STRATEGIES IN MEMORY FOR SHORT MELODIES: AN EXTENSION OF OTTO ORTMANN'S 1933 STUDY

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An experiment was designed to test the validity of Ortmann's *determinants* as variables in the immediate recall of short melodies. Ortmann's 20 five-tone melodies were presented to 122 volunteer subjects consisting of undergraduate college music majors (considerable music experience), high school instrumentalists (moderate music experience), and undergraduate college non-music majors (little music experience). Subjects in the first two groups were assigned randomly to four conditions: (a) written response (melodic dictation) to Ortmann's sequence of the 20 melodies, (b) written response to a randomized sequence of the 20 melodies, (c) sung response to Ortmann's sequence of the 20 melodies, and (d) sung response to the randomized sequence of the 20 melodies. The third group of subjects were assigned randomly only to conditions (c) and (d), since they did not have skills in music notation. With some exceptions, results confirmed the existence of the determinants (note repetition, number of note direction changes in a melody, conjunct-disjunct motion and the degree of disjunctiveness). However, the degree to which the determinants influence melodic memory is also a function of music experience, melodic carryover (Ortmann's sequence of melodies versus the random sequence), and response method (writing versus singing). Results also supported the recency effect, since overall accuracy on the final note was significantly greater than on the three preceding tones. While triadic structure and large interval *dwarfing* were found to alter response patterns in the four conditions on Ortmann's melodies, their precise individual effects on memory could not be determined because of the interaction of these variables with other elements.

Ortmann's (1933) concern for defining the fundamental structural determinants in melody that function as variables in immediate recall of short melodies has been shared by music teachers and researchers for many years. Although his study cannot be considered sophisticated in design or statistical analysis by contemporary standards, it does represent one of the most insightful early investigations into the structural nature of melody. His identification of a hierarchy of melodic determinants is a noteworthy conclusion and deserves contemporary examination. (Editor's Note: The reader may wish to refer to the original Ortmann study reprinted in its entirety in this issue.)

Aside from confirming or disconfirming the hierarchy, it would be useful to see if the determinants and hierarchy change (or cease to exist, perhaps with new determinants and hierarchy appearing) as a function of music experience.

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Furthermore, one might question the method of response to melodic stimuli. Does the complex process of transferring perceived sound to written music notation create an intervening variable in remembering melodies? It seems possible that singing back short melodies could facilitate memory, since singing may be a less complex and more expedient method of response. Finally, the redundant nature of Ortmann's 20 melodies (especially in regard to melodies 1-10 beginning on middle C and melodies 11-20 beginning on C an octave higher) could create a carryover effect. The listener could be responding to a large extent to an accumulation of previous melodies in the experiment, rather than responding to the immediate melody. Perhaps a random sequencing of the 20 melodies would eliminate or reduce the redundancy of Ortmann's melodies and somehow alter the listener's ability to recall them.

Recent research has provided strong evidence that melodic perception and memory can be influenced by variables not considered by Ortmann in his 1933 study. Some of these variables are musical training (Taylor, 1976; Long, 1977), serial position and melody length (Taylor, 1972; Williams, 1975), music context (Deutsch, 1973; Dewar, Cuddy, and Mewhort, 1977), tonality (Taylor, 1976; Krumhansl, 1979), transposition (Dowling, 1978; Cuddy, 1979), expectancy (Carlsen, 1981), octave displacement (Dowling & Hollombe, 1977; Jones, 1978), timbre (Gephardt, 1980), and melodic contour (Dowling, 1971, 1978; Taylor, 1976). It is probable that all of these variables have some degree of relevance to the melodic dictation setting, but among those with the most immediate interest are the ones just described: music experience, response method, and melodic carryover.

Therefore, this study sought the answers to two major questions:

1. Do the four determinants proposed by Ortmann (repetition, note direction, conjunct-disjunct motion, and degree of disjunctiveness) exist; and if so, are they ordered in the hierarchy of influence on melodic memory he suggested?
2. Do music experience, response method, and melodic carryover influence melodic memory, thereby altering the determinants and perhaps the hierarchy?

Ortmann's melodies present opportunities for additional study of two well-known variables in contextual music: the serial position effect (Taylor, 1972; Williams, 1975) and the triadic structuring of melodies (Aiello, 1978). The first variable has been studied in short melodies, with the general result that in remembering melodies, the middle part is least remembered. The first and last parts, however, are easier to remember—particularly the last part. Studies in the second variable have found that melodic memory is enhanced if the notes outline a triad (root position and both inversions). Ortmann did reference triadic structuring in his study, but provided little information. There is a third contextual variable that has received little attention: a perceptual dwarfing of small intervals (seconds) that are preceded or followed in a melody by larger intervals (thirds and beyond). Ortmann references the possibility of this effect for small intervals preceded by large intervals; and states that the small interval has less of a chance of being noticed than if it were preceded by other small intervals (p. 458).

These three contextual variables were included as part of this study's design; therefore, the answer to the following question also was sought:

3. Do the serial position and triadic structure variables affect memory, and do large intervals in melodies affect memory for the smaller intervals that they surround?

Methods and Procedures

Ortmann provided little detail about the methods and procedures used in his 1933 report: he presented the 20 five-tone melodies in the order illustrated in his Figure 4 (see Ortmann, 1933, reprinted in this issue; reproduced here as Figure 1) to several classes of "students of music" (number not specified); and the melodies were played only once on the piano at a "slow tempo" with "uniformly long notes." Given the first note, students wrote their responses on manuscript paper immediately after each melody was heard.

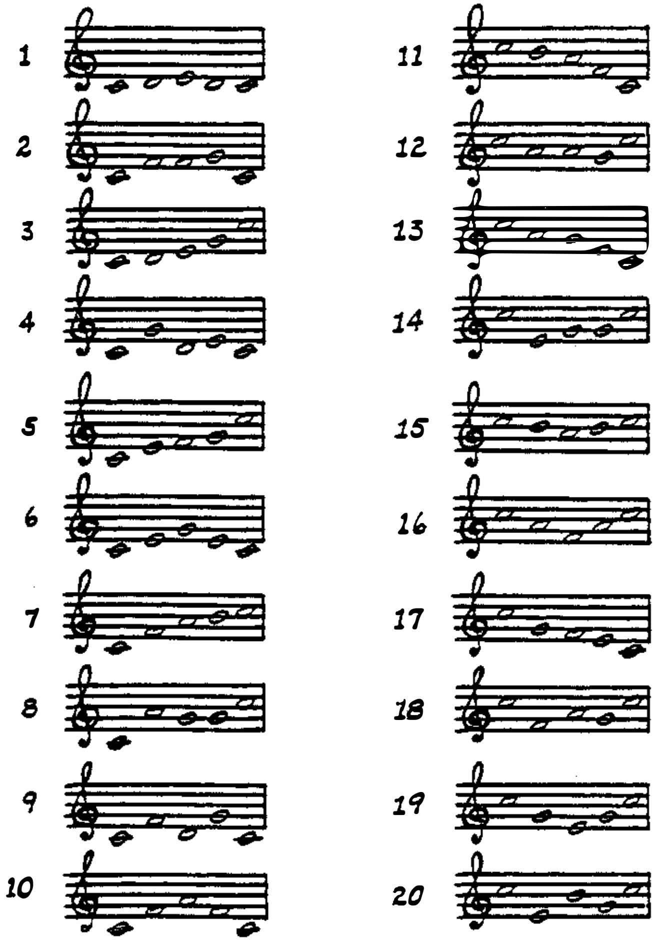


Figure 1. Ortmann's melodies (1933).

In the present study, 122 subjects from three different populations (and attending classes in the School of Music) representing three levels of musical experience volunteered to participate in the experiment: undergraduate music majors (considerable music experience), high school instrumentalists in the summer music program (moderate music experience), and undergraduate nonmusic majors in beginning music courses (little music experience). The music majors (15 per condition) and instrumentalists (8 per condition) were assigned randomly to four experimental conditions: (*a*) written response (notators) to Ortmann's sequence of the 20 melodies, (*b*) written response to a randomized sequence of the 20 melodies; (*c*) sung response (singers) to Ortmann's melody sequence; and (*d*) sung response to the randomized melody sequence. The nonmusic majors (15 per condition) were assigned randomly only to conditions *c* and *d*, as they lacked the necessary musical transcription skills necessary to participate in conditions *a* and *b*.

All melodies were recorded on 3M high density tapes directly from a piano by a Sony TC-152SC cassette deck (with noise suppression system) and were routed to two ADC 303AX loudspeakers by a Standard PM-403U amplifier. The sung responses (groups *c* and *d*) were recorded on 3M high density tapes by an integrated Sony TC-630 reel/reel tape deck/amplifier. All equipment was calibrated to ensure accurate transcription of responses from tape.

Subjects were tested individually and were seated at a desk. The two loudspeakers were placed on the desk, each angled directly toward an ear at a distance of one meter. The melodic stimuli were played at a comfortable level for each subject. The individuals assigned to the sung response conditions (conditions *c* and *d*) were screened in advance by means of the *Melodic Perception Ability Test* (MPAT described in Taylor, 1976). Section 2 of MPAT measures the ability of subjects to sing what they are mentally vocalizing, a skill required for conditions *c* and *d*.

The melodic stimuli were played at quarter note = 90 (the midpoint tempo of the range, quarter note = 60-120, which has maximized memory for short term memory in recent unpublished studies performed by the investigators), with 10 seconds allowed for written or sung responses after each melody. The entire experiment required 20 minutes (including MPAT) for each subject. Printed forms for melodic notation (which included the melody number, staves, treble clef, and first note) were used by the subjects in conditions *a* and *b*. Forms were not required for the sung responses. In transcribing the data, sung responses were coded to the nearest half-step. To guarantee accuracy, sung responses were transcribed twice from the response tapes (by different scorers) to standard music notation, then cross-checked for errors. Written responses, of course, already appeared as music notation.

Deciding the *correctness* of a response is a special problem in music dictation, since a single response includes the tone itself and the resulting distance (interval) from the previous tone. Therefore an incorrect response can be defined in the following ways: (*a*) both the note and interval are wrong, (*b*) the interval is wrong, but the note is correct, or (*c*) the note is wrong, but the interval is correct. Of course, case *a* represents an obvious error, but *b* and *c* are rather special. To illustrate, suppose that a subject responded to C-A-G-G-C with C-G-F-F-C. Certainly the G is an incorrect response (case *a*), but what about the pair of F's that follow? The subject remembered the correct interval (major second) but not the correct note (case *c*, or perhaps remembered the correct note but decided to maintain correct intervals rather than correct notes). Nevertheless, the last note (C) was correct, but the interval was not (case *b*).

Musically, it may be a mistake to consider cases *b* and *c* as incorrect responses. Both represent correct musical discriminations and for the experienced listener, at least, they are strategies that must be used in the course of taking melodic dictation. For the purpose of this study, responses were counted as errors only if both the notes and intervals were wrong (case *a*). It is not clear that Ortmann scored his results in the same manner, therefore this potential difference should be considered when interpreting the results of this study (additional comments are made in the *Discussion* section).

Results are presented in two parts. In the first part, mainly descriptive statistics and nonparametric tests are used because they accommodate the best direct comparisons between the results of Ortmann's research and the results of this study. *Results: Part 1,* is designed to answer the first major question cited in this paper; but when it is appropriate to do so, the effects of musical experience, response method, and melodic carryover are included in the discussion. *Results: Part 2,* is concerned with the second and third major questions and therefore concentrates on the current study, using mainly parametric tests to analyze the data. The alpha level for all statistical tests was set at .05.

Results: Part 1

Repeated Notes

In order to directly compare results of this study with those of Ortmann's, errors were tabulated across the 122 subjects for each of the 4 notes (the first note was given) in each of the 20 melodies. Errors for the four experimental conditions within the three experimental groups were calculated by summing the number of note errors relevant to the particular determinant. For example, subjects' errors in recall of repeated notes (directly repeated notes and interrupted repeated notes) required the summing of the number of errors on the directly repeated note in melodies 2, 8, 12, and 14 (Figure 1) and the summing of errors on the fourth note (interrupted repeated note) of melodies 1, 6, 10, 15, 16, and 19. In order to determine error percentages, these respective sums were divided by the number of subjects performing that specific task (the four direct repetition melody trials or the six interrupted repetition melody trials).

For a more precise understanding of errors on repeated notes, responses to directly repeated notes were analyzed separately from interrupted notes. A listing of error percentages made by all subjects in the melodies containing direct or interrupted repetition is outlined in Table 1. Error rates are reported as percentages for both the present study and Ortmann's study, and it is clear that the direct repetition error percentages for all groups in this study were much greater than Ortmann's error percentage (Ortmann did not report separate error percentages for interrupted repetition). It is also clear that the music majors outperformed the nonmusic majors and high school instrumentalists on the direct repetition melodies. Performances by all three groups on interrupted repetition notes generally were better than their performances on the direct repetition notes. But perception of repeated notes could have been influenced by their surrounding notes (melodic context). For example, notice that all direct repetition melodies contain large skips (thirds, fourths, fifths and sixths) and are not symmetrical. On the other hand, the indirect repetition melodies are symmetrical and either triadic or scalar. The latter structures could serve as memory aids. Strong evidence for this is found in the improved performance on the interrupted note melodies by all subjects as compared to their performance on the direct repetition melodies. The nonmusic majors improved substantially; in fact, their performance compares favorably to the performances by the music majors and instrumentalists.

All the error percentages listed in Table 1 are considerably higher than Ortmann's reported error rate of 0.8%. One might question Ortmann's conclusion that repeated notes (in the present melodic contexts) constitute a basic, simple determinant in the recall of short melodies.

Note Direction

A comparison of error percentages for changes in note direction (melodic contour) between Ortmann's study and the present study are illustrated in Table 2. Melodies are categorized according to number of note direction changes: no change, one change, two changes, and three changes. One can argue with Ortmann's designation of the melodies with unisons (2, 8, 12, 14) as two-change melodies. However, he considered that to the listener a unison meant "zero motion" (1933, p. 455; 1934, p. 30) and that the next interval following a unison, be it ascending or descending, represented a change in direction (see pages 29-31, 1934). Thus Melody 2, for example, has two changes: one after the unison and the other after the fourth note. Ortmann did not take

Table 1

Error Percentages for Direct and Interrupted Repeated Notes in Both the Present Study and Ortmann's Study

	Direct Repetition Present Study (Melodies 2, 8, 12, 14)		Interrupted Repetition Present Study (Melodies 1, 6, 10, 15, 16, 19)		Direct Repetition Ortmann's Study	Interrupted Repetition Ortmann's Study
Undergraduate Music Majors						
[a] *a*	6.7		3.3			
[b] *b*	8.3	$\bar{X}$ = 7.1	6.7	$\bar{X}$ = 4.2		
[c] *c*	3.3		4.4			
[d] *d*	10.0		2.2			
High School Instrumentalists						
a	12.5		10.4		All subjects 0.8	Error percentage not reported by Ortmann
b	15.6	$\bar{X}$ = 16.4	6.3	$\bar{X}$ = 9.4		
c	15.6		14.6			
d	21.9		6.3			
Undergraduate Nonmusic Majors						
c	23.2	$\bar{X}$ = 24.2	6.7	$\bar{X}$ = 7.3		
d	25.0		7.8			
Weighted Grand Mean		13.7		6.3	0.8	

[a]Condition *a*, Ortmann's sequence of the 20 melodies, notated response
[b]Condition *b*, Randomized sequence, notated response
[c]Condition *c*, Ortmann's sequence, sung response
[d]Condition *d*, Randomized sequence, sung response

into account the fact that although Melody 8 contains a unison, its contour is different than the other melodies with unisons.

In both studies, error percentages were based on the subject's ability to remember entire melodic contours (but not necessarily the exact intervals); therefore, the dependent variable was dichotomous: correct or incorrect contour. Some responses included deletion of unisons in Melodies 2, 8, 12, and 14; and in some instances unisons were added. Both of these response types were interpreted as incorrect.

The weighted, grand mean error percentages in Table 2 seem to confirm Ortmann's statement that "the increase in difficulty is much greater between one and two changes in note-direction than between two and three changes" (1933, p. 457). The undergraduate music majors (considerable music experience) performed the best—about equal to Ortmann's subjects in the one-direction and one-change melodies, but considerably better than his subjects in the two- and three-change melodies. Judging from the undergraduate music majors' lower error percentages for the two- and three-change melodies (10.0% and 8.7%), greater musical experience does seem to result in improved performance in melodies with more complicated contours. Chi-square analyses were performed on the data in order to determine if these effects were significant. The undergraduate music major were better ($\chi^2 = 41.89$, df $= 2$, $p < .001$) than the high school instrumentalists and undergraduate nonmusic majors in remembering melodic contours. There were no differences ($\chi^2 = 2.11$, df $= 1$, $p < .15$) between the instrumentalists and the nonmusic majors. No-change and one-change melodies elicited significantly fewer errors than two and three-change melodies ($\chi^2 = 83.70$, df $= 3$, $p < .001$). One might anticipate a significant difference between the no-change and one-change melodies, but the lack of that effect could be attributed to the symmetrical shape of all one-change melodies.

Table 2
Error Percentages for the Four Degrees of Note Direction Changes (Contours) in the 20 Melodies, Present Study and Ortmann's Study

	One direction only (Melodies 3, 5, 7, 11, 13, 17)		One change in direction (Melodies 1, 6, 10, 15, 16, 19)		Two changes in direction (Melodies 2, 8, 12, 14)		Three changes in direction (Melodies 4, 9, 18, 20)	
	Present Study	Ortmann	Present Study	Ortmann	Present Study	Ortmann	Present Study	Ortmann
Undergraduate Music Majors (*n* for each condition = 15)								
[a]*a*	1.1		1.1		10.0		5.0	
[b]*b*	5.6 $\overline{X}$ = 3.9		5.6 $\overline{X}$ = 2.2		13.3 $\overline{X}$ = 10.0		8.3 $\overline{X}$ = 8.7	
[c]*c*	4.4		1.1		1.7		8.3	
[d]*d*	4.4		1.1		15.0		13.3	
High School Instrumentalists (*n* for each condition = 8)		3.0		1.7		22.0		32.0
a	4.2		10.4		25.0		12.5	
b	0.0 $\overline{X}$ = 3.7		2.1 $\overline{X}$ = 7.4		25.0 $\overline{X}$ = 24.2		12.5 $\overline{X}$ = 17.2	
c	4.2		12.5		25.0		28.1	
d	6.3		4.5		21.9		15.6	
Undergraduate Nonmusic Majors (*n* for each condition = 15)								
c	6.7 $\overline{X}$ = 10.5		3.3 $\overline{X}$ = 5.6		20.0 $\overline{X}$ = 23.4		26.7 $\overline{X}$ = 25.9	
d	14.4		7.8		26.7		25.0	
Weighted Grand Mean	5.5	3.0	4.4	1.7	17.0	22.0	15.2	32.0

[a]Condition *a*, Ortmann's sequence of the 20 melodies, notated response
[b]Condition *b*, Randomized sequence, notated response
[c]Condition *c*, Ortmann's sequence, sung response
[d]Condition *d*, Randomized sequence, sung response

Ortmann hypothesized that retention of changes in note direction could be traced not only to the number of note direction changes in a melody, but also to the size of the interval at the point of change. He did not report statistics for this effect; but he did imply that the larger the interval at the point of direction change, the more noticeable the direction change—and therefore the fewer the errors.

In order to test Ortmann's hypothesis in the current study, intervals at all points in change of direction in all melodies were categorized by step (major and minor seconds) or skip (all other intervals) then checked for errors. The error percentages are reported in Table 3. Combining errors for all three subject groups in a chi-square analysis, significantly fewer errors were made at the point of direction change when the interval was a skip rather than a step (χ^2 = 4.83, df = 1, p = .03). However, the music majors performed better with both skips (χ^2 = 11.49, df = 2, p = .003) and steps (χ^2 = 26.76, df = 2, $p < .001$) than the high school instrumentalists and nonmusic majors. The high school instrumentalists' performance was better than the nonmusic majors only when the point of direction change in melodies was a step (χ^2 = 6.56, df = 1, p = .01).

The effect of melodic carryover (Ortmann's sequence of melodies versus the random sequence) was evident when a step was located at the point of direction change: subjects responding to Ortmann's melody sequence (conditions *a* and *c*, see Table 3) made fewer errors on steps than subjects responding to the random sequence of melodies (χ^2 = 11.24, df = 1, $p < .001$). The carryover effect described earlier may have assisted recall, but only when the point of direction change

Table 3
Error Percentages in Note Direction at Point of Change In the Multi-Directional Melodies (Present Study) Categorized by Interval Size (Step or Skip)

	Interval Size: step		Interval Size: skip	
Undergraduate Nonmusic Majors				
[a] *a*	0.9		1.0	
[b] *b*	2.9	$\overline{X}$ = 2.6	2.8	$\overline{X}$ = 1.9
[c] *c*	0.0		1.8	
[d] *d*	6.7		1.8	
High School Instrumentalists				
a	1.7		5.3	
b	7.4	$\overline{X}$ = 5.4	2.0	$\overline{X}$ = 4.5
c	3.5		7.9	
d	8.9		2.6	
Undergraduate Nonmusic Majors				
c	8.6	$\overline{X}$ = 12.9	4.6	$\overline{X}$ = 4.1
d	17.1		3.5	
Weighted Grand Mean		5.9		3.1

[a]Condition *a*, Ortmann's sequence of the 20 melodies, notated response
[b]Condition *b*, Randomized sequence, notated response
[c]Condition *c*, Ortmann's sequence, sung response
[d]Condition *d*, Randomized sequence, sung response

was a step. The carryover effect was not a factor in remembering skips ($\chi^2 = 1.40$, df = 1, $p = .23$).

A final element in note direction is ascending versus descending melodies. According to Ortmann, there should be fewer errors for ascending melodies. Table 4 confirms this fact, and the distribution of total errors (i.e., errors by all subjects on all notes across the 10 ascending and 10 descending melodies) was consistent across subjects and conditions. The ratio of difference between ascending and descending error percentages in this study was even greater than the error percentage reported by Ortmann: 39% (ascending) and 61% (descending) versus Ortmann's 45% (ascending) and 55% (descending). An ANOVA performed on total errors for the ascending and descending melodies for both notators and singers shows that in both cases, ascending melodies resulted in significantly fewer errors.

Table 4
Error Percentage Distribution for Melodies 1-10 (Ascending) Compared to Melodies 11-20 (Descending)

	Melodies 1-10		Melodies 11-20		Total Errors
Undergraduate Music Majors					
[a]*a*	37		61		
[b]*b*	41	$\bar{X} = 38.3$	59	$\bar{X} = 61.3$	
[c]*c*	37		63		
[d]*d*	38		62		
High School Instrumentalists					1793 total errors:
a	40		60		melodies 1-10 = 707
b	41	$\bar{X} = 39.5$	59	$\bar{X} = 60.5$	melodies 11-20 = 1086
c	39		61		
d	38		62		
Undergraduate Nonmusic Majors					
c	42	$\bar{X} = 40.0$	58	$\bar{X} = 60.0$	
d	38		62		
Weighted Grand Mean	39.0		61.0		

[a]Condition *a*, Ortmann's sequence of the 20 melodies, notated response
[b]Condition *b*, Randomized sequence, notated response
[c]Condition *c*, Ortmann's sequence, sung response
[d]Condition *d*, Randomized sequence, sung response

Conjunct-Disjunct Motion and Degree of Disjunctiveness

Conjunct-disjunct motion and degree of disjunctiveness are the third and fourth determinants proposed by Ortmann. He claimed that conjunct melodies (those that move by step) are easier to recall than disjunct melodies (those that move by skip); but he offered rather brief data in support of this statement. In the present study, an analysis of responses to all intervals in melodies consisting only of steps (melodies 1 and 15) revealed an error percentage of only 2.5% across all subjects and conditions as compared to the error percentage of 18.3% for the melodies consisting only of skips (melodies 9 and 20, possibly the most disjunct of the 20 melodies). Disjunct motion melodies do appear to be more difficult to

Table 5
Confusion Matrix or Error Percentages (Incorrect Response Intervals) for Each Interval Across All Subjects and All Melodies

[a] Intervals used in the 20 melodies	Incorrect Response Intervals U	m2	M2	m3	M3	P4	T	P5	m6	M6	m7	M7	P8	No response	[c] Total error %	Error % for intervals M2 above/below given intervals (boxed entries)	Number of intervals in the 20 melodies	N (number) of intervals X 122 Ss
U	---	1.6	4.7	1.6	1.4	1.6	0.3	1.5	0	0	0	0	0	1.8	12.7	49.6	4	488
m2	3.1	---	1.0	7.9	0.8	1.8	0.3	0.1	0.1	0	0	0	0	1.4	15.1	79.5	6	732
M2	1.7	0.9	[b] 0.8 / 0.6	2.9	2.5	2.2	0.8	0.6	0	0.1	0	0	0	0.8	13.1	71.8	18	2196
m3	1.4	3.4	3.1	---	0.9	6.9	0.3	1.1	0.4	0.1	0	0	0	0.9	17.6	81.3	12	1464
M3	2.6	0.9	7.7	1.0	--	2.8	1.2	1.9	0	0.5	0	0.1	0	0.5	18.7	67.9	14	1708
P4	0.4	0.5	1.1	3.9	4.8	---	0.5	2.0	0.3	0.5	0.1	0	0.1	1.2	14.2	78.9	18	2196
P5	1.3	1.3	0.8	4.1	3.1	11.6	1.0	---	2.8	0.8	0.3	0	.5	0.8	27.6	58.7	5	610
m6	0	0	0	4.1	2.0	12.7	9.4	14.0	---	0.4	2.5	0	2.9	0.8	48.0	54.8	2	244
M6	1.6	0	0.8	0.8	1.6	3.3	0.8	13.9	1.6	---	0.8	1.6	0.8	0.8	27.6	64.9	1	122
																	80	

[a]Ortmann did not include the tritone, m7, M7, or P8 in his melodies.
[b]Digits above line represent percentage for error of M2 *ascending* (correct direction is descending), and digits below line represent percentages for errors of M2 *descending* (correct direction is ascending).
[c]Does not include the no response column.

recall than conjunct motion melodies. In order to examine this determinant an ANOVA was run across the five groups of subjects (music major notators, music major singers, high school notators, high school singers, and nonmusic major singers) on data consisting of total errors for each melody on both the conjunct melodies (1 and 15) and the disjunct melodies (6, 9, 10, 16, 19, and 20). Disjunct melodies were more difficult to remember ($F[1,966] = 65.66, p < .001$). The group factor also was significant ($F[4,966] = 18.77, p < .001$), and a Scheffe test on group means revealed no significant differences among the five groups, with the exception of the high school notators. Their performance was significantly worse than the other groups.

Ortmann made three claims regarding degree of disjunctiveness: (a) errors in recall are a function of the interval's size (larger intervals are more difficult to remember than smaller intervals), (b) most errors are confined to the interval of a major second above or below a given interval, and (c) the range of errors for large intervals is wider than the range of errors for smaller intervals. These claims were substantiated by the present study. The data are presented as a confusion matrix in Table 5.

The *total error percentage* column in Table 5 illustrates small differences in error percentages for intervals ranging in size from a minor second to a fourth. Melodic intervals of the fifth, minor sixth, and major sixth resulted in considerably higher error percentages than the smaller intervals (the minor sixth elicited an error percentage of 48%). For the subjects in this study, error rate was a function of the two categories of interval sizes (unison to perfect fourth and perfect fifth to major sixth), not simply the increasing function of interval size as suggested by Ortmann.

When one examines the error rates surrounding the individual intervals in Table 5 (the boxes enclose intervals which are 2 half-steps above and below the interval) it can be seen that from 49.6% to 81.3% of the errors (see *Error percentage for intervals M2 above/below given intervals, boxed entries* column) were confined to the interval of a major second above or below a given interval. Furthermore, errors ranged from a minor second to a perfect fifth for the melodic unison and increased in range up to an octave for the melodic perfect fourth through the major sixth. An exception is the interval of a minor sixth. Its error rate ranged from the minor third (a near inversion) to the octave.

Results: Part 2

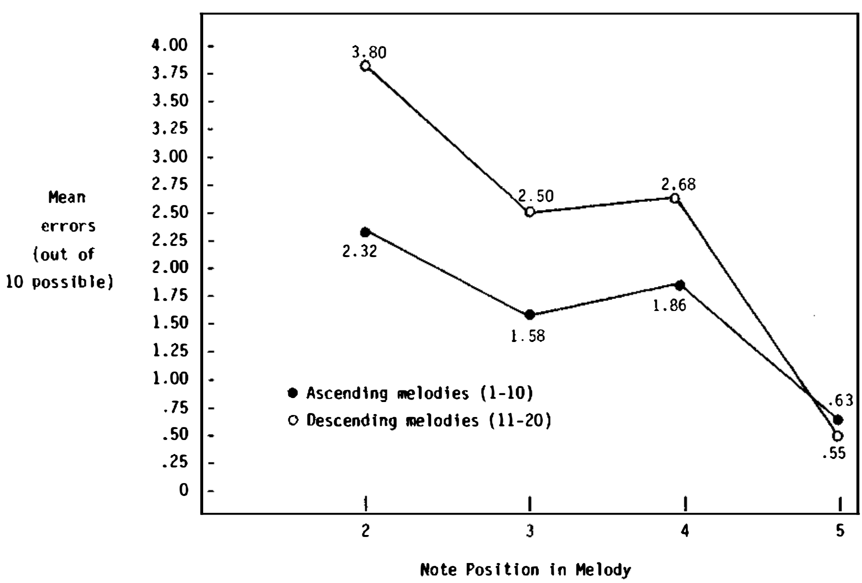
For a more complete response to Question 2, and for the answering of Question 3, a series of ANOVA tests was applied to the data of the current study. Since the nonmusic majors participated only in the singing response method and not the notated method (they were not trained in the skill of music notation) it was decided that three separate ANOVA designs would best match the purpose of this study.

The first ANOVA includes analysis of the musical experience, response method, and carryover factors, but excludes data from the nonmusic majors. Raw data were the total number of mistakes for each of the four notes (intervals) across the 20 melodies and 92 subjects (music majors and high school instrumentalists). Results indicated a significant difference between response methods ($F[1,84] = 7.00, p < .01$). Singers made fewer errors ($\overline{X} = 11.02$) than writers ($\overline{X} = 16.00$). The musical experience factor also was significant ($F[1,84] = 15.76, p < .001$): the music majors made fewer errors ($\overline{X} = 10.78$) than the high school instrumentalists ($\overline{X} = 18.62$). The carryover factor (Ortmann and random sequence of melodies) was not significant, nor were any of the interactions.

A second ANOVA was run on all subjects (including the nonmusic majors), but the analysis was limited to the singing response method. The factors of ascending/descending melodic direction and serial position were added to the design, the latter including analysis of note positions 2, 3, 4, and5 (the first note was given to the subjects) for the 20 melodies. Results show significant differences for serial position ($F[3,560] = 55.32, p < .001$), musical experience ($F[2,560] = 45.48, p < .001$), melodic direction ($F[1,560] = 35.36, p < .001$), and the carryover x musical experience interaction ($F[2,560[= 10.18, p < .001$). As Ortmann suggested, fewer errors were made in the ascending melodies. Again, music majors performed better than the high school instrumentalists and nonmusic majors, but there was no difference in errors between the latter two groups. However, the high school students did perform as well as the music majors in the random sequence of melodies, but their error scores in the Ortmann melody sequence tied the nonmusic majors as the highest error rate (($\overline{X} = 2.42$ errors out of a possible 10). Music majors made fewer errors than nonmusic majors in both melody sequences. The reasons for the instrumentalists' poor performance in the Ortmann sequence are not clear. The serial position factor was interesting, because results showed a significant difference only between the last position (note 5) and positions 2, 3, and 4. There were fewer errors on that last note, and error totals were much higher and approximately equal across notes 2, 3, and 4. Thus the typical effect of a reduced memory for the middle part of a series of events was not observed for singers. The strength of the final note overshadowed the previous notes, and perhaps this is not surprising when one considers that a C tonality was reinforced across all 20 melodies, including the use of C as beginning and ending notes. Wrong note errors on the final position were only 3%.

The third ANOVA included the four factors just described in the paragraph above, but only used data from the notated response method (which excluded the nonmusic majors' responses). Again, serial position ($F[3,336] = 31.78, p < .001$), musical experience ($F[1,336] = 30.00, p < .001$), and melodic direction ($F[1,336] = 17.46, p < .001$), were significant. In contrast to the second ANOVA, the carryover effect was significant in this analysis ($F[1,336] = 11.21, p < .001$). Additionally, the serial position x direction interaction was significant ($F[3,336] = 3.09, p < .05$). As in the singing response method, music majors made fewer errors than the high school subjects, and all subjects performed better with the ascending melodies as compared to the descending melodies. Furthermore, Ortmann's melody sequence resulted in fewer errors than the random sequence. As for serial note position, subjects performed significantly better (Scheffe Test) on positions 3, 4, and 5 when compared to position 2—but this was true only for the ascending melodies. There were no differences among note positions 3, 4, and 5 (ascending melodies). In the descending melodies, subjects made fewer errors on position 5 as compared to note positions 2, 3, and 4. There were no differences among note positions 2, 3, and 4 (descending melodies). Figure 2 illustrates the serial position x direction interaction. While positions 3 and 4 in the descending melodies are not significantly different than those positions in the ascending melodies, they represent a substantial increase in error. The mean error for position 2 in the descending melodies *is* significantly higher than position 2 in the ascending melodies. With the understanding that more total errors were made in descending as compared to ascending melodies, it appears that the increase in errors was spread across positions 3, 4, and (especially) 2 in the descending melodies. Errors in both ascending and descending melodies for position 5 were similar, probably due to the strength of the tonal environment as described earlier. Wrong-note errors on the final position were 4.7%, very close to the singers' 3% error. The serial position effect is not an obvious element in these short melodies, because for both singers and notators, errors in note positions 2, 3, and 4 were almost equal with the exception of position 2 in the descending melodies only.

Figure 2. The serial position x direction (ascending-descending) interaction for the notated response method (music majors and high school instrumentalists only).



The triad as a perceptual and memory variable was apparent when melodies 6, 10, 14, 16, and 19 were compared across the notating and singing response methods. When errors were made in those melodies, a number of them consisted of replacement of the triadic structure by another triad. Furthermore, the notators made significantly more of this type of error than the singers (z = 2.25, p = .0122). In melody 10, 19% of the total errors (notators and singers) resulted from replacing the C-F-A-F-C inverted triad with C-E-G-E-C. The percentage was even greater for descending melodies 16 and 19, the former replaced with C-G-E-G-C (27% of the total errors and 37% of the notators' errors), and the latter replaced with C-A-F-A-C (27% of the total errors, and 48% of the notators' errors). No replacement errors were made on melody 6, probably because of its obvious root position, ascending progression. Only 5% replacement errors were made in melody 14 (C-F-A-A-C), but its triadic outline is less obvious than melodies 6, 10, 16, and 19.

The fact that the triad can be a strong perceptual organizer is evidenced in this study by the manner in which the notators used it in descending melodies 16 and 19. The fact that the notated response was more difficult and time-consuming than the singing response, combined with the relative difficulty of descending melodies as compared to ascending melodies, could very well have forced the notators to rely upon an organizer that may remain in memory longer than other organizers: the triad concept. Singers, who could bypass the mechanical and time-delaying problems of music notation, made no triad replacement errors in melody 16 and only 12% replacement errors in melody 19.

The *dwarfing* phenomenon, or errors on notes that move stepwise when preceded or followed by skips, appears to exist, but more so for the singers than the notators. For example, melodies 1 and 3 begin with C-D-E, but melody 1 ends with steps while 3 ends with skips. On melody 3, 22% of the singers and 2% of the notators missed the D and E (second and third notes) as compared to 3% and 2% for the D and E on melody 1. Errors on the equivalent descending versions (melodies 11 and 15) were somewhat larger: 30% of the singers and 7% of the notators missed the B and A (second and third notes) on melody 11 as compared to 9% and 4% on melody 15. Of course, these statistics apply to the dwarfing of *previous* intervals. Only melody 7 can provide evidence for dwarfing of stepwise intervals that follow skips. In this case, errors were even greater: 75% for singers and 48% for notators (on notes B and C). Although the difference in errors between singers and notators as a function of dwarfing (melodies 1, 3, 7, 11, and 15) was not significant (z = 1.61, p = .0537), this study provides some evidence that the dwarfing concept could be a factor in music perception and memory. Further investigation certainly is warranted.

Discussion

The main results of this study are summarized and listed below according to the two parts of the Results section:

Results: Part 1

1. Ortmann claimed that repeated notes were the "easiest" determinant,

but the error percentage for direct repetition in this study was much greater than the percentage reported by Ortmann (13.7% versus 0.8%). However, music majors outperformed the high school instrumentalists and nonmusic majors. The error percentage for interrupted repetition melodies was lower than direct repetition for all groups (6.3% versus 13.7%), but the symmetrical contour of the interrupted repetition melodies could have been a confounding variable.

2. Ortmann's statement that a melody is considerably more difficult when it changes directions two or three times as compared to one change was confirmed by this study. Music majors outperformed the other two groups. They made about the same percentage of errors as Ortmann's subjects for the one-change melodies (2.2% versus 1.7%), but they performed much better with the two- and three-change melodies (10% and 8.7% versus 22% and 32%). Also verified was Ortmann's claim that a change in direction was more noticeable when the interval at the point of direction change was a skip, rather than a step. Fewer errors were made with skips; however, the majors performed better with both skips and steps than the other two groups. The instrumentalists made fewer errors than the nonmajors when the point of direction change was a step. Fewer errors were made on steps (but not skips) for the Ortmann melody sequence as compared to the random sequence. Ortmann also found more errors for descending melodies (55% versus 45% ascending melody errors), and this study confirmed his findings (61% versus 39%).

3. According to Ortmann, conjunct melodies are easier to recall than disjunct melodies. It appeared to be true in this study, with the instrumentalist notators performing worse than the majors (notators and singers) and the nonmajors (notators and singers). The following claims made by Ortmann also were substantiated in the present study by a confusion matrix: (a) errors in recall are a function of the interval's size (larger intervals are more difficult to remember than smaller intervals), (b) most errors are confined to the interval of a major second above or below a given interval, and (c) the range of errors for large intervals is wider than the range of errors for smaller intervals. However, in most instances a single incorrect response interval accounted for at least 39% (and usually much more) of the total error percentages.

Results: Part 2

1. Three separate ANOVA analyses provided the following results:
   a. In comparing college music majors with high school instrumentalists, majors made fewer errors, singers made fewer errors than notators, and majors made fewer errors than the instrumentalists in the notated-response method.
   b. Majors made fewer errors than instrumentalists and nonmajors in the singing response method.
   c. Singers and notators made fewer errors in ascending versus descending melodies.
   d. Notators made fewer errors in the Ortmann sequence of melodies, as compared to the random sequence.
   e. High school instrumentalist singers performed as well as the major singers in the random sequence, but their mean score in the Ortmann

sequence tied the nonmajor singers as the highest error rate for singers. Majors made fewer errors than nonmajors in both melody sequences.

f. Fewer errors were made by singers on note position 5 than on note positions 2, 3, and 4, and there were no significant differences among the latter positions.

g. Fewer errors were made by notators on note positions 3, 4, and 5 as compared to note position 2, but this was true only for ascending melodies. There were no significant differences among note positions 3, 4, and 5. In the descending melodies, notators made fewer errors on note position 5 as compared to note positions 2, 3, and 4. There were no significant differences among note positions 2, 3, and 4. Examination of the error means for the serial position x direction interaction showed that the additional errors made by subjects in the descending melodies (as compared to the ascending melodies) were spread across note positions 3, 4, and (especially) 2, but not position 5.

2. Singers made fewer errors than notators in replacement of the melody's triadic structure with another triad.

3. Notators made fewer errors than singers on notes that move stepwise when preceded or followed by skips (dwarfing), although the effect was not significant.

In response to this study's first research question, "Do the four determinants proposed by Ortmann exist; and if so, are they ordered in the hierarchy he suggested?," the answer to both parts of the question has to be a limited, yes. For the most part, Ortmann's four major determinants (repetition, note direction, conjunct-disjunct motion, and degree of disjunctiveness), when cast in the structure of the present experiment, generally seemed to elicit responses similar to those by Ortmann's subjects of 50 years ago.

However, there appears to be no simple explanation for the larger number of errors on the directly repeated notes (melodies 2, 8, 12, and 14) when compared to Ortmann's study. Repeated notes may be the basic determinant in a hierarchy of phenomena that influence music perception and memory, but it must be noted that melodic context (serial position and surrounding intervals) influences memory for repeated notes, just as it influences memory for other two-tone sequences (intervals).

The note direction, conjunct-disjunct motion, and degree of disjunctiveness determinants closely match Ortmann's error percentages—or when he did not provide statistics, they matched his speculations. But it is not so evident that the determinants are arranged in the hierarchy that Ortmann would have us believe. It is not so much that this study found otherwise (a clear hierarchy was not evident); it is more the case of Ortmann not having tested all the variables in his melodies—which at times may have led to questionable conclusions. The most obvious example of this problem was his discussion about melodies with *interrupted* repetition of notes (melodies 1, 6, 10, 15, 16, and 19). He did not take into account the scalar, triadic, and symmetrical features of those melodies—which undoubtedly served as strong mnemonic reinforcers in melodic dictation, making it impossible to form reliable conclusions about interrupted repetition of notes.

Clearly, a complete hierarchy of determinants would constitute a very long list, because not only would the many melodic structures be included, but also their interactions with subject and environmental variables. The ones included in the present study (musical experience, melodic carryover, and response method) provided evidence that the melodic determinants are not constant; rather, they vary as a function of the subject and environmental factors, which in turn can have significant effects on music discrimination and memory. Therefore the answer to the second research question is positive: musical experience, response method, and melodic carryover do influence melodic memory, thereby altering the strength of the proposed determinants and perhaps their hierarchy. Experience or training in music is a strong factor, as the music majors outperformed the other two groups in almost all melodic dictation tasks. Additional support for the training factor is provided by the performance of the high school instrumentalists. As developing musicians, their scores usually were not as good as the music majors, but better (in many instances) than the nonmusic majors.

Generally, subjects made fewer errors when they sang the melodies. Notating was, in fact, a task that seemed to increase dictation errors. But errors did decrease in writing the melodies when subjects heard Ortmann's sequence of the 20 melodies, rather than the randomized sequence. The carryover effect of melodies 1-10 beginning on middle C and melodies 11-20 beginning on the C an octave higher must have served as a sort of perceptual or memory "anchor" in the more difficult process of writing melodies.

The *middle position slump* was not obvious in this study, as note positions 2, 3, and 4 were equally troublesome in most instances. However, remembering the second note was somewhat more difficult for all subjects, regardless of their response method. One would not expect so many errors at the beginning of a melody, but an explanation could be the design of Ortmann's melodies. He used only three intervals of the sixth (two minor and one major), and all of them are placed between positions 1 and 2 (melodies 8, 14, and 20). The error percentages for the minor and major sixths were 48.0 and 27.6, respectively, making them (and the perfect fifth, 27.6) by far the most difficult intervals in this experiment. Ortmann did not use sevenths and octaves. Recency effect—remembering the last item in a series—was the prominent feature in these 20 melodies. But one could expect the last note to be not so well remembered if Ortmann had used a variety of key structures and had started and ended some of his melodies with nontonic notes.

Earlier in this report it was stated that for the purpose of this study, a response was considered correct if either the note or the interval were correct, and it was argued that musically, this decision seemed proper. Table 6 categorizes error type by case *a* (incorrect interval and note, case *b* (incorrect interval but correct note), and case *c* (incorrect note but correct interval). Errors in each of these cases are distributed across the four note positions. This experiment considered responses in case *a* to be errors, and it is certain that Ortmann did the same. But it is possible that he also included case *c* errors. If so, comparisons between this study and Ortmann's should be interpreted with care, even though the errors in case *c* amounted to only 9% of the total error percentage.

Table 6
Errors Summed Across the 20 Melodies and 122 Subjects According to Note Positions 2, 3, 4, and 5 and Error Type

Error Type	Note Position 2	3	4	5	Totals
Case *a* Incorrect Interval and Note	590 (20.6)	536 (18.7)	465 (16.2)	106 (3.7)	[b]1697 (59.2)
Case *b* Incorrect Interval (Note Correct)	a	160 (5.6)	214 (7.5)	538 (18.7)	912 (31.8)
Case *c* Incorrect Note (Interval Correct)	a	127 (4.4)	131 (4.6)	3 (< 1.0)	261 (9.0)
Totals	590 (20.6)	823 (28.7)	810 (28.2)	647 (22.5)	2870 (100.0)

NOTE: Numbers in parentheses represent percentage of total errors.
[a]Error type not possible in note position 2.
[b]The "No response" errors (96) are not included here.

The statistics for cases *b* and *c* in Table 6 indicate that subjects remember both (or either) intervals and notes in these short melodies, and there does not seem to be occasions when one kind of strategy takes precedence over the other, particularly as memory applies to serial position. The obvious exception is position 5 where subjects almost always responded with the correct note, regardless of the interval (case *b*). Of course, pitch and interval memory are only two of many potential mnemonic aids, and one should not discount the fact that even in Ortmann's simple, short melodies a number of perceptual and memory factors are being used by the subject.

The answer to the third research question, "Do the serial position and triadic structure variables affect memory, and do large intervals in melodies affect memory for the smaller intervals that they surround?,"is mixed. It has been demonstrated that serial position influences memory, but it cannot be stated positively that the same is true for triadic structures and the *dwarfing* effect. Those variables should be isolated and studied more intensively in future research.

It is also recommended that the present study be replicated and/or expanded to include a larger *n*, a broader spectrum of musical experience groupings, all descending and ascending intervals (Ortmann did not include the tritone, minor seventh, major seventh, and octave), and perhaps transpositions of the 20 melodies into different key structures.

It is a tribute to Ortmann that the current investigation basically confirmed his 1933 work. When one examines his continuing research in music structures (1934) which included detailed study of rhythmic and harmonic dictation, it becomes obvious that Ortmann was a careful, intelligent researcher. Although his work grew out of a concern to improve music dictation pedagogy, Ortmann nevertheless provided the psychomusicologist with a wealth of ideas for studying the relationships among music structures, perception, and memory.

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