fMRI Study of Auditory- Somatosensory Multisensory Interaction

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Introduction

During functional magnetic resonance imaging (fMRI) tasks the patient is prone to gradient noise and vibrations from the scanner. The investigation of multiple stimulation effects in fMRI is crucial for clinical fMRI studies. A few reports state that multi stimulation with a tactile and an auditory stimulus can result in either more complicated or weaker response. The auditory task of listening to random words or the stimulus of rubbing the palm are useful stimulations for clinical fMRI studies. In this study, we investigated the correlation between the hemodynamic response to auditory、somatosensory stimuli and simultaneously given stimuli, by means of functional magnetic resonance. We presented all subjects to unimodal auditory (A) or tactile (T) stimuli, respectively, or both of them simultaneously(AT), using the right ear and palm. The differences of the responses between the A stimulus, T stimulus and the simultaneous AT stimulus were compared to investigate the interaction of multisensory stimuli.

Materials and Methods

Five healthy volunteers participated in the experiment. The subjects were scanned in a 1.5 Tesla clinical MR scanner (Signa Horizon, GE, USA.) using a standard head coil. The functional scans were acquired using a gradient echo EPI sequence (TR/TE/FA=3s/50ms/90°), 64x64 matrix, 5 mm slice thickness, FOV= 220x220 mm, 30 slices). The 2D multi slices T1 weighted MRI with spin echo sequence (TR/TE= 500/15 ms) were measured in the same locations as the EPIs. The 3D gradient echo MRI was measured to normalize the EPI data. The auditory (A) stimuli of randomized words was presented to the right ear via a plastic tube and the tactile stimulus was presented by manually rubbing the palm of the right hand with the rough surface of a sponge. Experiments were executed in a blocked design: after 30 s resting period, stimulation and resting periods were alternated 4 times. All data were analyzed using SPM2 software (Welcome Department of Cognitive Neurology, London, UK). All functional images were normalized and averaged across subjects, and transformed into the MNI template (Montreal Neurological Institute, Montreal, Canada) and Talairach coordinate. Maps were thresholded using a corrected P value of less than 0.001. A T test value at voxel-level was used to estimate the degree of signal changes in the activation area in SPM2.

Results

Activation of the auditory cortex for A and AT or somatosensory area for T and AT was found in all subjects. Contralateral activation was found in the right tactile stimuli. However, bilateral activation of auditory stimuli was found during right auditory stimuli. During the AT stimuli, activation was found in the bilateral auditory cortex and the primary somatosensory cortex.
The T values were 7.16 (x,y,z=-58,-20,2; on MNI template) in the contralateral superior temporal gyrus and 6.51 at (x,y,z=60,-14,0) and the ipsilateral superior temporal gyrus in A, 7.22 at (x,y,z=-58,-22,14) contralateral superior temporal gyrus and 4.68 (x,y,z=62,-10,0) in the eral superior temporal gyrus in AT, and 10.55 at (x,y,z=-40,-28,66) contralateral precentral gyrus in T and 10.36 (x,y,z=-38,-26,68) in the contralateral precentral gyrus in AT.

Discussion

It has been reported that multisensory stimuli induces larger activation in fMR [1], whereas it causes less activation in MEG [2]. In this experiment, activations found in the contralateral auditory cortex as a response to multisensory stimuli and auditory stimuli, were approximately in the same range. However, the activation of AT in the ipsilateral auditory cortex was less than the one in A. The left superior temporal gyrus is crucial for word listening. This may be a reason for suppression of activation in the ipsilateral auditory cortex in AT. The ipsilateral activation of AT was located 14 mm anterior to the contralateral activation. This is consistent with previous MEG study [3]

Conclusion

We found significant decrease of activation in the region of the right temporal gyrus during AT than A, T, which indicates the existence of an audio-tactile interaction, suppressing the response to AT stimuli in the right superior temporal gyrus.

[Reference]
[1] Foxe JJ, Wylie GR, Martinez A, et al.Auditory-somatosensory multisensory processing in auditory association cortex: an fMRI study. J Neurophysiol. 88(1):540-3, 2002
[2]Lutkenhoner B, Lammertmann C, Simoes C, and Hari R, Magnetoencephalographic Correlates of Audiotactile Interaction, NeuroImage **15,** 509–522, 2002
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Fig. 1 MIP images in A (a), T(b) and AT (c) calculated by SPM2.