Visuospatial processing and training effects in Alzheimer’s disease (AD) and healthy subjects assessed with fMRI


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Introduction
AD related pathological processes are distributed in a specific pattern across the visual system. Higher amounts of neurofibrillary tangles and greater impairments of regional cerebral metabolic rate and regional cerebral blood flow were found in higher visual association areas than in primary visual cortex in AD patients. The amount of these pathological changes were found to correlate positively with impairments of visuocognitive abilities. The goal of our study was to investigate whether the reported differential distribution of pathology has a counterpart in functional activation patterns during active performance of visuospatial tasks, which are known to stress not only primary but also higher visual areas, particularly the superior parietal cortex. Having in mind that the activation levels could not only depend on the diagnosis but also on the familiarity with the task and performance level, an additional interest of our study was to evaluate the role different training states of controls and patients are playing in the determination of BOLD signal intensities in different regions.

Methods
Fourteen AD patients and 14 healthy control subjects, matched for gender and age, were investigated with functional magnetic resonance imaging (fMRI) during a visuospatial discrimination task. The task consisted of serially presented analogue clocks with the clock hands forming different angle sizes. All subjects were advised to press a button every time a specified angle occurred. The examination was carried out using a 1.5 Tesla MRI scanner. Fifteen slices covering the whole cortex were obtained every 4 seconds using a single-shot echo-planar (EPI) functional imaging sequence. We additionally examined a subsample of 5 patients and 5 controls which underwent three training sessions practicing the same task and who were re-examined one week after the initial fMRI measurement.

Results
The task performance of AD patients and controls did not differ significantly. A specific fMRI activation pattern could be established for the control group, with a greater activation in the right superior parietal lobule (rSPL) compared to right primary visual cortex (rPVC). The AD group showed an inverse pattern with lower activation in the right superior parietal lobule (rSPL) than in rPVC.

The subsample of trained controls revealed a significant reduction of BOLD signal change in right and left SPL after training. Only 3 of 5 trained patients showed a reduction of SPL activation after training, which was significantly smaller extent than in controls.

Discussion
These results correspond to neuropathological findings of differential damage to cortical areas of the visual system in AD. This study indicates that assessing local task related alterations of brain activity by fMRI can help to elucidate the neurobiological and neuropathological mechanisms of AD. The results of the training study suggest a redundant activation in SPL in healthy subjects, which is lowered – perhaps owing to a more efficient use of cortical tissue – after training. A (albeit smaller) effect of practice could also be observed in some AD patients, which indicates that mechanisms of neuronal plasticity are preserved to some extent in AD.