

Musical Building Blocks in the Brain

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Our own private experience of the world is seamless, a smooth and continuous flow of sensory impressions and perceptions of objects and events, sights and sounds. When we see an object, such as a red ball, we do not experience the shape of the ball separately from its color. And when we hear a violin, we do not perceive its pitch separately from its timbre. The notes in a chord are not heard as several individuals but rather in a more wholistic fashion. Yes, it is possible to learn to pay more attention to one feature of a composition at the expense of attention to other features. But this process does not fractionate the sound into all of its separate constituents, the building blocks of music such as pitch, contour, interval, harmony, melody, timbre (tone color), and rhythm.

Because our experience is so immediate, clear and effortless, we tend to take it for granted. However, the integrated nature of our musical and other experiences constitutes a major puzzle for brain scientists who search for the answer to how our brains apparently effortlessly meld all of these aspects of sound into a meaningful whole, that presents to us personally ... music. An unlikely answer is that our brains are specialized for music so that each of music's building blocks is processed by a different part of the brain. The simultaneous activation of these many special purpose processors would constitute the wholistic experience. In other words, there is no little neural person in our brains who is listening to the music and then telling us what it is. Although this type of idea has often been popular, it leaves us with having to explain how the little brain genie achieves wholistic perception of music, and so explains nothing.

An increasing amount of research findings support the first theory, that the brain is specialized for the building blocks of music. In the first issue of *Musica Research Notes*, we reviewed the evidence that the highest level of the auditory system, the auditory cortex, processes pitch rather than raw sound frequencies (see "A Note on Pitch", volume 1, number 1, Spring, 1994). Additionally, there are individual brain cells that process melodic contour, the pattern of increasing and decreasing notes in music (1). Cells have been found in the auditory cortex that seem likely to process specific harmonic relationships, such as the simultaneous presentation of the second and third harmonics of a note (2). Temporal, including rhythmic, aspects of sound streams also seem to be handled by certain cells in particular parts of the auditory cortex (3).

Findings from humans who have suffered damage to the auditory cortex by stroke or by surgery to correct intractable epilepsy are particularly fascinating. For example, damage to the right hemisphere selectively impairs the ability to process timbre (4). Also, the processing of melody and rhythm can be separated by specific brain lesions. Some patients show impaired discrimination of melodies while they have normal discrimination of rhythms, and vice versa for lesions in different regions (5). And even different aspects of the processing of temporal information seem to be handled by different parts of the auditory cortex, rhythm by the left hemisphere and beat (meter) by the right hemispheres (6).

These dissociations of the elements of music in neurologically impaired persons provide strong support for "building block" theory but might be questioned by some on the grounds that the findings do not come from normal people. This is not a very strong criticism because such patients can show completely normal levels of performance on the capabilities that remain. In any event, there are findings from intact people that support and complement these neuropsychological findings. It is possible to determine which areas of the brain are active during various tasks, including listening to music. One powerful method is to measure increases in the regional distribution of blood flow to parts of the cerebral cortex because these reflect the increased metabolic needs of brain cells that are active. In a recent study, normal subjects were tested in two passive listening conditions, noise bursts or music matched for sound frequencies, and two active judgement conditions, comparing the pitch of the first two notes of melodies or the first and last notes of melodies (7). Listening to melodies produced an activation of the right temporal (auditory) hemisphere relative to the left ("language") hemisphere. Comparing notes, which also involved short term memory, also showed a preferential activation of the right auditory cortical system, plus some other areas of the right hemisphere. These findings indicate that there are specialized neural substrates in the auditory cortex of the right hemisphere that process melodies vs. other non-melodic sounds.

Space limitations preclude a more comprehensive review. However, these examples should suffice to highlight the many types of evidence, from animals, the neurologically impaired and the normal human, that the brain contains an organization that is specialized to process the individual elements of music, the building blocks of music. These findings have relevance to basic neurobiological problems, to clinical and therapeutic approaches to treatment and last, but not at all least, to the realization that music has a deep biological basis.

Footnotes

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(2) Sutter, M.L., & Schreiner, C.E. (1991). Physiology and topography of neurons with multi-peaked tuning curves in cat primary auditory cortex. *Journal of Neurophysiology*, 65: 1207-1226.

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(4) Samson, S. & Zatorre, R.J. (1994). Contribution of the right temporal lobe to musical timbre discrimination. *Neuropsychologia*, 32: 231-240.

(5) Peretz, I., (1990). Processing of local and global musical information in unilateral brain-damaged patients. *Brain*, 113: 1185-1205.

(6) For a general review of brain specializations for music see Peretz, I., & Morais, J. (1993). Specificity for music. In: F. Boller, & J. Grafman, (Eds.) *Handbook of Neuropsychology*, 8: Amsterdam, Elsevier Science Publishers.

(7) Zatorre, R.J., Evans, A.C. & Meyer, E. (1994). Neural mechanisms underlying melodic perception and memory for pitch. *The Journal of Neuroscience*, 14: 1908-1919.

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<http://www.musica.uci.edu/mrn/V1I2F94.html#cognitive>