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Citation for published version (APA):

Klaasen, E., Evers, L., De Groot, R., Backes, W., Veltman, D., & Jolles, J. (2012). *Age differences in brain activation associated with verbal learning and fatigue*. Poster session presented at Research Day, Maastricht, Netherlands.

Document status and date:

Published: 02/02/2012

Document Version:

Peer reviewed version

Document license:

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Age differences in brain activation associated verbal learning and fatigue

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Background

Fatigue is rated as one of the most serious health concerns by the general population, with strong adverse effects on quality of life¹. Some studies have suggested that the middle-aged working population is at particular risk for the development of cognitive fatigue². Unfortunately, fatigue is difficult to measure, with objective measures rarely providing validation of subjective complaints. However, recent neuroimaging studies have begun to provide new insights into the mechanisms underlying fatigue.

Introduction

Learning abilities have already started to decline in middle age³. However, middle-aged adults are commonly required to continue to maintain performance in fulltime employment. We investigated whether the ability of middle-aged adults to maintain performance despite the effects of cognitive aging comes at the cost of increased cognitive fatigue.

Functional MRI studies in patients with disorders characterised by fatigue, such as Multiple Sclerosis³ and Chronic Fatigue Syndrome⁴, have shown that, although patients could maintain task performance comparable to healthy participants, their performance was associated with increased and more dispersed brain activation. This finding has been attributed to the exertion of greater cognitive effort by patients which, consequentially, has been suggested to underlie their experience of increased cognitive fatigue.

Behavioural studies have shown that cognitive fatigue symptoms can be induced in healthy participants by the prolonged performance of cognitively demanding tasks⁵. In the present study we used fMRI to examine verbal learning related brain activation in young and middle-aged adults following a control intervention and following a fatigue inducing intervention.

Methods

Participants: 14 young (25-35) and 16 middle-aged (50-61) male school teachers

Intervention: Control - 1.5 hrs of relaxation

Fatiguing - 1.5 hrs of cognitively demanding tasks

Subjective fatigue measure:

Profile of Mood States fatigue subscale (difference score from baseline measurement)

Verbal learning task:

Encoding – categorisation of 100 words into 4 semantic categories

Recognition – presentation of the 100 encoding phase words plus 100 new words. Participants indicated whether words were 'old', 'maybe old', 'maybe new', or 'new'.

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Objective

We aimed to determine the effect of induced cognitive fatigue on brain activation during a verbal learning task in healthy young and middle-aged participants. Furthermore, we investigated correlations between brain activation during the task and subjective fatigue ratings.

Results

Subjective fatigue ratings: Fatigue ratings were higher in all participants following the fatigue intervention (compared to the control intervention), however no age differences were found.

Verbal learning task performance:

Encoding: There was no effect of age or fatigue intervention on the number of successfully encoded words or RT.

Recognition: There was no effect of age or fatigue on the number of successfully recognized words however, RT was slower in middle-aged than young.

Verbal learning fMRI activation (block design: main effects tested at $p(\text{FWE}) < .05$; interaction effects tested at $p_{(\text{uncorrected})} < .001$ masked inclusively with task-related activation):

Encoding: Activation did not differ between the two age groups following the control intervention, but was greater in middle-aged than in young following the fatigue intervention (in bilateral parietal and right DLPFC).

Recognition: No effects of age or fatigue intervention were found.

Subjective fatigue and verbal learning task activation correlations (tested at $p_{(\text{uncorrected})} < .001$ masked inclusively with task-related activation):

Encoding: Subjective fatigue correlated negatively with task activation in young and middle-aged (in left DLPFC).

Retrieval: Subjective fatigue correlated negatively with task activation in young only (in bilateral DLPFC).

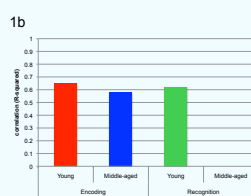
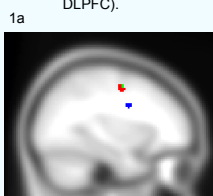


Figure 1a: depiction of left DLPFC areas in which a correlation between subjective fatigue ratings and task activation was found.

Figure 1b: correlations between subjective fatigue and task activation.

Conclusion

- Middle-aged maintained comparable verbal learning performance to young, and did not indicate greater feelings of subjective fatigue.
- Middle-aged showed greater activation than young in areas associated with cognitive control and attentional effort following the fatigue intervention during encoding, but not during recognition.
- Greater subjective fatigue was associated with decreased activation in the left DLPFC in both age groups during encoding, but in young participants only during recognition.
- It is suggested that middle-aged responded to the increased demands of verbal recognition by switching to more automatic processing.

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