

DIFFUSION TENSOR IMAGING OF CEREBRAL WHITE MATTER: IMPLICATIONS FOR AGE-RELATED CHANGES IN VISUAL ATTENTION

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INTRODUCTION

Diffusion tensor imaging can provide detailed delineation of white matter pathways based on rates of microscopic water diffusion. Higher degree of white matter integrity is reflected in a greater degree of fractional anisotropy (FA) of diffusion. Previous research suggests an age-related decline in FA, particularly in prefrontal regions. We investigated age-related decline in white matter integrity for several regions of interest (ROIs). In addition, we examined the relation between white matter integrity and measures of attention obtained from a visual search task. Our hypothesis was that both the age-related decline in FA, and the relation between FA and search performance, would be most pronounced for prefrontal ROIs.

METHOD and RESULTS

❖ Participants

Right-handed, community-dwelling individuals; 16 younger adults (19-28 years; 8 female); 16 older adults (60-82 years; 8 female). Participants were screened for major health problems and use of psychotropic medication.

❖ Imaging Parameters

Diffusion Tensor Imaging: Magnetic resonance imaging conducted at 1.5 T. In diffusion tensor sequence, 27 contiguous near-axial slices parallel to AC-PC, 6 mm thick TR = 12000; per slice, diffusion measured in 6 directions ($b = 1000 \text{ sec/mm}^2$) plus one image with no diffusion weighting ($b = 0$); four signal averages. Diffusion tensor eigenvalues calculated from custom MATLAB scripts.

Structural:

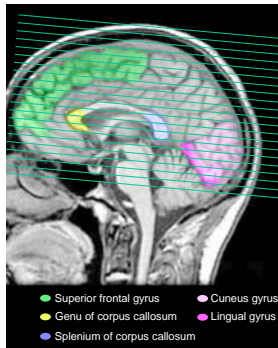
T1-weighted near-axial gradient-echo images, 21 contiguous slices, parallel to AC-PC, 5 mm thick; TR = 450.

❖ Visual Search Task

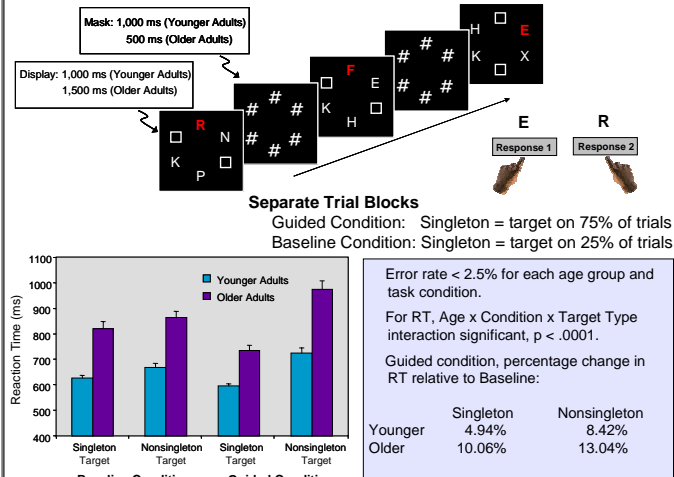
While in the magnet, participants performed a two-choice search task in which an E or R target was present among three distractor letters— see figure in center panel (top). Each display contained a red singleton. In the Guided condition the singleton was usually the E/R target (75% of trials); in the Baseline condition the singleton was the target on 25% of the trials.

❖ Regions of Interest (ROIs):

ROIs were drawn directly on the diffusion tensor images on a slice-by-slice basis for each participant, using the high-resolution T1 images as a reference. The ROIs included the genu and splenium of the corpus callosum, pericallosal frontal area (PCF), superior frontal gyrus (SFG), anterior limb of the internal capsule (ALC), posterior visual pathway (PVP [cuneus & lingual gyri]), and the fusiform gyrus (FFG)— see figure in center panel.

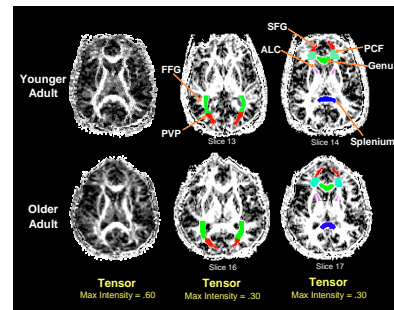


Visual Search Performance



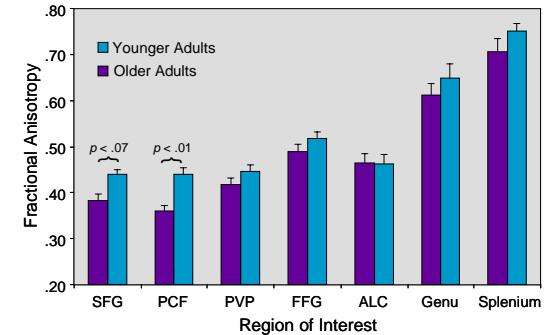
Fractional Anisotropy (FA) Images

Note: Leftmost images are FA images in which whiter voxels indicate higher FA values (i.e., FA values of .60 and greater appear as pure white). For ROI drawing (center and rightmost images), maximum FA image intensity was set to .30, so that all voxels with FA values greater than .30 appeared as pure white. This threshold helped minimize potential biases for selecting voxels with relatively high FA values.



Age Differences in Fractional Anisotropy

ANCOVA of mean FA values, covaried for region size, yielded significant Age x Region interaction, $p = .014$, which was driven by age-related decline in FA within white matter for the superior frontal gyrus (SFG) and pericallosal frontal region (PCF).

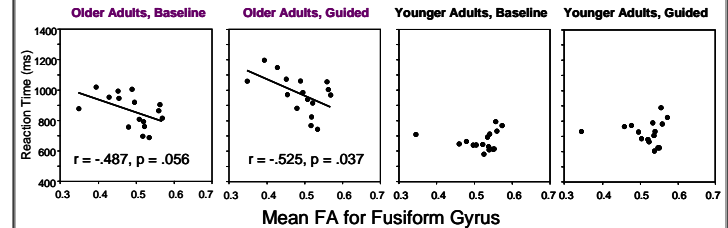


Correlation Between Fractional Anisotropy and Reaction Time

Correlations conducted on RT within each task condition and FA value for each ROI.

Older adults exhibited faster responses, as a function of increasing FA, for the fusiform gyrus, in those task conditions requiring an attentional shift, i.e., when the singleton was not the target.

NONSINGLETON TARGETS



CONCLUSIONS

❖ Age-related decline in white matter integrity (FA) is most pronounced in prefrontal regions, although some degree of decline is evident throughout the brain. This decline in white matter integrity may contribute to a disconnection between neural systems.

❖ The age-related change in the association between FA and behavioral performance is independent of the age-related decline in FA.

❖ The older adults' correlation between fusiform FA and search performance, in this search task, may represent increased visual processing of the display when attention must be shifted away from the expected location of the target.

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