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), P300-Max, 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 VBMB 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<0.001)

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

*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 bootstrap p<0.05)

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

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