Brain functional correlates of accuracy and reaction time during performance of the digit symbol substitution test in the elderly.

V. Venkatraman[1], H. J. Aizenstein[1,2], J. Guralnik[3], J. D. Williamson[4], M. Pahor[5], L. Launer[3], A. B. Newman[6,7], S. Studenski[7], N. Glynn[6], and C. Rosano[6]

[1]Dept of Bioengineering, University of Pittsburgh, Pittsburgh, PA, United States, [2]Dept of Psychiatry, University of Pittsburgh, [3]Laboratory of Epidemiology, Demography, and Biometry, National Institute of Health (NIA), [4]Wake Forest University School of Medicine, [5]Institute of Aging, University of Florida, [6]Dept of Epidemiology, University of Pittsburgh, [7]Dept of Medicine, University of Pittsburgh

Background: Several previous functional MRI (fMRI) studies in the elderly have identified age-related increased prefrontal activation in association with working memory performance. The primary hypotheses accounting for the increased activation include compensation (1, 2), which suggests that increased recruitment is used to compensate for decreased neural efficiency, or dedifferentiation (1, 3), which suggests that the increased activation reflects a loss of specificity. The compensation hypothesis predicts that better performance would be associated with increased activation, whereas dedifferentiation predicts that worse performance would be associated with greater activation. The current study tests these competing models using the digit symbol substitution task (DSST), a task involving working memory and processing speed, which is particularly sensitive to cognitive changes associated with aging.

Hypothesis: Activation of the dorsolateral prefrontal cortex (an area important for: working memory) and the posterior parietal cortex (visuospatial orientation and attention) will be associated with greater accuracy and shorter reaction times on the DSST.

Methods: Brain fMRI data of 14 subjects who had previously participated in the Lifestyle Interventions and Independence for Elders (LIFE-P) Pilot Study at the Pittsburgh site (mean age: 81.5 years, 10 women) were acquired with a 3T Siemens Trio using EPI sequence (axial view, TR=2 secs, TE=32 ms, thickness = 3mm) and a block design task. Brain activation was measured while the participants performed the modified version of the DSST (4) and during a control condition. The task lasted a total of 9 mins and 20 secs, with 5 blocks of the control condition and 5 blocks of the experimental condition. Accuracy (number of corrected symbols) and reaction time (time in seconds to respond) were also measured. The data was preprocessed (motion corrected, normalized and smooth) and analyzed using SPM5 (5). Performance analysis was performed on 14 subjects; the groups were classified based on accuracy and response time.

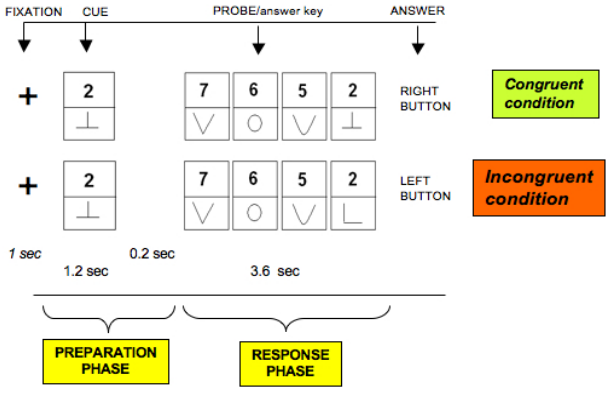

Figure.1. Digit symbol substitution task (Experimental condition)

Results: A main effect between the experimental versus control conditions for the task was observed as expected, with greater brain activation (p=0.01, contiguity threshold k=20 voxels) in the dLPFC, Supplementary motor area, posterior parietal cortex and left insula. The accuracy-related network included left ventro-lateral prefrontal cortex, and the parietal and motor areas bilaterally (p=0.05 and k=20 voxels). The reaction-time related network included dLPFC, motor and supplementary areas in the right hemisphere (p=0.01 and k=20 voxels). The accuracy and reaction time related networks also showed activation in the superior temporal gyrus.

Conclusion: These findings suggest that older adults engage distinct overlapping networks of fronto-parietal regions to perform the DSST with greater accuracy and shorter reaction times. These findings support the compensation model for cognitive aging.

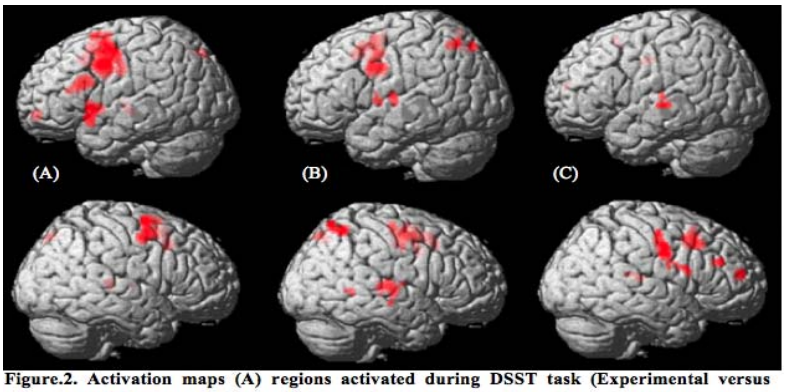

Figure.2. Activation maps (A) regions activated during DSST task (Experimental versus control condition), (B) regions associated with greater accuracy, (C) regions associated with shorter reaction time. Only the cortical lateral regions are shown.

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Acknowledgements: This study is funded by the National Institutes of Health/National Institute on Aging Cooperative Agreement #U01 AG22376 and by the Intramural Research Program, National Institute on Aging, NIH.