials

The 48 melodies used in the experiment were based on a random selection from the 52 possible seven-note contours containing at least two changes of direction (64 possible combinations of six ups and downs minus 12 monodirectional, V-shaped, and inverted V-shaped contours). Melodies were next generated from these contours by determining the pitch intervals between the notes comprising the selected contour. Following the rules established by Dowling (1978), the melodies contained no intervals larger than two diatonic steps and intervals of one diatonic step were twice as frequent as intervals of two diatonic steps. The 48 resulting melodies were divided randomly into two blocks of 24, Block 1 (outside) and Block 2 (inside). In Block 1 (outside), each of the 24 melodies was randomly assigned to one of 24 musical keys (12 major, 12 minor). The Block 2 (inside) standard melodies were randomly assigned a key either a perfect fourth or a perfect fifth (five or seven semitones, respectively) removed from the key of the outside standard with which it was paired and the two standards retained the same mode, major or minor. This assignment determined the starting note for the melody (the tonic of the chosen key) and consequently the set of pitches used to create it.

Although this method of key assignment does determine the key signature of the melody, it does not necessarily guarantee its tonality. The particular notes chosen from a key could imply another tonality altogether. A fairly thorough examination of the stimuli used in the present experiment, however, indicated that in general the melodies implied the intended tonality in agreement with the key assignment.

For each of the 48 standard melodies, three comparison melodies were generated for use in the three possible test conditions. The three types of comparison melodies were targets, relateds, and lures. The target melodies were exact transpositions of the standard melodies; that is, they retained both the contour and interval information of the standard but started on a different pitch. The related melodies retained the contour information of the standard but not all of its interval information. These related melodies were composed in the contrasting mode to the standard to which they were to be compared: If the standard was in C major and its target comparison in A major than the related comparison was in A minor. Following the method of Dowling and Bartlett (1981) the related melodies were always "tonal answers" of the standard, either in a "six–one" or a "one–six" relationship. In other words, if the standard was in a major key the melody in the related comparison condition would be in the relative minor key and if the standard was in a minor key the related comparison melody would be in the relative major. Because of this key assignment of the related condition and in order to control for change of absolute pitch height, the melody in the target comparison condition was in the parallel key (major or minor) to the related comparison. The lure melodies began on the same note as the corresponding target and related melodies, but used the inversion of the contour of the standard to which they were being compared (the lure went up when the standard went down and vice versa) and therefore retained neither the contour nor the interval information of the standard. Figure 2 shows an example of a standard melody and its three comparison melodies.

Apparatus

Haskins Laboratories' Sine Wave Synthesizer was used to generate the melodies. Each tone was 333 msec long with steady amplitude throughout its duration. The melodies were recorded on reel-to-reel tape using an Otario MX-5050 tape recorder. The tapes were presented to subjects through a single speaker using a Tandberg three-head stereo tape player/ recorder.

Subjects

Thirty Yale University undergraduates participated as a group in the experiment as part of a class demonstration.

Design

The 48 standard melodies, 24 in each of two blocks, were combined in an outside/inside arrangement resulting in 24 trials. Only one of the three possible comparison conditions (randomly assigned but equally distributed) was tested for each standard melody. First, the subjects heard a standard melody from Block 1 followed by a 10-sec pause. Then, a standard melody from Block 2 was presented, followed 1 sec later by its comparison melody. The subjects responded in the following 5 sec, after which they heard the comparison melody for the first melody, which they had heard 25 sec earlier, and responded to it. Figure 3 illustrates this "outside/inside" procedure.

Procedure

Subjects were informed that they would be comparing seven-note melodies and judging their similarity on a scale from *same* (1) to *different* (5). As described above, each trial required the subject to make two comparisons, one after a short (1 sec) delay, inside, and one after a longer (25 sec) delay, outside. This outside/inside design of nested standard and test melodies was explained to the subjects. Subjects were encouraged to rehearse the melodies during the interstimulus intervals by instructing them to "sing in their minds." Example trials using familiar melodies were presented to the subjects in order to familiarize them with the procedure and also to demonstrate *same, somewhat the same, somewhat different,* and *different* comparison melodies. The 24 outside/inside pairs were then presented.

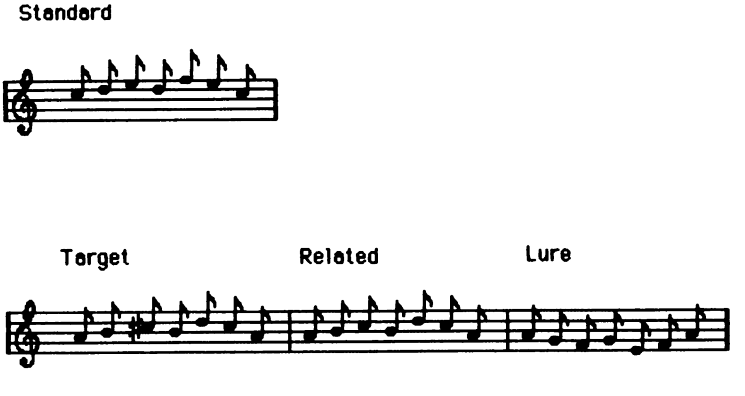

Fig. 2. A sample standard melody and its three comparison melodies: target, related, and lure.

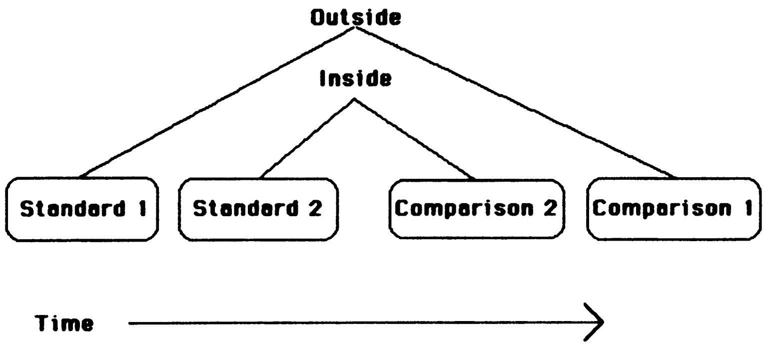

Fig. 3. The design of each "outside/inside" trial.

Results and Discussion

Two analyses were performed. To compare the current results with those of Dowling and Bartlett (1981) most directly, we calculated areas under the MOC separately for each condition and for each subject, using the four criteria possible with a five-point rating scale (McNicol, 1972). Area under MOC is used as an estimate of the unbiased proportion of correct responses where chance would be .50. For each delay condition, areas were calculated using responses to Targets or Relateds as hit rates versus responses to Lures as false-alarm rates. This resulted in a Target vs. Lure and Related vs. Lure area score for both long (outside) and short (inside) delay conditions for each subject.

TABLE 1
Mean Areas under MOC in Experiment 1[a]

	Item Type		
Delay	Target	Related	Mean
Inside	.89 (.75)	.90 (.72)	.90 (.74)
Outside	.75 (.65)	.67 (.57)	.71 (.61)
Mean	.82 (.70)	.78 (.64)	.80 (.67)

[a]The mean areas under MOC obtained by Dowling and Bartlett (1981) appear in parentheses.

Table 1 shows the mean area scores obtained for the four conditions along with those obtained by Dowling and Bartlett (1981, Exp. 4). An analysis of variance performed on the area scores indicated better recognition performance in the short delay (inside) condition than in the long delay (outside) condition, $F(1,19) = 33.364, p < .0001$. Target melodies showed overall better recognition than Related melodies, $F(1,19) = 4.592, p < .05$. More importantly, the analysis revealed a significant interaction of item type and delay, $F(1,19) = 5.290, p<.05$. Thus, comparison melodies which retained *only* the contour information of the standard were not easily discriminated from exact transpositions of the standard after the short delay but *were* discriminated from the exact transpositions after the long delay.

The same conclusions are supported by an analysis of variance on the rating scores themselves. Table 2 shows the mean rating scores obtained for each condition. A preliminary contrast of Target and Related conditions versus the Lure condition was conducted to verify that subjects' ratings of Lures were significantly more "different" than their ratings of Targets and Relateds to allow us to focus our analyses on the crucial Target and Related conditions, $F(1, 19) = 121.822$ $p < .0001$. A subsequent 2 Item Types × 2 Delays ANOVA revealed that subjects rated both Target and Related comparisons as more similar to the standard in the short-delay (inside) condition than in the long-delay condition, $F(1, 19) = 27.772, p < .0001$. There was no main effect of item type; however, as in the MOC analysis, the interaction of delay and item type was significant, $F(1, 19) = 5.293, p < .05$.

Thus, by either measure, the interaction between delay and item type—only a nonsignificant trend in Dowling and Bartlett (1981)—was reliable at conventional levels here. If availability of interval information is defined as better recognition of Target than Related melodies, then people show better memory for interval information at the *long* (25 sec) delay than after only a short (1 sec) delay.

TABLE 2
Mean Rating Scores in Experiment 1

	Item Type			
Delay	Target	Related	Lure	Mean
Short	2.14	2.07	4.51	(2.91)
Long	2.62	3.00	3.94	(3.19)
Mean	(2.38)	(2.53)	(4.23)	(3.05)

Experiment 2

As we said in the introduction, the outside/inside procedure confounds degree of learning and retention interval. Furthermore, the subjects could have adopted different strategies for the short (inside) and long (outside) retention intervals because, knowing the design of the trials, they were aware of which melody in a trial would be tested under which condition. The second experiment was designed to remove these confoundings, Experiment 1 having assured us that our stimulus materials were acceptable and that the crucial interaction "really was there."

In Experiment 2, which used an adaptation of the Brown–Peterson method, the standard melodies were each tested in separate trials rather than nested in the same test trial. The short (1 sec) and long (30 sec) delay conditions were randomly assigned to the trials so subjects were unaware, on listening to the standard, whether they would be tested after a short or long delay. Finally, on the long-delay trials the subjects were required to perform a distractor task. By eliminating the opportunity for rehearsal in the long-delay conditions degree of study time was no longer confounded with retention interval.

Method

Materials

The melodies used in Experiment 2 were the same as those prepared for Experiment 1.

Apparatus

A Radio Shack TRS-80 Model I microcomputer was used to generate the square-wave tones comprising the melodies. (The Sine Wave Synthesizer was unavailable to us at the time of this experiment.) The software used to generate the tones was "Music-80" (Freese, 1983). The tones were amplified through an Archer Mini Amplifier-Speaker placed directly in front of the subject.

Subjects

Thirty Yale University undergraduates participated in the experiment for course credit.

Design

Each of the 48 standard melodies was presented on a separate trial. To compare the effects of long and short delays prior to the memory test, each standard was assigned to one of six possible conditions, short (1 sec) or long (30 sec) delay crossed with target, related, or lure comparison. Six assignments of conditions to trials were created in a rotating arrangement such that each standard melody participated in each of the six conditions across six groups of subjects.

Procedure

Subjects were instructed as for Experiment 1 with the following exceptions: They were told that on some of the trials there would be a long (30 sec) delay indicated by the word "count" spoken after the standard melody was heard. On these trials they were to count out loud, backwards, by threes from an indicated number until they heard the word "test," at which time the comparison melody would be presented. On other trials the subjects would just hear the word "test" after the standard melody and the comparison would occur immediately. Example trials using familiar melodies were presented to the subjects in order to familiarize them with the procedure and also to demonstrate *same, somewhat the same, somewhat different,* and *different* comparison melodies. The 48 test items were then presented. After all the test items had been presented, subjects filled out a Musical Background Questionaire.

TABLE 3
Mean Areas under MOC in Experiment 2

	Item Type		
Delay	Target	Related	Mean
Short	.85	.86	(.86)
Long	.73	.69	(.71)
Mean	(.79)	(.78)	(.78)

Results and Discussion

Table 3 shows the mean area scores obtained for the four conditions. Recognition performance was better in the short-delay condition than in the long-delay condition, $F(1,29) = 19.104$, $p < .0001$, but the subjects were no more accurate in their overall recognition of Targets than of Relateds. The interaction of delay and item type, however, was significant, $F(1,29) = 4.710$, $p < .05$.

Mean rating scores appear in Table 4. The 2 Delays × 2 Item Types analysis of variance performed on the rating scores also revealed a significant main effect of delay, $F(1,29) = 108.22$, $p < .0001$, but no effect of item type. A significant interaction of delay and item type was also found, $F(1,29) = 8.176$, $p < .01$.

To evaluate the effect of musical training on the ability to discriminate target from related melodies the Musical Background Questionaires were independently ranked according to degree of musical training by three musically trained individuals. The subjects were divided into two groups using a median split of the mean rankings received. A 2 Groups × 2 Delays × 3 Item Types analysis of variance was performed on the rating scores. No significant differences were found involving the groups.

TABLE 4
Mean Rating Scores in Experiment 2

	Item Type			
Delay	Target	Related	Lure	Mean
Short	1.90	1.83	3.79	(2.50)
Long	2.73	3.00	3.76	(3.16)
Mean	(2.31)	(2.41)	(3.78)	(2.83)

The results indicate that the interaction of item type and delay is not simply the result of a procedure that confounds degree of learning or listening strategy and retention interval. Even with the confounding removed, subjects still rated related melodies as more different from target melodies in the long (30 sec) delay condition than in the short (1 sec) delay condition. Subjects seem to have available, or use, contour information in making their same–different decision after a short delay (and therefore perceive target and related melodies as the same). After longer (30 sec) delays they seem to have accessible, or use, interval information more (and therefore perceive target and related melodies as different). This conclusion was the same reached by Dowling and Bartlett (1981), but was based on insufficient evidence. Before attempting to explain this finding, however, we report a third experiment, conducted to see if the effect generalized to other melodies.

Experiment 3

Experiment 3 was an attempt to strengthen our conclusion about the interaction between item type and delay found in Experiments 1 and 2 by testing whether the effect generalizes to easier melodies. Five-note, instead of seven-note, melodies were used as stimuli because it was believed that shorter melodies would be easier for subjects to remember. It was expected that with the shorter melodies subjects would also be better able to discriminate between target and related melodies even at short delays. Apart from the length of the melodies the design of Experiment 3 remained identical to that of Experiment 2.

Methods

Materials

Ninety-six standard five-note melodies were composed by combining the 16 possible five-note contours with each of six of the possible interval patterns (randomly chosen) combining intervals of one and two diatonic steps with the probability of an interval of one diatonic step always greater then or equal to the probability of an interval of two diatonic steps within each pattern.

Apparatus

The same synthesizer, tape recorder, and tape player used in Experiment 1 were used in Experiment 3.

Subjects

Eighteen Yale University undergraduates, none of whom participated in the prior experiments, participated in the experiment for course credit.

Procedure

The subjects in Experiment 3 experienced procedures identical to those in Experiment 2.

TABLE 5
Mean Areas under MOC in Experiment 3

	Item Type		
Delay	Target	Related	Mean
Short	.93	.93	(.93)
Long	.73	.74	(.74)
Mean	(.83)	(.83)	(.83)

Results and Discussion

Table 5 shows the mean areas under the MOC for Experiment 3. A 2 Delays × 2 Item Types analysis of variance performed on the area scores revealed only a significant main effect of delay, $F(1,17) = 45.305$, $p < .0001$. Neither the main effect of item type nor the interaction of delay and item type was significant.

Table 6 shows the mean rating scores for Experiment 3. The analysis of the rating scores revealed significant main effects of both delay and item type, $F(1,17) = 58.846$, $p < .0001$ and $F(1,17) = 4.689$, $p < .05$, respectively. The interaction of delay and item type was not significant.

The effect of musical training was evaluated as in Experiment 2. The 2 Groups × 2 Delays × 3 Item Types analysis of variance was performed using the rating scores. The interaction of group, delay, and item type was significant, $F(2,28) = 6.382$, $p < .005$. This was due to the musicians showing better discrimination of Lures from Targets and Relateds at the short condition.

The interaction of item type and delay which was found in Experiments 1 and 2 was not evident in Experiment 3. The shorter, five-note melodies were generally more easily recognized (.78 Experiment 2 versus .83 Experiment 3), however, they did not facilitate the use of interval information at either short or long delays. If, as in usually assumed, interval information is represented as an ordered series of pitch distances, it is puzzling that shorter melodies, which contain a shorter series of intervals, would lead to poorer discrimination of targets versus relateds. This difficulty will be explored below.

TABLE 6
Mean Rating Scores in Experiment 3

	Item Type			
Delay	Target	Related	Lure	Mean
Short	1.56	1.67	4.09	(2.44)
Long	2.31	2.49	3.55	(2.78)
Mean	(1.93)	(2.08)	(3.82)	(2.61)

General Discussion

The three experiments reported here help to clarify the roles of contour and interval information in memory for melodies. Prior research on melody recognition (Dowling & Bartlett, 1981) indicated a trend toward differential retention of contour and interval information with contour information more easily encoded and recognized at short delays and interval information more difficult to encode but "emerging" after long delays. Experiment 1 verified the significance of this trend using procedures similar to those of Dowling and Bartlett (1981). A clarification of this differential retention of contour and interval information was obtained in Experiment 2, which unconfounded degree of learning with retention interval yet still found an interaction. This was our most important result. The attempt to generalize it to shorter melodies in Experiment 3 was unsuccessful. Subjects in that study could not discriminate between target and related melodies at either short or long delays.

The lack of replication in Experiment 3 may actually serve to challenge the conventional interpretation of interval information. The assumption has been that interval information is represented as an ordered series of pitch distances (Dowling, 1978, 1982). Figure 4 illustrates this assumption about interval information using a familiar melody. If interval information were really encoded in this format, shorter melodies, represented by a shorter ordered series of pitch distances, should be easier to remember and therefore easier to discriminate on the basis of interval information than longer ones. In terms of Figure 4, the series $+2 - 2 - 2 - 1$ would be more easily remembered than $+2 - 2 - 2 - 1 + 1 + 2$. The results of Experiment 3, however, while showing that the five-note melodies were better remembered, showed no improvement in their discriminability on the basis of interval information. Perhaps interval information should be characterized in some other way.

One alternative is that interval information is not explicitly represented at all, but instead serves to determine the modality and/or tonality of the melody. The present experiments are consistent with the possibility that subjects use interval information to derive the mode (major or minor) of the melody. They could then use that information to identify, as different, melodies in the other mode. Our experiments used a procedure to compose the

Fig. 4. The interval information contained in "London Bridge" represented as an ordered series of pitch distances (in semitones).

melodic stimuli that resulted in the Targets and Relateds being generally in different modes (although see Experiment 1, Materials). To the extent there was a modality change from Target to Related, the melodies *could* have been discriminated by an identification of mode change and not by "pure" interval cues. Bartlett and Dowling (1980) expressed a similar view of mode-key information in melodies but because of the nature of their stimuli were unable to substantiate this account.

The view that interval information can guide perception of modality or tonality gives an intuitive explanation for the finding of differential retention of contour and interval information. The modality of a musical entity is generally considered to be a more abstract property than either its intervals or contour. If the more abstract melodic information, modality, is remembered after long delays, and the less abstract information, contour, after short delays, then these results are comparable to findings in verbal memory (Sachs, 1967). But now we must add to this interpretation a reason why the modality (gist) played no role at short delays: The lack of discrimination between Target and Related melodies after short delays may be accounted for by greater initial salience of the more detailed contour information. This interpretation may also explain the lack of generalization to short melodies obtained in Experiment 3. The shorter melodies may have not provided sufficient musical content from which to derive a modality therefore making Targets and Relateds more difficult to discriminate from each other.

Another possible explanation for the lack of discrimination between Target and Related melodies after short delays may be the difference in key-relatedness between Standard–Target pairs and Standard–Related pairs. Since Target comparisons were always in the same mode as the standard but transposed a minor third they were in moderately distant keys. Related comparisons, on the other hand, were always in the relative minor (or major) of the standard. These relative keys are generally considered to be very closely "related" to each other since they share the same pitch set (but change the chosen starting pitch, the tonic). Therefore, the related melodies may actually be, in this sense, more similar to the standards than the targets. Because specific key information is considered to be short-lived this explanation would affect only the short-delay condition. Key information could be considered more detailed than information about mode; therefore, this explanation is broadly consistent with explanations that emphasize memory for more abstract information at longer delays in comparison to memory for more detailed information at shorter delays.[1]

We could not examine key-relatedness directly, so we investigated this alternative interpretation by examining factors typically indicative of key-

[1]We thank an anonymous reviewer for pointing out this alternative explanation.

relatedness (e.g., number of common notes) that may have varied across Standard–Target and Standard–Related pairs. We found little evidence to encourage a key-relatedness explanation of our original results. For example, people were not inclined to assign lower (more the same) ratings to comparison melodies as a direct function of the number of shared notes with the standard.

What possible musical implications can be drawn from these results? What connections could there be between musical practice and a perceptual system that selectively attends to the contour of melodies at short delays but can discriminate changes in mode and tonality at longer delays. A few examples of common practice in Western music may serve to illustrate some instances in which such a perceptual system would be useful. (This is not to say which determines the other, the perceptual system or musical practice, rather just to illustrate how the two seem to work together.)

At the beginning of a fugue, the different voices enter, one after the other, separated by rather short time intervals. The other voices are not exact transpostions of the first entrance but are closely related versions of the fugue theme which usually retain the *contour* of the theme but change the *intervals,* often by changing key. In order for listeners to follow the fugue they must recognize these entrances as "the same" theme. The fact that our perceptual system seems to attend to the contour of melodies at short time intervals would thus facilitate our ability to make sense of a fugue by considering these slight variations on the fugue theme to be entrances of the same theme.

The ability to discriminate one melody from another similar (same contour) melody may be more important at longer time intervals. For example, in a Sonata-Allegro form, once the themes have been established in the exposition they go through various alterations (including changes of modality and tonality) in the development section. At this point the listener must recognize these changes, not as just further repetitions of the by-now-familiar theme, rather, as variations on it. Later, the "real" theme (in its original key) returns in the recapitulation. Since this really is the theme, it should be recognized as such and not confused with related melodies. The recapitulation section would not be effective in reestablishing the tonic "home base" if the listener did not recognize the return of exactly the original theme.

These musical examples serve to illustrate correspondences between our perceptual system and Western musical practice. Although the present experiments certainly provide no proof of our conjecture for real music listening, they do provide some useful suggestions as to what short- and long-range recognition processes might be operating.[2]

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