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

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Introduction Executive functioning is one of the cognitive domain that declines in healthy aging (Salthouse, Atkinson, & Berish, 2003). In addition, neuroimaging studies pointed out diverse neurobiological modifications associated to normal aging, such as reduced grey and white matter volumes and cortical thickness (Raz & Rodrigue; 2006). In that context, Voxel Based Morphometry (VBM; Ashburner & Friston, 2000) and Partial Least Square (PLS; McIntoch at al., 1996, 2004) were used to investigate the effect of grey matter atrophy on executive abilities in normal aging.

Methods Thirty six young (age range: 18-30) and 43 healthy older (age range: 60-78) adults were included in this study. Executive functioning was assessed by inhibition, updating and shifting tasks (Miyake et al., 2000), and a composite score for general executive ability was created. 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). The structural images were segmented using VBM8 toolbox, normalized to the MNI stereotaxic space and the resulting grey matter volume images were smoothed (Gaussian kernel: FWHM 8mm). PLS analyses were performed to determine regional grey matter volume differences between young and older adults, and next to identify the regional grey matter volumes specifically associated to executive performance in older participants ($p<0.001$). PLS is a validated multivariate approach that robustly identifies whole brain activity patterns correlated with behavioral data or experimental design (i.e., scores, conditions or tasks).

Results Behavioral data showed a significant age-related decline in executive functioning ($t=-5.43$; $p<.001$). MRI analyses showed that significant age-related grey matter volume decrease was mostly observed across a large network including frontal, parietal, and temporal regions. Moreover significant positive correlations between the executive score and the grey matter volumes in older participants were found in a subset of these cortical areas: the inferior, middle and superior frontal cortex, the pre and postcentral gyri, the anterior and middle cingulate cortex, the inferior and superior parietal regions, the retrosplenial cortex, and finally, the inferior, middle and superior temporal regions.

Discussion This study first replicated that executive abilities decline with age (Salthouse et al., 2003). This age-related executive decline is related to specific cerebral regions within a large fronto-temporo-parietal network sensitive to age. Interestingly, the areas whose atrophy is linked to executive abilities are quite similar to those evidenced in functional neuroimaging studies in young participants (see Collette & Van der Linden, 2002; Collette, Hogge, Salmon, & Van der Linden, 2006 for reviews). Therefore, using PLS multivariate analyses, we demonstrated that executive changes in normal aging are not dependent on atrophy in frontal areas only but rather comes from a grey matter volume decrease in a large antero-posterior brain network.

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