

An fMRI Study of Synesthesia

– Brain activity in colored-hearing by listening to music –

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Introduction

Synesthesia is a phenomenon in which the stimulation of one sensory modality involuntarily elicits a perception in another modality. One of the typical synesthesiae appears to be seeing color while listening to acoustic stimulation, which has been called colored-hearing. In this study, we observed brain activity by using fMRI in colored-hearing synesthetes when listening to music. We compared the activity of colored-hearing and non-colored-hearing subjects. Additionally, we analyzed the relationship between the common areas of only the colored-hearing synesthetes and the regions of color perception.

Materials and Methods

Two colored-hearing subjects and 11 non-colored-hearing subjects participated in this study. Both colored-hearing subjects were musicians and they could see colors equivalent to musical tonalities, whereas all the non-colored-hearing subjects were not musicians. The design of the experiment was a block design, and the stimuli used were music as the task and beep sounds as the control task. All the subjects listened with open eyes and closed eyes.

T2*-weighted gradient echo echo-planar images (TR/TE = 4 s/55 ms, flip angle = 90 deg, slices = 38, slice thickness = 4 mm, FOV = 256 mm). A Magnex Eclipse 1.5T Power Drive 250 (Shimadzu Medical Systems, Kyoto, Japan) was used to acquire, and pre-processing and analysis was conducted using SPM99 (Dept. of Cognitive Neurology, London, UK). The non-colored-hearing subjects' images were combined into a fixed effects group analysis, for comparison with the colored-hearing subjects.

Results and Discussion

We acquired images of the brain activity of each colored-hearing subject and of the combined non-colored-hearing subjects when listening to music. From these images, we found that only the colored-hearing synesthetes, one was open eyes and the other was closed eyes, activated the fusiform gyrus (indicated by yellow circles in Figure 1) and the superior frontal gyrus (indicated by light blue circles in Figure 1) .

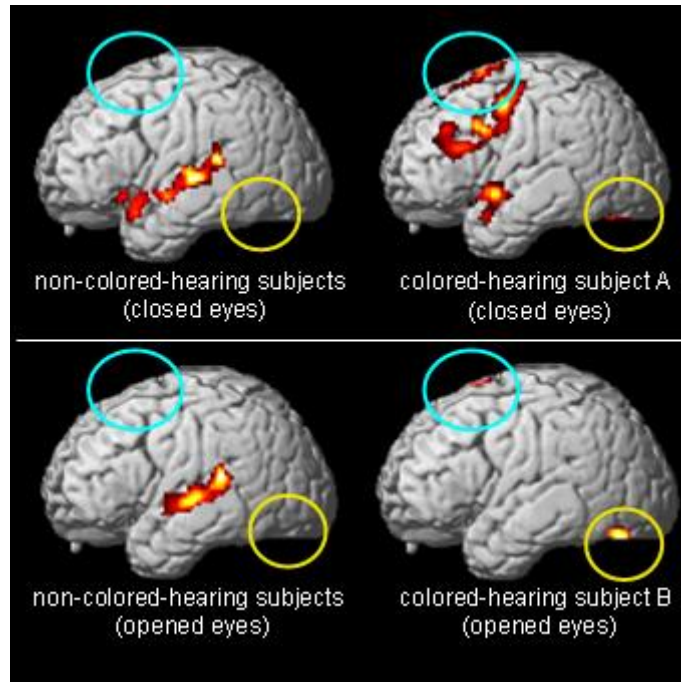


Figure 1 Brain activation of subjects when listening to music

Subsequently, we compared only the colored-hearing synesthetes and the regions of color perception (V4, V8, V4a, and V4v) researched by previous studies [1, 2]. In the analysis, both the colored-hearing subjects activated regions V4, V8, and V4a on the left and V4, V8, and V4v on the right and left. In addition, we found some common areas around these regions (indicated by yellow circles in Figure 2). From these results, we suggest that colored-hearing subjects actually perceive colors when listening to music, and a direct interaction between the acoustic and visual senses occurs to them.

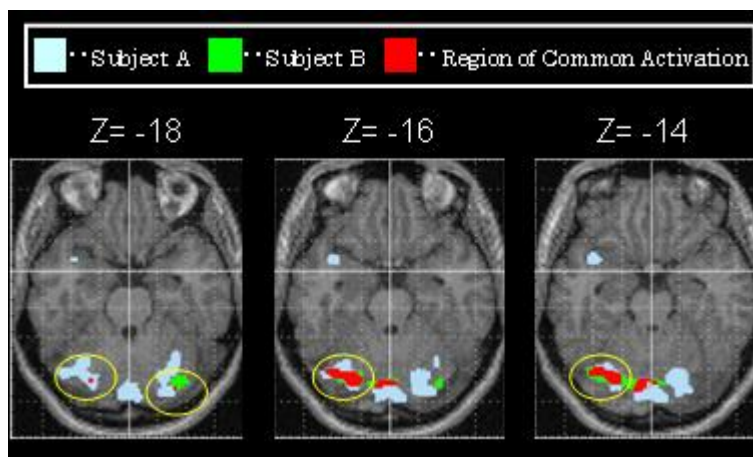


Figure 2 Activity of colored-hearing subjects in slice images in region of color perception

Conclusion

The colored-hearing subjects in this study actually showed color perception activity when listening to music. This may be neuroscientific proof that colored-hearing synesthetes have a specific ability. Additionally, this study adds to our knowledge of the interaction between music and color.

References

- [1] Zeki, S., & Bartels, A. (1999). Measurement of cortical (in)activity, *Phil. Trans. R. Soc. Lond. B* 354, 1371-1382.
- [2] Hadjikhani, N., et al. (1998). Retinotopy and color sensitivity in human visual cortical area V8, *Nat. Neurosci.*, 1(3), 235-241.