

Working Memory as a Function of Cognitive Decline in Old Age: An fMRI Study

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INTRODUCTION:

Age related decline in working memory performance is apparent throughout the adult lifespan. Esposito et. al. (1) identified age-related working memory deficits in cohorts of participants extending from 18-80 years. However little work has been done to investigate the working memory-related brain processing in those who age successfully, compared to those who suffer more cognitive decline on old age. The 1947 Scottish Mental Survey tested most eligible Scottish children born in 1936 and at school on 4th June 1947, using one of the Moray House Tests (2) of general intelligence used here to estimate baseline cognitive ability (age 11 IQ). We studied individual differences from this childhood baseline to cognitive performance in late mid-life.

METHODS:

With ethical approval, 508 local residents who took part in the 1947 survey were recruited into a prospective, longitudinal study of brain aging and health, including a non-verbal measure of fluid type intelligence (Raven's Standard Progressive Matrices test [RPM]). From this sample, 52 individuals (aged 69/70) with an age 11 IQ between 85 and 115 volunteered for functional MRI using a 1.5-T scanner (NVi, General Electric Medical Systems, Milwaukee, WI). Volunteers were grouped according to RPM score with a value of <34.1 (group mean - 0.5 SD) representing cognitive decline (decliners, n=15) and a score of >41.6 (group mean + 0.5 SD) representing successful aging (sustainers, n=22). That is, starting with a group of people in the normal IQ range in childhood, we defined groups in late middle age with relative good (cognitive sustainers) and poor (cognitive decliners) cognitive ageing. A quadrature head coil was used to obtain one set of functional images using BOLD contrast in the axial plane with a T2*-weighted single shot, gradient-echo, echo-planar sequence. Working memory was assessed with a two-condition N-Back task. Stimuli (letters B, C, D, F, G, H, J, K, M, N, P, Q, R, S, T, V, X, and Z) were presented every 3 s. In the low-load version of the N-Back task (0-back), participants were asked to press a button if a specific target, "X", appeared (4 targets in each block of 14 items). In the high-load version (2-back), participants determined whether an item was the same as one at two trials back (4 targets in each block of 14 items) and pressed a button. Each working memory condition plus a rest condition was repeated 4 times, for a total scanning time of 9 mins. Fifteen participants failed to complete the task because of an inability to correct vision, feeling unwell or scoring below 50% correct for the 2-Back task. The time-course fMRI image data were processed with SPM2 (3).

RESULTS:

There was no significant difference in correct response rate (decliners: mean correct 11 +/- 2, sustainers mean correct 12 +/- 2; p=0.077) or reaction time (decliners: mean 810.34 ms +/- 334.34 ms, sustainers mean 778.56 ms +/- 252.25 ms; p=0.3) between groups in the high load task. In a comparison of the high load working memory task (2-Back) with rest extensive increased bilateral activation was found in the parietal lobe in the cognitive decliners compared with the sustainers (Figure 1). Co-ordinates of cluster maxima: Right cluster x=58, y=-18, z=50, extent=319 voxels; Left cluster x=-56, y=-34, z=24, extent=658.

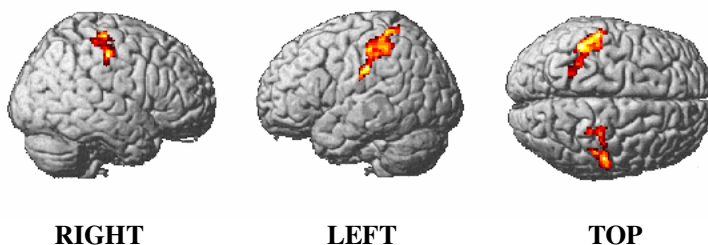


Figure 1: Whole brain analysis showing regions of increased activity in the decliners group compared with the sustainers group during a high load working memory task (significance threshold, $p < 0.05$ corrected for multiple comparisons at the cluster level).

DISCUSSION:

In the largest study of its kind, to date, we have shown that a relatively simple working memory task (2-Back verbal identity monitoring) elicits an increased cognitive processing load in volunteers age 69/70 experiencing relative cognitive decline compared to their peers who have aged more successfully. Left parietal activation is consistent with verbal/numeric tasks (4) and shows more extensive regional difference in this study.

REFERENCES:

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