

Contour, Interval, and Pitch Recognition in Memory for Melodies

W. J. DOWLING

Department of Psychology, University of California, Los Angeles, California 90024

DIANE S. FUJITANI

Department of Psychology, University of Nebraska, Lincoln, Nebraska 68508

Melodic contour (the sequence of ups and downs in a melody, regardless of interval size) expresses those aspects of a melody that are most essential to manipulation of that melody in various musical structures, e.g., folk tunes and fugues. This is demonstrated by brief analyses of actual music. Two experiments demonstrate the role of melodic contour recognition in memory for melodies. Experiment 1 (2x3 factorial design) involved short-term memory with comparison melodies either transposed or not transposed from the key of the standard. Separate groups had the tasks of distinguishing (a) between same and different melodies; (b) between same melodies and ones with only the same contour; and (c) between melodies with the same contour and different ones. The effects of transposition and task and their interaction were significant (p < 0.001). Untransposed melodies were recognized by their exact pitches, so that tasks (a) and (b) were equally easy. Contour recognition was more important with transposed melodies, so that task (b) was very difficult, and tasks (a) and (c) were easier. Task (c) was about equally difficult under both conditions. Experiment 2 involved recognition of distorted versions of familiar folk tunes having the same length and rhythmic structure. In ascending order of recognizability, these distortions preserved merely the harmonic basis of the melody, the melodic contour, and the contour plus the relative sizes of successive intervals between notes (chi-square = 50.4, p < 0.001).

INTRODUCTION

"Melody is the organization of successive musical sounds in respect of pitch" (Tovey, 1956, p. 91). The pattern of relationships among tones in a melody is what is important, and not their absolutely defined pitches. Hence, a given sequence of tones remains the same melody if each pitch is changed by the same amount. In musical terms, a melody is unchanged by transposition to a new key. Thus, we can represent the melody of Fig. 1, "Three Blind Mice," by stating the interval sizes between successive tones. With interval sizes measured in semitones, "Three Blind Mice" can be represented in sequence as

$$[-2-2+1-2-2]+7[-2-1+3-2-1]. \quad (1)$$

(A semitone is an interval in which the frequency ratio between tones is 1.059/1. The unisons in the second phrase are ignored here.)

The phrases in Expression 1 are bracketed. The second phrase of "Three Blind Mice" ("See how they

run . . .") strikes the listener as very similar to the first phrase. But notice that only the directional relationships among the notes are preserved in the second phrase, not the exact interval sizes of the first phrase. This set of directional relationships between successive tones in a melody is what we are calling its "contour." The contour will be represented by the signs of the intervals. The contour

$$- - + - - \quad (2)$$

is the same in both phrases of Expression 1, while the interval sizes are different. This suggests that preservation of contour through changes in interval size is an important organizational principle in such tunes. This organizational principle is based on the psychological similarity of phrases having the same contour. Memory for the contour is an important aspect of memory for melody, so that tunes like "Three Blind Mice" derive cohesion from the fact that the listener recognizes the contour of the first phrase as he hears the second phrase.

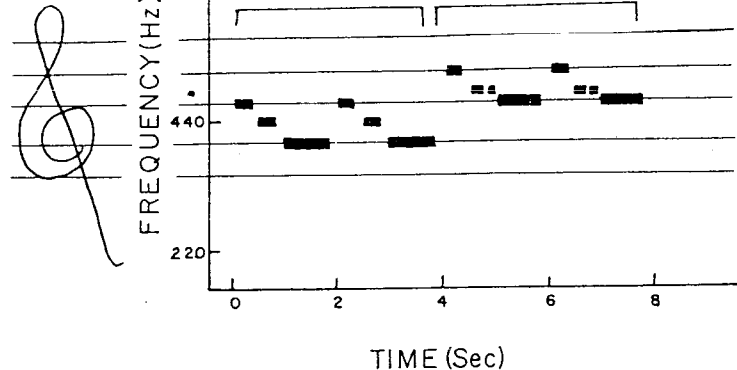
Fig. 1. The brackets in the second phrase analysis...

Nell (1956) of different almost univ. The same used in form is often pu that destroy the fugue in voices after shows the s Bach's Wel duces a me on C (the tr

The second dominant note):

Note that a cted) of the first phrase contour, th unchanged. attention t subject, bur "The answe points that position of adding sever dominant p effected by aesthetic in thumb" (T In the re bracketed) the same re to other m interval si

1. The nursery tune "Three Blind Mice." Brackets indicate phrases. The unisons in the second phrase are treated as single notes in analysis.



Tovey (1956) cites such repetitions of melodic material at different pitches as one of the unifying factors found most universally in the folk music of the world. The same unifying devices found in folk music are used in formal written music as well. Melodic contour is often purposely preserved through manipulations that destroy exact interval sizes. The basic structure of a fugue involves repetition of melodic material in other voices after its presentation in the first voice. Figure 2 shows the start of the C-Minor Fugue from Book I of Bach's *Well-Tempered Clavier*. The first voice introduces a melodic passage (called the subject) starting on C (the tonic note) which can be represented

$$[-1+1-5+1]+4-1+1+2-7\dots \quad (3)$$

The second voice (the answer) starts on G (the dominant note) and can be represented

$$[-1+1-7+3]+4-1+1+2-7\dots \quad (4)$$

Note that the interval sizes in the first phrase (bracketed) of the subject (Expression 3) are changed in the first phrase of the answer (Expression 4), while the contour, the sequence of pluses and minuses, remains unchanged. In his discussion of the fugue, Tovey calls attention to the preservation of the contour of the subject, but not its exact interval sizes in the answer. "The answer is (especially in its first notes and in points that tend to shift the key) not so much a transposition of the subject to the key of the dominant [i.e., adding seven semitones] as an adaptation of it to the dominant part of the scale or vice versa. . . . This is effected by a kind of melodic foreshortening of great aesthetic interest but difficult to reduce to rules of thumb" (Tovey, 1956, p. 37).

In the rest of the fugue in Fig. 2, the contour of the bracketed phrase in Expressions 3 and 4 is used with the same rhythm, but in varied contextual relationships to other material and with various combinations of interval sizes. The following contour-preserving de-

velopments of the first phase of Expression 3 occur in the fugue:

- 1+1-8+1, (5)
- 2+2-8+1, (6)
- 1+1-5+2, (7)
- 2+2-3+5, (8)
- 2+2-3+6. (9)

The exact version in Expression 3 occurs eight times in the whole fugue of 31 measures, and the version in Expression 4 twice. The versions in Expressions 5-9, respectively, occur 3, 6, 6, 2, and 1 time each. Developments of this little motif occupy 68 of the 124 quarter-note beats in the entire piece. This suggests that contour-preserving manipulations of melodic material play a very important part in fugal development. It also suggests that the melodic contour is an important part of what is remembered when one remembers a melody, since to understand the structure of the fugue one must be able to recognize the recurrence of the same melodic contour through changing keys and interval sizes.

Note that the versions shown in Expressions 4-7 of this brief phrase preserve not only the contour of Expression 3, but the relative sizes of temporally adjacent intervals as well. Using mathematical symbols to express the relationships between successive intervals in which the absolute value of the first interval of each pair is smaller than, equal to, or larger than that of the

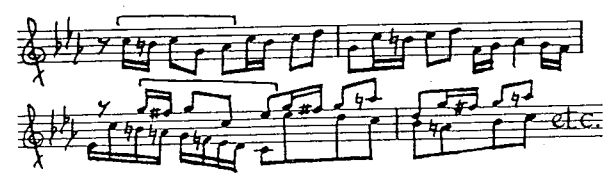


FIG. 2. The beginning of "Fuga II" by J. S. Bach. The first phrase of the subject is bracketed in each appearance.

second interval, Expression 3 can be rewritten as

$$[= < >] < > = < < \dots, \quad (10)$$

since $1=1$, $1<5$, $5>1$, etc. The answer (Expression 4) preserves these same relationships of successive intervals and so is also represented by Expression 10 in its entirety. The bracketed part of Expression 10 represents the phrases given in Expressions 5-7. Only in Expressions 8 and 9 are these relationships violated, and these latter examples account for only three out of the 28 occurrences of the motif. Preserving relative sizes of successive intervals seems important in the development of the phrase. If Expressions 3-9 can be thought of as coding the first-order differences (i.e., differences among notes) in the contour, then Expression 10 codes the second-order differences (differences among the sizes of successive pairs of intervals).

White (1960), in a study of the recognition of distortions of familiar tunes, changed interval sizes in the tunes in some of his distortions, but left relative interval size unchanged. This preservation of relative interval size was accomplished over the whole tune, rather than just in pairs of successive intervals as in the present experiment. White found that preserving relative interval size as well as contour was important to the recognition of distortions of familiar melodies. "Among the transformations altering only melodic pattern, the five which showed the least effect, and which were very similar in the extent to which they impaired recognizability, are distinguished by the fact that they left the relative sizes of the intervals unchanged as well as the sequence of ups and downs" (White, 1960, p. 103).

Music constructed according to principles like those just outlined is not unique to the baroque period in Western music, nor to forms such as the fugue. Reti (1951), for example, presents analyses of nineteenth and twentieth century works that make use of melodic contour invariance as a basic design principle. Nor are these principles unique to Western musical style—Harwood and Dowling (1970), Abrahams and Foss (1968), and Nettle (1956) argue that analogous principles for manipulation of musical materials operate in most if not all cultures of the world.

I. EXPERIMENT 1

The two experiments described in this paper explore ways in which melodic contour, in the sense used here, functions in memory for musical stimuli. Experiment 1 involves short-term recognition memory for brief melodies. Thus it is an experimental abstraction of the actual situation in which someone listens to the opening phrases of the fugue in Fig. 2. The listener hears and stores the subject (Expression 3) and then recognizes the answer (Expression 4) as containing the same melodic contour as the subject. [It is irrelevant to this argument whether the listener explicitly makes the

judgment "Expression 4 is like Expression 3." What we are claiming is that if explicit judgments are made such as "Expression 4 is like Expression 3," these judgments demonstrate an understanding of the musical structure, whereas judgments such as "Oh, how delightful" do not (cf. Wittgenstein, 1966, pp. 6 ff). It is in this sense that this experiment is relevant to the perception of actual music.] In Expt. 1 three groups of subjects were given different tasks. One group heard a standard melody (different for each trial) and after a 2-sec delay heard either an exactly identical comparison melody or a random collection of notes. The second group heard the standard and then either the same melody again, or a comparison melody with different notes and interval sizes but the same contour (ups and downs). These two groups were told to judge whether the comparison melody was identical to the standard or not. The third group heard the standard melody and then either a comparison with the same contour as the standard but different notes and intervals, or a random collection of notes. This third group was told to judge whether the comparison had the same contour as the standard.

A previous study (Dowling and Fujitani, 1969) indicated that when the comparison melody began on the same note as the standard, subjects tended to confuse same-contour melodies with identical melodies, but not to any great extent. There are three possible ways a listener can approach the task of recognizing the identical melody when both standard and comparison begin on the same note: (1) by recognizing the individual pitches in order; (2) by recognizing the pitch relationships in order (the contour plus the interval sizes); or (3) by merely recognizing the contour. [Between strategies (2) and (3) there lies a continuum of progressively less and less information stored about the interval sizes. The case discussed above of relative sizes of successive intervals falls in the middle of this continuum.] However, if the comparison begins on a different note from the standard (i.e., is transposed to another key, as the answer in Fig. 2), then only approaches (2) and (3) are applicable to recognizing the comparison melody, since even when the identical melody is repeated, *all* of its pitches have been changed. Therefore, in Expt. 1 half of each of the three groups did their task with transposed comparison melodies, the other half with comparisons beginning on the same note as the standard. The extent to which recognition of absolute pitches functions in recognition of untransposed melodies is seen in the degree to which performance in distinguishing identical from same-contour comparison melodies decreases when transposed comparison melodies are used.

A. Method

Forty-nine UCLA undergraduates served in six separate group sessions for class credit in Introductory

Psychology. Because some of the group unweighted mean cell sizes. Two subjects were so. Subjects were so. no reference to t. ment. Subjects I. training (including playing an instrument) taking courses in positively skewed. ples drawn from. series of experim. A Hewlett-Packard stimuli which were subjects over a large high-quality tape. ment. The tones. through an eight-. Experiment 1 was a 2X3 factorial. posed versus trans. tasks: (a) identical (b) identical ver (c) same-contour. group was given their particular trans. randomly ordered block containing the computer generated melody starting notes were selected chain in which they were as follows: (tones) = $P(\pm 3)$ were equally probable of six notes per sec and time intervals five-note melody standard melody. the computer generated the type of comparison condition and the were merely repeated comparison melodies. way as the standard contour comparison as the standard was but with different distribution of pitch with untransposed began on middle (starting note was from the 14 note semitones higher. comparison there sec warning time

Psychology. Because of failures of subjects to show up in some of the groups, the data were analyzed with an unweighted means analysis of variance for unequal cell sizes. Two subjects were discarded for not following directions in filling in their response cards properly. Subjects were solicited by a sign-up sheet which made no reference to the musical orientation of the experiment. Subjects had a mean of 2.17 years of musical training (including studying an instrument or voice or playing an instrument in an ensemble, but excluding taking courses in music or singing in a choir) with a positively skewed distribution, which is typical of samples drawn from this population in this way over a long series of experiments.

A Hewlett-Packard 2116B computer generated the stimuli which were recorded and presented to the subjects over a loudspeaker at comfortable levels with high-quality tape recording and reproduction equipment. The tones consisted of sawtooth waves produced through an eight-bit digital-to-analog converter.

Experiment 1 involved short-term memory and used a 2×3 factorial design with two conditions (untransposed versus transposed comparison melody) and three tasks: (a) identical versus random comparison melody; (b) identical versus same-contour comparison; and (c) same-contour versus random comparison. Each group was given 60 trials, 30 of each type involved in their particular task. The trials were arranged in five randomly ordered blocks of 12 trials each, with each block containing six trials of each type. For each trial the computer generated a different five-note standard melody starting on middle C (262 Hz). Succeeding notes were selected according to a second-order Markov chain in which the intervals between successive notes were as follows: $P(\pm 1 \text{ semitone}) = 0.50$; $P(\pm 2 \text{ semitones}) = P(\pm 3 \text{ semitones}) = 0.25$. Up and down intervals were equally probable. Melodies were produced at the rate of six notes per second, with note durations of 0.16 sec and time intervals between notes of 0.01 sec. The five-note melody thus had a duration of 0.84 sec. This standard melody was followed by a 2-sec pause. Then the computer generated a five-note comparison melody, the type of comparison depending on the experimental condition and the trial. Identical comparison melodies were merely repetitions of the standard. Random comparison melodies were generated in exactly the same way as the standard, but with changed contour. Same-contour comparisons were generated in the same way as the standard with the same contour as the standard, but with different intervals chosen from the same distribution of possible intervals. In those conditions with untransposed comparison melodies the comparison began on middle C. In transposed conditions a different starting note was selected for the comparison at random from the 14 notes of a chromatic scale, one to seven semitones higher or lower than middle C. Following the comparison there was a 5-sec response interval. A 0.2-sec warning time (4250 Hz) marked the close of the

TABLE I. Areas under the memory operating characteristics for Expt. 1, comparing the recognition of transposed and untransposed melodies which were the same as or had the same contour as the standard. (Chance performance is 0.50.)

Condition	Task		
	Same vs contour	Contour vs random	Same vs random
Untransposed	0.91	0.74	0.98
Transposed	0.53	0.85	0.89

response interval, and 1.8 sec elapsed between the end of the warning signal and the start of the next trial.

Subjects responded using the four-category scale: "Sure Same," "Same," "Different," and "Sure Different." Groups with tasks (a) and (b) were instructed to respond "Same" only if the comparison melody was exactly the same as the standard. Groups with task (c) were instructed to respond "Same" only if the comparison melody had the same contour, the same sequence of ups and downs, as the standard. Subjects were told to respond on each trial even if they had to guess, and to trust their first impressions. The entire task was preceded by an explanation of the task and the response categories, a description of the stimuli, and three examples of each of the two types of trials encountered in the particular condition. Subjects' questions were repeatedly invited, and with tasks (b) and (c), careful explanations were given of the definition of contour being used. After the experiment was completed the subjects were asked to write down what kinds of musical training they had had, for how long, and at what ages.

Subjects marked their responses on IBM cards which were scored by the computer. The scoring program used the four-category confidence judgments to determine a memory operating characteristic for each subject. (See Norman and Wickelgren, 1965, for a detailed description of a similar procedure.) Basically, memory operating characteristics are determined by plotting the cumulative probabilities of using less and less strict response categories on "same comparison" trials (the hit rates) against the corresponding cumulative probabilities on "different comparison" trials (the false-alarm rates). Areas under the memory operating characteristic were computed for each subject as estimates of the equivalent probability of correct response in an unbiased two-alternative choice procedure. Chance performance is thus 0.50. Subsequent statistical analyses dealt with these areas under the memory operating characteristics.

B. Results and Discussion

Table I shows the mean areas under the memory operating characteristics for the six groups. The effects of transposition [$F(1,43) = 18.34$, $p < 0.001$], task [$F(2,43) = 19.66$, $p < 0.001$], and their interaction

TABLE II. Correlations between performance on the various tasks of Expt. 1 and years of musical training.

Condition	Task		
	Same vs contour	Contour vs random	Same vs random
Untransposed	0.37	-0.41	0.55
Transposed	0.23	-0.39	0.27

[$F(2,43)=25.26$, $p<0.001$] were all significant by an unweighted means analysis of variance. The task was generally harder with transposed comparison melodies. Across both conditions, the easiest task was distinguishing same from random comparisons.

We attribute the interaction to differences in the way the tasks were performed with and without transposition. Without transposition, same comparisons can be distinguished from either same-contour or random comparisons because only the same comparisons contain the same notes as the standard. Performance in recognizing same comparisons was better than in recognizing same-contour comparisons in the untransposed condition, and so we conclude that subjects were mainly using recognition of pitches in solving the untransposed tasks.

With transposition, contour seems to provide the basis for recognition. Subjects distinguished those comparisons (both same and same-contour) which shared the same contour with the standard from random comparisons with about equal proficiency. However, distinguishing between same and same-contour comparisons with transposition was not appreciably better than chance [$t=1.51$, degrees of freedom (df)=6, $p<0.10$].

It remains to be explained why performance in recognizing the same-contour (versus random) comparisons would be worse without transposition than with ($t=2.42$, df=15, $p<0.05$). This may be due to a misunderstanding of the task. Subjects may have tried to recognize only same comparisons in the same-contour versus random tasks. With transposition, same and same-contour comparisons were themselves confused, and such a misunderstanding could have little deleterious effect. However, without transposition, same and same-contour comparisons were quite distinguishable. Therefore, if subjects were only responding "same" when they thought they heard a same comparison (rather than the same-contour comparison they were instructed to recognize) this would have led to poorer performance. If this explanation is correct, we would have found lower hit rates in the untransposed than in the transposed condition, since subjects would rarely have heard comparisons they would have been willing to call "same" in the former case. Mean hit rates at the three criteria for the untransposed same-contour versus random condition were 0.36, 0.68, and 0.83. Corresponding mean hit rates in the transposed

condition were 0.63, 0.83, and 0.95. Differences between corresponding pairs are all significant by a Mann-Whitney U test ($p<0.025$).

Recognition seems not to be dependent on recognition of exact interval sizes. This is shown by the fact that discrimination between transposed same and same-contour comparisons, which could be done on the basis of interval size, was not good. Moreover, performance on the transposed same versus random task was not appreciably better than on the same-contour versus random task. It is clear that the degree to which same and same-contour melodies were confused in the transposed condition was in part a function of the severe restrictions on possible interval sizes employed. Loosening these restrictions would make same-contour comparisons more different from same ones and improve performance in that condition.

Table II shows correlation coefficients between years of musical training and performance on the various tasks of the experiment. These correlations are quite low in absolute value, the largest being 0.55. The differences among these correlations are not significant by an analysis of covariance on a set of data pared down to equal cell sizes by random discarding of subjects [$F(1,23)=1.55$]. Note that all the correlations of Table II are in the range 0.27-0.55 except those for the task of distinguishing same-contour from random comparisons. The two latter correlations are negative: -0.41 and -0.39. This result suggests that the precision of pitch and interval judgment encouraged by musical training is of little help in recognizing melodic contour.

II. EXPERIMENT 2

Experiment 2 tested the recognition of distorted versions of familiar folk tunes. These distortions preserved (a) both the contour and relative sizes of successive intervals, (b) merely the contour, and (c) merely the first note of each measure with other notes changed so as to destroy the contour while preserving the implicit harmonic basis of the melodies. Comparison of performance on distortions (a) and (b) was intended to test the relative importance of relationships between successive interval sizes (along the lines developed in the introduction) in contour recognition. Experiment 2 dealt with long-term memory inasmuch as the tunes to be recognized were learned by subjects long prior to the experiment, most likely in their childhood. Experiment 2 was most comparable to the transposed conditions of Expt. 1, since with long time delays most subjects cannot recognize absolute pitches. [Wickelgren's (1969) subjects' performance approached chance level in recognizing single pitches with only 180-sec delay.] Recognition of a familiar melody is based on a succession of intervals (like those coded in Expression 1) for persons without the ability for absolute identification of pitches ("absolute pitch"). Experiment 2

tested the degree to which formation stored above contour and interval sizes.

Experiment 2 differs from Experiment 1 in several important respects. First, all melodies were played with the same contour to isolate the effects of interval size (in the sense of the contour, as opens the paper). While 10 melodies on the basis of interval sizes above chance. Therefore, from our experiment, rhythmic patterns. Since the distortions, we used interval sizes that were found to be characteristic of the type we used, but also the history of Western music in numerous non-Western cultures. This distribution is given by transformations, which distort relative interval sizes to one semitone distribution, and that poor performance here importance of this distribution in performance. White under which only rhythmic (33% correct) and undistorted was preserved with intervals the same distribution of tune (52% correct). The distortions in the Expt. sizes from the distribution

A.

Twenty-eight UCLA students in separate sessions and in the same population and in the same Stimuli were played frequency range beginning

TABLE III. Distribution of interval sizes of familiar melodies (roughly characteristic of songs in Merriam, 1964).

Interval size (semitones)
1
2
3
4
5
6
7

between Mann-

a recog- the fact d same- he basis orman- ce was not versus ch same e trans- e severe employed. contour improve

en years various re quite 5. The nificant d down subjects ions of for the random gative: he pre- guded by melodic

istorted ns pre- nd suc- nd (c) r notes serving parison ntended between d in the ment 2 e tunes prior to Experi- ed con- s most Wickel- chance 180-sec ed on a ression dentifi- ment 2

tested the degree to which persons can use the information stored about a melody to recognize its contour and interval sizes in a distorted version.

Experiment 2 differs from White's (1960) study in two important respects. First, we used melodies which could all be played with the same rhythmic pattern in order to isolate the effects of strictly melodic recognition (in the sense of the quote from Tovey, 1956, which opens the paper). White found that recognition of his 10 melodies on the basis of rhythm alone was still well above chance. Therefore we eliminated this set of cues from our experiment by using tunes with identical rhythmic patterns. Second, in replacing intervals in the distortions, we sampled from a distribution of interval sizes that approximates the distribution found to be characteristic not only of folk tunes of the type we used, but also of melodies throughout the history of Western music (Fucks, 1962) and of songs in numerous non-Western cultures (Merriam, 1964). This distribution is given in Table III. White's (1960) transformations, which preserved contour while distorting relative interval size (e.g., reducing all interval sizes to one semitone), departed severely from this distribution, and that may account for the relatively poor performance he obtained in those cases. The importance of this distribution is seen in the difference in performance White obtained between conditions under which only rhythmic information was preserved (33% correct) and under which rhythmic information was preserved with interval sizes drawn randomly from the same distribution of interval sizes in the particular tune (52% correct). Therefore the contour-preserving distortions in the Expt. 2 sample substituted interval sizes from the distribution in Table III.

A. Method

Twenty-eight UCLA undergraduates served in three separate sessions and were sampled from the same population and in the same manner as in Expt. 1.

Stimuli were played on a soprano recorder in the frequency range beginning on the C above middle C

TABLE III. Distribution of interval sizes used in distorted versions of familiar melodies in Expt. 2. This distribution is roughly characteristic of songs in numerous cultures (Fucks, 1962; Merriam, 1964).

Interval size (semitones)	Proportion of occurrence
1	0.06
2	0.39
3	0.26
4	0.17
5	0.06
6	0.03
7	0.03



FIG. 3. The first two phrases of each of the undistorted versions of melodies used in Expt. 2: (a) "Twinkle, Twinkle, Little Star"; (b) "Good King Wenceslaus"; (c) "Yankee Doodle"; (d) "Oh Susanna"; and (e) "Auld Lang Syne."

and ascending two octaves (to 2093 Hz). Every effort was made to maintain the same tempo in all stimuli. Stimuli were tape recorded and played to the subjects over loudspeakers as in Expt. 1.

Subjects were told first to identify recordings of five undistorted familiar melodies. These melodies were all played in a standard repeated rhythmic pattern, with passing tones and "pickup" notes (e.g., the first note of "Auld Lang Syne") eliminated. The first two phrases of each of the melodies are shown in Fig. 3. The melodies we used were "Twinkle, Twinkle, Little Star," "Good King Wenceslaus," "Yankee Doodle," "Oh Susanna," and "Auld Lang Syne." There were eight two-measure phrases in each of the melodies. As in White's (1960) experiment, subjects were given a list of these melodies from which to identify them. Subjects wrote down the name of the melody after each presentation. Two subjects made errors in identifying one melody each. The experimenter corrected these errors verbally, and in each case the subject indicated that he then knew which melody was which.

Subjects were next told that they would hear a series of distorted versions of these melodies and that they should identify the melody in each case. The distorted versions all used the same rhythmic pattern as the originals. Unisons in the original remained unisons in the distortion, and distorted versions were not allowed to go beyond the two-octave range limitation. Distortions, which were presented in random order, were of three types: (a) The distorted version preserved both the contour and the relative sizes of successive pairs of intervals of the original melody (as defined in the discussion of Expression 10 above). Intervals substituted into the distorted version preserved the direction of the intervals in the original, but had sizes drawn from the distribution in Table III. These intervals were drawn with the restrictions that they not equal the original intervals in size and that the relationships

TABLE IV. Proportions of correct recognitions of five familiar folk tunes and their distortions in Expt. 2. The first three proportions are based on 140 observations, the last on 112 observations.

Undistorted	Contour plus relative interval size	Contour only	First beats of measures
0.99	0.66	0.59	0.28

between the sizes of successive intervals in the original be preserved. (b) The distorted version preserved only the contour of the original. The substitute intervals were selected as for distortion (a), but without the restriction on relative interval size. (c) The distorted version preserved only the first notes of each measure and the implicit harmony of the original. Substitutions were made for notes on the three remaining beats of each measure. The directions of intervals were selected at random, and then the note in the chord implicitly underlying the beat which was closest to the preceding note going in that direction was chosen, provided it was different from the corresponding note in the original. (Only tonic, dominant, and subdominant triads were used.) Because of a technical accident, distortion (c) of "Oh Susanna" was destroyed, so that there were 14 trials in this part of the experiment. After each trial, subjects were given as much time as they desired to respond and were told to make their best guess as to the identity of the distorted melody, even if they could not recognize it.

B. Results and Discussion

Table IV shows the proportions of correct responses for each of the four types of trials. A chi-square test on the numbers of correct recognitions of each type of distortion is significant (chi-square=50.4, $p < 0.001$). Recognition of the original versions of the tunes was almost perfect. Recognition of the beat plus implicit-harmony-preserving distortions was not appreciably better than chance. (Chance level if subjects were sampling with replacement from the list of five tunes would be 0.20. The degree to which subjects sampled without replacement would determine how much higher than 0.20 the actual chance level was.) It should be noted that this poor performance with distortions preserving the implicit harmony was obtained with melodies that differ considerably in underlying harmonic structure. A comparison of the harmonies underlying all possible pairs of tunes shows that on the 44 beats free to differ from each other (excluding the first two and last two) these tunes share harmonies on a mean of 22.6 beats, with a range of 14 to 33 beats.

Performance in recognizing the contour plus relative interval-size-preserving distortions was slightly better than in recognizing the contour-preserving distortions.

Fourteen subjects did better with contour plus interval size, and six did worse, which by a sign test approaches significance ($p = 0.058$).

As in Expt. 1, melodic contour was an important factor in melody recognition, but it is clear that information about exact interval sizes was considerably more important in recognition of familiar melodies than in short-term memory for the stimuli of Expt. 1. This could be attributed to two possible factors. First, memory for exact interval sizes may depend on extensive learning of specific melodies, and thus the effect would appear in long-term memory for well-learned melodies, but not in the short-term memory conditions of Expt. 1. Second, the range of possible changes in interval sizes between same and same-contour stimuli in Expt. 1 was far smaller than in Expt. 2. This greater similarity between sets of stimuli may well have led to poorer discrimination in Expt. 1.

III. SUMMARY

If rhythm is ignored, a melody can be described as a series of intervals between successive pitches. This series of intervals can be broken down into the melodic contour (given by the signs of the intervals) and the series of interval sizes. Two experiments explored the role of melodic contour in memory for melodies. Experiment 1 showed that in short-term memory for brief melodies, subjects solved the task of recognizing same comparison melodies by pitch recognition when this was possible, i.e., when these identical comparison melodies were not transposed and contained the same notes as the standard. In this case, identical comparisons were relatively easy to distinguish from both random and same-contour comparisons. Melodic contour became much more important when comparison melodies were transposed. When identical comparison melodies no longer consisted of the same notes as the standard but were exact transpositions of the standard, they were almost completely confused with same-contour comparisons. Performance in recognizing just the contour (ups and downs) of the standard in the comparison melody was worse with untransposed than with transposed comparisons. This was attributed to subjects' misunderstanding of the task.

Experiment 2, on long-term memory, carried the analysis of the notion that melodies consist of a contour plus interval sizes, one step farther, to include relative sizes of successive intervals. Subjects were asked to recognize distorted versions of familiar folk tunes. We found that performance in recognizing the contour was far better than chance, and that distortions preserving both contour and relative sizes of successive intervals were slightly easier to recognize than ones which merely preserved the contour. Recognition of undistorted versions was almost perfect, so it appears that subjects remember more about tunes they recognize than just the contour and relative interval sizes. Subjects appear

have good long-term memory for the context of familiar tunes.

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