McCollough, C. (2000). Do McCollough effects provide evidence for global pattern processing? *Perception & Psychophysics, 62,* 350–362.

Watson, T. L., & Clifford, C. W. G. (2006). Orientation dependence of the orientation-contingent face aftereffect. *Vision Research, 46,* 3422–3429.

Melody Perception

Melody consists of a sequence of pitches organized in time. In a melody, it is the pattern of relationships among the pitches that is important, and not the absolute pitch levels. That is, we can pick any pitch on the piano, and if we play a succession of pitches that goes up two semitones, up two semitones, down four semitones, and so on, we will have "Frère Jacques." (To go up one semitone on the piano keyboard, just move one key to the right, including both black and white keys.) We could write the pitch pattern of "Frère Jacques" [+2 +2 −4 0 +2 +2 −4 +4 +1 +2 −3 +1 +2]. The zero indicates where we repeat a pitch. We could start anywhere on the keyboard, and as long as we follow this pattern the result will be "Frère Jacques." This property of being transposable to any pitch level made melody a favorite example of the Gestalt psychologists in the early 1900s to illustrate the idea that the whole was different from the sum of the parts. We can change every pitch in the melody, but as long as the pattern is preserved the melody remains the same. This entry describes the contour, constraints, and perceptual frameworks of melody perception.

Contour

A melody has been described as a dynamic shape in the musical space of pitch and time. The singer can move the melody up or down in pitch, elongate it by slowing it down, condense it by speeding it up, and within broad limits it remains the same melody. Important features of this dynamic shape are its contours of pitch and rhythm—the pattern of relations between successive notes. Beethoven illustrates this at the start of his Fifth Symphony, where the same pitch-and-rhythm contour is repeated at numerous pitch levels and with many different pitch intervals between the two pitches in the pattern. The song "Frère Jacques" in a minor key [+2 +1 −3 0 +2 +1 −3 +3 +2 +2 −4 +2 +2] is still recognizable as "Frère Jacques" (though you can tell that there's something different about it), an effect Mahler uses in his First Symphony. The pattern of ups and downs [+ + − 0 + + − + + + − + +] is important.

Constraints

The human auditory system imposes constraints on melodies. The pitches in melodies must lie within the audible range of frequencies, and, less obviously, must go neither too slow nor too fast. To be easily recognized, familiar melodies must be presented in a range of tempos between about 0.6 notes/second (1,670 milliseconds/note) and 6 notes/second (167 milliseconds/note). Ornamental arabesques and flourishes can go faster (up to about 20 notes/second), but the notes tend to blur into a continuous stream. Phrases in melodies are usually shorter than five or six seconds, fitting easily into our immediate memory buffer for audition.

Other constraints arise from the musical culture. All but perhaps two of the cultures of the world make use of tonal scales—pitch patterns that divide the octave into five, six, or seven pitch categories and establish a hierarchy of pitches in relation to the tonic (in European music, the familiar "*do re mi*" scale). A culture's melodies will use that culture's pitch categories, and it will be difficult for someone brought up with a different scale system to sing them in tune. Melodies generally move by small steps along the scale, only occasionally leaping across pitch categories, and typically begin and end on the tonic pitch. (See the "Frère Jacques" description earlier. Note that European scale steps are usually one or two semitones apart, never more than three.) Hermann von Helmholtz suggested that people need the landmarks of the scale categories to keep their bearings in tonal space—they show us the way back to the tonic "home base."

Perceptual Frameworks

Cultures also have systems for the organization of time: meters that establish a pattern of regularly recurring beats. The perceptual frameworks of the tonal scale for pitch and the metrical organization of time distinguish music perception from perception in other domains, such as the perception of visual shapes or of tastes and smells. They facilitate the speed and accuracy of our perception of patterns that conform to the frameworks. Strongly tonal melodies are better remembered than weakly tonal ones. For example, Leonard Cohen's song "The Sisters of Mercy" is much easier to remember than his "Suzanne." And our judgment of temporal intervals improves markedly when those intervals are presented in relation to a beat.

According to E. Glenn Schellenberg, Paul Iverson, and Margaret McKinnon, people can often identify highly familiar popular songs in less than a quarter of a second. But when they do that, they are clearly not relying on the pitch pattern and the rhythm of the song, but rather on the timbres and texture of the music. If we restrict the cues to just the pitches and rhythm, it generally takes musicians and nonmusicians alike six or seven notes, or about 3.5 seconds. That's still quite fast, considering the very large number of songs that people know.

We often wonder, what makes a melody really memorable? The earlier considerations suggest that conformity to the tonal and metrical frameworks of our particular culture helps. Many highly memorable melodies exemplify that: "La donna è mobile" from *Rigoletto,* Beethoven's "Ode to Joy," Rodgers and Hart's "Where or when," the Beatles' "Hey, Jude." Nevertheless, there must be countless melodies that exemplify those properties and yet rarely come to mind. We still have much to learn about the mind and brain in order to understand what makes some melodies hit our nervous system just right.

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See also Audition: Pitch Perception; Music Cognition and Perception

Further Readings

Dalla Bella, S., Peretz, I., & Aronoff, N. (2003). Time course of melody recognition: A gating paradigm study. *Perception & Psychophysics, 65,* 1019–1028.

Dowling, W. J. (2001). Music perception. In E. B. Goldstein (Ed.), *Handbook of perception* (pp. 469–498). Oxford, UK: Blackwell.

Dowling, W. J., & Harwood, D. L. (1986). *Music cognition.* Orlando, FL: Academic Press.

Hannon, E., & Trehub, S. E. (2005). Metrical categories in infancy and adulthood. *Psychological Science, 16,* 48–55.

Jones, M. R., Summerell, L., & Marshburn, E. (1987). Recognizing melodies: A dynamic interpretation. *Quarterly Journal of Experimental Psychology, 39A,* 89–121.

Schellenberg, E. G., Iverson, P., & McKinnon, M. C. (1999). Name that tune: Identifying popular recordings from brief excerpts. *Psychonomic Bulletin & Review, 6,* 641–646.

Warren, R. M., Gardner, D. A., Brubaker, B. S., & Bashford, J. A., Jr. (1991). Melodic and nonmelodic sequences of tones: Effects of duration on perception. *Music Perception, 8,* 277–290.

Winkler, I., & Cowan, N. (2005). From sensory to long-term memory: Evidence from auditory memory reactivation studies. *Experimental Psychology, 52,* 3–20.

MICROSTIMULATION

Microstimulation is a tool used to study the neural substrates of perception. This entry discusses the procedures, history, mechanisms, and applications of microstimulation. The electrical pulses presented during microstimulation mimic the pulses generated naturally by small groups of neurons. To produce microstimulation, the tip of a fine insulated wire electrode is sharpened, and insulation is removed for several micrometers to expose the metal surface at the tip. The tip of the electrode is positioned within the brain area of interest using both anatomical and physiological landmarks for guidance. Electrical pulses are then generated at the tip of the electrode with the amount of current, frequency of pulses, and duration of the pulse train adjusted to best imitate the activity of neurons in the area stimulated.

The use of electrical stimulation is associated with the very beginnings of the study of the nervous system. In the 18th century, the Italian scientist Luigi Galvani discovered that a charge of static electricity applied to the nerve of a frog's leg produced lifelike twitches. Later, in the 19th century, the German physiologist Emil du Bois-Reymond's use of electrical stimulation of a nerve and its muscle led to his discovery of the action potential—the fundamental unit for electrical propagation along nerve fibers.