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Chapter 8

Memory for Melodies

Andrea R. Halpern and James C. Bartlett

8.1 Introductory Comments

Memory for music presents a paradox. On the one hand, memory for music that people have already learned can be astonishingly good, both in extent and longevity. On the former point, consider how many tunes an average person could recognize, or even recall. No one has even attempted to measure the limits of musical memory. Concerning longevity, older adults can show excellent retention of music learned decades previously (Bartlett and Snelus 1981; Rubin et al. 1998). Even early-stage Alzheimer's disease patients can almost perfectly discriminate familiar tunes such as patriotic and holiday songs from musically similar but unfamiliar tunes (Bartlett et al. 1995). And this memory can persist not just for songs that have words, but also for purely melodic motives, and without much context. For instance, it is not uncommon to turn on the radio and hear just a few notes of a tune, and be able immediately to hum along or at least recognize the tune as familiar.

Musical memory also shows its persistence by being veridical, or capturing aspects of the music reasonably faithfully. Several researchers have shown that the absolute pitch of familiar music is remembered fairly well, within two semitones, even among nonmusicians and nonpossessors of absolute pitch (Halpern 1989; Levitin 1994; Schellenberg and Trehub 2003), as is tempo (Halpern 1988; Levitin and Cook 1996). Some evidence also suggests that even judgments of musical emotion can be extracted from remembered music similarly to those extracted from sounded music (Lucas et al. 2010). These demonstrations are notable because the identity of music comes from the *relationships* between successive pitches and temporal units, so the memory for absolute tempo and pitch seems to be beyond what is required for making sense of music.

On the other hand, memory for music can be very poor, particularly when learning new music. Typically, memory for music is assessed by recognition, as

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recall invites difficult issues of production competence. Thus this chapter does not consider the kind of deliberate memorization for later recall required in musical performance. But even the simplest kind of recognition test for melodies shows how poor musical memory can be, in comparison to other kinds of memory. A student was recently setting up a study of recognition memory for paintings. The study session consisted of viewing each of 28 paintings for 3 s, followed by 45 min of visual illusion distraction, and then a surprise old/new recognition test with 28 old and 28 new paintings. Performance was virtually perfect and measures had to be taken to make the task harder. Almost legendary is Standing's (1973) finding that memory for pictures is nearly limitless (10,000 items were presented in that study).

In contrast, Halpern and O'Connor (2000) designed a music recognition memory test that would be feasible for early-stage Alzheimer's patients. Eight novel tunes were presented for incidental encoding, followed immediately by eight old and eight new tunes. Pilot work showed that young adult normal controls could not do this task much above chance levels, necessitating two presentations of the tunes during learning (which brought performance up to a respectable but not overwhelming level). Using longer study sequences, Halpern and Müllensiefen (2008) presented 40 unfamiliar melodies under various encoding conditions, followed by old/new recognition of 80 tunes, using a 6-point confidence scale. Area-under-the-Receiver-Operating-Characteristic (ROC)-curve scores were about 0.70 (0.50 = chance; 1.0 = perfect performance), which is in the range of performance levels in quite a few of the studies reviewed herein. Again, the results are respectable but not spectacular, and far below recognition levels for other rich materials.

This paradox is interesting, most obviously because it raises the question of how new music becomes well learned, if learning is so laborious at first or second exposure. It is also an intriguing puzzle because music is eventually learned even by nonmusicians, who have few analytic strategies to help them, and even for music with few semantic associations or internal references, such as classical themes.

In other domains, variability in learning can be partly accounted for by quality of encoding. In Levels of Processing (LOP) studies (Craik and Lockhart 1972), memory researchers can often increase quality of retrieval by imposing or encouraging elaborative encoding tasks, such as asking people to generate a synonym for a to-be-remembered word. Perhaps music learning is often difficult because listeners do not (or cannot) use elaborative encoding. However, evidence suggests rather that this memory "law" does not seem to obtain in music. As one indication, a recent database search for "Levels of Processing" and "music" turned up virtually no entries. A few studies have shown encoding task effects for well-known tunes (judging familiarity of the tune produced better recognition than judging what instrument was playing the tune; Peretz et al. 1998), but memory for well-known music may also rely on semantic or other nonmusical strategies. Certainly both of the current authors have failed to find LOP effects for unfamiliar music on numerous occasions (some published, some languishing in bottom drawers). Thus it is likely that factors other than conditions of encoding are more important in memory for music than in other domains.

This chapter examines some of the other factors that appear to modulate tune learning. (Note: Many of the studies considered here use simple, single-line melodies, without words. However, a few use fully realized music with orchestration and harmonies, which are pointed out when appropriate). Long-term retention (Sect. 8.2.1) is one focus, as detailed in the preceding text, but another focus is short-term retention such as that needed for immediate same–different comparisons (Sect. 8.2.2). Other factors affecting memory for music include aspects of the tunes, for example, degree of familiarity of the item (Sect. 8.2), as well as familiarity and well-formedness of the musical system from which the tunes are derived (Sect. 8.4). The chapter also considers temporal factors, such as the influence of retention interval on what listeners learn about melodies (Sect. 8.3), as well as two important aspects of listeners themselves: their musical experience (Sect. 8.5) and their age (ranging for current purposes from young to senior adult, Sect. 8.6). It turns out that these last two factors have some expected, but also some unexpected relationships (or absence thereof) with retention of music. The relationship between these two variables is also intriguing, on the supposition that benefits from increased domain-related experience might mitigate some age-related declines in memory. As seen further on, this does not appear to be the case, unfortunately. The chapter concludes with some thoughts on how memory for music may be similar to and different than memory for other kinds of materials.

8.2 Familiarity and Nameability of Melodies

Perhaps the most powerful variable affecting music recognition has been referred to in the literature as familiarity. The term is not ideal, for at least two different reasons. First, in most of the relevant research, familiarity has been operationalized through a comparison of tunes unknown to participants prior to a study with well-known tunes they had heard frequently in life. Although in general the investigators have attempted to avoid confounding “familiarity” with perceptual and musicological features of the stimuli (e.g., tonality, or adherence to a scale, and rhythm), another confounding factor has been less often addressed: that between the extent of prior “real life” exposure to a melody and its verbal identifiability, through, for example, recall of its title, some of its lyrics, or identifying contextual information (“it’s theme song of the musical ‘Cats’”). In the remainder of this chapter, these two aspects of tune knowledge are referred to as “real-life exposure” and “nameability.” One key point that emerges in this discussion is that some of what researchers know about *familiarity* effects might be better characterized as *nameability* effects.

A second problem with “familiarity” is that a wealth of evidence from the human memory literature supports a dual-process theory of memory: the notion that two cognitive processes underlie retrieval, referred to as “familiarity” and “recollection” (see Yonelinas 2002 for a review). Familiarity is viewed as an overall feeling of “oldness” that can vary in strength but lacks any context cues (“I cannot place that tune but it sure sounds familiar”), whereas recollection refers to the conscious

recollection of detailed perceptual and contextual information about a prior experience (“I heard that same song last night at a party”). This state of affairs can lead to mind-bending tongue-twisters (e.g., “familiarity affected both recollection and familiarity”) that can cause confusion. To minimize such confusion, the term “prior knowledge” refers to comparisons of well-known to novel tunes (or musical genres). A distinction is made in cases where a prior knowledge effect might be better characterized as a “nameability effect” as opposed to a “real-life exposure effect.” The terms “recollection” and “familiarity” are used in accordance with the human memory literature, as mentioned previously.

8.2.1 *Long-Term Memory*

A task showing dramatic prior knowledge effects is long-term recognition memory. The most common method of testing such memory is that of presenting a variable-length sequence or list of stimuli, depending on how memorable the stimuli are, followed by a test including “old” items from the study list intermixed with “new” items not heard before. The test typically follows the study phase by 10–30 min, which qualifies this paradigm as testing “long-term” memory, at least in contrast to comparison of two tunes played in succession (see next section). Performance accuracy is typically assessed by examining both hit rates (the proportion of old items called “old”) and false-alarm rates (the proportion of new items called “old”), with a high hit rate and low false-alarm rate signifying good performance. Recognition judgments are substantially more accurate for well-known tunes than for novel tunes (Bartlett et al. 1995). However, some nuances surrounding this basic observation offer valuable clues as to the nature of the processes that support melodic memory.

Bartlett et al. (1995) employed a trained musician to compose a set of novel tunes that matched a set of novel tunes in number of notes, average interval size, rhythmic units and general pleasantness. In two of their experiments, the well-known and novel tunes were presented in separate study lists, each followed by a recognition test. Both young adults and healthy older people (59–80 years old) showed higher hit rates and lower false-alarm rates for the well-known tunes than for the novel tunes, suggesting a difference in recognition accuracy. This pattern is quite often observed in comparisons of easier and more difficult items in recognition memory (Glanzer and Adams 1985), so it was not surprising. What was surprising was the absence of this pattern when the well-known and novel tunes were intermixed in the study lists and tests. In this case the hit rates were dramatically higher for the well-known tunes than for the novel tunes, as was true in the separate lists. However, the false-alarm rates were approximately equal for the two tune types. In terms of signal detection theory, old–new discrimination was much greater for well-known tunes than for novel tunes, but there also was a bias to judge the well-known tunes as “old.”

What might it mean that the intermixed list of novel and well-known tunes prevented people from suppressing false alarms to the well-known tunes? One plausible

hypothesis is that old–new judgments in tune recognition are based to a substantial extent on subjective familiarity, in the absence of recollection of information specifying the source of the familiarity (e.g., the studied items versus last year’s Christmas party). Familiarity will be much stronger for well-known tunes than novel tunes, and this will tend to increase the hit rate advantage of well-known tunes, while possibly increasing false-alarm rates for those same well-known tunes. In a between-list design, where well-known and novel tunes are presented and then tested separately, listeners can easily compensate for this tendency by adopting a more stringent recognition criterion for well-known tunes than novel tunes. In other words, listeners might only say “old” to a well-known tune if the tune seems *very* familiar. In a within-list (intermixed) design, however, this would be harder to do as the listener would need to adjust that criterion trial by trial. There is substantial evidence that participants often fail to adjust their recognition criteria for individual items in a single recognition test (see Benjamin 2008 for a review).

Some findings of McAuley et al. (2004) underscore the importance of familiarity in the absence of recollection, in recognition memory for tunes. These investigators compared memory for novel and well-known melodies in a variant of the standard recognition task designed to test knowledge of how recently and how frequently tunes had been studied. The novel melodies were composed for the experiment in a range of major and minor keys, rhythms, speeds, and melodic contours, with the goal that they would be at least as distinctive as the well-known melodies and approximately as long (mean = 12.3 notes versus 15.6 notes for the well-known tunes). The participants heard a sequence of novel and well-known melodies in which half of the items were presented one time and the others were presented three times. One day later, they heard a second sequence of (different) melodies, constructed in the same way. The second list was followed by two memory tests, one in which subjects judged the frequency of items (one versus three presentations), and a second in which they judged the recency of items (same day versus previous day). Frequency judgments were slightly less accurate for novel tunes than for well-known tunes, but discrimination between thrice-presented items and once-presented items was well above chance for both. By contrast, recency judgments were substantially less accurate for the novel tunes than for well-known tunes, and discrimination between day-1 items and day-2 items approximated chance for the novel tunes. Moreover, the recency judgments to novel tunes were affected more by frequency than by recency itself. That is, thrice-presented tunes heard on day 1 received more “same day” judgments than did once-presented tunes heard on day 2. These findings suggest that, in the case of novel tunes, time of presentation is poorly recollected and that memory judgments are based for the most part on familiarity strength.

What about judgments to well-known tunes? The improved recency judgments with well-known tunes suggest that recollection is greater with such tunes than with novel tunes. However, McAuley et al. performed an analysis suggesting that this difference reflects the often high nameability of well-known tunes rather than the fact that they have been experienced in life. Specifically, the authors found a reliable positive correlation between the accuracy of recency judgments to well-known

tunes and the nameability of these tunes (based on a naming test administered to each participant at the end of the experimental session, $r = 0.52$). Hence, the recollection advantage of well-known tunes is due not simply to the fact that they are known; it depends on nameability.

A link between the nameability of tunes and the process of recollection has also been supported in a study that actually tested melodic recall, unlike experiments considered heretofore that tested simply recognition and related judgments (frequency and recency) Using a unique methodology, Korenman and Peynircioğlu (2004) presented tunes paired with animal names, followed by tests of (1) recall of the animal names in response to the melodies and (2) recall of the melodies in response to the animal names (the hummed responses were recorded and later scored). Participants in three different groups received: (1) original recordings of well-known melodies with full orchestration, (2) single-line versions of these same melodies played on a synthesizer, and (3) single-line versions of unknown melodies played on the synthesizer. The same animal names, paired at random with the melodies, were used in all conditions.

The recall results were straightforward: Recall of names in response to melodies was better than recall of melodies in response to names, perhaps because it was easier to guess a correct name than to guess (through humming) a correct melody. Correct recall was substantially higher for well-known tunes than for novel tunes, despite the fact that the study list was shorter in the novel-tune condition to minimize floor effects. As in the McAuley et al. (2004) study, the authors assessed knowledge of the names of the well-known tunes in the last phase of the study. Associative recall (both melody-from-name and name-from-melody) in the group with above-average knowledge of the tune names (“experts”) was approximately twice that in the group less knowledgeable about the tune names (“nonexperts”), indicating that nameability of melodies is an important factor in recollecting contextual information. In considering these data, it is important to remember that the participants were tested on their memory for new associations between melodic snippets and animal names, not actual tune titles or lyrics. Thus, the findings indicate that recollecting the verbal context of a melody’s presentation – or the melodic context of a word’s presentation – is better if the melodies are well known, and especially if they are nameable.

It is interesting to note that when the participants in the Korenman and Peynircioğlu (2004) study could not recall an animal name in response to a melody or a melody in response to a name, they estimated their chances of recognizing the association (i.e., they made a “feeling of knowing” judgment). Moreover, all of the participants were subsequently tested on associative recognition (i.e., they attempted to select which of three names belonged with each of a set of melodies and which of three melodies belonged with each of a set of names). Neither feeling-of-knowing ratings nor associative recognition differed between well-known and novel tunes or between “experts” and “nonexperts” with the well-known tunes. This finding is important because it demonstrates that the nameability of a tune does not affect memory for contextual information so long as the pairing of a tune and its context at study are reinstated at test (as in an associative recognition test). Rather,

the effect of nameability is on *recollection* of contextual information not physically available at test.

In sum, the evidence suggests that recognition of well-known tunes differs from recognition of novel tunes in two important ways. First, well-known tunes create a stronger feeling of familiarity, and because familiarity is an important basis for old–new judgments in recognition memory, participants show a bias to judge well-known tunes as “old” (i.e., heard previously at study). They show this bias only in within-list designs presumably because, in between-list designs, they are able to use a more stringent criterion for recognizing well-known tunes than for recognizing novel tunes. When such criterion adjustments are difficult, as they are in within-list designs, the high familiarity of well-known tunes often leads to “old” judgments even when these tunes are new. Second, many well-known tunes are more nameable than novel tunes, and nameability is linked to the power of tunes to spur recollection of contextual and associative information. Recollection is a hallmark of “episodic memory” (Tuvling 1983), a major component of memory – possibly involving a dedicated brain system (Schacter and Tulving 1994) – that mediates our ability to consciously re-experience events from our personal pasts. Performance in tests of episodic memory are seriously impaired in amnesic patients who have suffered damage in medial–temporal and prefrontal brain regions, and McAuley et al. (2004) make the interesting observation that the memory performance of healthy adults with unfamiliar (and unnameable) tunes resembles that of amnesic individuals with well-known words (i.e., frequency and recency are confused). The brain processes of episodic memory, presumably intact in healthy adults tested by McAuley et al., cannot be engaged in the processing of tunes that cannot be uniquely identified or named.

An alternative hypothesis holds that hard-to-identify tunes engage episodic memory processes, but suffer with respect to elaborative encoding. A wealth of evidence suggests that successful recollection in tests of episodic memory depends on elaborative encoding when the item is first presented (Yonelinas 2002, and see Sect. 8.1), and that such elaborative encoding aids in the creation of distinctive representations that yield good recollection because they are less confusable with other memories at retrieval (see, e.g., Eysenck 1979). Nameability may improve elaborative encoding of the type that produces distinctive and retrievable memory codes. For example, an elaborative encoding of an unknown tune might include information that it sounds very pleasant and might make a good Christmas carol. However, such an encoding is likely to be applicable to several different tunes in a study sequence, and so it is not distinctive. By contrast, elaborative encoding of a nameable tune might be highly distinctive (e.g., “that was mother’s favorite Christmas carol”), supporting recollection in a subsequent test.

How familiarity and nameability are linked to episodic memory is an important issue for future research to address. However, it likewise is important to understand the processes underlying the detection that a tune is familiar and the retrieval of its name. Dalla Bella et al. (2003) explored this issue by presenting the beginnings of known and novel tunes in a “gating” paradigm in which listeners first heard the first note of a tune, then the first two notes, then the first three notes, and so on until they

judged the tune to be familiar with high confidence on each of three successive trials. The known melodies had been previously classified as “highly familiar” or “moderately familiar” in a prior norming study. High-confidence identification of tunes as familiar occurred after six notes (on average) for the “highly familiar” tunes and about eight notes for the “moderately familiar” tunes. Similar results were obtained in a second experiment in which tune identifications were based on singing continuations with accuracy and high confidence on three successive trials. These analyses were based only on tunes that were, eventually, successfully recognized (Experiment 1) or sung (Experiment 2), and so the findings suggest that even when tunes are known by a listener, they can be identified more quickly if they are more “familiar.” In light of the preceding discussion, it is important to learn if this “familiarity” effect is one of nameability or merely real-life exposure. It also is important to know whether a tune that sounds familiar and yet cannot be named can nonetheless be uniquely identified through singing its melody. In the Billy Joel song, “The Piano Man,” the denizens of a bar sing out an old song for which they cannot recall either title or lyrics (due perhaps to their level of intoxication), raising the hypothesis that nonverbal identification (through singing) and verbal identification (through naming) might be dissociable.

8.2.2 *Short-Term Memory*

Another popular paradigm for studying melodic processing is the short-term same–different task in which two short melodies are presented in succession, with the second (comparison) matching or mismatching the first (standard) in some designated way. If the melodies are short – say, five to seven notes long – and the task is simply to judge whether the two melodies are physically identical, as opposed to having one or two notes changed, performance will be near the ceiling. However, the task is more difficult if the melodies are longer, or if they are presented at extremely fast or slow tempos. Another difficulty ensues if the two melodies of a pair begin on different notes and the task is to judge whether, despite the change in absolute pitch levels, the second is an accurate transposition of the first into a different key. This transposition detection task requires the processing of *pitch interval* information, as opposed to *absolute pitch* information, as only the former remains constant when a tune is transposed.

When the same–different task is made difficult in any one of the aforementioned ways, prior knowledge of melodies has very large effects. In one recent study, Dowling et al. (2008) asked their listeners to compare well-known and novel melodies 11–21 notes in length in a short-term same–different task, presenting the melodies at extremely fast, medium, or extremely slow tempos (0.6, 3.0, and 6.0 notes/s, respectively). To make the task even more challenging, the different trials involved changes in only two notes. The largest effect in the study was that of prior knowledge, with area-under-ROC scores averaging 0.85 and 0.63 for the

well-known and novel tunes, respectively. The knowledge by tempo interaction was reliable as well, reflecting the fact that, although an advantage for well-known tunes was everywhere apparent, it was stronger at the medium tempo (which was approximately the familiar tempo for the tune) than at the fast and slow tempos. This was a surprising result, as the intuitive prediction was that fast or slow presentation would produce the greatest difficulty with unfamiliar tunes. However, the result should be viewed in the context of prior evidence that identification of well-known tunes is impaired at fast and slow tempos (Warren et al. 1991; Andrews et al. 1998). Thus, if the advantage of well-known tunes results from the fact that they are nameable, it makes sense that fast and slow presentations, which reduce nameability, should reduce the advantage.

Strong effects of prior knowledge in short-term memory have also been found in transposition detection (see Dowling 1982 and Dowling and Harwood 1986 for reviews). This task is a good test of pitch-interval processing, as that information is the same no matter what the starting note is (“Happy Birthday” is the same melody with the same pitch intervals regardless of what pitch someone begins with). If the standard and comparison melodies both are novel and also share melodic contour (the sequence of ups and downs in pitch), the task is quite hard, even for persons with musical training (though more musical participants do perform somewhat better). Indeed, if the standard and comparison are in the same or closely related keys, discrimination of exact from inexact transpositions is close to chance (Bartlett and Dowling 1980). With well-known melodies, however, the task is quite trivial, with even musically untrained participants performing near ceiling. For example, if the standard melody is from a well-known tune (e.g., the first phrase of “She’ll Be Coming Around the Mountain”), and the comparison is a transposed version with one note changed, participants almost always detect the difference: the comparison is perceived as simply not the same song. This is notable in light of work suggesting that monkeys will accept a transposed tune as the same as an original only if the notes have been changed by exactly an octave (Wright et al. 2000).

What does the effect of prior knowledge on transposition detection tell us about melodic processing? Since the transposition detection task poses a minimal load on short-term memory (again, as long as the melodies are short) the clearest implication concerns the process of perceptually encoding the precise melodic intervals that – along with rhythm, meter (for instance a 2-beat march versus a 3-beat waltz) and a few other factors – distinguish one song from another in our culture. Such encoding is apparently quite difficult the first few times a novel melody is heard, and yet it is eventually accomplished for all the tunes that people know well. Deutsch (1979) has shown that transposition detection with novel tunes improves if the first tune in each pair is presented six times as opposed to only once. Beyond this, however, almost nothing is known about the time course of pitch interval encoding as a tune progresses from being completely novel to being very well known.

In fact, researchers do not even know how to characterize the codes that capture pitch-interval information at different levels of learning and musical expertise. In some cases, interval information might consist of something akin to the ratios of frequencies between successive notes (inter-note interval information). In other cases, however, interval information might be encoded in terms of steps on the diatonic scale (this is the *do-re-mi* scale that many learn in childhood). Diatonic scale-step information is referred to as chroma information and is contrasted with “pitch height” information in the literature. Thus, when the note C is played in different octaves, pitch height changes but chroma remains constant (Shepard and Jordan 1984; Dowling and Harwood 1986; Dowling et al. 1995). Chroma encoding is used in recognition of well-known tunes (see Dowling 1991 for a review). For example, well-known tunes can be recognized when the pitches of individual notes have been manipulated by transposing them up or down by one octave, maintaining chroma while drastically altering pitch height (Idson and Massaro 1978). However, good recognition of such octave-manipulated melodies depends on their maintaining correct melodic contour, which means that the code used to recognize such melodies is more than simply a sequence of chromas. Specifically, the code must contain some information about inter-note pitch intervals, though this information might be global and not very precise (e.g., it might be melodic contour, the sequence of rises and falls in pitch height). Along similar lines, the transposition detection study by Deutsch (1979) included a condition in which the successive notes of the standard melody were placed in different octaves across six presentations. Surprisingly, performance in this octave-scrambled condition was actually worse than in the single-presentation (and unscrambled) condition, and substantially worse than in the unscrambled six-presentation condition. This finding suggests it is difficult to learn the pitch-interval structure of novel melodies through the encoding of chromas alone. However, encoding of melodies based on chroma and contour appears to provide a viable account of the data in hand (Dowling 1991).

In summary, people seem to remember some aspects of melodies reasonably well over the short term. As mentioned previously, simple same–different judgments to pairs of novel melodies of five to seven notes are made with high accuracy when transposition detection is not required, suggesting highly accurate short-term memory for several different pitches. Second, whereas transposition detection with novel melodies is highly error-prone, it can be greatly improved if the “different” trials involve changes in contour (e.g., if the third interval is rising in the first melody and falling in the next), suggesting that a general up and down pitch pattern is encoded easily (at least if the pattern is relatively simple; see Boltz et al. 1985). Finally, participants appear to be highly sensitive to whether changed notes in the second melody violate the key of the first (Dowling 1978; Bartlett and Dowling 1980), again suggesting that a general sense of scale is encoded fairly well after a short exposure. Thus, it is not that novel melodies are generally hard to encode. Rather, it is the precise pitch interval information in novel melodies that is a source of difficulty. How this difficulty can be overcome – as certainly it is when a tune is well learned – is an important unknown.

8.3 Short-Term Versus Long-Term Memory

After reading Sect. 8.2, the reader may be struck by the very different nature of the questions and methods involved in studies of knowledge effects in short-term memory versus long-term memory. Indeed, little attention has been paid to the short-term-memory/long-term-memory distinction by music cognition researchers. This is unfortunate, as there are indications that the information retained about melodies might be quite different in the two kinds of tasks. The role of contour information, in particular, appears to be different, as suggested by studies by and DeWitt and Crowder (1986) and Dowling and Bartlett (1981). These investigations showed that whereas melodic contour is a salient property of tunes in conditions of immediate testing, even brief filled intervals between a standard melody and a comparison melody greatly reduce its importance. Specifically, if a musically filled interval of even just a few seconds separates a standard tune from a same-contour comparison, listeners have difficulty detecting that their contours match. In line with this observation, the Idson and Massaro (1978) study using scrambled melodies found poor identification of well-known tunes if their chromas were altered, even if their contours were retained. Hence, while contour information can contribute to tune recognition when note chromas are preserved (a point made earlier), contour by itself is a weak cue for recognition in long-term memory tasks.

Although melodic contour appears less important in long-term memory than in short-term memory, this conclusion may depend on defining contour narrowly in the traditional way, as the sequence of ups and downs in pitch within a melodic phrase. Jones et al. (1987) have argued for a broader view of contour which they term “dynamic shape.” Dynamic shape includes rhythmic information as well as melodic ups and downs, and reflects those points in a melody that are attentionally more salient. In support of this view, Jones et al. showed that if a set of study tunes differ in rhythm, lures that match targets in both contour and rhythm attract substantial numbers of false alarm errors. Further, they obtained this result in a long-term memory task across three different levels of initial learning. A subsequent study expanded this result to more familiar melodies (Jones and Ralston 1991).

Whereas melodic contour (as traditionally defined) appears less important in long-term memory than short-term memory, the reverse may be true for interval information. Using a variant of the short-term same–different task, Dowling et al. (2002; see also Dowling et al. 1995) found that discrimination between target melodies and same-contour lures actually improved over a musically filled interval of 5–15 s. By contrast, discrimination between targets and different-contour lures remained roughly constant. This result may suggest that pitch-interval information needs time for consolidation in memory (see, e.g., Patel 2008). Another possibility is that listeners use different codes for interval information in short-term memory versus long-term memory. Note that contour information can be extracted from a sequence of actual inter-note intervals that maintain exact pitches, but not from a sequence of chromas. Hence, if listeners use inter-note interval codes to maintain melodic information in short-term memory tasks, this could explain why they are highly sensitive to contour in these tasks.

Apart from these interpretive issues, an important implication of the Dowling et al. (2002) study is that the classic short-term same-different task requiring transposition detection may underestimate the encoding of interval information into long-term memory. Testing after filled delays may be required to assess the extent of such encoding. Of course, contour and interval are only two types of information that might change in importance, function, and/or representational format between short-term melodic memory and long-term melodic memory. Hébert and Peretz (1997) compared recognition of well-known tunes when pitch interval information had been removed by playing all notes at the same pitch, and when rhythmic information had been changed by playing all notes for the same duration. Performance was much better in the latter condition, suggesting that interval information is more important than rhythm for tune recognition in long-term memory. Given the difficulty that listeners have in the initial encoding of pitch interval information (as revealed in transposition detection tasks), it is not at all clear that the analogous conclusion would hold in immediate short-term memory. Rhythm is also maintained over the long term to some extent, as shown by the fact that performance was best when both types of information were available in the Hébert and Peretz (1997) study. Schulkind (1999) showed that many rhythmic manipulations diminished long-term recognition performance. In light of recent evidence that long-term memory representations contain information about “absolute” musical properties such as pitch and tempo (Halpern 1988, 1989; Levitin 1994; Levitin and Cook 1996; Schellenberg and Trehub, 2003), it is important to compare the roles of such properties in short-term and long-term memory tasks.

8.4 Tune Structure

People remember better items that make sense to them. Tunes can “make sense” (or not) in two major ways. The first way is adherence to tonality. Most music that most people listen to is tonal: Notes and implied or realized harmony conform to a diatonic (musically logical) scale structure. In other words, in most melodies, most notes stay inside in the key of the piece. Sometimes composers violate tonality for aesthetic reasons, such as was true in the 12-tone movement, but not many listeners find that genre appealing. Listeners seem to prefer melodies the more closely they conform to a tonal structure (Cross et al. 1983). This scale structure also facilitates musical processing, as notes are not processed one by one, but as part of a hierarchy of tonal relationships (Dowling 1978).

The second way that tunes can make sense to listeners is if they conform not to just any tonal system, but to *the listeners’* tonal system. In other words, cultural familiarity with a tonal system may facilitate initial processing and thus retention. This second point is different from the first because atonal materials conform to no system, implying that continued exposure to atonal music would not significantly improve processing to such sequences. In contrast, cultural familiarity is assumed

to be an entirely environmental effect, as seen by cross-cultural and some developmental evidence.

The effects of tonality on melody recognition have been studied by several researchers. The typical format for studies varying tonality is short-term transposition detection, one of the tasks described earlier. A common finding is that tonal sequences yield more successful retention over a brief period. For instance, Cuddy and Lyons (1981) presented a standard melody followed by a correct and an incorrect transposition in which one note (and thus two intervals) were changed. Listeners were best able to distinguish these for highly tonal melodies, and were less adept for sequences with ambiguous tonalities. Halpern et al. (1995) compared tonal to atonal sequences in a similar paradigm, although only one comparison was presented at a time. Recognition performance was higher for tonal than for atonal sequences, regardless of whether the tonality manipulation was between or within subjects. Using slightly longer delays in a continuous running memory paradigm (for every melody, say whether it is old or new; some melodies are repeated in the list), Dowling et al. (1995) also found tonal sequences were superior to atonal, but only in the more challenging versions of the task where the delays were filled with other melodies.

On closer inspection, it turns out that the beneficial effects of tonal melodies are not uniform across variations in the task. In the Cuddy and Lyons (1981) study, the changed note in the different comparison sequence did not change the contour of the melody; in the other two studies, new notes (and thus intervals) that changed the contour were compared to note changes that did not change the contour. These latter two studies showed that tonality and type of discrimination interacted: tonality made a difference only when contour was preserved so that the sizes of intervals (as opposed to the directions of intervals) needed to be detected. Performance on changed-contour sequences was not sensitive to tonality. This pattern suggests that the processing benefit of well-formed melodies remembered over short time intervals may be particularly marked when listeners are discriminating fine pitch interval changes rather than coarse contour features of melodies.

Another interesting commonality between the Cuddy and Lyons (1981) study and that by Halpern et al. (1995) is that both tested participants with varying levels of musical training. No interactions of tonality and training were observed. This suggests that nonmusicians have abstracted the orderliness of the tonal system, and use it to increase processing fluency in these discrimination tasks. Recent evidence suggests that some aspects of tonality are processed preattentively even by nonmusicians. Brattico et al. (2006) found that nonmusicians show a robust early negative Event-Related Potential (ERP) response to tunes containing an out-of-key note, even when they were not paying attention to the tunes.

It would be useful to know if tonality confers benefits in retention of melodies over longer time intervals than are typically tested in the laboratory, given that the music that most people eventually learn and retain is highly tonal. No doubt such a task would be aversive to listeners, and perhaps many would predict that tonal items would yield superior memory. But the finding is hardly a foregone conclusion, as false-alarm rates might be higher for new melodies that are tonal versus those that

are atonal, a result that would suggest that if a melody matches well with diatonic scale structure, it feels more familiar (viz. Sect. 8.2). In addition, tonality effects might differ depending on whether tonality is varied between subjects or within subjects. Exposure to a pure list of atonal or weakly tonal items might encourage list-specific strategies, for instance, a note-by-note encoding strategy, because higher-order strategies such as chroma encoding would be ineffective with atonal melodies.

The other kind of musical structure is familiarity with a musical system, defined either as broadly cultural (Chinese versus Western scales) or as a specific idiom (classical or jazz). It seems reasonable that people would use the schemata of their “native” musical tongue to facilitate memory, but few studies have looked at this. Gardiner and Radomski (1999) presented Polish and English listeners with a list of single-line melodies from familiar folk songs from each culture. In immediate recognition, Polish and English listeners were better at discriminating old from new tunes in their own versus the other culture, but only for old responses that were definitely “remembered” (listeners had a clear recollective experience) versus “known” (listeners could say only that they knew the item to be old, but without any clear memory of having heard it). In terms of dual-process theories of human recognition memory, the finding may indicate that if melodies fit well with the musical idiom that a listener has internalized, this improves those processes underlying recollection, but not those that support familiarity.

The familiar music in Gardiner and Radomski’s (1999) study was familiar both culturally and also because the melodies were well known. Demorest et al. (2008) tried to isolate cultural familiarity by using fully realized but unfamiliar music in a cross-cultural study. They recruited listeners in the United States and Turkey. Both groups were presented short lists of excerpts of unfamiliar classical music from Western and Turkish musical traditions, followed by a recognition test. The styles were blocked, and foils were carefully matched to targets in musical aspects. Another test used classical Chinese music. The three musical cultures use different scale systems. US and Turkish listeners were presumed to be unfamiliar with Chinese musical systems, although the Turkish listeners were somewhat familiar with Western music. The authors found a crossover interaction whereby listeners remembered excerpts from their own culture (US or Turkish) better than those from the other culture. Chinese music was recognized poorly by both groups. Turkish listeners did perform better on Western compared to Chinese melodies, consistent with their exposure to Western music (US listeners were equally poor on the nonnative tunes). Musical training did not moderate any of these effects.

Lynch and Eilers (1992) also varied the familiarity of the musical context to look at its effect on detection of mistunings. Although a perception rather than a memory test, they confirmed that adult nonmusicians could detect mistunings quite well in a familiar major scale context, and performed equally poorly on melodies using a novel scale pattern based on augmented intervals and on melodies using an unfamiliar Javanese scale. Interestingly, 1-year-olds showed a pattern similar to that of adults, whereas 6-month-olds performed equally on the major and augmented melodies (and were worse on the Javanese). The authors suggest that musical

acculturation can proceed quickly between 1 and 12 months, but it is clear that some acculturation is in place by 6 months given the poor performance for the Japanese melodies in all age groups.

In summary, it seems that exposure to a body of music that conforms to a particular scale system or style engenders schematic knowledge of the underlying structure of the music. This knowledge can be used to assist encoding of tonal and culturally familiar music, yielding a memory superiority. It is remarkable that only incidental exposure is necessary for these effects to emerge, as the familiarity of the musical system does not seem to interact with musical experience; indeed the Lynch and Eilers (1992) study showed that 1-year-old infants show this schematic knowledge. Nearly universally, musical exposure is widespread, from infant-directed singing to communal activities such as religious services and school assemblies, to the nearly ubiquitous use of electronic musical playback devices among young people in contemporary developed societies. This last point leads to a consideration of what additional benefits in remembering music are associated with deliberate musical training.

8.5 Musical Experience

It is a common, and not unfounded, belief that experts should remember material in their domain better than nonexperts. Indeed, some classic studies have shown that as long as the material is well structured, experts exceed nonexperts in domain-specific memory in such varied domains as chess (Chase and Simon 1973) and figure skating (Deakin and Allard 1991). It turns out that although musical experts exceed nonexperts in some aspects of remembering music, frequently this outcome does not occur.

First, a methodological note: Different studies define musical expertise differently. In some countries, national music competency exams allow a uniform classification scheme. However, other countries such as the United States do not have national exams. Frequently, researchers use years of musical experience (often further defined as music lessons) as the metric for musicianship. This is typically instantiated in forming a group of musicians and one of nonmusicians, but sometimes years of training is used as a covariate. Rarely do researchers actually give musical competency tests before an experiment, allowing years of music lessons (experience) to serve as a proxy for accomplishment (expertise). In some situations, performing experience is counted in lieu of lessons, for instance for jazz musicians, some of whom are largely self taught. Finally, it is standard practice to exclude possessors of absolute pitch, unless that is the topic of interest.

Surprisingly few studies have examined old–new recognition as a function of experience, defined in any way. Two studies mentioned earlier are relevant here. McAuley et al. (2004) presented familiar tunes one or three times, on two successive days, and then asked musicians and nonmusicians for frequency and recency judgments. They found that musicians did not outperform nonmusicians in any

condition. Korenman and Peynircioğlu (2004) failed to find experience effects on either memory or metamemory judgments for musical recognition. As one recent exception to the general findings, Mungan et al. (submitted) presented 24 familiar tunes to trained and untrained listeners, followed by old–new recognition. This was a particularly large sample of 48 people per group, and thus may have been particularly sensitive, but the musicians were superior to nonmusicians in this task. Their advantage occurred not in the hit rate, but in a lower false alarm rate than that of the nonmusicians.

A few studies have embedded this basic task within a more complicated design. For instance, Halpern et al. (1995, Experiment 2) presented 24 unfamiliar melodies, each four times in three different keys, for ratings on pleasantness. Thereafter, old and new items were presented in a short-term same–different task (described later), but participants were asked at that point to indicate old–new recognition for each item as well. Musicians and nonmusicians were both young adult and senior citizens. No effects of musical experience on recognition memory emerged, once vocabulary score was entered as a covariate. In a similar vein, Halpern and Müllensiefen (2008, Experiment 2) presented 40 unfamiliar melodies for later recognition from among 40 new items. This sample had a range of musical experience background, but no effect of years of training as a covariate emerged. In a study previously mentioned, Demorest et al. (2008) found no differences between musicians and nonmusicians on recognition memory of culturally familiar versus unfamiliar songs.

Experience differences are more commonly tested, and found, in short-term musical recognition judgments. As one example, Mikumo (1992) presented tonal or atonal standards to listeners, followed by 12 s of various interference conditions, and a target that could differ from the standard by being an exact transposition, a change of one note in the comparison (but preserving contour), a change of two notes to violate contour, or the comparison was a completely different melody. Musicians outperformed nonmusicians overall, but particularly in the transposition condition, where nonmusicians made many false alarms. Radvansky et al. (1995) presented tonal but unfamiliar tunes as standards, followed by 30 s of a working memory task, then a target that was melodically similar or not to the standard. Half the items also changed timbre. Musicians outperformed nonmusicians in identifying the melodically similar target (timbre change did not affect either group).

In a somewhat more elaborate version of short-term recognition, Halpern et al. (1995) presented standards that were transposed to three keys (for a total of four presentations), followed by a 6-s silent interval, and then a target that was yet another exact transposition, or that changed two of the seven notes. Sometimes the two new notes changed the contour and sometimes they did not. In addition, sequences could be tonal or atonal. The task was to discriminate exact transpositions (same) from inexact (different) ones. In several experiments, musicians were superior to nonmusicians, but only in the condition wherein contour was left unchanged so that changes in exact intervals needed to be monitored. Musical experience was not an advantage when a change of contour was the cue to a different

trial. Musicians were not differentially superior to nonmusicians on tonal or atonal materials.

Another example of short-term recognition was seen in the previously described study by Dowling et al. (2008), which presented pairs of familiar or unfamiliar tunes for comparison at very slow, medium (normal), or very fast tempos. Some trials were exact repetitions and different trials changed two notes with a preserved contour. Musicians were superior to nonmusicians in all conditions in discriminating exact from changed repetitions, including in the easiest condition of comparing two familiar songs at normal speed. This result concurs with the previously mentioned study of tune identification by Dalla Bella et al. (2003), who found that musicians identified well-known and moderately familiar melodies in fewer notes than did nonmusicians, suggesting that training might increase the efficiency of tune identification as a general rule, and not specific to challenging conditions.

To sum up, these studies all suggest that the primary advantage of musical training in remembering melodies occurs when the task requires participants to make fine musically relevant distinctions such as those of interval size, as might occur during a piece when a composer presents variations of a theme. Nonmusicians are quite capable of detecting contour change, which one could argue does not involve such fine musical discrimination as transposition detection. Skills in making fine musically relevant distinctions among melodies are typically tested over short retention intervals and thus within a span of working or short-term memory. Hence, it is unknown whether musical training would confer an advantage in making these same distinctions in long-term episodic memory tasks. The literature seems to show that nonmusicians are as capable as musicians in tests of long-term episodic memory for tunes, but these tasks have typically used simplified materials and have not required the types of subtle musically relevant discriminations required in the short-term memory studies where tunes are presented in quick succession. That musicians appear to be better at identification of tunes known from life requires more research attention, but it may suggest that certain fine discriminations (of precise musical intervals, for example) can facilitate discrimination of such tunes from unknown tunes.

8.6 Aging

One of the issues that has interested the current authors for some time is how music cognition, including memory, changes in normal and pathological aging. This interest stems from both everyday and theoretical bases. It is evident that many older people enjoy music of many genres, as listeners, performers, and financial patrons. In fact, performing arts personnel refer to a “Q-tip Effect” at concerts of jazz, Big Band, or classical music, describing the view from the stage when the spotlights shine through the gray-haired audience. Community bands and orchestras often count senior citizens among their most avid participants, and many retirement communities and nursing homes offer musical activities as part of enrichment and therapy.

Yet very little research has been conducted on this topic. This dearth is regrettable because of some interesting if not unique perspectives that using music as a domain can bring to the study of cognitive aging. For instance, music without words is completely nonverbal yet conveys messages such as valence and arousal (Lucas et al. 2010), making a useful contrast with the large majority of studies in cognitive aging that use language to convey messages. Except for musicians practicing for a concert, most music is learned incidentally, allowing researchers to examine how both particular pieces of music, and the underlying musical structures, may be learned by mere exposure over the lifetime. In addition, musical training can vary at any age, making it possible to separate effects of years of exposure and deliberate training. That is hard to do in most other domains. Finally, one can examine whether music memory is more preserved in pathological aging, such as Alzheimer's disease, compared to well-known verbal impairments.

In most studies of cognitive aging, older adults are defined as 60+ years. In some studies, age is grouped into two or three levels. At other times, age can be used as a continuous variable for somewhat more statistical power. When possible, researchers administer at least one cognitive test not related to music, such as a vocabulary test, to help ensure that any age-related impairments are not attributable to general cognitive decline. This section mostly concerns explicit memory for newly learned material in normally aging adults, where the rememberer is aware that he or she is engaging in an attempt to remember the material, but touches on some other forms of memory and pathological aging as well.

The first point to consider is semantic memory for music, or general memories about music not tied to a specific learning experience. Do older adults remember music learned as younger adults? Several studies agree that familiar music, once firmly encoded, seems retrievable decades later. As noted earlier, Bartlett et al. (1995) presented familiar and novel songs in a recognition task to young adults, normal older adults, and Alzheimer's disease (AD) patients. As part of verifying the stimuli, all groups were asked at the end of the experiment to classify the tunes as familiar or unfamiliar, and to name each one or at least give a descriptor or a few lyrics from the song. The familiar songs were selected to be "lowest common denominator" songs that most Americans would likely learn in childhood, such as patriotic and folk songs. The young and older adults were nearly perfect in classifying the songs, and also scored highly in naming or describing these songs. In fact, this kind of memory seems very robust, as the AD group was very adept in the classification task (they had more problems naming the songs, which is consistent with naming deficits in AD). All three groups were perfect in calling well-known songs "familiar," and they showed a low false alarm rate (occasionally a novel tune was called familiar; the novel tunes were in fact permutations of the familiar tunes, so the occasional false alarm should not be surprising.)

A few other studies have shown that memory for popular music that is first learned in youth seems particularly robust to aging. Bartlett and Snelus (1981) presented middle-aged and older listeners with music popular from various decades for a familiarity and time-last-heard judgment, and lyric recall for tunes deemed familiar. Of course, they could not guarantee that listeners had been exposed to all

the tunes, but the older listeners had a higher proportion of “familiar” judgments than the middle-aged adults, for music popular when the former group were young adults but the latter group were children or not yet born. This early-learned advantage was confirmed by Rubin et al. (1998) and also Schulkind et al. (1999), who showed that these songs elicit high emotionality ratings, which could partially explain the memory advantage.

The retention of familiar music over decades may depend on the extent to which the music was the focus of attention during early exposure. Maylor (1991) found that older adults were worse than middle-aged adults in recognizing television themes no matter what the retention interval (i.e., era of learning). However, it could be the case that this kind of incidental music has less musical and emotive meaning than music learned among peers as a young adult, or in settings such as summer camp or as part of religious services. It is possible that older adults have a particular disadvantage in the very casual learning situations of hearing background music to a television show.

Overall, research seems consistent with everyday observations that older adults can store representations of music for decades, but does this memory ability extend to newly learned music? As noted earlier, there is some folk belief that memory for music may be somewhat protected from the usual age-related impairments in episodic memory. However, it seems that at least in episodic memory over the long term, aging is associated with the kinds of impairments that are seen in other domains. Again, research is sparse but there are a few such studies.

Two relevant studies were already described in the context of experience and tune-knowledge effects. One was the Halpern et al. (1995, Experiment 2) study, which presented 24 unfamiliar melodies, each four times in three different keys, for ratings on pleasantness. In a subsequent old–new recognition test, musical experience did not affect performance (the point made earlier), but young adults were significantly (but not drastically) better than older adults. In the second relevant study, Bartlett et al. (1995) presented well-known and novel tunes (the latter permutations of the well-known tunes) for old–new recognition. In Experiment 2, the tunes were presented blocked by knowledge (i.e., only well-known tunes in one study list and test, only novel tunes in another), whereas in Experiment 3, well-known and novel tunes were mixed in each study list and test. Young adults performed better than older adults in both of the experiments particularly because older adults had large false alarm rates to familiar tunes. The size of the age difference was stronger in the mixed condition in which both the young and old began having trouble suppressing false alarms to new but well-known items (a problem attributed to familiarity in the absence of naming). Blanchet et al. (2006) found that older adults had hit rates equivalent to younger adults when asked to memorize a short set of unfamiliar tunes for later recognition, but had trouble suppressing false alarms. An encoding task (classifying the tunes as march or a waltz) actually hurt older people’s performance. The authors suggested that the task did not provide enough distinctive cues but served instead as a divided attention task, consistent with the earlier point about the lack of distinctiveness in memory encoding.

From the small amount of evidence available, it seems that retention of a set of items for recognition later in the experimental session is subject to the same age-related decline as seen in many other domains (Park and Schwarz 2000). However, short-term retention in same–different tests does not always show an age-related deficit. Meinz (2000) presented musical notation in a variety of short-term memory tasks, both recall and recognition, to musically literate people of various ages. She found age-related deficits in only a few memory tasks, and no age-related impairment in her composite memory score. Halpern et al. (1995) found that older adults were less adept than younger adults in differentiating exact transpositions from different-contour transpositions. But it was this study that found age invariance when the task was to differentiate exact transpositions from changed-interval transpositions. So the age-related deficit here seemed more tied to the more global task of contour processing, not the detailed task of interval detection. All listeners performed the contour task much more accurately than the interval task, belying another folk belief that age-related impairments are always larger in harder tasks.

Only small deficits due to aging were found in another type of short-term comparison task (Dowling et al. 2008). This was task mentioned earlier of comparing familiar or unfamiliar standards with an exact repetition or a changed-interval target, at slow, medium, or fast speeds. Whereas results showed a large effect of experience, only a modest effect of age occurred, even for tunes going very fast or very slow. This is surprising because one reasonable hypothesis was that older adults might have trouble integrating a very fast stream of notes due to attentional problems, or remembering a very slow stream of notes due to working memory limitations. But these near side-by-side comparisons do not task the more deliberate encoding used in list learning experiments and where deficits are the hallmark of cognitive aging.

One aspect of memory not so far addressed is implicit testing. Most of the studies presented so far involve explicit testing, usually recognition. Implicit tests involve a change in behavior without the testee necessarily experiencing a conscious memory act. And in fact, in real life people often retrieve music without necessarily having a memory retrieval experience. For instance, a person may hum along with a song on the radio without being able to recall the tune by name, or find that she or he likes a tune for some reason, only later realizing it had been heard previously. A friend told an anecdote of suddenly feeling sad while a certain hymn was being sung at her church. Only later did she remember that the tune had been sung at her mother's funeral.

A few studies have found that music can be tested implicitly. Warker and Halpern (2005) adapted a stem completion task to music: a list of unfamiliar tunes was presented, followed by the first few notes (stems) of old or new tunes. People were asked to hum a note that “sounded good” after the stem. They sang the correct note more often for old than new tunes, independent of explicit memory for that note. Peretz et al. (1998) found dissociations of recognition memory for music (explicit) from increases in liking for old tunes (mere exposure effect, implicit).

A common finding in cognitive aging is that implicit testing often reveals smaller aging effects than explicit testing (Fleischman et al. 2004), possibly due to more automatic nature of the encoding and/or retrieval processes used in implicit tests compared to explicit. Is this result also shown in studies with music? Gaudreau and Peretz (1999), and Halpern and O'Connor (2000), showed that recognition memory was quite impaired in older versus younger adults, but age made no difference in the implicit task of an affective judgment to each tune. Thus it may be the case that effortful retrieval is a locus of age-related effects than encoding, as the tunes had to be encoded to be rated as more pleasant or better liked. On the other hand, it might be argued that elaborative encoding at the time of study is important for explicit-test performance but not for implicit-test performance, and that older persons are deficient at such encoding. However, it was argued earlier that elaborative encoding strategies seem largely ineffective in changing music recognition performance, and thus is evidence against this view.

The final question raised in this section is whether the deleterious effects of normal aging and the beneficial effects of experience can offset one another. That is, are there any situations in which age and experience interact? It turns out that this is a perhaps desired but not-often-found pattern in various domains. For instance, Morrow et al. (1994) failed to find this for airline pilots, except for one or two specific tasks. Meinz (2000) did not find age by experience interactions in her notation memory studies. A review of work from the research program of the current authors (Halpern and Bartlett 2002) examined 13 experiments that could have revealed such a compensatory pattern. In only one instance did such a pattern obtain, and even there, the interaction accounted for very little variance. In fact, that review concluded that age and experience typically affected different tasks and that the benefit of younger age and more experience are not interchangeable.

The opposite side of this coin is that nothing suggests that age diminishes the positive effect of experience. In fact, Meinz (2000) found that because experience usually increases with age, this “confound” can lead to an apparent diminution of age effects with experience. So even though this is not an interaction in the theoretical sense, in a practical sense, older musicians would be expected to exceed younger nonmusicians, in experience-sensitive tasks.

8.7 Conclusions and New Directions

Perhaps the major message of this chapter is that memory for melodies depends upon knowledge. First, it depends on knowledge of individual tunes, their perceived familiarity and nameability. Second, it depends on knowledge of the tonal structure and well-formedness of tunes, including knowledge of in-key versus out-of-key notes. Finally, it depends on the musical knowledge of the listener, using the term rather broadly to include both symbolic knowledge and procedural skills developed in the course of musical training.

Knowledge of individual tunes is important in the simple short-term memory same–different task of judging pairs of tunes as same or different. Performance is much higher if the first-presented tune in a pair is a well-known melody, and this is true whether or not the task requires recognition of targets that have been transposed to different keys, so long as ceiling effects are avoided and accurate same–different judgments cannot be based on global aspects of the tunes such as melodic contour. In the domain of long-term memory, tunes that have been rated as highly familiar are recognized more quickly (i.e., after fewer notes) than those rated as only moderately familiar, and prior knowledge of tunes is also important for “episodic memory,” that is, recollecting the contexts in which tunes have been presented. Recollection of context appears to depend not simply on a tune being familiar to the listener, but on its nameability; that is, its unique identifiability with a proper name, word, or phrase. It is unknown whether familiarity without nameability is sufficient to produce (1) quicker identification of tunes and (2) high performance in short-term same–different tasks, including those requiring accurate encoding of musical interval information. Regarding the latter point, it is clear that listeners have rather poor knowledge of the intervals of novel tunes heard only once before, and yet these same listeners – even if they are musically untrained – have accurate knowledge of the intervals of tunes they know well. An open question is whether accurate knowledge of the intervals of well-known tunes can be developed with tunes that have been heard repeatedly without ever being linked to names or other verbalizable information that uniquely identifies them.

It will surprise no one that tunes that conform to familiar tonal structures are easier to recognize, and indeed they are. However, researchers have only started to examine what aspects of tonal structure in a given musical culture are important for learning and remembering of melodies, and how these aspects of tonal structure themselves are learned. The research covered here suggests that a very basic aspect of tonal structure – the set of in-key versus out-of-key notes – is implicitly learned by virtually all listeners, and produces effects of tonal structure on memory. However, it is unclear whether other aspects of tonal structure might affect melodic memory at different levels of musical expertise. In light of evidence that nonmusicians show relatively poor differentiation in their ratings of the centrality of different notes within a key (Krumhansl 1990), and are poor at classifying melodies as major versus minor (Leaver and Halpern 2004), it is likely that such more subtle aspects of tonal structure will affect melodic memory only among the more highly experienced or trained. It likewise will surprise no one that more musically trained listeners show better memory for tunes. However, the research in this area has advanced to a point quite beyond common knowledge. Certainly, few “people on the street” would intuit that musicians do not differ from nonmusicians in their sensitivity to a melody’s out-of-key note, but that musicians are better in making the basic judgment of whether one novel melody is a transposition of one heard a few seconds before (this task is trivial even for nonmusicians if the first melody is known, but is more difficult if the first melody is novel).

The ability to group musical materials during encoding may play a role in the effects of expertise. In chess, for example, it is very well known that experts chunk

together multipiece configurations of chess pieces, enjoying very high memory for chess-board displays as a consequence (Chase and Simon 1973). Similarly, much research with faces – with which it is argued all of us are experts – supports this chunking, or configural, encoding. Moreover, recent evidence suggests similar forms of configural encoding can emerge with expertise in identification of birds, automobiles, and invented three-dimensional forms (i.e., “greebles”; see Bukach et al. 2006). In fact, research summarized by Bukach et al. suggests that two different types of configural processing – holistic processing of the whole object and relational processing of spatial relations among features – both are related to expertise with visual stimuli. Although these two subtypes of configural processing are separable in terms of brain function (and probably in other ways), they may be functionally related in that attention to a whole object is likely to facilitate encoding of spatial relations among its constituent features.

By analogy, attention to the whole of a musical phrase might impair selective processing of individual notes, but improve the encoding of musical relations among these notes. Indeed, the Dalla Bella et al. (2003) study cited earlier in this chapter, as well as research by Schulkind and colleagues (Schulkind 2004; Schulkind et al. 2003), has shown that the most important notes for identifying melodies tend to occur at boundaries of musical phrases of five to seven notes. In another relevant study, Kim and Levitin (2002) replaced the notes of well-known melodies with bandpass filtered sounds that severely disrupted the absolute and relative pitch of the individual notes. Melody identification was approximately 75% when bandpass filtering had reduced identification of individual pitches and inter-note intervals to almost 0%, a striking example of tune recognition based on inter-note relations when the notes themselves are not accurately encoded. Unfortunately, it is not yet clear whether the relational processing supported by these studies is linked to expertise. Dalla Bella et al. (2003) found that both musicians and nonmusicians appeared to recognize melodies through processing of phrase-level units, and Schulkind (2004) found no reliable correlations between musical training and inter-condition differences that would have suggested a linkage of phrase-level coding to musical expertise. Finally, Kim and Levitin’s listeners had at least 10 years of musical training, raising the question of whether untrained individuals would show similar evidence for relational recognition of melodies – or not.

One of the most encouraging findings pertaining to musical expertise is that its enhancing effects on melodic processing holds up well in old age. Although age-related deficits in melodic processing have been found, the melodic processing advantages linked to music training appear not to decline at all in old age. Moreover, age-related deficits in melodic processing do not appear to involve the more intrinsically musical aspects of melodies such as tonality, key, or chroma. Thus, so far the evidence is quite well aligned with anecdotal reports of preserved memory for music among the very old and demented

The effects of expertise have been examined primarily in short-term memory tasks, and, of all the many gaps in the literature to date, perhaps none is more striking than the lack of information about expertise effects in long-term melodic memory. It certainly is possible that such expertise effects are present, and remain largely

unknown simply because they have not been examined. On the other hand, the processes and representations used in long-term melodic memory may be fundamentally different than those used in short-term memory tasks. Kosslyn's (1980) influential theory of visual imagery drew a sharp distinction between the "surface display" underlying the experience of visualizing an object and the "deep representations" that support long-term retention of visual information (the latter being at least partly propositional). Research and theory on melodic processing, and on how musical knowledge affects such processing, should be directed at this question.

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