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The Cognitive Psychology of Music

By W.J. Dowling

I am happy to have this opportunity to explain to an audience of humanists what it is I do and why. Just as the results of humanist research into the history and structure of music have been very valuable to me in my work, I hope that some results from the psychology of music may be of some use to the humanist. The psychology of music is in one sense "humanist," since in his concern with the structure and function of musical works the psychologist focuses on the skills and experiences of the human beings who produce and perceive them. This focus leads the psychologist to inquire into how music is produced and perceived in cultures besides our own—to be as interested in ethnomusicology as in the traditional areas of music study in our own culture. I will provide some examples in this article illustrating aspects of man's musical life that seem to be universal across cultures, as well as aspects that are specific to particular cultures.

The questions I investigate are related to a certain corner of the traditional area of aesthetics, and it may help put them in context by locating that corner within the field. There are questions with which (rightly or wrongly) aesthetics has been traditionally concerned which do not concern the cognitive psychologist of music. One of these is, What is music? The psychologist is content to study behaviour that is generally agreed to be musical—singing songs, chanting prayers, listening to concerts, writing notes on paper, or improvising jazz. There are always borderline cases, and their study often illuminates the mainstream cases. In particular, I do not think it worthwhile for the psychologist to go hunting for some specific "aesthetic response" in the people he studies. A lesson to be learned from Dewey as well as Wittgenstein is that the cognitive processes people bring to the apprehension of art are so various and so pervasive in the rest of their cognitive life that the attempt to use any of them as a defining correlate of art must fail.[1]

A second type of question that does not concern me is that of the person's emotional response to music. This is not to say that I don't think the question is important—I do. It is just that I think before we can learn much about how a person reacts emotionally to music we must first find out much more about what it is, psychologically, to which he is reacting. We need to know what it is in the physical sound waves that the person perceives and remembers. Just because some aspect of a piece of music is notated on paper or described by a musicologist doesn't mean that that aspect is meaningfully perceived in the sound. For example, are the elaborate key relationships in Mozart's *The Marriage of Figaro* perceptible to a listener lacking absolute pitch? Without answers to such questions I believe it is premature to study the emotional effects of that and similar devices. (The reader who wishes to tackle the question of emotional response immediately will find excellent attempts in the work of D.E. Berlyne and his associates.[2]).

A third question, and one that I think important though premature, is the question of greatness. If it were not for the Mikado's sentencing pop singers to a diet of "Bach interwoven with Spohr and Beethoven" most of us would never have heard of Spohr.[3] Yet Ludwig Spohr (1784-1859) wrote in much the same idiom as Beethoven and in the 1880s could be mentioned in the same breath with the master. I think that in our present state of knowledge we are investigating questions for which the difference between Spohr and Beethoven is largely irrelevant. There are basic questions of how pieces in the classical-romantic style are perceived whose answers apply equally to both composers; for example, for how long and through what sorts of intervening material can listeners remember theme A so that they can recognize it when it recurs? We could know the answers to such questions and still not know what makes Beethoven great. In fact, such questions usually take the rule system of a style as given, and then ask what the psychological limitations of the listener mean for the application of those rules. However, it may be precisely in not following the given stylistic rules too slavishly that a composer's greatness is to be found.[4] By way of analogy, in the psychology of reading we are at present concerned with how the reader encodes and stores the words he sees on the page, it mattering little whether those words were written by Shakespeare or by John Webster. We are at a similar stage in the psychology of music, and I think that questions of value in works of art must be deferred until we know more about the processes by which works of art both great and merely competent are perceived and understood.

I can turn now to those questions that I think ripe for study now. I am most concerned with cognition—with the perceiving and remembering of music. The basic questions involve what, out of the wealth of information in the physical sound waves of music, gets attended to, compared with other sounds, and what gets stored in memory by the human listener. It has been pointed out that if we make very straightforward physical analyses of loud selections of music such as the chords near the end of Beethoven's *Fifth* the result is all but indistinguishable from physical analyses of noise.[5] But people hear such stimuli as meaningful. How do they do it? What mental structures in the person from a European culture give him a meaningful interpretation of a stimulus that a European machine cannot understand? Alternatively, how can we design a machine to attend to just those aspects of European music that the European person attends to? (It isn't that we really want such a machine, but that if we could design the machine we'd be understanding the structure of the person a little more precisely).

There are certain emphases that cognitive psychologists make in their theories that may seem congenial to you in spite of the foregoing talk of machines.[6] First, we tend to emphasize the notion of an *active* processor of information. The person is not just a passive receptor of information. If he were he might behave just as the machine cited above, and understand nothing. What we need to do is identify what the acculturated listener brings to the music that enables him to make sense of what he hears. An experiment I did in 1966 casts some light on this.[7] The key word is acculturation. People in my study were acculturated so that they had tunes like "Twinkle, Twinkle," "Frère Jacques" and their school Alma Mater firmly stored in their memories. I presented these people with highly ambiguous stimuli by interleaving the notes from a pair of these familiar melodies—in the case of "Twinkle, Twinkle" and "Frère Jacques" this made Cc-CdGeGcAcAdGeGc (capital letters represent one melody, lower-case the other). This sequence is a meaningless jumble of notes if you don't know what melody you're listening for. However, if I told listeners the name of one of the tunes they could hear it very clearly. Sometimes I gave the listeners erroneous titles, and then they couldn't hear what they were asked to (this last is a control condition, which we include in the experiment just to make sure the first batch of listeners really could hear the tune and weren't just trying to be agreeable). What this experiment indicates is that the listener has internal representations of the melodies he knows. He can use these representations to search actively for a melody in a confusing context. One implication of this is that the listener who knows a complex piece of music well actually hears something different than does a naive listener. Interesting inner parts the composer has hidden in the texture become clearly audible once you know they're there.

There is another kind of confusing context for melodies that psychologists have used with similar results. Diana Deutsch of the University of California, San Diego, found that splitting up a familiar melody so that successive notes fell into different octaves made the tune very hard to recognize.[8] This type of distortion destroys the melodic continuity of pitches in the melody while leaving intact the chroma—the *do*-ness, *re*-ness, *mi*-ness—of each note. Therefore what we have stored when we remember a melody cannot simply be a list of chromas of successive pitches. The listener also needs information about the melodic contour, the sequences of ups and downs from note to note in order to recognize the melody. In subsequent experiments I found that preserving the contour in its entirety, even when the skips were more than an octave, made octave-scrambled familiar tunes much more recognizable, at least if the listener knew that the contour was there to be retrieved.[9] In fact, simply providing the listener with the title, as in the above experiment with interlaced melodies, is sufficient for him to verify the presence of the tune.[10] (This is an experiment you can try on your guests after dinner—actually how I got some of my subjects for it. Using a die, write out some familiar tunes with the notes randomly assigned to six different octaves on the piano, with the constraint that no two successive notes fall in the same octave. You might practice playing the scrambled melodies—it's not easy skipping around from octave to octave all the time. Then assign labels to the scrambled tunes, with half the labels correct and the other half incorrect. When you play them for your listeners precede each melody with the label, asking the listeners to verify whether what you're playing matches the label. I trust you'll find that with the correct label the tunes are easy to recognize, but without it they're difficult). My interpretation of these studies is that the contour or the label allows the listener to generate a mental model of the tune he knows, which he then can match up against the notes of the confusing scrambled stimulus he hears. When the chromas of the model match the chromas he's hearing he says "aha, that's 'Frère Jacques'." If not, he doesn't. The set of chromas of the scrambled tune alone do not provide enough meaningful information. It's important, though, that the chromas be there to be recognized. Howard Kallman and Dominic Massaro of the University of Wisconsin did an experiment very similar to the preceding, except they changed chromas of the scrambled notes by one semitone in each case. That again made the tunes very difficult to recognize.[11] So it seems that, even though the sequence of chromas alone is not enough to produce immediate recognition, they must still be there for the tune to be recognized.

The above series of studies represents just one line of evidence converging on a fact that musicians have always known: that the set of pitches—chromas—of the musical scale are of fundamental importance in the perception and production of music.[12] By the time a child is six or seven the interval patterns of the *do, re, mi* type scales of the culture are deeply etched in the mind. Whenever we hear a melody in a non-western scale that divides the octave differently than does ours we tend automatically to translate the pitches into those of our own scales. If we were to sing such a melody back it would be in a scale of our own. And this same scale structure that distorts music from outside our cultural experience serves to make it easier to understand and remember materials from within our culture which are constructed in its terms. In what for me is the classic of this field Robert Francès describes a series of experiments he did in the 1950s demonstrating among other things that listeners find it much easier to recognize tonal melodies they have heard than atonal ones.[13] These results have been extended by Lola Cuddy and her associates at Queen's University who showed that, not only are tonal melodies easier to remember, but that even single pitches are more easily remembered when they are first presented in a tonal, rather than an atonal, context.[14] Moreover, as the listeners in Cuddy's experiments became more familiar with the atonal tone sequences, single pitches in them became easier to recognize. This shows that even with atonal materials our memory for the single notes in a tone sequence can't be separated from our memory for the whole sequence. Just as knowing a piece better makes the melodies within it more recognizable, knowing a melody better makes the pitches in it more recognizable. And the melodic context is especially useful when it uses a musical scale system well known to the listener.

Another way of looking at the function of scale structures in our listening is with a series of experiments I have done over the past ten years. In the first of these experiments I used five-note atonal melodies.[15] On each trial of the experiment the listener would hear a pair of these brief melodies, and have to say whether they were the same or different. In order to be called "same" the second melody would have to be an exact transposition of the first; otherwise it should be called "different." The second melody in each pair actually was one of the following: an exact transposition of the first melody; a slightly distorted version of the first melody in which the starting note and the intervals between notes had been changed but in which the contour—the pattern of ups and downs—remained unchanged; or a version of the first melody with a different starting note and a different contour. As you might expect, it was easy for the listeners to tell the difference between melodies having different contours. What was difficult for the listeners was distinguishing between exact transpositions and other atonal sequences that maintained the contour. This result led me in my thinking to what I now perceive as an overemphasis on melodic contour. I did a series of experiments showing that when listeners are asked to recognize inversions, retrogrades, and retrograde inversions of brief atonal melodies all they can succeed in doing is to recognize appropriate transformations of the contour. They lose track of the exact interval sizes between notes just as they do in recognizing transpositions.[16] I began to think that all we can succeed in storing when we hear a brief melody once is the sequence of ups and downs. Then it gradually dawned on me that I was ignoring a very important component of the cognitive equipment each of us uses in perceiving melodies—our tonal scale system. As Annabel Cohen has demonstrated, even hearing the first four notes of a tonal piece such as a Bach Prelude—for example, the very rapid sequence C-G-E flat-G—is sufficient to invoke in the listener the tonal scale in which the piece is written.[17] So I repeated the experiment I had done with atonal melodies, this time using tonal melodies.

This experiment was structured the same way as the one I just described, except that the first melody of each pair was a tonal sequence beginning on C in the key of C major.[18] The second melody was one of the following: an exact transposition to the key of A or E; an atonal, same contour melody beginning on A or E; or it was a melody with a different contour. I also added another kind of comparison, a "tonal answer" beginning on A or E but remaining in the key of C. As before, listeners found it very easy to reject different contour stimuli as being different from the first melodies in the pairs. But now it was also fairly easy for them to reject the same contour, atonal items as well; and this was particularly true of listeners with some musical training. The listeners were able to use their knowledge of the major scale system to tell that an atonal melody was not what they had originally heard. Now it was the tonal answers which caused confusion because, when you hear two melodies in the same key, both with the same contour and same diatonic intervals between the notes, they sound very much alike. Nothing in the second melody forces you to shift gears into another key, and it is difficult while remaining within a key to distinguish diatonic intervals of different sizes. (Professional musicians were not confused between transpositions and tonal answers, but people with five years of training were.) So it appears again that the scale system functions as a cognitive framework in terms of which we hear melodies. If a melody violates the framework, that is easily noticed. But if a melody preserves contour and diatonic intervals while changing the physical size of the intervals in semitones, the difference is very difficult to hear.

After reading the preceding experiment, James Bartlett suggested that I had left out an important kind of comparison; namely, a sequence whose pitch level changed and which remained tonal but shifted to another key from the original. An example would be the pair C-C-G-G-A-A-G and F#-F#-C#-C#-D-D-C# in which "Twinkle, Twinkle" has not only been shifted to the key of D, but now begins on the third degree of the scale. So we did a new experiment in which tonal comparisons that shifted keys were included.[19] The shift in key was either to a near key (C to G or D) or far key (C to B or E) around the circle of fifths. We found that the key shift made the tonal imitations easier to distinguish from transpositions, though they remained more difficult than atonal imitations. And far-key imitations were easier to reject than near-key imitations, presumably because they introduce more pitches foreign to the inferred scale of the C-major original. Being tonal and having the same diatonic intervals makes a comparison melody sound very much like the original even if it changes key, but not so much like it as if it stayed in the same key as a true tonal answer.

While we were working on this experiment we began to think more and more about the possibility that, although the musically untrained listener finds it difficult to listen once to a brief, unfamiliar melody and then distinguish it from tonal imitations in the same and other keys, he might find the task much easier if it used melodies he knew well. A result that led us to this notion was obtained by Fred Attneave at the University of Oregon.[20] Attneave and Olson had their subjects tune continuously variable pitch oscillators to the pitches of the familiar NBC chimes at pitch levels spanning the range of musical pitch. Even untrained people were able to perform the task with considerable precision. This shows that for familiar melodies people generally have precise notions of interval sizes. Therefore, if we were to repeat our experiments on the recognition of exact transpositions using familiar tunes, then we should find that tonal imitations would be much easier to distinguish from exact transpositions. This is in fact what we found. Even musically untrained people are able to tell when a familiar melody has been distorted by changing the interval sizes as in the example of "Twinkle, Twinkle" above. But, although persons with five years of training could perform the task with familiar melodies almost perfectly, untrained listeners still showed a greater tendency to be misled by tonal imitations in the same key or a key nearly related to the key of the original melody. Even with familiar melodies there seems to be an effect due to a kind of tonal inertia—as long as a new sequence can be heard in the same key as the previous sequence that in itself will make them sound similar, and if they have the same diatonic intervals and contour they will tend to be confused with each other.

The above examples show how pervasive and stable the diatonic scales of our culture are in our musical behaviour. If we could run analogous experiments in other cultures I am confident they would yield similar results. With very few if any exceptions the musical cultures of the world use scales that repeat their interval patterns at the octave.[21] The exceptions are cases in which a culture sometimes uses a chant centred around one or two pitches where it is hard to say that definite scale-like pitch relationships are being used. But as far as I know no culture group in the world uses that kind of music exclusively, and in the great majority of cases it is possible to find evidence for the systematic equivalence of pitches an octave apart, such as when men and women sing together in octaves. The octave seems to be built into the human auditory system and is a true crosscultural universal. It also seems universal that cultures divide the octave into some definite number of pitch categories—typically five or seven—and that melodies move in discrete steps from pitch to pitch rather than in a continuous glissando. Helmholtz attributed this human tendency to categorize pitches to our cognitive need to be able to measure the extent of melodic movement.[22] He argued that even if a melody did move in glissandi that we would still need a mental scale of discrete pitches to tell how far it was moving. We don't really know what the biological function of human pitch categories is, but Helmholtz's reasoning seems as good to me on this point as any other.

Although all cultures divide the octave into discrete categories each culture uses a set of categories different from those of all the others. What the different systems of dividing the octave seem to have in common is some way of balancing diversity of interval sizes between pairs of notes against some commonalities. No culture makes its six or seven or eight diatonic scale intervals into equal logarithmic steps, such as in our "whole tone scale." Equal temperament seems to be a development peculiar to China and Europe, and that only since the sixteenth century. There does seem to be a tendency, however, to divide scale intervals roughly into "large steps" and "small steps" and it is often the case that "very small steps" are added to the system for purposes of ornamenting the main pitches of the diatonic scale. This ornamentation with microtones outside the diatonic scale is especially characteristic of the music of India and Indonesia, but an analogous usage can be found in western music. In the sixth of Mozart's "Variations on '*Ah, vous dirai-je, Maman*'" ("Twinkle, Twinkle") he gives the right hand the sequence of notes G-F#-G-F#-G etc. against the dominant-seventh chord G-D-F in the left. The F# is foreign to both the chord and the C-major scale, and is functioning purely as a melodic ornament to the scale note G. And, although all cultures establish a hierarchy of tonal functions on the notes of the scale, the hierarchies differ from culture to culture, often so much so that it is impossible to say unequivocally which note is the "tonic" and so on.

In this article I have concentrated on the melodic, pitch aspects of music because that is what I have worked on most. There are other aspects—for example, rhythm—which I have left out, but not because I don't think they are important. The wealth of complexity in man's musical thought and behaviour is enormous. I think it is important to realize, when we are searching for the truly human in all of this diversity, that we aren't brought to a premature halt when we find a few cultural universals. It is important to realize that, beyond the universals, the truly human may lie in the diversity itself.[23]

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NOTES

1. J. Dewey, *Art as Experience* (New York: Putnam, 1934); L. Wittgenstein, *Lectures and Conversations on Aesthetics, Psychology and Religious Belief* (Berkeley: University of California Press, 1966).

2. D.E. Berlyne, *Aesthetics and Psychobiology* (New York: Appleton-Century-Crofts, 1971); and *Studies in the New Experimental Aesthetics* (New York: Wiley, 1974).

3. W.S. Gilbert, *The Complete Plays of Gilbert and Sullivan* (New York: Garden City, 1941), p. 332.

4. Elaborations of this suggestion can be found in L. Meyer, *Music, the Arts, and Ideas* (Chicago: University of Chicago Press, 1967), and L. Bernstein, *The Unanswered Question* (Cambridge, Mass.: Harvard University Press, 1976).

5. F. Winckel, *Music, Sound and Sensation* (New York: Dover, 1967).

6. W.J. Dowling and K. Roberts, "Historical and Philosophical Backgrounds of Cognitive Psychology," in E.C. Carterette and M.P. Friedman (eds.), *Handbook of Perception*, vol. 1 (New York: Academic Press, 1973).

7. W.J. Dowling, "The Perception of Interleaved Melodies," *Cognitive Psychology*, 5 (1973), 322-337.

8. D. Deutsch, "Octave Generalization and Tune Recognition" *Perception & Psychophysics* 11 (1972), 411-412.

9. W.J. Dowling and A.W. Hollombe, "The Perception of Melodies Distorted by Splitting into Several Octaves: Effects of Increasing Proximity and Melodic Contour," *Perception & Psychophysics* 21 (1977), 60-64.

10. W.J. Dowling, "Listeners' Successful Search for Melodies Scrambled into Several Octaves," *Journal of the Acoustical Society of America* 64 (1978), S146 (Abstract).

11. H. Kallman and D. Massaro, "Tone Chroma is Functional in Melody Recognition," *Perception and Psychophysics* 26 (1979), 32-36.

12. For more extensive reviews of the psychological literature see W.J. Dowling, "Scale and Contour: Two Components of a Theory of Memory for Melodies," *Psychological Review* 85 (1978), 341-354, and "Musical Scales and Psychophysical Scales: Their Psychological Reality," in T. Rice and R. Falck (eds.), *Cross-Cultural Perspectives on Music* (Toronto: University of Toronto Press, in press).

13. R. Francès, *La Perception de la Musique* (Paris: Vrin, 1958).

14. K.M. Dewar, L.L. Cuddy, and D.J.K. Mewhort, "Recognition Memory for Single Tones With and Without Context," *Journal of Experimental Psychology: Human Learning & Memory* 3 (1977), 60-67.

15. W.J. Dowling and D.S. Fujitani, "Contour, Interval, and Pitch Recognition in Memory for Melodies," *Journal of the Acoustical Society of America* 49 (1971), 524-531.

16. W.J. Dowling, "Recognition of Melodic Transformations: Inversion, Retrograde, and Retrograde Inversion," *Perception and Psychophysics* 12 (1972), 417-421.

17. A. Cohen, "Inferred Sets of Pitches in Melodic Recognition" (Paper presented to the Western Psychological Association, San Francisco, April, 1978).

18. Dowling, "Scale and Contour."

19. J.C. Bartlett and W.J. Dowling, "The Recognition of Transposed Melodies: A Key-Distance Effect in Developmental Perspective," *Journal of Experimental Psychology: Human Perception and Performance* (in press).

20. F. Attneave and R.K. Olson, " 'Pitch as a Medium:' A New Approach to Psychophysical Scaling," *American Journal of Psychology* 84 (1971), 147-166.

21. Dowling, "Musical Scales and Psychophysical Scales;" M. Kolinski, "The Structure of Music: Diversification Versus Constraint," *Ethnomusicology* 22 (1978), 229-244.

22. H. Helmholtz, *On the Sensations of Tone* (New York: Dover, 1954).

23. I thank James Bartlett, Kathy Madden, Kelyn Roberts, and Darlene Smith for helpful suggestions. Requests for reprints should be sent to W.J. Dowling, Program in Psychology and Human Development, University of Texas at Dallas, Richardson, Tx 75080.