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Congenital Amusia: All the Songs Sound the Same

Dispatch

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Recent evidence from individuals born with a profound musical impairment suggests that the ability to process pitch information is normally present from birth. This finding supports the idea that the perception and appreciation of music, both of which critically depend on pitch processing, have a biological basis in the brain.

What is music and why does it exist in human culture? Is it, as some have suggested, merely a form of "auditory cheesecake — an exquisite confection designed to tickle our mental faculties" [1], or does it represent an innate human adaptation [2]? Musical competence in perceiving, appreciating and producing music is achieved spontaneously, without conscious effort and in the absence of explicit training; most people can recognise, dance to and sing a song. Despite this, only a subgroup of the population would consider themselves to be musical, and individuals without formal training generally underestimate their musical capabilities. It is not uncommon to hear someone claim that they are 'tone-deaf', meaning that they cannot carry a tune. But such claims usually reflect a self-consciousness about singing in public rather than a genuine musical impairment. However, a small number of individuals, termed 'congenital amusics', exhibit profound impairments in the musical domain in the absence of any other auditory perceptual problems.

Although congenital amusia was first reported in 1878 [3], a systematic characterisation of this condition has only recently emerged with the work of Peretz, Ayotte and colleagues [4]. Subjects whose performance on a battery of musical tasks "unambigously indicated the presence of a receptive musical disorder" were tested on a task requiring detection of an anomalous, 'out of key' note within a tune. These amusic subjects performed with an accuracy less than 25% that of a matched control group. They also displayed a relative insensitivity to consonance or dissonance — the perceived pleasantness or unpleasantness associated with hearing two or more notes played together, which is determined by the ratio of frequencies of the constituent notes.

Paradoxically, when required to detect a pitch change in speech, the amusic group were unimpaired. Sentences, presented as statements such as "He speaks French", or questions such as 'He speaks French?", which differed only in the pitch direction of the final syllable, were easily discriminated. But when these sentences were stripped of their linguistic content and the same pitches were played, the amusic group were considerably impaired, despite the fact that the statements and questions could only be discriminated by discerning the pitch direction of the final syllable. Such a finding suggests that the processing of pitch proceeds differently according to whether the context is musical or linguistic, even when the pitch information is identical in each case. A musical recognition task, in which subjects were required to identify familiar songs from either the tune or the lyrics, revealed a selective impairment of recognition from tunes alone.

The amusic group were, however, unimpaired at recognition of other auditory stimuli, such as human voices or environmental sounds. And while memory for lyrics and environmental sounds was normal, musical memory was relatively impaired. Musical production suffered, as one might expect in these amusic subjects. When asked to repeat a musical fragment sung by the experimenter, all but one of the 11 amusics were judged to be significantly poorer than normal subjects. Independent observers rated subjects to be worse on the melodic, rather than the temporal, aspects of the performance.

The musical impairments described above cannot be explained on the basis of a hearing impairment, as all subjects had, or grew up with, normal hearing. Neither can they be explained by a lack of exposure to music, as all subjects had lessons during childhood and were raised in families in which siblings were musically normal. Finally, the music deficits cannot be viewed as part of a general learning disability, as all the amusic subjects had reached a high level of education.

Although the amusic subjects were impaired on a number of perceptual, recognition and memory-based musical tasks, the primary deficit appears to be one of pitch processing. While pitch information is not exclusive to music — for example, intonation relies heavily on the encoding of pitch information — the specificity of the deficit to the musical domain is presumed to arise because perception of musical melodies requires particularly fine-grained pitch discrimination. Melodies typically use intervals of a tone or semitone (1/6 and 1/12 of an octave, respectively) while pitch changes in speech are considerably greater (typically 1/2 an octave). A detailed evaluation [5] of one of the amusic subjects, Monica, was particularly interesting because her pitch discrimination varied as a function of the direction of the pitch change. An ascending change in pitch was detected only if it was greater than 1/6 of an octave, while a descending pitch change was undetectable even with the largest interval of 11/12 of an octave (non-amusic subjects are typically sensitive to pitch changes as small as 1/24 of an octave).

Pitch processing is an ideal candidate for a musical 'universal' — an element of the musical system which is biologically hardwired from birth and independent of training and cultural effects. Infants as young as six

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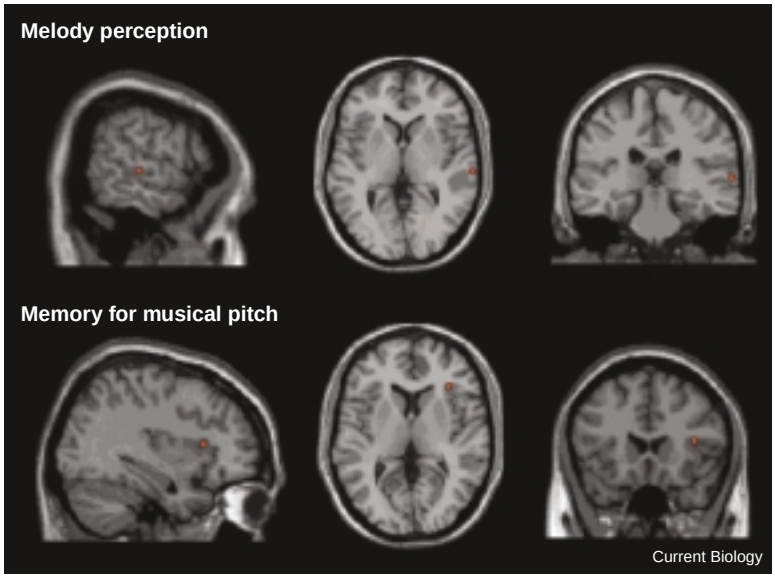
Figure 1. Music in the brain.

The red circles mark the location of positron emission tomography (PET) activations associated with processing of melodies. Top: saggital, horizontal and coronal views representing the location of an activation in the right superior temporal gyrus which was associated with listening to a series of short, unfamiliar tonal melodies, compared with a baseline condition of listening to noise bursts that were acoustically equated to the melodies. Bottom: saggital, horizontal and coronal views representing the location of an activation in the right frontal/opercular region associated with making judgements about the pitch of the first and last notes of the tonal sequences as compared to making judgments about the first two notes (redrawn from [7]).



months, for example, show sensitivity to musical scales and respond preferentially to consonant, as opposed to dissonant intervals [6]. But Monica's brain exhibited no apparent anatomical abnormalities. The absence of a structural impairment suggests that pitch processing may rely on functional integrity of a given brain area — brains may be structurally similar but functionally different if neural resources are employed differently.

Several studies have now begun to probe musical function in the brains of musically unimpaired subjects. A PET study [7] revealed that listening to melodies, as opposed to noise bursts, activated the right superior temporal gyrus, while a musical memory task, requiring subjects to compare the pitches of the first and last notes of a melody, additionally activated an area in frontal cortex of the right hemisphere (see Figure 1). A strong prediction would be that this right hemisphere temporo-frontal network would either fail to be activated or would be activated differently in the amusic subjects of Ayotte *et al.* [4].

The demonstration that pitch perception can be selectively impaired as a result of a failure in normal development indicates that pitch processing usually emerges spontaneously. Although pitch is only one aspect of music, it does appear to be a central one. As Zatorre [8] notes "it is difficult to conceive of a musical system of any type which does not involve the patterning of pitches". With this in mind, and given the findings regarding pitch processing in infants and congenital amusics, the argument that music can be viewed as mere cheesecake appears somewhat crumbly.

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