SOME TONAL DETERMINANTS OF MELODIC MEMORY[1]

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The training of the ear in melodic memory forms an essential part of the music training of children. The following test was made, as a preliminary survey, in order to learn what causes the difficulties in melodic memory which are commonly met with in classroom situations.

A series of short melodic phrases was given to a group of classes, relatively unselected as to age, intelligence, and amount of training. All were students of music, familiar with the procedure of this test. The examples were played on the piano, once each, and the pupils, immediately after each example, wrote on printed forms what they heard. It is thus a test in immediate recall. The phrases were played at a uniformly slow tempo and the first tone was given in order to eliminate the need for so-called "absolute pitch."

Five-toned examples were used because previous experimentation had proved this number of tones to be sufficiently short to permit some perfect answers and sufficiently long to bring out individual differences and especially the determinants which were sought. The use of short melodic phrases with uniformly long notes is advisable in order to reduce to a minimum harmonic and rhythmic complications. Many studies on the psychology of melody have assigned to melody, attributes that are really harmonic or rhythmic contributions. It is for this reason that the results obtained in this test cannot be applied *in toto* to full phrases as we find them in musical literature. But whatever modification will be necessary is the result of harmonic and rhythmic determinants, not melodic.

Figure 4 gives the complete series with the error distributions for each tone, each dot representing one error. A study of these reveals the operation of certain basic factors which I have called determinants. (For a detailed treatment of the fundamental attributes of melody, the reader is referred to the author's study: On the Melodic Relativity of Tones. *Psychological Monographs,* Vol. XXXV, No. 1).

Repetition

The pitch series, upon which all melody is necessarily based, may be considered a one-dimensional series, motion in which, for our purposes here, may be described as up or down. Repetition of a tone, therefore, means zero motion. Since pitch-motion is the most fundamental aspect of melody, the discrimination between motion and non-motion becomes the most fundamental discrimination. And, in turn, tone-repetition should become the most easily recognized attribute of melody.

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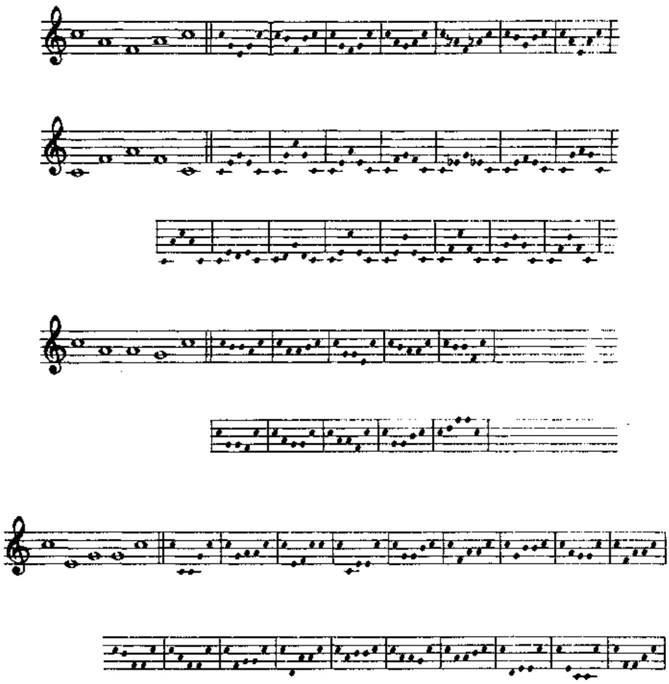


Figure 1. Variants of melodic phrases containing an element of direct repetition.

We can test for this by using melodic phrases containing an element of direct repetition: Exs. 2, 8, 12, 14; and, in modified form, Exs. 1, 6, 10, 15, 16, 19. In the examples containing immediate repetition, this element was missed only six times in 724, an error of less than one per cent frequency. Conversely, in 2064 examples not containing direct repetition, this was introduced by pupils only four times, an error of approximately one-fifth of one per cent.

Further proof of the fact that we are here dealing with the most fundamental aspect of melody, is given by the frequency with which the element of repetition is retained in misplaced position, at times with a radical alteration of melodic outline or pitch-contour.

Figure 1 illustrates some variants found for the given examples. In each case a repeated tone is present in spite of errors in pitch-range of a seventh. In one version of Ex. 12, the entire melody is inverted and the intervals changed, yet the element of repetition is retained. Even the presence of an intermediate one (Ex. 10) does not eliminate the recognition and memory of repetition. Variants similar to those given for Exs. 10 and 16, Fig. 1, were found equally frequently for all other examples containing interrupted repetition: Exs. 1, 6, 15, 19 (see Fig. 4).

The frequency with which repetition was retained in the most diverse tonal environments, and its absolute frequency when compared to the frequencies of errors yet to be considered, make tone-repetition or pitch-repetition the first determinant of melodic memory.

Pitch-Direction

Whereas, in tone-repetition, the choice was simply between sameness and difference, or motion and non-motion, pitch-direction, the next determinant, forces a choice between ascent and descent, or a choice of direction of motion.

If we examine the examples containing only one pitch-direction: Fig. 4, Exs. 3, 5, 7, 11, 13, 17, we find that a change in direction was added only twenty-two times in 691 examples, an error of three percent frequency. No instance was found in which an entirely ascending series or an entirely descending series was reversed. This would not be the case if pitch-direction were not a fundamental attribute of melody.

If we count only the first interval, pitch-direction was reversed in only four cases out of 2580, although many errors in the size of the interval occurred.

The most interesting proof, however, of the fundamentality of pitch-direction is given by the frequency with which variations from the model occur, all of which retain the proper ascent-descent relationships. Some of these have already been given in Fig. 1. A few others are given in Fig. 2. Here, in spite of pitch-errors ranging from a second to a sixth, the pitch-contour remains correct: Ascent remains ascent, descent remains descent.

As we increase the number of changes in pitch-direction in an example, we break this unity, complicate the pitch-outline, and therefore make the recognition and retention of each change more difficult. In examples containing one pitch-change this was missed in a given class-group in one and seven-tenth per cent cases; in examples containing two changes, twenty-two per cent; in examples containing three changes, thirty-two per cent. For all classes tested and all examples, the average retention of all phases of pitch-contour was approximately seventy-five per cent. The increase in difficulty is much greater between one and two changes in pitch-direction than between two and three changes. That is to say, a direction division of a phrase into two parts offers little or no difficulty; a division into three parts introduces considerable difficulty, even in a short phrase of five tones.

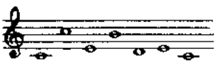
Figure 2. Variants of melodic phrases containing pitch errors but correct pitch contour.

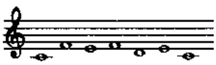
The extent to which the factor of symmetry affects recognition and retention of changes in pitch-direction cannot be determined from the data here used, since we cannot eliminate the element of repetition. The symmetrical examples—those in which the descending part is symmetrical to the ascending—Exs. 1, 6, 10, 15, 16, 19, all necessarily contain repetition. Speaking generally and very guardedly, however, it seems that such examples are somewhat easier to retain than those in which the change in pitch-direction is assymetrical: C-E-F-G-C or C^1-G-A-B-C^1.

The recognition and retention of changes in pitch-direction are further influenced by the absolute value or amount of change and also by the relative value in terms of the tonal environment. Changes involving only step-wise progression C-D-C or C^1-B-C^1 are, other things equal, less notices than changes involving skips: C-F-C- or C^1-G-C^1; and these, in turn are less noticed than wider skips: C-B-C- or C^1-D-C^1.

In Ex. 4, the change at the second tone was missed twice, that on the third tone, eleven times; in Ex. 9, that at F, five times, that at D, four times; in Ex. 18, that at F, six times, that at A, thirteen; in Ex. 20, that at E, four times, that at B, eleven. The frequency of this error thus varies with the size of the intervals at the point of change.

In five-toned examples, the functioning of the relative value of pitch-change is very limited on account of the shortness of the examples. Slight indications are found in Ex. 4 where the ratio of error at E, compared to that at G, is higher than for other less pronounced progressions. Moreover, tests made with seven-toned examples showed a more marked difference. In the following





the ratio which the change at D in the second example, bears to that at D in the first example, in frequency of being noticed, was approximately seven to one. The step-wise difference in the first example is "dwarfed" by the size of the preceding intervals.

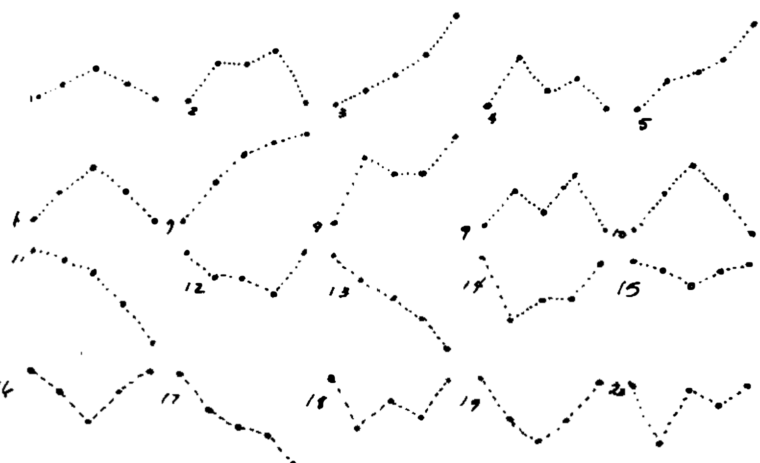


Figure 3. Visual representation of pitch contours for complete series of 5-toned melodic phrases.

Both the absolute and relative values of such pitch-changes can best be seen by projecting visually the examples we have used, taking the up-down aspect of the pitch series for the vertical dimension and temporal order as the horizontal dimension. This is done in Fig. 3. The agreement between the basic pitch attributes and those of such a visual projection is so marked, that a study of Fig. 3 will at once bring to light most of the salient features of the melodies we have been studying. What "stands out" for the eye in the outlines of Fig. 3, "stands out" also for the ear when the melodies are played; what escapes the eye at first glance also escapes the ear at first hearing. Accordingly, pupils react to the major outlines of a melody first, later on, to the details. (The two senses, of course, have also salient points of difference.)

Finally, we must consider ascent *versus* descent. On account of the fundamentally ascending basis of our tonal system (scales and chords are constructed ascendingly) we may expect to find the ascending examples (1 to 10) somewhat easier than the descending (11 to 20). The actual percentile error distribution for all was forty-five per cent for ascending, fifty-five per cent for descending examples. For single intervals (first interval only) the ascending third, Ex. 5, was missed twenty-seven times, the descending third, Ex. 13, was missed forty-two; the ascending fifth, Ex. 4, forty-eight times, the descending fifth, Ex. 18, seventy-one times. Although other determinants in some examples contribute to this distribution, it occurs with sufficient constancy and in sufficient degree to make descending intervals generally somewhat more difficult than ascending intervals.

The frequency of error in pitch-direction or melodic outline points to this as the second determinant of melodic memory.

Conjunct-Disjunct Motion

The next most fundamental distinction made in the raw material of our tonal system is the division into step-wise (conjunct) and skip-wise (disjunct) progression. Consequently, we may expect to find this distinction one of the determinants of melodic reaction.

For proof we need to look no further than Ex. 1 and Ex. 15. They are the only very easy examples of the entire series. The total errors for both examples was twenty-seven; the total errors for the next easiest example alone was thirty-four. The fundamentality of diatonic (stepwise) progression is shown further in the distributions for Ex. 3 and Ex. 11, in which the errors are concentrated on the skip (disjunctive) parts of the melody. It functions also when such examples as Ex. 11 are heard as C^1-B-A-G-F.

The number of times that the step of a second was incorrectly written was approximately half that for the lowest error frequency between two skips. If we array all examples of Fig. 4, on a scale from easy to difficult, we find a marked preponderance of diatonic progression for the easiest, and a gradual reduction of this as we increase the difficulty, until, for the two most difficult examples only a single step-wise interval remains, all others being skips.

We have, then, as the third determinant of melodic reaction, step-wise progression, or conjunct motion as against skip-wise or disjunct motion.

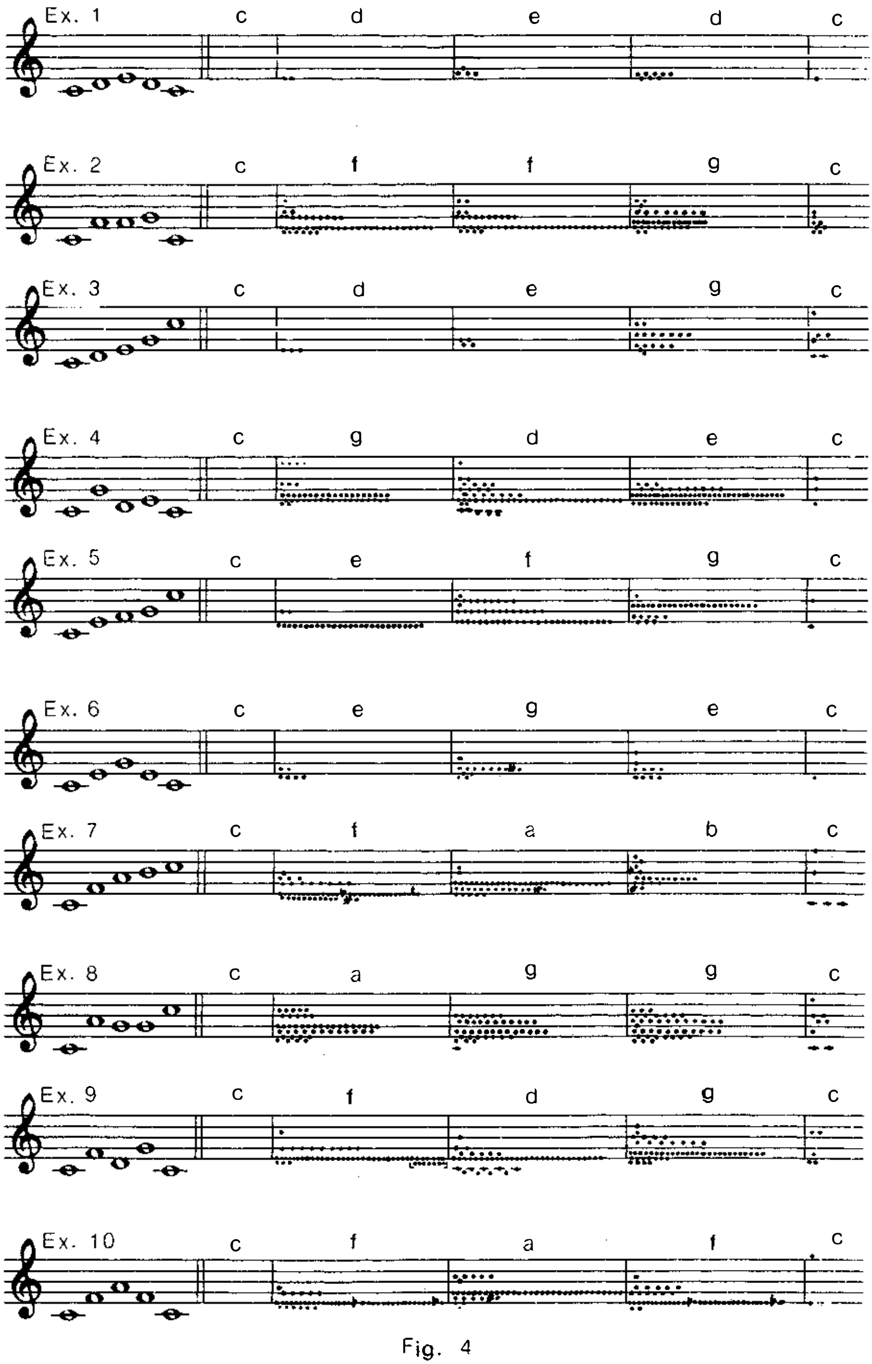


Figure 4. Notation for complete series of 5-toned melodic phrases with error distributions for each tone, each dot representing one error.

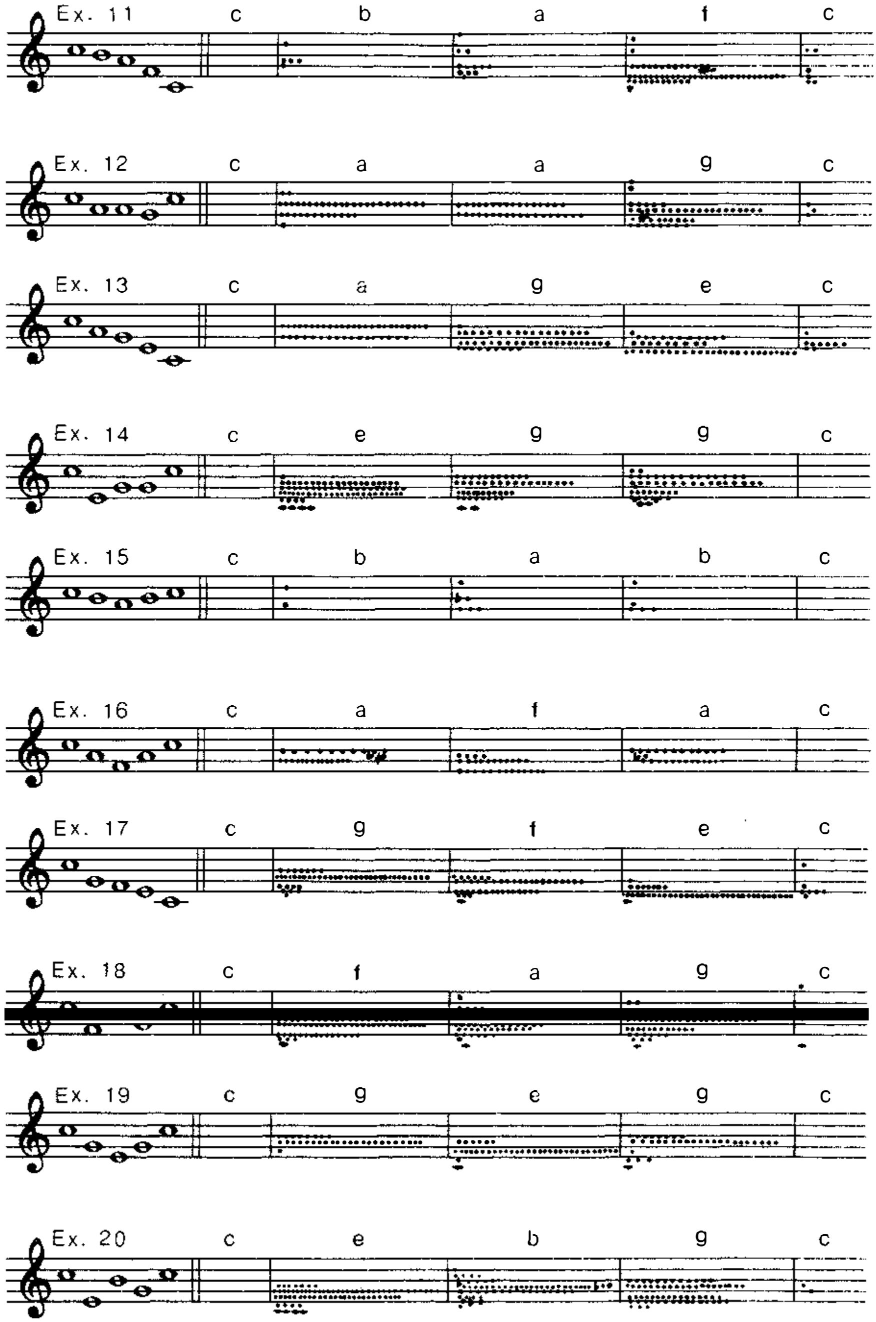


Fig. 4 (continued)

Degree

The determinant fourth in fundamentality is the degree-of-skip. That it is much less basic than any of the preceding three determinants is shown in the high frequency of errors made in the degree-of-skip discrimination. Whereas a second is seldom heard as a third or any other skip, a third is frequently heard as a fourth or fifth, and other wide intervals are heard incorrectly even more often.

The frequency of the degree-of-skip error varies directly with the pitch distance of the given interval. A fifth is heard more frequently as a sixth or a fourth (neighboring intervals) than as a seventh or a third. In the examples here used, ascending and descending errors of one scale degree totalled eleven per cent; of two scale degrees four per cent; of three, one per cent; and of four, four-tenths of one per cent. That is to say, as we increase the distance from the given interval, we decrease the frequency of error.

This applies, however, to melodic intervals only. If the two tones of an interval be given simultaneously (harmonically), the fusional aspect (concordancy and discordancy) modifies the melodic distribution. (For a brief discussion of the harmonic aspect see the author's Notes on Interval Discrimination. *Peabody Bulletin*, May, 1932.) It is the playing over of this harmonic aspect into the melodic field that accounts for some of the octave transpositions seen in Fig. 4, especially for the final tones.

We find, further, that narrow intervals have a smaller range of error than wide intervals: Errors for thirds varied from seconds to fifths; for fourths from seconds to sevenths; for fifths and sixths from seconds to octaves. This brings to light the characteristic difficulty of wide intervals. Training, accordingly, should proceed from narrow skips to wide. If the problem be discrimination between melodic intervals, the procedure should be from wide pitch differences between each pair, to small differences.

In the light of these results, the fourth determinant of melodic reaction may be considered pitch-distance, or the degree of disjunct-motion in either pitch-direction.

Miscellaneous Determinants

Order

An important element of any group of linear items is order. It accounts for the typical reversal of letters in word-spelling and that of figures in number-spelling. In tone-spelling it would likewise show a reversal of tones: C-F-D-E-C might become C-F-E-D-C. Such a reversal, however, involves two changes in pitch-direction and this, as a major determinant, tends to emphasize the reversal. Accordingly, such reversals are not frequently encountered, so long as auditory memory is allowed to function.

Reversals that do not involve changes in pitch-direction occur more frequently. In such cases the reversal concerns intervals. If C-E-F-A-C' is reproduced as C-E-G-A-C', the interval of a second and that of a third have been reversed. No change in pitch-direction takes place and since the degree-of-skip determinant is much less basic than pitch-direction, interval reversal is more frequently found.

The frequency with which errors of tone-reversal occur compared with that of tone-substitution (the introduction of a pitch not present in the given example) is so small that it scarcely functions as a determinant. For the entire twenty examples it was slightly more than one per cent. If we consider interval reversal, the ratio would be considerably higher. However, the fact that interval reversal occurs, does not necessarily mean that it caused the error. In examples of single ascent or descent, such as Exs. 3, 5, 7, 11, 13, 17, *any* attempt to arrange the five tones within an octave, would result in such a chance change of interval, of which the pupil need not be aware at all.

The relatively infrequency of order-error holds for auditory retention. If the pupil retains merely the letter-name order, without its melodic equivalent in sound, the reaction becomes exactly similar to the number series, and the frequency of reversal of items increases.

Since the tones of a melody are necessarily successive, not simultaneous, our reactions to the first and the last parts will differ. When the first tone is given, the second tone, other things equal, is easier than the third tone, and this is easier than the fourth. Thus in Ex. 3 the diatonic progression C-D-E, which we have found to be easy, occurs first. In Ex. 7, the similar diatonic progression, A-B-C^1, occurs last. The distribution of errors is much greater for Ex. 7 than Ex. 3, a difference determined primarily, but not entirely, by the position of the group in the phrase as a whole. Using the three examples: C-D-E-G-C^1; C-E-F-G-C^1; C-F-A-B-C^1, which have the diatonic progression respectively at the beginning, in the middle, and at the end, the error distribution for three classes was 7, 57, 50, showing the first to be much easier than the other two, and the position at the end to be slightly easier than that in the middle.

The fact that pitch-outline is a major determinant means that when a single tone is heard incorrectly, the succeeding tone or tones will be incorrect in a great many cases. When C-F-G-G-C is heard C-G-A-A-D, the errors on tones 3, 4, and 5, result from the error on tone 2, because the melodic outline: Ascending step, tone-repetition, descending fifth, remains correct. This "order" error is, without doubt, the most frequent single type that occurs. Consequently, it deserves much consideration in teaching. It shows conclusively the need for extensive drill on two-toned melodies (single interval) before attempting longer phrases. The importance of this interval preparation in the dictation and recall of melody cannot be overemphasized.

A further interesting instance of order transfer is seen in the examples of Fig. 1. In nine of the versions the repeated element is misplaced from the standpoint of order, but the element of repetition is retained. (A similar error occurs in word-spelling where the wrong letter is doubled.)

Chord-structure

The presence of harmonic relationships in our tonal system plays over into our melodic reactions to modify and sometimes obscure the determinants which we have considered. Melodically C-E-G-E-C is less "unified" than C-D-F-D-C, since step-wise progression is the essence of melodic unity (Exs. 1 and 15). Yet the first group is so strongly associated with the harmonic idea: Triad-on-C, that the entire group is reacted to as a familiar higher-unit, thus making the example easier than it otherwise would be. In the second example any harmonic unity,

Conclusions

In the light of the preceding analysis we can arrange the examples given in Fig. 4 on the basis of difficulty of retention and assign the causes for the difficulty.

Ex. 1. Very easy; diatonic progression only; pitch-change symmetrical.

Ex. 2 Moderately difficult; interval error (degree-of-skip) on with retention of repetition and pitch outline. The first error accounts for the wide pitch-range (D to C^1 for second tone); the other errors for the retention of this wide range from tones 3 and 4, and, to some extent, 5.

Ex. 3. Easy; concentration of errors on tones 4 and 5 on account of the ease (step-wise progression) of the first part: C-D-E.

Ex. 4. Difficult; wide first interval; frequent change of pitch-direction; variety of interval. Hence all variables, no constants (The ascending first interval is easier than the same descending interval of Ex. 18.)

Ex. 5. Moderate; variety of interval; relative ease of first interval.

Ex. 6. Easy; basic chord-determinant.

Ex. 7. Moderately difficult; moderately wide first interval; variety of interval; retention of pitch-outline (See Ex. 2.)

Ex. 8. Moderately difficult; wide first interval; retention of pitch-outline; variety of interval.

Ex. 9. Difficult; all skips; frequent change of pitch direction. Less difficult than Ex. 18 or 20 on account of similarity of interval.

Ex. 10. Moderately difficult; contraction error and chord substitution: C-E-G-E-C. Note concentration of errors on this chord form and absence of such concentration in Ex. 6.

Ex. 11. Moderately easy; concentration of difficulty on tone 4; ease of first part, diatonic progression.

Ex. 12. Moderate; contraction error on first interval; retention of pitch outline; mixed outline, similar to Ex. 2.

Ex. 13. Difficult; descending progression; order of interval.

Ex. 14. Difficult; width of first interval; descending direction. (See Ex. 8)

Ex. 15. Very easy. (See Ex. 1.)

Ex. 16. Moderately easy; chord determinant, but descending. Whereas in Ex. 10 the errors are almost entirely a contraction into the triad on C, in Ex. 16 they are divided between the chord form C^1-G-E-G-C^1 and the contraction C^1-B-G-B-C^1.

Ex. 17. Difficult; variety of intervals; descending progression.

Ex. 18. Very difficult; wide descending first interval; frequent change of pitch-direction; variety of interval. All variables, no constant.

Ex. 19. Moderate; chord determinant.

Ex. 20. Very difficult; see Ex. 18.

On the basis of this classification we can develop an extended series of examples for drill, leading by small increments from very easy to very difficult. We can likewise immediately isolate points of difficulty, thus eliminating waste of time and effort on non-essential drill. We can, further, separate errors that are such as inversion of incomplete secondary seventh chord, is much more complex, and does not function so readily.

This chord reaction or memory accounts for our hearing a group such as C-F-A-F-C as C-G-C^1-G-C or C-A-C^1-A-C; and a group such as C^1-A-F-A-C^1 as C^1-G-E-G-C^1. It explains the octave transpositions seen in Fig. 4.

Other instances of error resulting from the chord-structure determinants are the following: C-A-G-G-C^1 as C-A-F-F-C^1; C^1-A-G-G-C^1 as C^1-A-F-F-C^1; C-D-E-G-C^1 and C-D-E-B-C; C-D-E-G-C^1 as C-D-E-D^1-C^1; C-E-G-E-C as C-^{b}E-G-^{b}E-C. A harmonic error such as this may alter the percentile distribution found for the degree-of-skip determinant. C-E may be more frequently heard as C-G (parts of the triad C-E-G), than as C-F, which is melodically nearer. This is an instance of the melodic determinant being modified by the harmonic, and it is wrong to assign the C-G preference to melodic attributes.

Contraction

When we study the frequency with which intervals are contracted into smaller intervals and expanded into larger intervals, we find a rather pronounced tendency to contract them.

Table 1
Expansion and Contraction of Intervals

Interval	Contraction percent	Expansion percent
Thirds	64	36
Fourths	78	22
Fifths	75	25
Sixths	77	23

This table divides into two classes: (1) thirds, and (2) the other intervals. The distinctive feature for thirds results from the step-skip determinant; a third (skip) can be narrowed only to a second (step), a change which is a fundamental difference (see III).

The contraction determinant accounts for the following frequency of errors: C^1-A-F-A-C^1 heard as C^1-G-E-G-C^1 (expansion) in fifteen per cent of cases; C^1-G-E-G-C^1 heard as C^1-A-F-A-C^1 (contraction) in thirty-seven per cent of cases; C-E-G-E-C heard as C-F-A-F-C (expansion) in zero per cent of cases; the reverse (contraction) in thirty-five per cent of cases. The psychological reason for this general tendency to contract is not easily explained. It may have some connection with the Muller-Lyer illusion in optics.

caused by difficulties in the subject-matter from errors caused by individual variation. Thus the substitution of C-E-G-E-C for C-F-A-F-C is typical; but the last version of Ex. 12, Fig. 1, showing complete pitch-inversion is purely individual and of no consequence to other students. The fact that melodic memory is an important element in all work in music, even in mere appreciation without participation, and the fact that it is distinctly trainable, both show the need for improving the teaching procedure wherever possible. In outlining such training, the following points should be kept in mind.

1. Begin with melodies of two tones, first tone given. Stepwise progression first, then narrow skips. Wide skips last.
2. Use repetition as the easiest element to remember, first with diatonic progression, then with skips.
3. Use diatonic progression; first with no change in pitch-direction; then with one change.
4. Introduce skips one at a time, preferably at the beginning of the example.
5. Use triad figures, root position.
6. Introduce wide skips by restricting them to the first interval.
7. Introduce more than one change of direction by using interrupted repetition, first with diatonic progression, then with skips. The adding of a second pitch-change increases the difficulty considerably.
8. Increase variety of interval in any one example gradually; first without change of pitch direction.
9. Introduce changes in pitch-direction by repeating the same interval.
10. Reserve examples containing all variables: change of direction, skips, variety of interval, until the preceding types have been mastered.

Footnote

[1]Reprinted from *Journal of Educational Psychology*, 1933, *24*, 454-467.