MELODIC AND RHYTHMIC CONTOUR IN PERCEPTION AND MEMORY

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As the Gestalt psychologists knew, and as William James and Christian Ehrenfels already saw in the 1890s, a melody is a prime example of an integrated whole in perception and memory. Changing any aspect of a melody--its pitches, rhythm, timbre, tempo, harmony, even its articulation--has an impact on how the other aspects are perceived and remembered. This does not mean that we can't analyze a melody in terms of its features. It just means we need to be cautious in drawing conclusions about the effects of those features, and be aware of the interactions operating among our variables. With that in mind we can arrive at a very good model of the relative contributions of the various analytic features of melodies.

Pitch, Rhythmic, and Dynamic Contour

A feature of melodies that we have emphasized in research over the years is the melodic contour--the pattern of ups and downs in pitch of the melody. We have come to realize that the rhythmic contour of a melody--the pattern of relative lengths of notes in time--is at least as important as the pattern of ups and downs of pitch. We refer to these patterns as "contours" because they call attention to aspects of melody where it is the relative values of pitch, loudness, and time that are important, and not their absolute values (as tends more to be the case with patterns of timbre and articulation, for example). While these contours may operate relatively independently of one another, they are often closely linked and virtually inseparable in perception and memory. Yi (1990), for example, has demonstrated the integration of pitch and rhtyhmic contours in the lieder of Schubert and Schumann.

At this point we wish to suggest an improvement in our terminology. Even in the title we refer to "melodic and rhythmic" contour. We now believe that that way of talking involves a confusion of levels of categorization. We should rather say that melodic contour has two aspects: the pitch contour of ups and downs, and the rhythmic contour of longs and shorts and patterns of accent. "Melodic contour" is the superordinate category. Further, we believe that the two aspects of melodic contour--pitch and rhythm--are essentially inseparable features of the melodic pattern.

To illustrate the inseparability of the pitch and rhythmic contours, take as an example a pair of melodies that share not only their pitch contours, but also have identical pitch patterns: the popular song "Rudolf, the Red-Nosed Reindeer" and the old hymn "Rock of Ages." The pitch patterns [in C major: G, A, G, E, C, A, G; contour: + - - + - -] are identical, but due to the differences in rhythm and tempo that fact is not at all obvious. In fact, in our laboratory we didn't realize the identity of the pitch patterns until we started using them as stimuli. We could say that the pitch pattern has a different "meaning" when it is given a different rhythm.

While we can almost do without the pitch component of melodic contour--in some melodies it almost disappears--the rhythmic component is indispensible. Let us look first at the relative dispensibility of pitch contour. Beethoven in particular was able to build a long stretch of melody out of a single pitch. For example, if we symbolize unisons of pitch with a zero, the opening theme of the Moonlight Sonata has the pitch contour [0 0 0 0 0 0 0 0 - + -], and the theme of the Allegretto from the Seventh Symphony the contour [0 0 0 0 0 0 0 0 0 0 0 + + 0 0 0 0 0] --very little there except for the unisons. These melodies are memorable largely because of the rhythms and their associated harmonies. Further, as William James (1890) observed, if we eliminate the pitch contour of a familiar melody, leaving only the rhythmic contour, it will still often be recognizable; take "Rudolf," for example: [. _ . _ _ _ _] is unmistakeable (where . and _ represent short and long notes, eighths and quarters, respectively). The importance of the rhythmic pattern has been borne out in a series of experiments by Monahan and Carterette (1985).

The rhythmic contour, unlike the pitch contour, is almost impossible to eliminate. As Fraisse (1974) showed, even an isochronous repetition of one tone will be heard as having a rhythmic pattern; we cannot help but impose a temporal organization on the notes. And if a melody with more than one pitch is isochronous, the pitch contour itself will establish a rhythmic contour by inducing accents by flexions and leaps (Drake, Dowling, & Palmer, 1991). "Yankee Doodle" provides an example; others are the beginning of the Dance of the Furies and of the aria "Cet asile aimable et tranquille" from Gluck's *Orphee et Eurydice.*

In addition to contours of pitch and rhythm, we should also recognize that music involves patterns of loud and soft that are shaped into a dynamic contour, as Kopiez has suggested (Kopiez & Langner, 1998). Sometimes this shaping involves the contrast of whole phrases or whole sections, as when the first eight bars of a minuet are repeated softly, or when a distant voice echoes a phrase. But in other instances the dynamic contour is used as a rhythmic pattern in itself, as in the Minuet from Mozart's *Quartet in G*, K. 387, the first of the six dedicated to Haydn (Figure 1). In measures 3-6 the first violin alternates rapidly between soft (p) and loud (f), and this pattern is echoed by the cello when it enters in measure seven. It is perhaps evidence of Mozart's inimitable and irrepressible personality that not only does he use this dynamic contour to tie this minuet together (see, for example, measures 65-70), but he also makes an explicit cross-reference to it seven measures from the end of the Andante con moto in the third quartet dedicated to Haydn, the Eb major, K. 428.

Figure 1. Beginning of Mozart's Minuetto from the Quartet, K. 387.

Melodic Features and Musical Meaning

In constructing a piece the composer has at his disposal in the auditory realm what E. G. Boring (1933) aptly called the "physical dimensions of consciousness." Musical meaning arises from combinations of sound organized in terms of pitch, time, timbre, loudness, and spatial location. Melodic contour represents a higher-level organization of the elements of pitch and time, and manipulation of materials at the level of contour can indicate shifts of meaning. Taking the rhythmic contour [. . . _] at the start of Beethoven's Fifth Symphony as an example, we observe that the same contour occurs with a shift of accent and of metrical context occurs in the last movement. The shift of meaning and of emotional impact is strengthened by the contour link between movements.

Melodic contour is one of the higher order organizing principles of melody. Other principles involving pitch are the pitch range and average pitch level. Consider in Mozart's *Magic Flute* the contrast between the music for Sarastro and for the Queen of the Night and its dramatic appropriateness: low pitch and relatively narrow range and interval sizes for the calm priest, high pitch and wide range and leaps for the angry witch. Another global organizing principle for pitch is tonality (Krumhansl, 1990). Examples abound of shifting relationships between pitch contour and tonality; one is the reprise of the opening theme in the minor, and in an altered relation to the tonic in the middle of the first movement, of Haydn's *"Sunrise" Quartet* (op. 76, no. 4); another is the treatment of "Frere Jacques" in Mahler's First Symphony. Tempo is an organizing principle whose relationship to rhythmic contour deserves considerably more research effort. To round out the list, we have timbre and articulation.

The Listener's Implicit Knowledge

These sets of features can be used systematically to explore the implicit, procedural knowledge the listener brings to hearing music (Dowling, 1993). Recent articles by Smith (1997) and Cook (1994) appear to claim that not only have psychologists of music neglected the musically untrained listener, but that what we do know of the untrained listener suggests that he or she is incapable of grasping the structural aspects of music thought to be essential to understanding. Neither of these claims is true. Not only have musically untrained listeners been studied intensively, but we have found out a great deal about their cognitive processing of music. That new knowledge allows us to specify in many instances where the music cognitions of experienced and inexperienced listeners overlap, and where they diverge. In what follows we will just touch on a few of the discoveries of the past 30 years concerning untrained listeners.

Contour. Inexperienced listeners are usually as good or better than experienced in recognizing distorted pitch contours of melodies (Dowling & Fujitani, 1971).

Intervals. Inexperienced and experienced listeners alike are precise in their tuning of the intervals of a familiar tune (the NBC chime pattern) when presented at arbitrary, novel pitch levels (Attneave & Olson, 1971).

Tonal Material. Like experienced listeners, inexperienced listeners assimilate quarter steps presented in the midst of very rapid melodic patterns to their neighboring semitones, especially ones in the familiar diatonic major scale (Dowling, 1988, 1992).

Tonality. Untrained listeners readily detect out-of-key alterations in a tonal melody (Dewar, Cuddy, & Mewhort, 1977). They are also more confused by near-key lures in a recognition task than musically trained listeners (Bartlett & Dowling, 1980). This shows the strength of the tonal scheme underlying their perceptions, and that they cannot avoid using it even when it hurts performance. The trained listeners, in contrast, have greateer conscious control over the use of the tonal scheme.

Inexperienced listeners' ratings of melodies varying in tonal strength are closely parallel to the ratings of trained listeners (Cross, Howell, & West, 1983). The enhancing effect of tonal strength on melody recognition is the same for inexperienced and experienced listeners (Dowling, 1991). And experienced and inexperienced listeners show the same tonality-based asymmetries of judgment.

When a brief tonal melody is followed by a highly similar atonal melody with the same contour, the two are judged to be less similar than when they occur in the order atonal-tonal (Bartlett & Dowling, 1988). This is an example of an often observed effect of prototypes on similarity judgments, where the tonal melody is seen as prototypical. One surprising aspect of these results is that when listeners are asked to judge contour, and occasional contour differences are introduced along with the tonal-atonal differences, listeners' ratings of contour follow the same pattern as their previous similarity ratings, alike for inexperienced and experienced listeners. That is, listeners' presumably "analytic" judgments of contour differences are heavily influenced by the global tonality relationships of the melodies, and susceptibility to that influence is not any weaker for untrained than trained listeners. This is one more illustration of the strength of the tonal scheme underlying the cognition of listeners across a wide range of expertise.

Melodic Contour in Memory

My initial work on melodic contour showed that contour is a dominant factor in immediate recognition memory for brief, novel, isochronous melodies (Dowling & Fujitani, 1971; Dowling, 1978). With such materials it is a straightforward matter to test the relative contributions to recognition accuracy of preservation of the contour of a target and preservation of the exact pitch pattern. A particular input melody can be tested (following a delay filled with other items) with a target (T) that preserves its exact interval pattern, with a similar lure (S) that preserves the pitch contour but not the exact intervals, or with a different lure (D) having a changed contour. The listener's ability to discriminate Ts from Ss increases with the importance of interval pattern, and decreases with the importance of contour. If T/S discrimination is low, then the importance of contour is indicated by T/D discrimination. That is, contour is important to recognition to the degree that listener's cannot detect changes in intervals, but can detect changes in contour.

An interesting result that arose out of the research on contour with brief isochronoous melodies is that while contour dominates immediate recognition memory its importance diminishes over time, so that after a delay T/D discrimination is surpassed by T/S discrimination (Dowling & Bartlett, 1981; DeWitt & Crowder, 1986; Dowling, 1991). We believe the initial domination of contour is due to the confusing sense of similarity between a target melody and a similar lure having the same contour in a closely related key. However, the importance of contour diminishes as additional melodies are presented, since contours of isochronous melodies tend to be rather similar and fine intervallic details are necessary to differentiate the melodies.

Dowling, Kwak, and Andrews (1995) introduced "real" novel melodies with their natural rhythms--Scottish folk songs--into this paradigm. The main result was that with more complex contours including differentiated rhythms, T/D discrimination was never overtaken by T/S discrimination, even though T/S performance tended to improve over periods of minutes. It is not surprising that T/S and T/D performance should be more similar when contour becomes more complex and conveys more information. What is surprising is the gradual improvement in performance, especially with the complex T/S discrimination, and especially under conditions where an item and its test are separated by the presentation of a series of other items to be remembered.

Erdelyi (1996) presents evidence that, especially with complex materials such as poetry, repeated testing leads to better memory performance, or "hypermnesia." The listener's working memory tends to keep active track of those items it expects will be tested, with the result that performance for those items can improve over time. The continuous-running-memory paradigm, with its continual series of test items, leads to the expectation that items will be tested.

Demonstrations of hypermnesia with recognition memory are rare--failures to find it are more common (Payne & Roediger, 1987; Otani & Hodge, 1991). This may be due to intensive retrieval processes induced by recall but not by recognition. Erdelyi and Stein (1981) found hypermnesia in recognition of cartoon pictures deprived of their captions (that were present when the cartoons were initially seen). This may be because the captionless cartoon stimulates an attempt to retrieve the missing caption. Similarly, it may be that the continual initiation of retrieval processes in the continuous-running-memory task may itself foster hypermnesia by keeping the working memory system in expectation of additional retrieval attempts. As Erdelyi and Stein (1981) say, "For recognition hypermnesia to be obtained, ... retrieval search must be a nontrivial component of the recognition task." The possibility that this might operate with a continuous-running-memory task is explored in the following experiments.

One issue that this characterization of the improvement over time of recognition memory for melodies raises is that of the effect of repeated testing of other items between the introduction of a new item and its test. If testing tends to enhance performance, then more testing should lead to better performance. That expectation is in contrast to the possibility that increased numbers of intervening items between the introduction of a melody and its test should simply produce interference in memory and hence worse performance. In the Experiment 3 the time delay and the number of intervening items are varied independently of each other.

EXPERIMENTS

We report five experiments that extend the results of Dowling, Kwak, and Andrews (1995), using the same folksong materials as they did but with longer delays (up to 11 min) before testing (Experiments 1-3), as well as sound-bites from recordings of Celtic popular music (Experiments 4 and

5). Taken together, Experiments 1-3 illustrate the phenomenon of improvement in recognition memory over the first 5 min after a novel melody is introduced. In Experiments 1 and 2 the number of intervening melodies between the introduction of a novel item and its test varies directly with time, with the successive melodies in the experiment occurring at equal intervals of time. Experiment 3 varies the time delay between the introduction of a new melody and when it is tested independently of the number of intervening items during that delay, with the consequence that the temporal spacing of the melodies varies.

General Method

The experiments used the following general design, departures from which are described in the individual method sections. Each experiment consisted of about 72 trials arranged in a continuous running memory task (Shepard & Teghtsoonian, 1961). On each trial a melody was presented, which could be a new melody that had not been heard before in the series of trials (labeled D for "different"), a test melody identical to a melody that had been heard before (labeled T for "target"), or a test melody in which two pitches had been altered, preserving diatonicity and contour (S for "similar lure"). As shown in Figure 2, each new item could be tested after various delays filled with varying numbers of intervening items. Each bracket denotes a pair of items. The lists contained between 36 and 60 pairs of melodies, each pair consisting of the introduction of a new melody, and its test as a target or a slightly altered lure. In Figure 2 the melody introduced on trial 1 is tested on trial 5 with a target (T); the melody introduced on trial 2 is tested on trial 4 with a similar lure (S), etc. Test items were always in the same key and at the same pitch level as initial members of pairs. Note that in such a task subjects respond to every item in the list, including items filling the delay between the introduction of an item and its test. This means that subjects' set in perceiving each item, whether a newly introduced or a test item, is the same. The task also has the motivational advantage that subjects find it more congenial than tasks in which they continually have to "shift gears" in altering their set for a more stressful test sequence.

Figure 2. Structure of a continuous-running -memory list. New items are introduced on trials 1-3. Item 2 is tested with item 4, a similar lure (S). Item 1 is tested at item 5 with a target (T).

Listeners were instructed to respond toward "same" on a 6-point confidence-level scale to Ts, and toward "different" for Ss and Ds. Thus we could measure hit rates to Ts and false-alarm rates to the two types of lure: S and D. Not all new items functioned as D items for purposes of data analysis, but only those falling in appropriate test positions with respect to earlier new items. A given D item was assigned as a test of only one initial item. The dependent variable was area under the MOC taken as an estimate of unbiased proportion correct where chance is .50 (Swets, 1973). Two areas were calculated for each listener, referred to as T/S and T/D for the comparison of hits with the two types of lure.

All the experiments used actual melodies and not artificial ones. In Experiment 1 both familiar and unfamiliar melodies. Twenty-four familiar melodies were chosen as well-known to the subjects on the basis of previous experiments, and 60 stylistically comparable melodies were chosen from McColl and Seeger's (1977) Travellers' songs from England and Scotland. The familiar melodies included such tunes as "Over the Rainbow," "Frosty the Snowman," "Take Me Out to the Ball Game," and "When the Saints Go Marching In," as well as highly familiar folk, nursery, and patriotic tunes. Melodies were 10-21 notes long and had equivalent tempos in notes/sec. Melodies were between 6 and 12 sec in length. The starts of trials were spaced 20 sec apart, so that listeners had at least 8 sec to respond to each melody. Stimuli were produced on a Yamaha synthesizer using its "acoustic piano" voice controlled via a MIDI interface by a PC-type computer running Cakewalk software, and presented to subjects via loudspeakers at comfortable levels.

The experiments were generally arranged in a 2 Experience Levels X 2-3 Test Delays X 2 Test Comparisons (T/SC, T/DC) design. All but the first of those variables involved within-groups comparisons. For purposes of counterbalancing, different groups received different versions of the list. The main goal of counterbalancing was to ensure that equal numbers of subjects received lists in which a given melody was tested at different delays, so that effects attributed to test delay could not be due to the memorability of particular items. That is, to generate each additional counterbalancing list the original 60 (or 48) melody pairs were reassigned to delay conditions with the constraint that no pair could be assigned again to a delay condition to which it had already been assigned on previous lists.

Procedure. Listeners were introduced to the experiment by brief explanations of the continuous running memory task, the differences among T, S, and D test items, and the confidence-level response scale. The experimenter explained the intermingling of new items and test items in the list, and informed the subjects that several items might intervene before an item was tested, up to an amount somewhat longer than the longest delay being tested). The experimenter used a sequence of familiar tunes to demonstrate the structure of the list and the distinctions among the stimuli.

Listeners. Undergraduates at the University of Texas at Dallas (mean age 27.4 years) served as part of their course requirements in psychology. Those categorized as musically experienced had more than 2.0 years of explicit musical training (defined as at least 2 years of music lessons or playing in an instrumental ensemble; mean = 8.2 yr, S. D. = 4.7 yr). Those with less training were categorized as musically inexperienced.

Experiment 1

Method. Experiment 1 tested delays between the introduction of a melody and its test of 0.5, 2.5, and 5.0 min, with 1, 7, and 14 intervening items in those delays. This gave a 2 Experience Levels X 3 Delays X 2 Test Types design. Seventeen listeners, seven inexperienced and ten moderately experienced, served in the experiment. There were 72 trials, and hence 36 novel melodies tested. That provided 6 T and 6 S trials at each delay, as well as 8 D trials. There were two counterbalanced lists, and approximately equal numbers of listeners at each experience level performed the experiment with each list.

Table 1
Areas Under the MOC for 3 Delays and 2 Test Types in Experiment 1.

	Delay (min)		
Test Type:	0.5	2.5	5.0
T/S	.53	.58	.57
T/D	.65	.68	.69

Results. Experienced listeners performed better than inexperienced (area scores of .65 vs. .58), $F(1, 15) = 7.61$, $p < .02$. T/D comparisons were easier than T/S (.67 vs. .56), $F(1, 15) = 20.94$, $p < .01$. No other effects were significant. Mean performance at the three delays is shown in Table 1 and in Figure 3.

Discussion. Though there is a hint of improvement of recognition performance over time in Experiment 1, in keeping with the results of Dowling, et al. (1995), the effect was not significant. Experiment 2 extended the time delays to 11.0 min, and also included familiar as well as unfamiliar melodies. One reason for including familiar melodies was the presumption that they would invoke very different encoding processes from the unfamiliar; namely, that they could be labeled, and their labels remembered. Since the verbalized labels were unlikely to produce memory improvement, as noted above, we expected to observe a decline in performance over time for the familiar melodies, contrasting with the possibility of hypermnesia with the unfamiliar melodies.

Experiment 2

Method. Experiment 2 tested delays between the introduction of a melody and its test of 3.0, 5.5, and 11.0 min, with 8, 16, and 32 intervening items in those delays. Both familiar and unfamiliar melodies were included in the list of 72 items, with the result that there were three instances of each trial type in the list. This gave a 2 Experience Levels X 2 Familiarity Conditions X 3 Delays X 2 Test Types design. Thirty-one listeners, 15 inexperienced and 16

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Table 2
Areas Under the MOC for 2 Familiarity Conditions, 3 Delays, and 2 Test Types in Experiment 2.

		Delay (min)		
Familiarity:	Test Type:	3.0	5.5	11.0
Familiar	T/S	.74	.74	.77
	T/D	.83	.80	.66
	Mean	.79	.77	.71
Unfamiliar	T/S	.64	.66	.56
	T/D	.69	.74	.56
	Mean	.67	.70	.56

moderately experienced, served in the experiment. In all other respects the method was as in Experiment 1.

Results. Familiar melodies were easier than unfamiliar (areas of .76 vs. .64), $F(1, 29) = 25.83$, $p<.01$. The effect of delay was significant, with improvement between 3.0 and 5.5 min and then a decline, as shown in Table 2, $F(2, 58) = 8.05$, $p<.01$. That inverted-V pattern over time occur red only with with the unfamiliar melodies, and was more pronounced with the T/D tests as shown in Table 2. The Delay X Test Type interaction was significant, $F(2, 58) = 11.79$, $p<.01$; and the Delay X Test Type X Familiarity interaction approached significance, $F(2, 58) = 2.65$, $p<.08$. No other effects were significant. The results for unfamiliar melodies are also shown in Figure 4.

Discussion. Hypermnesia occurred with the unfamiliar melodies between 3.0 and 5.5 min, especially with the T/D tests. This was in contrast to the forgetting observed for familiar melodies with T/D tests. (It is not surprising that performance for T/S tests of familiar melodies did not decline, since most S items are obviously altered with respect to their familiar versions, and rejecting them thus does not depend on time.)

In Experiments 1 and 2 the number of intervening melodies between the introduction of an item and its test varied directly with the time delay. The confound of time and intervening items makes it impossible to assess the possible effects of interference with memory processing by the intervening items, as distinct from the effects of time on forgetting or improvement in memory. Experiment 3 was designed to remove this confound by varying delay and intervening items independently.

Experiment 3

Method. Experiment 3 tested two delays of 1.5 and 3.0 min, with either 2 or 4 intervening melodies between the introduction of a melody and its test. This gave a 2 Experience Levels X 2 Delays X 2 Levels of Intervening Melodies X 2 Test Types design. There were 70 trials, including 64 trials that counted plus six buffers that were not scored placed at various points in the list, especially at the start. There were 32 pairs of melodies, providing four trials of each type. Varying delay and number of intervening melodies independently meant that there was inevitably an uneven distribution of melodies in time, so that the list had dense regions and sparse regions. Sixty-nine listeners, 28 inexperienced and 41 moderately experienced, served in the experiment. There were three counterbalanced lists. In all other respects the method was as in Experiment 1.

Results. The effect of delay was significant, with performance better after 3.0 min than after 1.5 min (areas of .69 vs. .64), $F(1, 67) = 4.14$, $p<.05$. The effect of test type was significant, with T/D performance better than T/S (.74 vs. .59), $F(1, 67) = 164.34$, $p<.01$. The interaction of Delay X Test Type is shown in Table 3, $F(1, 67) = 7.45$, $p<.01$, and indicates that the effect of delay was operating principally on T/S performance. The interaction of Delay X Intervening Melodies is shown in Table 4, $F(1, 67) = 13.74$, $p<.01$, and indicates that while performance improved across intervals filled with two intervening melodies, it declined across intervals filled with four. The Delay X Intervening Melodies X Test Type interaction was

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Table 3
Areas Under the MOC for 2 Delays and 2 Test Types.

	Delay (min)	
Test Type:	1.5	3.0
T/S	.55	.62
T/D	.73	.74

Table 4
Areas Under the MOC for 2 Delays and 2 Levels of Intervening Stimuli.

	Delay (min)	
Intervening Stimuli:	1.5	3.0
2	.59	.72
4	.69	.65

Table 5
Areas Under the MOC for 2 Delays, 2 Levels of Intervening Stimuli and 2 Test Types.

	Delay (min)			
	1.5		3.0	
Intervening Stimuli:	T/S	T/D	T/S	T/D
2	.48	.70	.68	.76
4	.63	.76	.56	.73

significant, $F(1, 67) = 17.12$, $p<.01$, and is shown in Table 5. Hypermnesia, the improvement of memory over time, occurred only in the two-intervening-melodies conditions, and then most markedly with T/S performance. No other effects were significant.

Discussion. In Experiment 3 recognition performance improved between 1.5 and 3.0 min, and this improvement was especially pronounced for T/S comparisons (Table 3). The interpretation that at least some of this improvement is fostered by repeated testing during the delay interval is supported by the fact that at 1.5 min performance with 4 intervening items is better than with 2 (.69 vs. .59--Table 4). That that improvement occurs over time independent of amount of testing can be seen in the 2 intervening items condition going from 1.5 to 3.0 min (.59 vs. .72--Table 4).

It is clear that these results, along with those of Erdelyi and Stein (1981), demonstrate the occurrence of hypermnesia in recognition memory. One reason this may have occurred is the complexity of the materials. It is clear from Erdelyi's (1996) review that hypermnesia in recall occurs commonly with complex materials such as poetry; and Payne and Roediger (1987) and Otani and Hodge (1991) failed to find it in recognition with simple word lists. Note that hypermnesia did not occur with familiar melodies in Experiment 2, in a situation where the melodies were very likely to have been encoded verbally by the listeners on first hearing. The complexity of melodies may foster continued processing in memory even as new items are presented. A second reason that may have led to hypermnesia here is that the continuous-running memory paradigm involves continued testing following the presentation of a novel melody. This continued testing may stimulate continued processing of the melodies, whether by stimulating retrieval processes as Erdelyi and Stein (1981) suggested, or by leading the working memory system to keep memory traces active that could be expected to be tested in the near future.

It is noteworthy that there was no main effect of number of intervening melodies. The effect of intervening melodies is clearly not simply one of interference with memory processing. Table 5 shows that at the 1.5 min delay increasing intervening melodies helped, while at 3.0 min it hurt performance. This is one of the puzzling interactions in Experiment 3 involving the number of intervening items. Those are compatible with the supposition that recognition improves in a situation where the working memory operates on the expectation that items will be tested in the near future. This improvement is especially strong where recognition of the exact earlier pattern is concerned (that is, for T/S discrimination), and takes the form of increasing rejection of the highly similar S lures. But the grosser T/D discrimination improves as well (Table 5, row 1). Improvement can be accelerated by massed testing (as in the 4 intervening items condition), but then performance fades, probably due to the interfering effects of the massed test items, themselves to be remembered.

Figure 3 summarizes the results of Experiments 1-3 concerning their bearing on the time course of recognition memory performance following the introduction of a novel melody. The results of Experiment 1 (0.5, 2.5, and 5.0 min) are presented along with the results for unfamiliar melodies in Experiment 2 (3.0, 5.5, and 11.0 min). The results of Experiment 3 that are shown are drawn from the conditions that are most comparable to those of Experiments 1

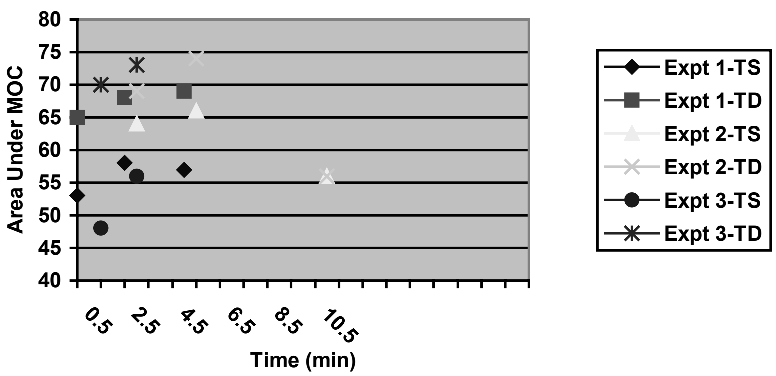

Figure 3. Area under the MOC for TS and TD trials in Experiments 1-3, showing results for unfamiliar melodies in Experiment 2 and for conditions with density of intervening items proportional to delay in Experiment 3.

and 2, namely, those where the number of intervening melodies was proportional to the delay: the 1.5 min delay with two intervening melodies and the 3.0 min delay with four. This approach softens the dramatic increases over time shown in Table 5, but contributes to an overall picture of the rise and fall of memory performance over time under comparable conditions. Performance peaks somewhere around 5 min and then declines.

Experiment 4

Experiments 3 and 4 adapted the methods of Experiments 1-3, but with the substitution of brief excerpts of recorded musical performances by popular music groups for single-line melodies. We selected pairs of excerpts in which generally the same musical material was repeated but with more or less subtle changes: a new background instrument, a different pitch level, a slightly altered melodic sequence, etc.

Method. Experiment 4 tested two delays of 1.5 and 3.0 min in a 2 Experience Levels X 2 Delays X 2 Test Types design. There were 72 trials and 36 pairs of melodies, providing nine trials of each type. Fourteen listeners, five inexperienced and nine moderately experienced, served in the experiment. There were two counterbalanced lists. We selected 36 pairs of musical passages 8.5 to 11.0 sec in length from a variety of recordings of Celtic popular music by such artists as The Chieftains, Clannad, and Loreena McKennitt. The excerpts were selected in pairs so that the second member of the pair had the same general texture and melodic-rhythmic contour, but differed slightly in instrumentation, pitch level, or melodic ornamentation. The differences between members of a pair were chosen so that the range of difficulty of the test items would be comparable to those of Experiments 1-3. For the 1.5 min delay two intervening melodies separated the introduction of a new melody and its test, while there were four intervening melodies for the 3.0 min delay. In all other respects the method was as in Experiment 1.

Results. The effect of test type was significant, with T/D performance better than T/S (.81 vs. .64), $F(1, 12) = 94.31$, $p<.01$. The interaction of Experience X Test Type was

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Table 6
Areas Under the MOC for 2 Delays and 2 Test Types in Experiments 4 and 5.

	Experiment 4		Experiment 5	
Delay (min):	1.5	3.0	3.0	6.0
Test Type:				
T/S	.67	.62	.66	.69
T/D	.80	.82	.82	.81

significant, $F(1, 12) = 5.79$, $p<.05$, with performance about equal (.65 vs. .64) for T/S items, but better for inexperienced listeners on T/D items (.87 vs. .77). No other effects were significant. The results for the two test types at the two delays are shown in Table 6.

Experiment 5

Method. Experiment 5 was just like Experiment 4, except with delays of 3.0 and 6.0 min, containing four and eight intervening items, respectively. Twenty-nine listeners, 12 inexperienced and 17 moderately experienced, served in the experiment.

Results. Only the effect of test type was significant, with T/D performance better than T/S (.82 vs. .68), $F(1, 12) = 92.03$, $p<.01$. The results for the two test types over delay are shown in Table 6.

It is noteworthy, in view of our discussions above of the effects of musical training, whether the field of music cognition ignores the musically untrained, and the importance of using natural musical materials, that effects of musical experience were not much in evidence. With the natural melodies of Experiments 1-3 there was just one effect of experience, favoring moderately experienced listeners in Experiment 1. And in Experiments 4 and 5, where even more natural materials were used, there was only an interaction in Experiment 4, and that favoring the inexperienced (who did better on T/D discrimination). It could well be that using materials that are more natural and closer to what listeners experience in everyday life makes the tasks more accessible to listeners without special training.

Summary

In closing, there are a few things we wish to re-emphasize. First, we want to remind readers of what we know concerning the musical cognitive abilities of listeners who have never taken music lessons. We also wish to note in passing that some of the things we have found concerning moderately experienced listeners would not have been expected on the basis of our experience with music students in conservatories (for example, that they encode melodies implicitly in terms of do-re-mi scale steps, Dowling, 1986).

Second, we wish to emphasize the importance of using as "real" a set of musical materials in our experiments as we can. This is both because ultimately we want to generalize to the understanding of actual music, and also because it is clear from these and other experiments that we obtain different results when richer materials approximating actual music are used.

Third, we wish to call attention to the relatively rare and surprising result of hypermnesia over a period of minutes in recognition memory. It is surprising when hypermnesia occurs at all, since we are used to the course of events in which things, once entered into our memory, are simply forgotten over time. Hypermnesia is more rare in recognition tasks than in recall, perhaps because the processes that bring it about are stimulated by ongoing retrieval attempts. The continuous-running-memory task used here may also stimulate continued processing through its continual presentation of "test" items. And it may well be that complex stimuli like melodies and poetry themselves lead the memory system to continue processing them even as new stimuli are presented.

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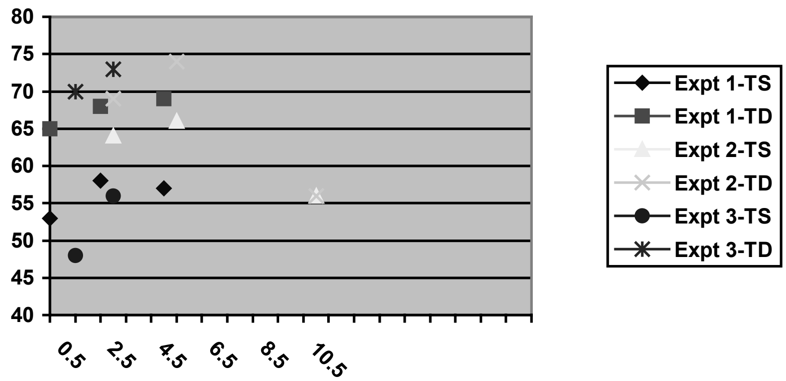

Figure 3. Area under the MOC for TS and TD trials in Experiments 1-3, showing results for unfamiliar melodies in Experiment 2 and for conditions with density of intervening items proportional to delay in Experiment 3.