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Andrea Halpern

Bucknell University, ahalpern@bucknell.edu

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Organization in Memory for Familiar Songs

Andrea R. Halpern

Stanford University and Bucknell University

The organizing principles in memory for familiar songs were investigated in two experiments. The hypothesis was that we do not store and remember each song in isolation. Rather, there exists a rich system of relationships among tunes that can be revealed through similarity rating studies and memory tasks. One initial assumption was the division of relations among tunes into musical (tempo, rhythm, etc.) and nonmusical similarity. In the first experiment, subjects were asked to sort 60 familiar tunes into groups according to both musical and nonmusical criteria. Clustering analyses showed clear patterns of nonmusical similarity but few instances of musical similarity. The second experiment explored the psychological validity of the nonmusical relationships revealed in Experiment 1. A speeded verification task showed that songs similar to each other are confused more often than are distantly related songs. A free-recall task showed greater clustering for closely related songs than for distantly related ones. The relationship between these studies and studies of semantic memory is discussed. Also, the contribution of musical training and individual knowledge to the organization of the memory system is considered.

Humans from infancy to old age are able producers of music. Even before reaching an age of 2 years old, children can produce spontaneous songs using distinct pitches and occasional rhythmic patterns (McKernon, 1979). Most adults whistle or sing an enormous repertory of songs and fragments of larger pieces. In addition, people of all ages are competent and enthusiastic music listeners. Simply the ubiquity of music perception would make it a topic of interest to cognitive psychologists. In addition, the fact that music lacks facile verbal referents presents a challenge to theorists accustomed to dealing with perception and memory for verbal, pictorial, and propositional material. Are there regularities in music processing comparable to those found in these other subfields of cognitive psychology?

Most previous studies in the psychology of music have used units of analysis at or below the level of single, short, often unfamiliar melodies. A guiding principle for the current research is that musical cognition exists at a higher level than the analysis of single melodies. Specifically, I propose that there exists an associative memory system of all musical materials. Recently, there have been two broad approaches to studying memory organization in other domains: the clustering and semantic memory approaches.

The first approach focuses mainly on the amount of organization subjects impose on stimuli and the subsequent effects on memory. The organization may be more (Bousfield, 1953) or less (Mandler, 1967) inherent in the to-be-recalled items, but in either case, the pattern of recall presumably reflects the subject's mental organization of the items.

How might the subjective organization approach be applied to a study of musical memory? One could conduct an experiment asking for generation of song titles (or recall of a stimulus list) and could measure the amount and kind of clustering that occurred. Another experimental alternative is a sorting task, where subjects are given song titles to place into categories to reveal mental organization. The former technique was used in Experiment 2 and the latter in Experiment 1.

These experiments formed part of a doctoral dissertation submitted to Stanford University. A condensed version of this report was presented at the meeting of the Eastern Psychological Association, April, 1983, in Philadelphia.

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Requests for reprints should be sent to Andrea R. Halpern, Department of Psychology, Bucknell University, Lewisburg, Pennsylvania 17837.

Another approach to memory organization is derived from computer simulations of memory. These semantic memory models offer a more complete statement about the structures and processes involved in a memory system. For instance, when Quillian (1969) started to simulate a Teachable Language Comprehender (TLC), he was forced to decide how the system's knowledge would be represented and how the system would go about retrieving information from the data base. As is now well known, Quillian chose a hierarchical representation where objects and their properties were combined into more general supersets at each level of the hierarchy (for instance, canary $\rightarrow$ bird $\rightarrow$ animal). The system was designed to answer questions of the type: Does object x possess property y ? The latencies to answer such questions provided a test of the representational structure.

Following this approach, Experiment 2 used a question-answering technique with musical materials. The goal was to find out whether a "semantic memory" of tunes with different degrees of relatedness could be reflected in on-line processing. This is a step toward describing the way in which our whole vocabulary of tunes is interrelated in the spirit of the above memory models. But what does *semantic distance* mean for musical memory?

At least two kinds of "semantic" associations may operate in musical memory. One class I call *musical relations*, that is, relations among patterns of a purely musical nature. Musical relations refer to such features as tonality, contour, tempo, and rhythm. The other class is *extramusical relations*. These relations refer to the category of the tune (patriotic song, commercial jingle, score from a musical), age of acquisition, episodic connections (songs heard at a particular concert), or the dramatic value of a piece. (Of course, these classes of relations may be correlated.)

Evidence for use of both kinds of relations can be seen anecdotally and dramatically in the popular television game show *Name That Tune*. Contestants, who know an exceptional number of songs, are given an extramusical clue, such as a hint about the composer, and then the first n notes of a melody. The object is to minimize n and to still correctly give the tune's title. As most correct answers are given within a few seconds, it seems reasonable to

suppose that their search has proceeded through an organized memory system.

Additional evidence for extramusical relations was observed in a pilot procedure for the current experiments. As a step toward assembling stimulus materials for this study, a sample of students was asked to list tunes they thought others would know. No specific recall instructions were given, yet groups of songs, such as Beatles tunes, hymns, or children's songs, were clustered together in the output.

Additional evidence for musical relations comes from singing errors. Uncertain singers produce singing errors with definite patterns. Rarely does a random collection of pitches emerge in place of the chosen tune. Instead, the pattern resembles the correct tune at least in contour (the up or down direction of successive pitches). McKernon (1979) reported that young children can initially produce the right pace, contour, and phrase boundaries of a song; later they produce the correct pitches and rhythm. These nonrandom errors may occur because isolated tunes are stored in a schematic form. Because generalized representations obscure differences among individual items, each schematic form may stand for more than one melody. Then these schemata may in turn be related in the memory system. How can we characterize these schemata?

Much of the research in the psychology of music investigates how individual melodies are represented in memory. These studies of melody perception form the basis of hypotheses about the musical relations that may exist among the melodies. Some aspects of a melody that are important in its representation may be the intervals between contiguous or non-contiguous pairs of notes, the contour (pattern of ups and downs of successive notes), the harmonic relation of each note to the tune's tonal center, and rhythm.

The importance of individual interval size in melody recognition was shown by Dowling and Bartlett (1981). They found that interval information was especially important in long-term memory for real music. In musical memory retrieval, exact interval knowledge could prove crucial in a fast search of long-term memory. Classification of tunes by their first few intervals would be an efficient scheme. Perhaps all melodies beginning with some particular interval are classified and stored to-

gether, at least within an extramusical class (e.g., patriotic songs).

People also use pitch contour in melody recognition. Many researchers have found that melodies with the same contour as a target melody are sometimes misidentified as the target (Dowling, 1978; Dowling & Fujitani, 1971; Massaro, Kallman, & Kelly, 1980). Thus, in the absence of memory for exact pitches, melodies are remembered partly as contours. Tone sequences having similar contours may be associated in the proposed memory system.

Another aspect of melody recognition discussed extensively in the literature is tonality. Tone sequences may be understood by relating each tone to its key center (the most important note in a given key). Dowling (1978) found that subjects could not discriminate between an exact and a tonally similar transposition of a tune. The system of tonality can function as a framework that obscures the interval differences. As another example of tonality, the mode of a piece (major or minor key, for instance) may be included in the memory representation. Perhaps tunes with similar modal structures are associated in the proposed musical memory.

Rhythm by itself can be a reliable cue to a familiar song's identity (White, 1960). Indeed, many researchers have found that people are excellent perceivers, producers, and perhaps rememberers of rhythmic patterns (see Fraisse, 1978, for a review).

The evidence reviewed suggests that well-known melodies are not stored randomly in memory. The following experiments attempted to verify organizational principles already put forward, to add new ones, and to evaluate manipulations based on these principles in memory tasks. A brief summary of the research follows.

The goal of the first experiment was to characterize the organization of well-known tunes by applying multidimensional and clustering techniques to subjects' sorting of tune names by similarity. The solutions obtained were compared with the proposed musical and extramusical relations.

The next study used a verification task to test how much the similarity structure gleaned from the first study predicted memory performance. If two items are psychologically

"close," we expect that rejecting their mismatch in verification would be more difficult than if the items are far apart. Reaction times and error rates were examined to test this prediction. This experiment also tested free recall of the song names after random presentation. Evidence of clustering predicted by the previously found intersong distances was examined.

Experiment 1

This initial study gathered similarity measures between songs that were well known to subjects. Of major interest was the difference in similarity structures obtained when subjects were asked to sort song titles under two sets of instructions. One set emphasized musical similarity, the other, nonmusical similarity. Because both of the studies used the same carefully selected stimulus set, its means of construction is described first.

Stimulus Preparation

The songs used in these studies were required to be familiar to both the undergraduate subject population and to the experimenter. The songs also had to have recognizable titles and to have titles that cued the beginning part of the music. This last requirement enabled a title to serve in place of the actual music to save time and tedium for the subjects.

Because asking people simply to generate song titles produced few items, almanacs and catalogs of popular music were consulted to yield song candidates. Including suggestions by colleagues resulted in a list of 210 candidate songs. These songs were then rated for familiarity by 19 people ranging in age from 16 to 36. The raters used a 1-7 scale, ranging from *they had never heard of the song* (1) to *the song was so familiar they could "hear it in your head"* (7).

The mean rating and standard deviation for each song were computed. The complete list can be found in the Appendix. To select the final pool of 60 items, the 65 songs with the highest mean ratings and lowest standard deviations were chosen first. Another 5 were eliminated because their most well-known part was not at the beginning of the song (one example was "Home on the Range"), and it was

imperative that both subject and experimenter implicitly agreed on the aural referent to any given title. The 60 songs used in the experiments are noted by their abbreviations in the Appendix. (Figures use these abbreviations rather than the complete names.)

Method

Subjects. Participants were 20 Stanford undergraduates who received course credit for volunteering. For all the experiments in this article, subjects were required to have been raised in the United States, to have been native English speakers, and to have had no hearing impediments.

Materials. For the sorting task, the full name of each song was typed on a separate index card. For an initial familiarization phase, subjects heard a tape of the beginning of each song without lyrics. The music for this and all succeeding experiments was produced by an Apple II Plus computer driving a Mountain Computer music system. Each tone was a triangle wave with 30 ms rise and decay times. The fragments were recorded from the musical notation that a professional musician produced when supplied with the name of the tune. Tempos were adjusted individually for each tune. The tune fragments were recorded on audio tape. Each fragment lasted approximately 7 s, with about 5 s of silence between each one.

Procedure. Subjects were tested in small groups. For the familiarization phase, subjects were provided with a sheet of paper containing the song titles in the same order as they appeared on the tape. They were instructed to reveal one title at a time (a large white card served as a mask), to think of how the corresponding music sounded, and then to check their guess by listening to the ongoing tape. This phase lasted about 10 min and presumably ensured that subject and experimenter were referring to the same song.

The sorting procedure then began. Each subject received a randomized deck of the 60 song-title cards. They were instructed to sort the cards into small piles such that the songs referred to by the titles were similar in some way. "Similarity" is further explained later. They were told to have at least 2 piles and it was suggested but not required that they have no more than 10. To ensure informed judgments, subjects were allowed to set aside any title they felt too insecure about to judge properly. Most participants took advantage of this option for a few songs.

Subjects were given ample time to consider their selections carefully and to make adjustments. When they were satisfied, they recorded the number and composition of each of their piles by means of code numbers on the back of each card. They then shuffled the cards and repeated the exercise after receiving a new set of instructions.

There were two versions of the similarity instructions. The *musical* instructions informed subjects that the songs in each pile should "go together on the basis of how similar they sound—musical similarity." The *nonmusical* instructions were that sorting should be done "on some basis other than how similar they sound." In either case, subjects were told to "ignore any characteristics of the titles themselves; we are interested in the songs they refer to." Half the subjects received musical similarity instructions first, and half, the nonmusical instructions first. The session lasted about 1 hr.

Results and Discussion

The dependent measure in the task was the co-occurrence frequency of each possible pair of songs, that is, the number of subjects placing any given pair in the same pile. High co-occurrence frequency is taken to mean that for the group as a whole, the two songs are closely related. Before the data were analyzed, the number of times a melody had been rejected because of unfamiliarity was tabulated. A criterion of at least 17 of the 20 subjects having answered an item was set for retaining that item in the analysis. All analyses were performed separately for the two sorting instructions. Three songs were eliminated for the nonmusical sort and one, for the musical sort.

The co-occurrence frequency matrix was submitted to a multidimensional scaling analysis (KYST, Kruskal, Young, & Seery, 1973) and an additive tree-fitting program (ADDTREE, Sattath & Tversky, 1977). These techniques represent subjects' similarity structure of the stimulus items by referring them to points in space or to nodes in a tree.

The most interpretable results came from ADDTREE, shown in Figures 1 and 2. The ADDTREE solution is the most thoroughly discussed, although a few comments are offered about the other solutions when appropriate.

In an additive tree, stimulus items appear to the far right of the figure, and similarity between items is defined as the sum of the horizontal paths that connect them. Vertical placement of the tree on the page is arbitrary. The program clusters together items that are simultaneously maximally similar to each other and minimally similar to other items. The clustering structure is revealed by the branching pattern. The program does not label the branches. However, a measure of how well the procedure has captured the similarity relations is the ease of assigning meaningful labels to them. A more quantitative measure of how well a solution captures the relationships in the data is the proportion of variance in the data it accounts for.

Nonmusical sort. The ADDTREE solution for the nonmusical sort is shown in Figure 1. Most of the clusters and branches could be given reasonable names as displayed. The good fit of the tree is indicated by the large proportion of variance accounted for, namely, .92.

Marching Home." Another is "I'd Like to Teach the *World* to Sing" and "He's Got the Whole *World* in His Hands." Subjects had been explicitly told to avoid considering the title wordings in both instruction sets, yet this strategy appeared only in the situation where

they were supposed to have been considering the sounds of the songs themselves.

Another divergence was that the formerly distinctive Christmas group broke into groups similar in affect: Happy Christmas songs joined with children's songs, and solemn Christmas

Figure 2. Additive tree-fitting program solution for the musical sort in Experiment 1. (See Appendix for complete song titles.)

songs, with patriotic songs. This perhaps reflects some consideration of the global musical properties of the songs. However, the groupings cannot be categorized by simple musical distinctions (e.g., slow/fast or major/minor).

Other scaling solutions. The two- and three-dimensional KYST solutions were obtained for both data sets. The three-dimensional solutions, with nearly 60 items, were very difficult to interpret and are not further considered. The two-dimensional, nonmusical KYST solutions showed groupings similar to those in ADDTREE, for instance: Christmas songs, children's songs, and patriotic songs. The solution did not give a very good fit to the data. Stress (Formula 2) was a fairly high .23; the monotone function plotting obtained against derived distances was noisy. The KYST solution for the musical sort was even a worse fit, stress (Formula 2) was .41 with a very noisy monotone fit. The one interesting contribution of the musical KYST was the nearness of "For He's a Jolly Good Fellow" and "We Wish You a Merry Christmas." Both start with a similar rhythm, tempo, and harmonic structure. The dimensions for both solutions did not admit an easy interpretation.

In summary, the nonmusical sort produced a very satisfactory representation of relations among tunes. The musical sort was less satisfactory. It appears that very little of the musical sort solution reflects musical similarity; in fact, subjects found the task difficult and seemed to lapse into strategies other than the one required of them. This claim is supported by two main arguments.

First, the musical sort scaling solutions, both spatial and treelike, provided poor fits to the data. This implies wide disagreement among subjects about the groupings. This disagreement caused the breakdown of distinctive groupings and an increase in weak groupings, that is, simple pair-wise connections. The entire picture was less coherent than the nonmusical sort, with fewer instances of interpretable labels for branches of the tree.

Second, an informal analysis revealed few instances of songs solely related by contour, direction of first interval, tempo, or other musical devices. Rather, most of the groupings were similar to those in the nonmusical sort. Ideally, one would like to pursue this notion of musical similarity by asking people unfa-

miliar with the songs to make pair-wise musical similarity judgments. This is impractical on two counts: (a) 60 items require 1,770 pair-wise comparisons and (b) one would need subjects completely unfamiliar with these songs.

To summarize, the musical sort did not produce a strong similarity structure. The limited structure that was revealed could be accounted for by simply assuming a degenerate version of the nonmusical sort.

This experiment suggests that tunes can be thought of in two different ways. When regarded as a *percept*, the tune's musical attributes (contour, mode, etc.) are salient. The other way to regard a tune is as a *concept*, when the nonmusical characteristics of theme, composer, and so forth become salient. Apparently, the subjects preferred to regard the tunes as concepts and found the perceptual mode difficult. The use of title similarity perhaps reflects a last-resort basis for judgment when the required one is difficult.

The conceptual features that have become associated with familiar tunes dominate perceptual processing. This may be particularly true of the kind of stimuli used here, namely, familiar songs. The lyrics to a song allow for many thematic classifications that may be lacking for music without words. (Interestingly, a number of tunes lacking lyrics were present in the initial stimulus pool, but none passed all the tests for familiarity.)

As this article is specifically concerned with memory for familiar tunes, the next experiment tests whether the psychological reality of the nonmusical similarity structure can be verified by testing memory and comprehension of the tunes.

Experiment 2

The previous experiment demonstrated that familiar tunes are related systematically to one another in a similarity space. Ideally we would show that cognitive processing of these tunes can be predicted from the structure of this space. A working assumption adopted here is that items close together in psychological space should be harder to discriminate: a symbolic distance effect. Following a spreading activation theory (e.g., Collins & Loftus, 1975), we would predict that highly similar tunes would require a longer amount of time to discrim-

inate than would distant tunes. Another possibility is that subjects would produce more errors when processing close songs.

The paradigm in this experiment was a speeded verification task. Subjects decided as quickly as possible whether a tune presented aurally was named correctly by a title presented on a video screen. Only song/title mismatches were of interest. The prediction was that when mismatches were similar, reaction times and/or errors would increase. They would be better (faster reaction time or fewer errors) at rejecting a mismatch of two tunes that were far apart in the tree representation.

In addition, this experiment investigated clustering in free recall of song titles. If items are presented to a subject in random order (as they were in the verification task), then any organization in free recall of those items must reflect something about their internal organization. Specifically, songs clustered together in output are presumed to reflect their proximity in memory (as Rubin & Olson, 1980, found for Monopoly board squares). It was predicted that songs near one another in the ADDTREE solution would be recalled near to each other in the task. Songs a medium distance apart in the solution would be recalled together less often, whereas songs far apart would least often be recalled together.

Method

Subjects. Subjects were 16 Stanford students; none had participated in earlier experiments.

Materials. Thirty-five songs from Experiment 1 served as stimuli. Each song was paired with 3 other songs. One pair was close together in the ADDTREE solution, one pair was of medium distance, and one pair was far apart. The division of song pairs into the close, medium, and far groups was somewhat arbitrary because the distance units are peculiar to the ADDTREE program. However, there was no overlap in the number of distance units between pair members in the close, medium, and far groups.

All but three songs appeared exactly once as a member of a close, a medium, and a far pair. Three songs were each used twice in order to complete the design in which every song appeared in every distance category. A total of 54 pairs, 18 of each distance type, constituted the mismatch trials. A match trial was simply a song paired with itself. Each experimental session included 27 match trials. The possibility existed that a subject would respond *different* to a particular song simply if he or she had previously experienced that song in a match trial. To confound this strategy, 9 match trials were repeated, making a total of 90 trials for the session.

All stimuli were produced by an Apple II Plus computer, which also controlled timing and recorded responses during

the experiment. The music was a subset of that produced for Experiment 1. The monaural music was heard through Koss Pro-4 headphones after amplification.

Pilot work showed that error rates were too low to demonstrate any experimental effects. Therefore, tunes were masked by white noise to increase the difficulty of the task. A random-noise generator (General Radio) provided the auditory mask for the tunes. The white noise was a 2-kHz bandwidth centered at 10 kHz. It was fed into the amplifier and mixed with the tune so that the tune and noise were heard together in each earphone. The intensity of the noise was 50 dB and that of the tunes was 55 dB.

Tune titles were displayed on an Ultronic Videomaster video monitor. A cardboard mask covered the screen so that only one line of text showed. Titles were always centered on the screen and were in block capital letters.

Procedure. Subjects were tested individually in a sound-attenuated chamber. Each trial was initiated when the subject pressed a button on the response board. After a 750-ms delay, a song title appeared on the video terminal and simultaneously a tune plus noise began playing through the headphones. The subject decided as quickly as possible whether the song and title were the *same* or *different* and pressed the appropriate response button. Subjects used their dominant hand, and the button for *same* was on the right side of the response board for half the subjects and on the left for the other half.

Each subject received a different random order of the 90 trials. Two versions of the experimental session were prepared. If in one version Song A was a tune and Song B was a title on a mismatch trial, then the modalities of the trial members were reversed in the other version. Across versions, each tune appeared at least once in a match trial. Half the subjects received each version of the session; it lasted approximately 30 min.

Subjects first received 5 practice trials using songs not otherwise appearing in the experiment. They then performed the 90 experimental trials at their own pace. They were instructed to make their decisions as quickly as possible without making mistakes.

After subjects completed the verification task, without warning they were given a blank sheet of paper and were asked to write down all the song titles they could remember from the experiment. They were told to write them down in any order as long as the recall was consecutive, that is, the order of songs on the paper was the order in which songs came to mind.

No time limit was set for recall. Subjects generally spent about 5 min recalling rapidly and stopped after an additional 1 or 2 min of sporadic recall.

Results and Discussion

Verification. Errors and reaction times from the onset of the stimuli to the response were recorded by the computer during the session. The mismatch trials were of primary interest; there were 18 observations for each distance category for each subject. The means of the median reaction times on correct trials are shown in the first line of Table 1. Contrary to prediction, no significant differences among

Table 1
Mean of Median Correct Reaction Times (RT in ms) and Percentage of Error Rates in Experiment 2

Experiment version	RT			Errors		
	Close	Medium	Far	Close	Medium	Far
Main experiment (<i>n</i> = 16)	3,103	3,062	2,985	14.9	11.0	6.6*
Two groups (<i>n</i> = 25)	4,585	—	4,535	11.8	—	5.9*
No noise (<i>n</i> = 13)	2,808	3,087	2,947	11.0	9.8	5.0

Note. — = not applicable.

* $p < .01$.

the distance categories emerged, although the pattern is in the correct direction. The mean number of errors is also shown in Table 1. These error rates were significantly different and in the predicted direction, $F(2, 30) = 5.80$, $p < .01$. Subjects made fewest errors (6.6%) when rejecting a mismatch of songs far apart and made the most errors (14.9%) when rejecting closely related tunes. The medium distance produced an intermediate number of errors (11.0%).

Because every song appeared virtually equally often in each condition, effects of title length and other item idiosyncracies were thought to be minimized. However, the mean reaction time by item (over subjects) was tabulated to determine if particular songs or pairs of songs were producing unusual latencies. Inspection of these data revealed nothing to suggest that the null result was spurious. Approximately half the items followed the predicted reaction time ordering—a result to be expected by chance.

It might be argued that musical similarity could determine reaction times and errors. If two tunes sound alike, then they may be hard to tell apart. The item pairs had been constructed with nonmusical similarity in mind. However, one musical analysis was carried out post hoc. The song pairs were divided into three groups depending on whether the second note of the song was higher, lower, or the same as the first note. Trials on which tune pairs shared the direction of first interval (14 pairs) were compared with those where the members did not share the direction of their first interval (40 pairs). According to a musical similarity hypothesis, tunes with similar first intervals

should produce slower reaction times and more errors than those with different first intervals. In fact, no differences appeared between the groups on either measure.

Error rates reflected the fact that songs near to each other in nonmusical space were more likely to be confused than songs far apart. The error-rate pattern showed that under time pressure, subjects more readily confuse songs that other subjects classify together without time pressure. Songs rarely grouped together are rarely confused. This implies that a network representation like that in ADDTREE may be a good description of how tunes are grouped together in an active memory system.

One reason for the weak reaction time results might have been the decision to use three distance categories. Including a medium category and requiring each song to serve in each category prevented the use of songs in the strongest clusters. For instance, Christmas songs were very distinct in the ADDTREE representation. Each one had a number of close neighbors and many distant neighbors, but by definition, no medium distance neighbors. Although there was no actual overlap in distance units used in the categories, some medium items were virtually "adjacent" to close and far pairs. The medium category might have contained too many different kinds of relations within it to make it an effective manipulation. In fact, the reaction time variability was highest for medium pairs. The *SD* was 615 ms, as opposed to 534 ms for close pairs, and 527 ms for far pairs.

Reliability of procedural variations. In an attempt to produce reliable reaction time differences, an experiment was carried out only

using far and close pairs. There were 25 subjects. The procedure was identical except for the inclusion of three additional tunes (for a total of 21 close, 21 far, and 18 same pairs) and the presentation of tunes without the noise mask. As shown in Table 1 (Two groups), errors decreased somewhat but were still significantly different over conditions, $t(24) = 2.79$, $p < .01$. However, there were no reaction time differences between close and far trials.

A number of additional variations on the basic procedure were carried out to investigate the lack of reaction time effect. These included eliminating the noise mask, gathering two observations for each song-title pair, and inserting a 2-s delay between the onset of the title and onset of the tune. The results for the "no noise" variation (13 subjects; stimuli identical to the main part of Experiment 2) are shown in Table 1; the other variations were pilot procedures only. In no case did consistent reaction time differences emerge, and in every case the predicted error pattern occurred (although it was not always statistically significant). Possible reasons for this pattern of results are discussed later.

Recall. Some general characteristics of the recall protocols are mentioned first. Subjects recalled an average of 16.9 songs out of the 35. The recallability of the songs varied widely. Only 1 subject of the 16 failed to recall "America the Beautiful" and "Hey Jude." Least often recalled were "He's Got the Whole World in His Hands" (2 people) and "Happy Days Are Here Again" and "Yankee Doodle Dandy," with 3 people each. No intrusion errors were committed.

Only adjacent pairs of songs in each recall protocol were considered in the clustering analysis. It was predicted that the closer two songs were in nonmusical space, the more often the two songs would appear next to each other in the recall. Because of the variability among subjects as to which songs were recalled, a measure of clustering was used that took into account whether a certain pair was recalled by a subject, and if so, whether the songs appeared in adjacent positions. This measure is called adjacency probability (AP).¹

For each pair of songs (without regard to order in recall) it was noted how many subjects had recalled both pair members. Then, the proportion of those cases where the two songs

Table 2
Clustering as Measured by Adjacency Probability (AP) for Each Pair Distance in Experiment 3

Clustering	Pair distance		
	Close	Medium	Far
AP (all pairs)	.18	.12	.08
AP (trial pairs)	.27	.21	.08
Number of pairs	67	168	330

were adjacent was computed. The average of these conditional probabilities for all the pairs of each distance type constituted AP. To be more explicit:

AP = Probability(Song X adjacent to Song Y | Song X & Song Y recalled), averaged over all Songs X and Y in each condition.

As predicted (see Table 2), AP was largest for close pairs, intermediate for medium pairs, and smallest for far pairs. That means that when a song was recalled, it was likely to cue recall of a related song according to a distance gradient. The presentation of some tune-title pairs had of course been a part of the procedure in the verification task. The fact that some songs had been presented as pairs might have influenced AP. If one only considers pairs that appeared together during presentation, frequency of adjacent recall is higher for all distance categories, but the pattern of results remains the same. Thus, even though subjects had seen all the experimental pairs just prior to recall, they still recalled the close pairs in adjacent positions more often than they did the medium pairs and more often still than they did the far pairs. This result may be seen in the second line of Table 2.

The results can be summarized in another way. Of all possible close pairs, 40% of them in fact appeared adjacent on at least 1 subject's recall. This compares with 32% of the medium

¹ This measure seemed the clearest way to express adjacency relations where (a) only single recall is elicited, (b) only pair-wise comparisons are of interest, and (c) the list is not made up of categorizable items in the usual sense. Each item was in a preexperimentally defined relation to each other item, rather than a member of a category. Therefore, many of the more common clustering indexes (Murphy, 1979; Sternberg & Tulving, 1977) were less appropriate than AP for the current purposes.

pairs and 27% of the far pairs. One may think that 40% is still rather low for concepts presumably close in memory. However, there were 565 possible song pairs considered in the analysis. Over all the subjects, only 271 songs were recalled. Therefore, many pairs occurred infrequently on the same protocol and occurred even less frequently as adjacent pairs.

A formal test of significance on these AP measures was unnecessary in this analysis. The third line of Table 2 shows the number of pairs possible in each distance category. The number of far pairs exceeded the number of medium pairs, which exceeded the number of close pairs. Under the null hypothesis of random ordering of recall, any given pair would by chance be distantly rather than closely related. That is, chance was working against the hypothesis that songs close together in similarity space would be emitted close together in recall. Thus, it is fair to say that AP provides a very strict test of the predicted orderings.

A more conventional measure of clustering was obtained by correlating the conditional probability of adjacent recall for each song pair with the distance between them in ADDTREE units. A negative correlation was predicted if closely related songs frequently clustered together. The Pearson correlation was $-.17$, with 558 *d.f.s.*, which is statistically different from 0. Although only accounting for 3% of the variance, the correlation was severely attenuated by the large number of .00 conditional probabilities.

These results support the idea that the system of melody organization resulting from Experiment 1 is not just a description of the taxonomy subjects use for songs. Rather, the pattern of clustering in free recall mimics the sorting organization. This suggests that recall of one song activates the representation of nearby songs in conceptual space.

General Discussion

Multidimensional scaling and memory tasks together have shown that a semantic space exists for music. The system appears to be organized along conceptual lines, at least for the well-known tunes used in most of these experiments. Tunes near each other in the non-musical ADDTREE solution of Experiment 1 were confused with each other more often than

were distantly related pairs in a verification task and appeared adjacent to each other more often in a free-recall task.

Attempts to find organization along musical lines were less successful. I proposed that the nonmusical relations among familiar tunes were stronger than the musical connections. Nonmusical relations might have been particularly pronounced with the stimuli used here. All the tunes had lyrics in their original versions that added conceptual associations not found in purely instrumental selections. However, the familiarity of the tunes should have also ensured that the actual notes were very well learned. Perhaps for familiar tunes with neither lyrics nor story line, musical relations would be perceived more easily.

The distinction between musical and non-musical characteristics is not always clear. That is, some pieces both sound alike and share nonmusical information. This confounding could of course occur with any kind of music and might have occurred to some extent in these experiments. However, using these particular familiar songs hopefully minimized this confounding because the tunes were musically homogenous. All were simple, lyrical tunes; no gross musical difference distinguished non-musical groupings.

Based on these results, I suggest that we organize songs by their conceptual attributes. If conceptual attributes are unavailable, then organization proceeds by musical characteristics such as those referred to in the beginning of this article. This idea is supported by other work from my laboratory showing neat musical organization by musicians and non-musicians when novel sequences are used (Halpern, 1984). Another way to test these assumptions in the future would be to compose novel melodies that have well-defined musical relations. Then one could teach nonmusical associations to each tune and could test for effects of both kinds of similarity in memory and sorting tasks. The prediction is that with increasing knowledge, conceptual cues increasingly dominate over perceptual cues.

The question of individual differences in music memory was not explicitly explored in these experiments. It is likely that individuals have unique semantic spaces for many domains. Coltheart and Evans (1981) investigated individual differences in semantic mem-

ory for birds. For each subject, birds close together in his or her own semantic space were listed close together in the initial generation task, and they primed one another in a categorization task. They did not prove that "bird space" differed significantly from person to person. However, Shepard (1981) showed that musicians differ from nonmusicians in their mental representation of the musical pitch system. Knowledge of musical analysis might determine organization by musical attributes in memory, though the familiarity of the pieces used here probably minimized that aspect.

Another way the musical semantic space may be organized is by the amount of knowledge a person has about a particular genre of music. Knowledge about a genre would result in (a) a more extensively categorized space than a novice would have and (b) a proliferation of conceptual links among the tunes in each subcategory. Some links may be derived from musical relationships, but that origin becomes more obscure as familiarity increases.

For categories of music one is less familiar with, tunes would have fewer conceptual links and fewer subcategories. When required to make a similarity judgment between tunes, the individual would be forced to rely more heavily on the weaker musical relations that connect every pair of tunes in the system. In general, conceptual relationships dominate the musical ones, so that activation proceeds from song to song more readily along conceptual paths than along musical ones.

At this point, the presence of reliable error differences but not reaction time differences in Experiment 2 deserves further comment. Under traditional spreading activation assumptions (e.g., Collins & Loftus, 1975), concepts close together in semantic memory prime one another so that verification is made quickly. In the current paradigm, however, subjects were not asked to verify object-property statements. Instead, they rejected the identity of a musical referent and a verbal referent to a tune. In this case, subjects need not have traversed a mental network in search of a common superordinate between the two concepts. No path between the concepts needed evaluation in order to perform the task adequately. Instead, only the distance between the tune and title representations were important.

Let us suppose that on viewing or hearing a musical stimulus, its concept node in memory is activated. In the case of simultaneous presentation of both tune and title, the two nodes would activate simultaneously. To determine identity of the activated nodes requires only a very crude comparison process. One such process could be quasiperceptual. The intersong distances in this case would be represented analogically and would be "glanced at" by a device with imperfect acuity. The myopic device, interested in speedy operation, takes a uniform amount of time to relay its identity decision but makes mistakes more frequently when items are closer together. In support of this, the error rate on *same* trials was 14.4%, comparable to the rate for close trials. (However, correct *same* decisions are made more quickly, $M = 2,365$ ms, than any kind of *different* trial.) In contrast, if asked to verify object-category statements, subjects may use the links and concepts in the hierarchy structure described in Experiment 1. For instance, the truth of "'Hey Jude' is a Beatles tune" may be verified faster than "'Hey Jude' is a pop tune" because the former statement requires evaluation of only one (vs. two) superordinates.

The scaling solutions suggested just one way that musical material could be organized: a hierarchy arranged by genre. A hierarchical representation could accommodate increases in musical knowledge by increasing the breadth and depth of the hierarchy. This organization of course varies depending in what context the songs are encountered or if something other than general musical knowledge is used as the basis of organization. For instance, an expert in musical instruments may primarily organize instrumental music by those categories or a music librarian may internalize the Library of Congress classification.

References

- Bousfield, W. A. (1953). The occurrence of clustering in the recall of randomly arranged associates. *Journal of General Psychology*, 49, 229-240.
- Collins, A. M., & Loftus, E. F. (1975). Spreading activation theory of semantic processing. *Psychological Review*, 82, 407-428.
- Coltheart, V., & Evans, J. St. B. T. (1981). An investigation of semantic memory in individuals. *Memory & Cognition*, 9, 524-532.

Dowling, W. J. (1978). Scale and contour: Two components of a theory of memory for melodies. *Psychological Review*, 85, 341-354.

Dowling, W. J., & Bartlett, J. C. (1981). The importance of interval information in long-term memory for melodies. *Psychomusicology*, 1, 30-49.

Dowling, W. J., & Fujitani, D. S. (1971). Contour, interval, and pitch recognition in memory for melodies. *Journal of the Acoustical Society of America*, 49, 524-531.

Fraisse, P. (1978). Time and rhythm perception. In E. C. Carterette & M. P. Friedman (Eds.), *Handbook of perception: Vol. VIII. Perceptual coding* (pp. 203-253). New York: Academic Press.

Halpern, A. R. (1984). Perception of structure in novel music. *Memory & Cognition*, 12, 163-170.

Kruskal, J. B., Young, F. W., & Seery, J. B. (1973). *How to use KYST, a very flexible program to do multidimensional scaling and unfolding*. Murray Hill, NJ: Bell Laboratories.

Mandler, G. (1967). Organization and memory. In K. W. Spence & J. T. Spence (Eds.), *The psychology of learning and motivation* (Vol. 1, pp. 127-172). New York: Academic Press.

Massaro, D. W., Kallman, H. J., & Kelly, J. L. (1980). The role of tone height, melodic contour, and tone chroma in melody recognition. *Journal of Experimental Psychology: Human Learning and Memory*, 6, 77-90.

McKernon, P. E. (1979). The development of first songs in young children. *New Directions for Child Development*, 3, 43-58.

Murphy, M. B. (1979). Measurement of category clustering in free recall. In C. R. Puff (Ed.), *Memory organization and structure* (pp. 51-83). New York: Academic Press.

Quillian, M. R. (1969). The teachable language comprehender: A simulation program and theory of language. *Communications of the Association for Computing Machinery*, 12, 459-476.

Rubin, D. C., & Olson, M. J. (1980). Recall of semantic domains. *Memory & Cognition*, 8, 354-366.

Sattath, S., & Tversky, A. (1977). Additive similarity trees. *Psychometrika*, 42, 319-345.

Shepard, R. (1981). Individual differences in the perception of musical pitch. In *Documentary report of the Ann Arbor Symposium: Applications of psychology to the teaching and learning of music* (pp. 152-174). Reston, VA: National Music Educators.

Sternberg, R. J., & Tulving, E. (1977). The measurement of subjective organization in free recall. *Psychological Bulletin*, 84, 539-556.

White, B. W. (1960). The recognition of distorted melodies. *American Journal of Psychology*, 73, 100-107.

Appendix

Mean Familiarity Rating and Standard Deviation of Every Song Pretested for Experiment 1

M	SD	Song title	Abbreviation ^a
7.00	0.00	"Yesterday"	Yesterday
7.00	0.00	"We Wish You a Merry Christmas"	Merry
7.00	0.00	"This Land is Your Land"	Land
7.00	0.00	"The Star-Spangled Banner"	Star
7.00	0.00	"Silent Night"	Silent
7.00	0.00	"Row Row Row Your Boat"	Row
7.00	0.00	"Jingle Bells"	Jingle
7.00	0.00	"Happy Birthday"	Birthday
7.00	0.00	"Deck the Halls"	Deck
7.00	0.00	"America the Beautiful"	America
6.95	0.23	"When the Saints Come Marching In"	Saints
6.95	0.23	"Rudolf the Red-Nosed Reindeer"	Rudolf
6.95	0.23	"O Come All Ye Faithful"	O Come
6.95	0.23	"Hey Jude"	Jude
6.95	0.23	"A Hard Day's Night"	Hard Day's
6.89	0.46	"Puff the Magic Dragon"	Puff
6.89	0.46	"Michael Row Your Boat Ashore"	Michael
6.89	0.46	"Hark the Herald Angels Sing"	Hark
6.89	0.32	"Santa Claus is Coming to Town"	Santa Claus
6.89	0.32	"Raindrops Keep Fallin' on my Head"	Raindrops
6.89	0.32	"Oh Susanna"	Susanna
6.89	0.32	"For He's a Jolly Good Fellow"	Jolly
6.84	0.50	"White Christmas"	White Xmas
6.79	0.92	"Do Re Mi"	Do Re Mi
6.79	0.71	"Twinkle Twinkle Little Star"	Twinkle

Appendix (continued)

<i>M</i>	<i>SD</i>	Song title	Abbreviation ^a
6.79	0.42	"Yankee Doodle Dandy"	Yankee
6.68	1.38	"Old MacDonald"	MacDonald
6.68	1.38	"My Bonnie Lies Over the Ocean"	Bonnie
6.68	0.58	"California Girls"	California
6.63	1.38	"My Country 'Tis of Thee"	Country
6.63	1.38	"God Bless America"	God Bless
6.63	1.01	"Leaving on a Jet Plane"	Jet
6.63	0.96	"I'd Like to Teach the World to Sing"	Teach World
6.63	0.96	"Bridge Over Troubled Water"	Bridge
6.63	0.83	"When Johnny Comes Marching Home"	Johnny
6.58	1.43	"The First Noel"	Noel
6.58	1.39	"He's Got the Whole World in His Hands"	Whole World
6.58	1.39	"Frère Jacques"	Jacques
6.58	1.30	"Mary Had a Little Lamb"	Mary
6.58	1.26	"Three Blind Mice"	Mice
6.58	1.22	"I'm a Yankee Doodle Dandy"	I'm a Yankee
6.58	0.77	"Singing in the Rain"	Singing
6.53	1.43	"We're Off to See the Wizard"	Wizard
6.53	1.43	"Lucy in the Sky With Diamonds"	
6.53	1.43	"I've Been Working on the Railroad"	Railroad
6.53	1.43	"Home on the Range"	
6.53	1.43	"From the Halls of Montezuma"	Montezuma
6.47	1.61	"Over the Rainbow"	
6.47	1.50	"Rock-a-Bye Baby"	
6.47	1.47	"Let It Be"	
6.47	1.43	"O Tannenbaum"	Tannenbaum
6.47	1.17	"London Bridge is Falling Down"	London
6.42	1.57	"Twelve Days of Christmas"	
6.42	1.46	"Pop Goes the Weasel"	Pop
6.42	1.43	"Oh My Darling Clementine"	Clementine
6.42	1.17	"Up Up and Away"	Up Up
6.42	1.17	"Mrs. Robinson"	Robinson
6.42	1.07	"Sound of Music"	Sound
6.37	1.89	"She'll Be Comin' Round the Mountain"	
6.37	1.74	"Born Free"	
6.37	1.50	"Hello Dolly"	
6.37	1.46	"To Dream the Impossible Dream"	Dream
6.37	1.46	"Jesus Christ Superstar"	
6.37	1.42	"Lone Ranger Theme"	
6.37	1.30	"Do You Know the Way to San Jose?"	San Jose
6.32	1.89	"Blowin in the Wind"	
6.32	1.73	"On Top of Old Smokey"	
6.26	1.63	"Swing Low, Sweet Chariot"	
6.26	1.48	"Yellow Submarine"	Yellow
6.26	1.48	"Jimmy Crack Corn"	Jimmy
6.21	1.90	"It's a Small World After All"	
6.21	1.72	"Chestnuts Roasting on an Open Fire"	
6.21	1.62	"Tie a Yellow Ribbon"	
6.16	1.42	"You Are My Sunshine"	Sunshine
6.16	1.21	"Happy Days are Here Again"	Happy Days

(Appendix continues)

Appendix (*continued*)

<i>M</i>	<i>SD</i>	Song title	Abbreviation ^a
6.11	1.94	"If I Had a Hammer"	
6.11	1.88	"Supercalifragilisticexpialidocious"	
6.11	1.45	"Can't Buy Me Love"	
6.05	2.01	"Sunrise Sunset"	
6.05	2.01	"Camptown Races"	
6.05	1.96	"I Wanna Hold Your Hand"	
6.05	1.72	"Ding Dong the Witch is Dead"	
6.00	2.13	"My Favorite Things"	
6.00	1.97	"Who's Afraid of the Big Bad Wolf?"	
6.00	1.91	"Eleanor Rigby"	
6.00	1.89	"Strangers in the Night"	
6.00	1.49	"The Drummer Boy"	The Drummer
5.95	1.96	"Sounds of Silence"	
5.95	1.93	"Whistle While You Work"	
5.95	1.78	"Dixie"	
5.95	1.61	"I Dream of Jeannie"	
5.89	2.21	"Scarborough Fair"	
5.89	2.13	"Greensleeves"	
5.89	2.11	"A Tisket, A Tasket"	
5.89	2.05	"Where Have all the Flowers Gone?"	
5.89	2.05	"Oh What a Beautiful Morning"	
5.89	1.85	"She Loves You"	
5.84	1.83	"The Long and Winding Road"	
5.79	2.25	"A Little Help From My Friends"	
5.79	2.20	"Seventy-Six Trombones"	
5.79	2.12	"Take Me Out to the Ballgame"	
5.79	2.07	"If I Were a Rich Man"	
5.74	2.40	"House of the Rising Sun"	
5.74	2.26	"I Don't Know How to Love Him"	
5.74	1.91	"Bah Bah Black Sheep"	
5.68	2.50	"Here Comes the Bride"	
5.68	2.38	"The Eensy Weensy Spider"	
5.68	2.33	"Ten Little Indians"	
5.68	2.24	"Auld Lang Syne"	
5.68	2.00	"I Could Have Danced All Night"	
5.68	1.80	"Feelings"	
5.63	2.29	"Wedding March"	
5.63	2.29	"Ring Around the Rosey"	
5.63	1.98	"Give My Regards to Broadway"	
5.58	2.48	"Turn, Turn, Turn"	
5.58	2.29	"Somewhere My Love"	
5.58	2.06	"Five Hundred Miles"	
5.53	2.37	"Mr. Tambourine Man"	
5.53	2.27	"Georgy Girl"	
5.53	2.20	"Battle Hymn of the Republic"	
5.53	2.17	"Moon River"	
5.53	1.98	Theme from <i>M*A*S*H</i>	
5.53	1.98	"Good Vibrations"	
5.47	2.29	"When I'm 64"	
5.47	2.14	"You Take the High Road"	
5.47	2.14	"On the Good Ship Lollipop"	
5.47	1.98	"Cabaret"	
5.42	2.71	"Kum Ba Yah"	

Appendix (continued)

M	SD	Song title	Abbreviation ^a
5.42	2.55	"Alouette"	
5.42	2.09	"Those Were the Days" (<i>All in the Family</i>)	
5.42	2.09	"La Cucaracha"	
5.42	1.87	"Homeward Bound"	
5.37	2.59	"Tonight"	
5.37	1.86	"The Way We Were"	
5.26	2.35	"California Dreamin' "	
5.26	2.18	"Matchmaker, Matchmaker"	
5.26	2.02	"Swanee"	
5.16	2.71	"What Do You Do With a Drunken Sailor?"	
5.16	2.52	"Que Sera Sera"	
5.16	2.24	"My Sweet Lord"	
5.11	2.66	"I Like to Be in America"	
5.11	2.58	"Sing a Song of Sixpence"	
5.11	2.42	"We've Only Just Begun"	
5.11	2.18	"The 59th Street Bridge Song"	
5.05	2.53	"Summertime"	
5.05	2.34	"Maria"	
5.00	2.73	"Morning Has Broken"	
5.00	2.47	"Off We Go Into the Wild Blue Yonder"	
5.00	2.43	"California Here I Come"	
4.95	2.74	"Grand Old Flag"	
4.95	2.63	"Heigh Ho, Heigh Ho"	
4.95	2.59	"Red River Valley"	
4.95	2.55	"We Shall Overcome"	
4.95	2.53	"Both Sides Now"	
4.95	2.44	"How Much Is That Doggie in the Window?"	
4.95	2.30	"Ode to Joy"	
4.95	2.17	"By the Light of the Silvery Moon"	
4.95	2.12	"Goldfinger"	
4.89	2.64	"People"	
4.89	2.45	"Ain't She Sweet"	
4.89	2.31	"Getting to Know You"	
4.84	2.65	"Anchors Aweigh"	
4.79	2.76	"Blue, Blue, My Love is Blue"	
4.79	2.53	"Pomp and Circumstance"	
4.79	2.32	"Tea for Two"	
4.68	2.71	"Hava Nagila"	
4.68	2.67	"Bye Bye Love"	
4.68	2.63	"Ruby Tuesday"	
4.68	2.08	"Things Go Better With Coke"	
4.63	2.63	"Daisy"	
4.63	2.52	"Get Me to the Church on Time"	
4.63	2.41	"Shine On Harvest Moon"	
4.63	2.34	"Over Hill, Over Dale"	
4.58	2.46	"Billy Boy"	
4.53	2.91	"Good King Wenceslaus"	
4.53	2.52	"Waltzing Matilda"	
4.47	2.65	"I am a Rock"	
4.47	2.57	"Sailing, Sailing Over the Bounding Main"	
4.47	2.57	"Oh Dear, What Can the Matter Be?"	
4.42	2.22	"I Got Rhythm"	

(Appendix continues)

Appendix (continued)

<i>M</i>	<i>SD</i>	Song title	Abbreviation ^a
4.37	2.41	"Bye Bye Blackbird"	
4.37	2.36	"Hail Hail the Gang's All Here"	
4.26	2.84	"Reveille"	
4.21	2.68	"My Cherie Amour"	
4.16	2.65	"A Time For Us"	
4.05	2.78	"The Old Grey Mare"	
4.05	2.57	"Sidewalks of New York"	
4.00	2.77	"Guantanamera"	
4.00	2.47	"You're Gonna Make it After All"	
3.95	2.41	"Thanks for the Memory"	
3.95	2.32	"It Was a Very Good Year"	
3.84	2.85	"Somewhere"	
3.84	2.75	"When Irish Eyes are Smiling"	
3.84	2.36	"Chicago"	
3.79	2.80	"Marseillaise"	
3.74	2.66	"Shenendoah"	
3.74	2.58	"Mame"	
3.63	2.06	"To Sir With Love"	
3.53	2.95	"Sur le Pont d'Avignon"	
3.53	2.52	"As Time Goes By"	
3.53	2.46	"Yellow Rose of Texas"	
3.47	2.25	"Casey Jones"	
3.42	2.76	"The Shadow of Your Smile"	
2.74	2.45	"June is Bustin' Out All Over"	
2.63	2.59	"Old Folks at Home"	
2.37	2.09	"Traces"	
2.26	2.02	"On Wisconsin"	
2.16	2.06	"More Than the Greatest Love"	

^a For those songs used in Experiment 1.

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