

AGE-RELATED DECREASES IN CEREBRAL WHITE MATTER INTEGRITY: IMPLICATIONS FOR EPISODIC AND SEMANTIC RETRIEVAL PROCESSES

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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 semantic and episodic retrieval performance. Our hypothesis was that both the age-related decline in FA, and the relation between FA and memory retrieval, would be most pronounced for prefrontal ROIs.

METHOD

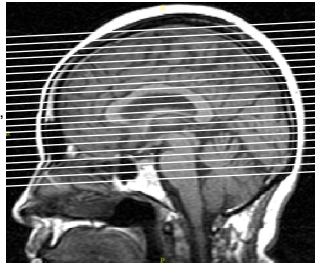
Participants

Right-handed, community-dwelling individuals; 19 younger adults (20-28 years, $M = 23.90$ years); 19 older adults (63-78 years, $M = 69.58$ years). Participants were screened for major health problems and use of psychotropic medication.

Imaging Parameters

Diffusion Tensor Imaging:

Magnetic resonance imaging conducted at 4 T. In diffusion tensor sequence, 30 contiguous near-axial slices parallel to AC-PC, 3.8 mm thick; TR = 30000; per slice, diffusion measured in 6 directions ($b = 1000 \text{ sec/mm}^2$) plus one image with no diffusion weighting ($b = 0$); five signal averages. Diffusion tensor eigenvalues calculated from custom MATLAB scripts.



Structural:

3D fast IRP SPGR sequence, 60 contiguous slices, parallel to AC-PC, 1.9 mm thick.

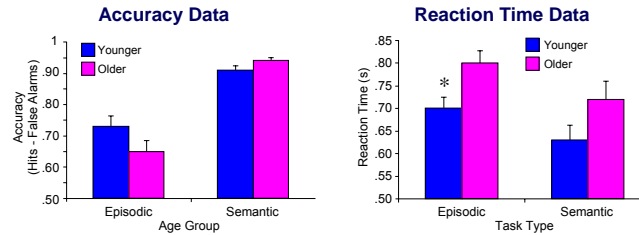
Memory Retrieval Task

During scanning, participants performed a task in which they judged individually presented words as pleasant or unpleasant. During semantic retrieval, participants made living/nonliving decisions for each word, whereas for episodic retrieval, participants made old/new decisions.

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 SPGR images as a reference. The ROIs included the genu (GNU) and splenium (SPN) of the corpus callosum, anterior (ALS) and posterior (PLS) regions of the superior longitudinal fasciculus, uncinate fasciculus (UNC), and the cingulum (CIN).

Semantic and Episodic Retrieval

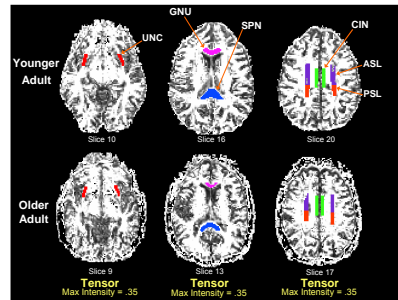


Accuracy Data
Episodic Hits = "Yes" response to previously seen words.
Semantic Hits = "Yes" response to living words.
Age Group x Task Type interaction, $F(1, 36) = 4.92, p = .03$.
Separate univariate ANOVAs were not significant.

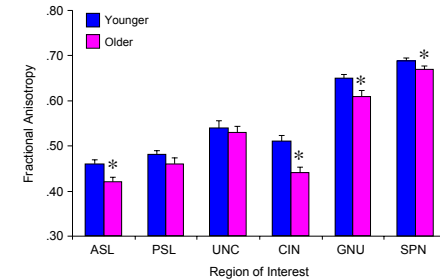
Reaction Time Data
Covaried for perceptual/motor speed.
Episodic RT: Younger adults are significantly faster, $F(1, 35) = 4.31, p = .05$.
Semantic RT: The age group difference was not significant.
Age Group x Task Type interaction was not significant.

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 .35, so that all voxels with FA values greater than .35 appeared as pure white. This threshold helped minimize potential biases for selecting voxels with relatively high FA values.



Age Differences in Fractional Anisotropy



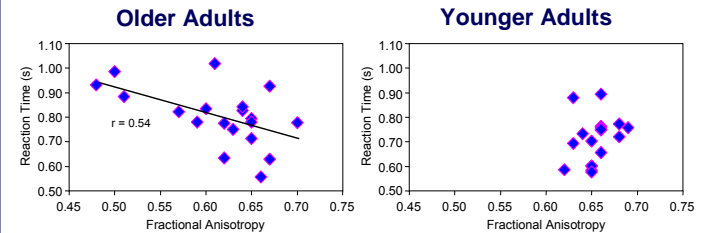
A MANOVA revealed a significant effect of region, $F(6, 31) = 7.32, p < .001$.
Univariate ANOVAs by age group revealed significantly lower mean FA for older adults in ASL, CIN, GNU, and SPN.

Correlation Between Fractional Anisotropy and Reaction Time/Accuracy

Overall, increased mean FA in the GNU was associated with increased accuracy on the episodic task, $r = .35, p < .03$. Increased mean FA in the GNU was also related to decreased RT on the semantic task, $r = -.30, p < .07$.

For the relationship between mean FA in the GNU and episodic RT, we obtained a significant interaction, $\beta = -.46, p < .003$. For older adults, increased FA in the GNU was related to decreased RT on the episodic task, $r = -.53, p < .02$.

Episodic RT and Genu FA



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.

- ❖ For both groups, increased FA in the genu is related to faster responses in the semantic task and with increased accuracy on the episodic task.
- ❖ It appears that for older adults, increased white matter integrity in the genu is important for fast episodic memory retrieval, a task in which we observed significant age deficits.