TIME COURSE INFORMATION EXTRACTED BY THE SLIDING WINDOW ANALYSIS DETECTED THE DECREASE OF T-VALUES IN HIPPOCAMPAL AREAS DURING A PAIRED ASSOCIATIVE LEARNING OF NOVEL FACES AND NAMES

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Introduction

A new method "Sliding Window Analysis (SWA)" was applied to extract a time course information of the fMRI activation process during the memory encoding. Instead of the t statistics for the whole session as in the usual fMRI analysis, the SWA moves a statistical window to examine how the t-value changes during the session [1-2]. This method is suitably applicable to the evaluation of learning processes. We designed a relatively long session of a paired associative learning of novel faces and names that were compared with well-known faces and names. We specifically examined the hippocampus (Hi) of young and elderly people in consideration of using this procedure to detect an early symptom of dementia. A downward trend of the t-values was expected because activation in the Hi was shown its decrease after the establishment of associations [3].

Materials and Methods

Forty-three normal volunteers participated in this study (age 20-65, F/M = 21/22, all gave written informed consent). We excluded volunteers who caused head movements over 1mm during the long session and remaining 28 people were father analyzed (young 23, age 20-30; elderly 5, age 60-65). Volunteers made a forced choice between two personal names displayed with a human face during a 14 min event-related fMRI session in a 1.5 T scanner (MAGNETOM Avanto, Siemens, Erlangen, Germany). A condition Famous showed 7 well-known faces alternately, whereas a condition Unknown showed 7 faces unfamiliar to volunteers (age and sex matched). Each face appeared 8 times in total during a session. The same amount of null events (plus mark) was also included. These events appeared every 5 sec according to a scheduling algorithm [4]. Volunteers first made a guess at the names for unknown people but gradually memorized them. Correct answers were given with the duration of 1.5 sec immediately after 3 sec stimuli presentation, followed by a 0.5 sec blank. Numbers of the faces they could orally name were counted after the session. The EPI parameters were: TR 3000 ms, TE 56 ms, FA 90 deg, FOV 220 mm, 64x64 matrix, slice thickness 4 mm with no gap interleaved, 30 axial slices, 282 images per slice. The first 2 frames (plus 1 automatically executed frame) were discarded to avoid initial signal instabilities. After the preprocessing, the signal intensity was estimated using SPM5. The 2 conditions were analyzed in separate design matrices that included realign parameters. The SWA was applied individually using the design matrices. The window width was set to 70 frames (volumes). The t-value sequences were bilaterally extracted and averaged at the local maxima and the adjacent voxels in the following 2 regions; the parahippocampal gyrus (PH) with the Hi, and the fusiform gyrus (FG). The local maxima were individually determined using the SPM of the Unknown condition (p < 0.005, uncorrected).

Results and Discussion

As modeled, the Unknown yielded extensive activation as compared with the Famous (Figs. 1&2). Decreasing trends were observed in the Unknown condition for both FG and Hi/PH in young participants, whereas they were obscure in the elderly people. When participants who could successfully name all 7 unknown faces (all young) were selected, the downward trend became more salient in the Hi & PH (Fig. 1, rightmost). The declining trends suggested the gradual establishment of the associations because the Hi is specifically involved in the encoding process.

Conclusions

The SWA is an efficient technique to extract a "time' information from fMRI series. Further research will contribute to the development of new diagnostic measures for the hippocampal areas using the SWA.
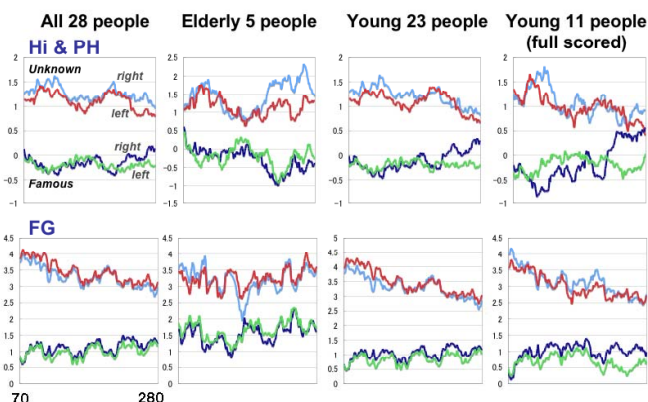

Fig. 1. Time courses of t-values during the fMRI session. The x-axis is the time course, whereas the y-axis is the t-value. The first 69 frames were deleted. The data are the averages of the participants' groups indicated at the top. Pale and dark blue lines represent the right hemisphere Unknown, whereas red and green lines represent left.

References

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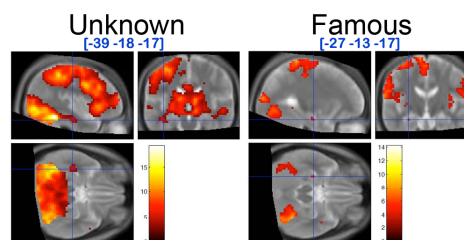[4] Wager et al., *NeuroImage*, 18, 293-309, 2003.

Fig. 2. A random-effect group analysis was conducted as a reference (one-sample t-test at FDR $p < 0.01$, N=28). The coordinates are Talairach's.