Recognition of Interleaved Melodies: an fMRI study

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ABSTRACT: An fMRI study on interleaved melody recognition was conducted to examine the neural basis of the bottom-up and top-down mechanisms involved in auditory stream segregation. Hemodynamic activity generated by a mixed sequence was recorded in eight listeners who were asked to recognize a target melody interleaved with distractor tones when the target was presented either before or after the composite sequence. fMRI results suggest that similar cortical networks were involved in both conditions, including bilaterally the auditory cortices within the superior temporal gyrus, as well as the thalamus and the inferior frontal gyrus. However, when listeners heard the melody before they had to extract it from the mixture, neural activation in the inferior frontal operculum was significantly enhanced bilaterally; no change in auditory cortical activity was detected.

KEYWORDS: Auditory Stream Segregation; Interleaved Melody Recognition; fMRI

INTRODUCTION

When listening to polyphonic music, listeners must separate voices played by different instruments or by the same instrument in different frequency registers. This ability to segregate sounds coming from different environmental sources has been called Auditory Scene Analysis.¹ This analysis is preattentive in part. However, acquired knowledge about sounds and sound sequences like music and speech can help us to extract them from a complex scene via top-down mechanisms. Results of electrophysiological studies tend to confirm the existence of these two components.²³ However the cerebral structures involved

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in these processes are still unknown. Therefore, we conducted an fMRI study on interleaved melody recognition to examine the neural basis of the bottom-up and top-down mechanisms involved in auditory stream segregation.

METHOD

Two unfamiliar six-tones melodies, one of which was interleaved with distractor tones, were presented successively to eight listeners who were required to decide whether the melodies were identical or different. Using a single-trial fMRI procedure with clustered volume acquisition, we recorded hemodynamic activity generated by the mixed sequence when the target melody was presented either Before or After the composite sequence, and also in a control condition consisting in a simple melody discrimination task when participants were listening to the first or the second twelve-notes melody (FIG. 1).

RESULTS AND DISCUSSION

fMRI results suggest that similar cortical networks were involved in both conditions, including bilaterally the auditory cortices within the superior temporal gyrus, as well as the thalamus and the inferior frontal gyrus. However, when listeners heard the melody before they had to extract it from the mixture, neural activation in the inferior frontal operculum was significantly enhanced bilaterally; no change in auditory cortical activity was detected (FIG. 2). Results of the control conditions were similar, suggesting that this effect could be explained by the sequence position, and is not unique to the top-down mechanism involved in stream segregation. Thus, the effect may be related to a matching process, i.e. the recognition of a target stored in working memory involving frontal cortical mechanisms in both control and experimental tasks. Alternatively, there may be an asymmetry in the hemodynamic response leading to greater activity in the second scanned sequence, contrary to our
assumption based on preliminary data and previous studies. Further study will be needed to examine this point.

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REFERENCES

FIGURE 1. Visual illustration of the experimental design.

FIGURE 2. Horizontal section (z = -7) showing significant activation in the Before versus After comparison. Color scale indicates z score values.