Executive function and grey matter atrophy in healthy aging: A voxel-based morphometry analysis

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Introduction

Healthy aging is often associated with cognitive functioning decline but also with neurobiological changes. Within the cognitive perspective, executive functioning is a major cognitive domain that declines early in healthy aging [1]. In addition, neuroimaging studies pointed out diverse neurobiological modifications associated with normal aging, such as reduced grey and white matter volumes and cortical thickness [2]. However, the relationship between cortical atrophy and executive functioning remains unclear. Indeed, experiments showed various correlative results when they attempted to analyze the influence of brain structure on the age-related decline in executive functioning, and some of these also reported null correlation [3]. Subjects sample and cognitive tasks selection, as well as preprocessing and statistical methods could at least explain some of the differences observed in the literature.

Objectives

This study was designed to investigate the potential influence of grey matter volume on age-related executive decline

Methods

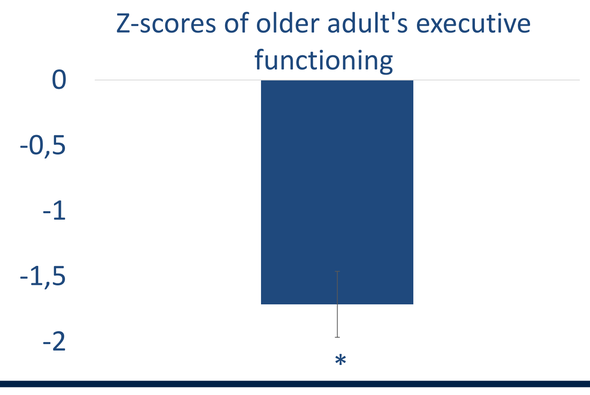
Participants	36 Healthy young adults (age range: 18-30) & 43 Healthy older adults (age range: 60-78)
Executive assessment	Composite score derived from diverse executive tasks* administered to participants during a cognitive testing session of 2 hours *Executive index was calculated on the following tasks: Wisconsin Card Sorting Test (perseverative & non-perseverative errors), Plus-Minus, fluency, n-back, random number generation (inhibition & updating), Stroop
MRI details	Structural high resolution T1-weighted images were acquired with a 3T head-only scanner using a standard transmit-receive quadrature head coil (Siemens, Allegra, Erlangen, Germany)
Preprocessing	Structural images were segmented using VBM8 toolbox, normalized to the MNI stereotaxic space and the resulting grey matter volume images were smoothed (FWHM 8mm).

Statistics

Partial Least Square (PLS) approach was used to (1) determine regional grey matter volume differences between young and older adults; and (2) identify regions where grey matter volume is associated to executive performance

Results #1 – Behavioral data

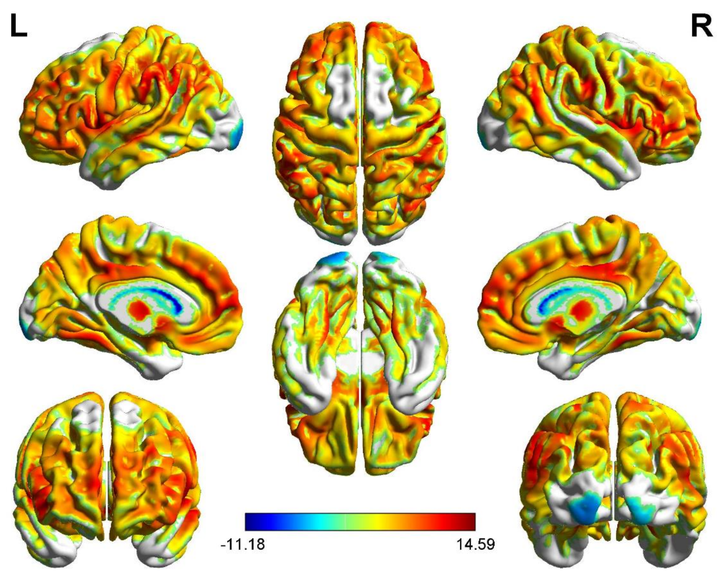
Behavioral data showed a significant age-related decline in executive functioning (t=-5.43; *p*<.001)



Results #2 – Age-related decline in grey matter volume

PLS non rotated task procedure*:

Significant (*p*<.001) age-related grey matter volume decrease observed across a large network including frontal, parietal, and temporal regions.

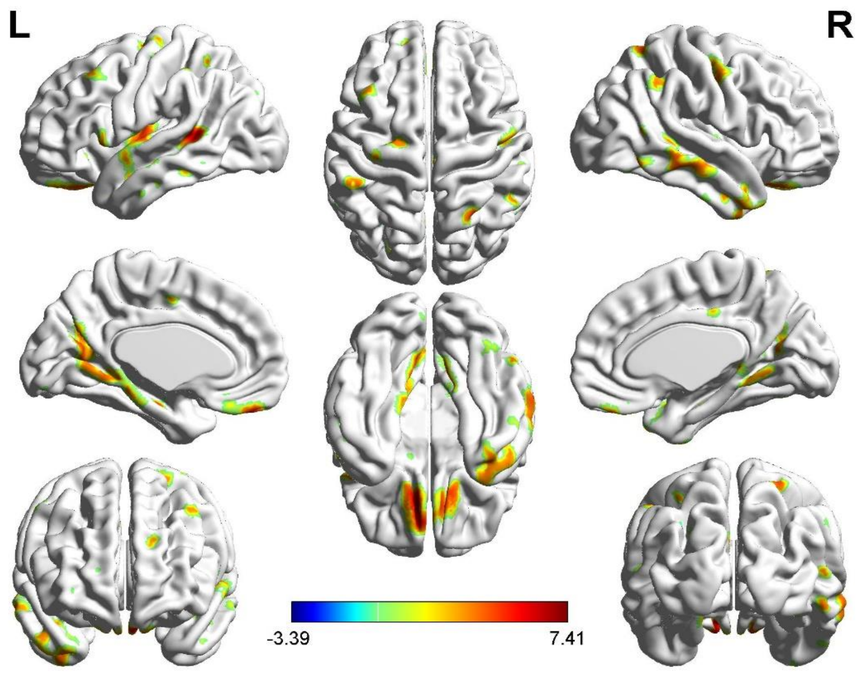


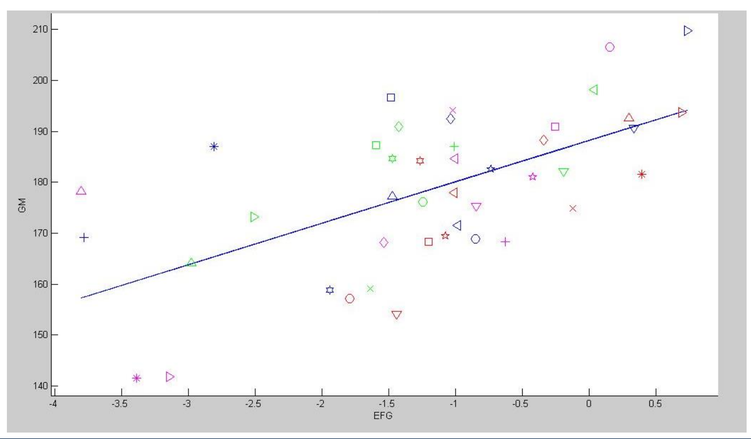
*This module of multivariate analysis allow the use of a priori contrasts to test the difference of grey matter volume between young and older adults (all analyses were conducted using 600 permutations and 150 bootstraps; *p*<0.05)

Results #3 –Executive-related decline in grey matter volume

PLS non rotated Behavioral procedure:

Significant (*p*<.001) age-related grey matter volume decrease observed across a large network including frontal, parietal, and temporal regions. (r=.61)





Discussion

As usually observed, this study showed a decline of executive abilities with age [1]. Additionally, a large shrinkage of grey matter is observed among a large fronto-temporo-parietal network when older adults are compared to younger ones. Finally, the age-related executive decline is related to frontal grey matter decline, but also to other areas such as parietal, temporal, cingulate as well as hippocampal regions and some part of the basal ganglia. Interestingly, the areas whose atrophy is linked to executive abilities are quite similar to those evidenced in functional neuroimaging studies in young participants [4]. Therefore, using the multivariate approach PLS, we observed that executive changes in normal aging are not only dependent on atrophy in frontal areas but are rather related to a grey matter volume decrease in several areas corresponding to an antero-posterior brain network.

References:

[1] Salthouse, T. A., Atkinson, T. M., & Berish, D. E. (2003). Executive functioning as a potential mediator of age-related cognitive decline in normal adults. *Journal of Experimental Psychology:General,132*(4),566-594.

[2] Raz, A., & Rodrigue, K. M. (2006). Differential aging of the brain: Patterns, cognitive correlates and modifier. *Neuroscience and Biobehavioral Reviews, 30,* 730–748.

[3] Van Petten, C., Plante, E., Davidson, P. S., Kuo, T. Y., Bajuscak, L., & Glisky, E. L. (2004). Memory and executive function in older adults: Relationships with temporal and prefrontal gray matter volumes and white matter hyperintensities. *Neuropsychologia, 42*(10), 1313-1335.

[4] Collette, F., Hogge, M., Salmon, E., & Van der Linden, M. (2006). Exploration of the neural substrates of executive functioning by functional neuroimaging. *Neuroscience, 139*(1), 209-221.