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Neuropsychology: Music of the hemispheres

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Music may be the food of love but it is also good fodder for cognitive scientists. Here we highlight a recent study of a neuropsychological patient who has lost her ability to read music, but not text, in the absence of any other musical deficit.

The English conductor Thomas Beecham insisted that "The plain fact is that music *per se* means nothing". But like language, music is universal: every culture uses music to mark rites of passage, to relax and to communicate [1]. The power of music to affect our emotional responses has led some to believe that "the ultimate mystery of musical experience...is not susceptible to neurological study" [2], while others argue that "clarifying the relationship between music and the brain is a legitimate goal of scientific research" [3]. Music can be studied in terms of its similarity to language; both functions consist of an arbitrary visual notation that can be mapped onto sounds which have meaning [4]. But one can list as many differences as there are similarities between music and language, and findings from brain-damaged patients showing that losses of verbal or musical function can be dissociated suggest that music can be viewed as a functionally distinct process that requires a unique set of cognitive operations [5,6]. The questions for cognitive neuroscience concern the nature of these cognitive operations and how they are instantiated in the brain.

That musical ability can be fractionated is well known to the musical community: Thomas Beecham, for example, defined a musicologist as "someone who can read music but not hear it". More formal demonstrations of dissociations of musical function have come from the amusia literature, where selective deficits in music perception, performance, reading or writing have been documented [7]. But selective deficits of musical processing after brain damage are rare, as the patient must earlier have shown a high level of musical ability. A recent study [8] of a professional musician who suffered damage to the left posterior temporal cortex and the right occipito-temporal cortex (Figure 1) shows that the ability to read or write music can be selectively impaired.

Cappelletti et al. [8] investigated a 51year-old professional musician who had suffered an episode of acute encephalitis and was in a coma for two days. Before the illness, patient 'PKC' composed and performed music and songs professionally. She played the piano and guitar and had published over 60 songs. She was an experienced musical proof-reader and could sight-read and sight-sing at the piano. Following the brain damage, she could no longer read musical notes, either by naming, singing or playing them. The deficit was specific to musical notation; reading and writing of text was normal and all other musical functions were spared, for example, she could remember and play familiar melodies and novel melodies.

Cappelletti et al. [8] propose a model for reading music as a framework for explaining their patient's deficit (Figure 2). In this model, music and language are distinct processes from the outset. At the level of visual/auditory recognition, non-musical and musical elements are processed in parallel, with the musical elements being encoded in an abstract, supramodal musical system. Information about these abstract representations, for musical parameters such as pitch and duration, are in turn conveyed to specific motor pathways, innervating, for example, the vocal musculature (for singing) or the hand muscles (for playing an instrument). Patient PKC's deficit appears to be restricted to the initial channelling of musical elements to the abstract musical system when the musical elements take the form of notes on the stave. The fact that she could remember and play melodies suggests that her abstract musical representations and the pathways downstream of them are intact.

The identification of component processes of music is, of course, only the overture to the neurobiological understanding of music. Neuroimaging studies have already begun to elucidate the neural networks involved in reading, playing, listening and emotionally responding to music [9–13]. Justine Sergent's work [3,10], for example, has shown that music requires a high degree of multi-modal interaction — as anyone who has learned to play an instrument will know. The combination of information from different modalities is central to sight-reading, requiring a visuo-motor mapping of novel material.

Sergent et al. [10] were able to demonstrate that the brain areas associated with sight-reading were not activated by either of the components of sight reading — key pressing or score reading. In other words, the 'sight-reading area' was only active when the input of one modality and the output of another needed to be co-ordinated. This study also showed that reading music and carrying out the visuo-motor transformations required for playing the keyboard activated brain areas close to, but separate from, the areas involved in verbal tasks. Taken in the context of these and other neuroimaging results [14–16], the deficits exhibited by Cappelletti et al.'s [8] patient are likely to be due to the right occipito-temporal lesion, rather than to the left posterior temporal lesion, as activation in the latter area has not, to date, been associated with reading music.

The use of neuroimaging techniques, in combination with psychological models of the kind proposed by Cappelletti et al. [8], provides a rational basis for investigating the neural correlates of music's component processes: perceptual structure and organization, memory, lexical–semantic associations, and sensori-motor integration. Studies of musical skill acquisition will also shed light on the neurobiology of perceptual learning and visuo-motor plasticity [7]. Once these component processes are well understood, it will be both appropriate and useful to ask how the brain coordinates these distinct cognitive processes to achieve the vastly complex and integrated end result that is music.

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Figure 1

A model of how we read musical notes [8].

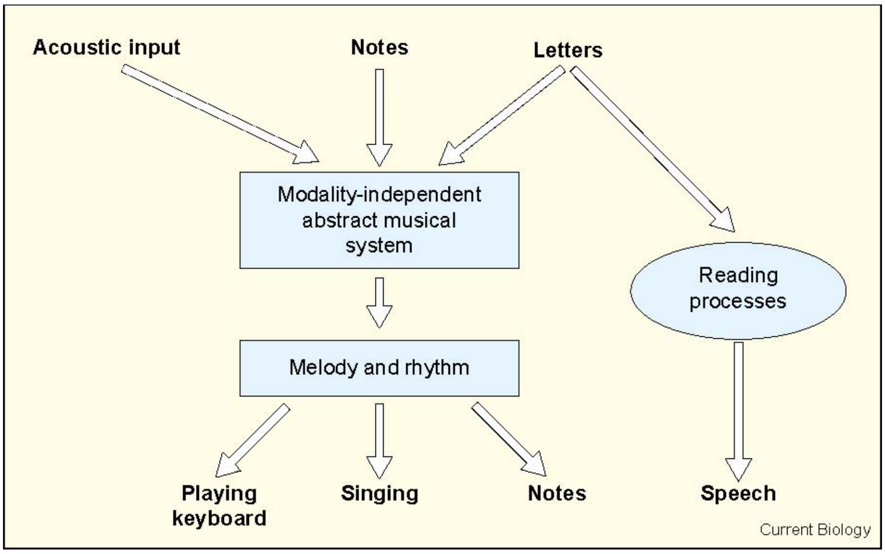

Figure 2

Brain sites activated in a PET study of sight reading [3] and lesion sites in patient PKC [8].