16th Annual Meeting of the Organization for Human Brain Mapping, Barcelona, Spain, June 6th - 10th 2010

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Auditory-motor interaction varies with rhythm complexity while listening to chanted vowel changes

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Introduction

The greater bilateral organization of singing compared to speech is one obvious reason for the implementation of singing instructions in the treatment of patients suffering from motor speech disorders or aphasia. Meanwhile the fact that listening to musical rhythms, speech, perceptual discrimination or vocal imagery recruits motor regions of the brain is well documented. Our objective was to investigate if auditory-motor interactions during action-related listening to simple singing also vary according to rhythm structure as we recently demonstrated for singing production.

Methods

Participants:
15 male and 13 female healthy right-handed non-musicians
mean age 26.3 (range 21-41).

Stimuli:
Stimuli consisted of metrical quadruple measure groupings with a duration of 4sec. which were chanted as (1) regular vowel changes (2) regular vowel changes with rests and (3) irregular vowel changes in contrast to single isochronously chanted vowel repetitions as control condition. The auditory stimuli were presented by fMRT compatible headphones (Resonance Technology).
The stimuli consisted of vowel change repetitions in order to avoid lexical or semantic components of speech processing and to focus on phonological processing as the basis of further research with groups of patients mentioned above. In order to reduce the influence of melodic components we choose a monotonous pitch repetition (chanting).

Task:
Subjects listened to vowel changes with increasing rhythm complexity in anticipation of repeating the heard stimuli during the latter portion of the experiment.

Data acquisition:
185 volumes each consisting of 41 contiguous transversal slices, with a thickness of 3.4 mm, were acquired using a T2*-weighted EPI sequence on a 3T Siemens Trio MRI-system.
TR 2200ms, TE 30ms, FOV 240, FA 90°, Voxel size: 3.44 x 3.44 x 3.74

Data analysis:
Imaging data were analyzed using SPM8. The reported results were derived from a random-effects group analysis with an FWE-corrected p-value of p=0.05 and an extent threshold of 10 voxel.

Results

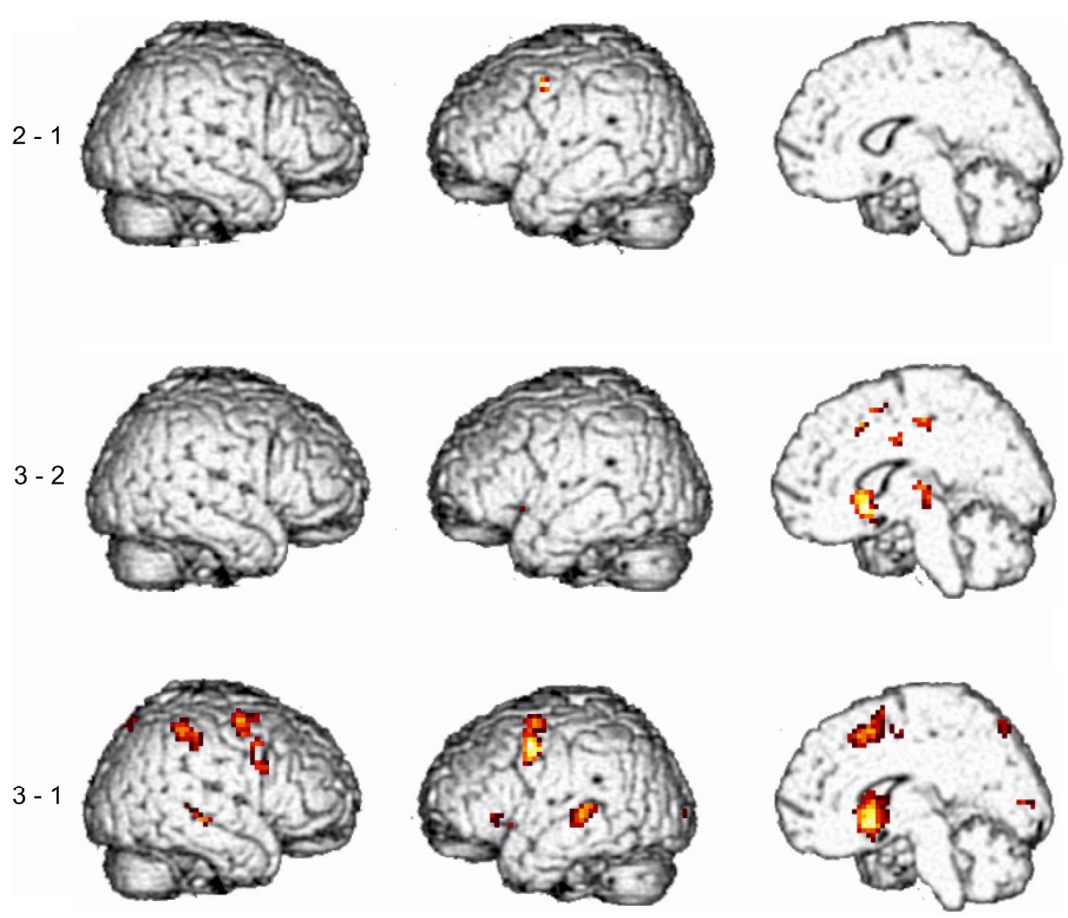

Fig. 1 Areas of significant brain activation derived from group analyses of the subtractions of the three listening tasks (FWE-corrected p=0.05, threshold=10 voxels)

While subtraction (2) minus (1) yielded additional activation exclusively in the left precentral gyrus (BA6,9) both subtractions from the most demanding condition (3) resulted in additional activation of bilateral putamen and caudate. Only subtraction (3) minus (1) yielded additional activation of bilateral pre-SMA, precentral gyrus (BA6,9) more distinct in the left hemisphere. Middle, superior, and transverse temporal gyrus (BA22,42,41) as well as ventrolateral prefrontal cortex (BA47,45) were activated most prominent in the left hemisphere. The insula (BA13) was activated exclusively in the left hemisphere. Inferior and superior parietal gyrus (BA40,7) and anterior cingulate gyrus (BA32,24) were activated most prominent in the right hemisphere.

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Discussion

Our findings are in line with the studies mentioned above concerned with auditory-motor interaction, although listening to rhythmically structured singing has not been investigated up to now. Rhythm structure seems to be a decisive factor which induces specific activations with increasing demands on cognitive capacities e.g. working memory and sequential processing. The more explicit segmentation is required the more distinct and left lateralized temporal, premotor, and prefrontal activation occurs during action-related listening to chanted vowel changes. If it was possible to support programming and planning of articulatory gestures also by listening to calculated vocal exercises this might be relevant for therapy interventions with patients mentioned above.

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