Characterization of non-verbal auditory perception deficits in congenital amusia

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Abstract

Non-verbal auditory perception is essential to interact with our environment. For example, prosody processing allows us to determine someone's intentions and emotions, or we can enjoy music listening. However, non-verbal auditory processing can be impaired in peripheral or central auditory deficits. The latter is the case in congenital amusia, a neurodevelopmental disorder characterized by a deficit of music perception and production. This disorder is due to an impairment in pitch perception and memory, and cannot be explained by brain lesion, hearing loss, or lack of environmental stimulation. Amusics have difficulties with detecting pitch changes and memorizing pitches. This deficit in pitch processing leads to difficulties with recognizing melodies without lyrics and an inability to detect when someone sings out-of-tune. Using anatomical and functional brain imaging, studies have shown that amusics present an altered fronto-temporal network, mainly in the right hemisphere. Currently, behavioral and cerebral mechanisms affected in congenital amusia are still under investigation. In the present study, we aim to characterize non-verbal auditory deficits in congenital amusia using a comprehensive set of behavioral and electrophysiological (magnetoencephalography, MEG) measures.

We compared performances on non-verbal auditory tasks between participants with congenital amusia (n=14) and nonmusician control participants (n=22). We characterized non-verbal auditory performance using five tasks: a pitch change detection task (PCD), a pitch direction change identification task (DCI), a short-term memory for pitch task (STM), an emotional prosody recognition task (EMO), and an auditory stream segregation task (ASA). PCD, DCI, and STM allow measuring various pitch processing abilities. ASA allows measuring hearing-in-noise abilities. Moreover, we used MEG recordings to better characterize the neural networks impaired in congenital amusia. We recorded brain responses during an active short-term memory task for pitch and a passive oddball paradigm with different pitch deviants.

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As expected, amusic participants showed impaired pitch processing compared to controls. For PCD, amusics' performance was decreased in comparison to controls' performance for trials with small pitch interval sizes ($<$ 1/2 semitones). In DCI, amusics' performance was also lower than controls' performance. For the STM, amusics showed decreased performance in comparison to controls, even when the pitch interval size was larger than their pitch discrimination threshold. There were no differences between the two groups for the emotional prosody recognition task with full sentences and the stream segregation task. These deficits of pitch processing were confirmed by electrophysiological data. In the right fronto-temporal network, the component N100m was reduced during encoding of S1 melodies. For the oddball paradigm, MEG recordings showed that amusics had a reduced MMN. Moreover, N100 and MMN abnormalities suggest an early deficit of pitch processing. Overall, this study presents a comprehensive assessment of non-verbal abilities in congenital amusia, which could be used to assess the potential effects of a pitch-related training program. We have also applied this battery to cases of peripheral auditory deficits. Preliminary behavioral data obtained in hearing-impaired participants with cochlear implants, suggest a different profile of pitch processing alteration.