

The dependency of age-related change of brain activation on the visual stimuli - Demand-reservation balance

T. Nakai¹, M. Miyakoshi¹, E. Bagarinao¹, M. Yoshida², C. Nakai³, and K. Matsuo⁴

¹Functional Brain Imaging Lab, National Center for Geriatrics and Gerontology, Ohbu, Aichi, Japan, ²Ophthalmology, The Jikei University, Tokyo, Japan, ³School of Health Sciences, Toyoshashi Sozo University, Toyohashi, Aichi, ⁴Psychology, National Taiwan University, Taipei, Taiwan

Introduction

The important role of fMRI in geriatrics is to assess the change of brain activation related to early signs of cognitive impairments. Various cognitive tasks increased the activation in the frontal or parietal areas in elderly subjects. On the other hand, age-related reduction of BOLD signal in the primary visual area (V1) has been discussed [1 - 3]. In this study, we investigated the effect of cognitive demand for visual processing on the age-related change of the hemodynamic response function (HRF) in healthy subjects. The characteristics of HRF were compared between V1 and the higher visual associated areas.

Material and Methods

Twenty-two healthy normal young subjects (Y; under 50 years old, 11 males) and 22 healthy normal elderly subjects (E; between 60 and 75, 11 males) who gave written informed consent participated in this study. All subjects were checked with visual acuity test, MMSE and GDS to pre-evaluate the task performance. Two sessions were conducted; 1) black and white checkerboard stimuli flickering at 8Hz in block design, 5 task and 6 rest blocks, each block 18sec (CB18), 2) gripping and opening movements of bilateral hands paced by visual presentation of the hand posture for each condition, 3 sec for each movement, 5 task and 6 rest blocks, each block 18 sec (GRIP). The visual stimuli were generated by using E-prime (PST, Pittsburgh). Functional data were obtained using a T2* weighted gradient recalled echo EPI sequence (TR = 2000 ms, TE = 24 ms, 39 axial slices, 3 mm thick, FOV = 19.2 cm) on a 3T MRI scanner. The functional images were realigned, normalized and the center coordinates of the ROI (3x3x3 pixels in the MNI coordinate) were determined by using SPM5 (RFX, $p < 0.001$). The HRFs of each ROI were extracted using BAX [4].

Results

The MMSE score was over 26 except one subject (23) in the elderly group and all subjects were found to be neurologically normal. In CB18, differential activation was detected only in bilateral V1 (right (R) [12 -87 -6] and left (L) [-12 -78 -12]). HRF analysis (Fig.1) revealed decreased % change of the BOLD signal in the elderly subjects (elderly; R 1.87 / L 1.14%, young; R 2.58 / L 2.56%).

In GRIP, activation in BA19/7/39 was significantly augmented in the elderly subjects, while there was no significant difference between the two age groups in V1. The % HRF at the differential peak coordinates of V1 determined by CB18 was almost the same amplitude between the two age groups and smaller than that observed by CB18, although a mild dip between the initial and post-stimulus peak (mid-dip) was observed in the young subjects (Fig.2). A deep mid-dip was observed at the locations of differential activation in bilateral BA7, although the % HRF was smaller than that of CB18 (Fig.3). Similar deep mid-dips were observed in BA19 and 39 in young subjects.

Discussion

The age-related change of BOLD signal in V1 has been controversial [1 - 3]. In our study, the % HRF was reduced in V1 by flickering checkerboard stimuli, but not by still pictures switching at every 3 seconds in the elderly subjects. It was suggested that age-related reduction of V1 activation depends on the types of visual stimuli, and the change may appear with high power stimulation. However, it should be clarified whether this change actually represents the decline of neuronal activation or change of the baseline CBF [1]. Age-related augmentation of activation was detected by the visual task with cognitive demand (to understand the hand posture and translate it into motor execution). The activation was increased along the dorsal and ventral visual pathway, suggesting more demand to analyze the visual information in the elderly subjects. The differential activation corresponded with disappearance of mid-dip in the elderly subjects. The extent of mid-dip may more reflect the demand for task performance for the age group, while the initial and post-stimulus peaks more represent an autonomic response when the brain area is recruited as a part of functional network for the target cognition. The difference between reduction and augmentation of age-related change may depend on the existence or the capacity of neuronal network to compensate the potential functional decline according to aging.

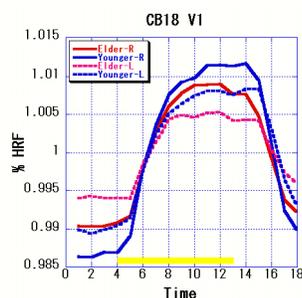


Fig 1 HRFs detected in V1 by CB18

The normalized HRF curves at the peaks of differential activation (V1) on each side (n=22 for each age group) obtained by CB18. Five task-rest cycles were averaged. Red lines; elderly subjects, blue lines; young subjects, solid lines; R, dotted lines; L, yellow line; task period. The %HRF was significantly reduced in the elderly subjects and the HRFs did not have a mid-dip.

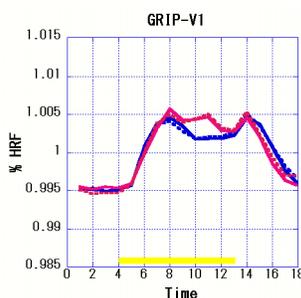


Fig 2 HRFs detected in V1 by GRIP

The normalized HRF curves obtained by GRIP at the coordinates of V1 differential peaks detected by CB18. Five task-rest cycles were averaged (n=22 for each group). The % HRF was smaller than that by CB18. A small mid-dip was observed in the young subject group.

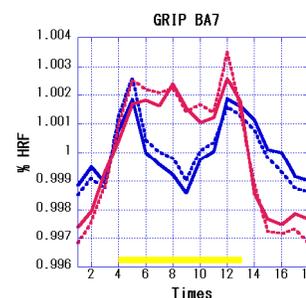


Fig 3 HRFs detected in BA7 by GRIP

Averaged and normalized HRFs from each age group at the peaks of differential activation (the contrast of elderly against young subjects) in the higher visual associated areas detected by GRIP. The % HRF presented major mid-dip in the young subjects, while the BOLD signal continued elevated in the elderly.

References

- [1] Ances et al., HBM, 29, 1120-, 2008
- [2] Ross et al., Neurology 48, 173-, 1997

- [3] Richter et al., Neuroimage 20, 1122-, 2003
- [4] Bagarinao et al., Neuroinformatics 6, 109-, 2008