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The White Matter Correlates of Domain-Specific Working Memory

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Introduction

Prior evidence suggests separable, domain-specific working memory (WM) buffers for maintaining phonological (*i.e.,* speech sound) and semantic (*i.e.,* meaning) information[1]. The phonological WM buffer's proposed location is the left supramarginal gyrus[2], whereas semantic WM has been related to the left inferior frontal gyrus, middle frontal gyrus, and angular gyrus[3–5]. Here we investigated the role of white matter tracts connected to these regions in supporting WM. The left AF, previously implicated in verbal WM[6], connects the supramarginal gyrus, the proposed location of the phonological store, to frontal regions supporting rehearsal. The IFOF, ILF, MLF, and UF connect temporal regions representing semantics to regions such as the angular gyrus or inferior frontal gyrus which may be involved in maintaining semantics. Thus, we predicted left AF integrity to relate to phonological WM and left IFOF, ILF, MLF, and UF integrity to relate to semantic WM.

Methods

For 24 individuals with aphasia following left hemisphere brain damage, behavioral scores were available on single word processing (picture-word matching with phonological and semantic distractors), phonological WM (digit matching span; mean 4.03, sd 1.12), and semantic WM (category probe span; mean 1.73; sd .71). T1 and diffusion weighted (b = 800 sec/mm^2) scans were obtained for each participant. Left and right hemisphere tracts of interest were dissected with ROIs drawn manually in native space[7]. Bivariate correlations between fractional anisotropy (FA) values and behavioral measures were computed (Table 1). A multiple regression approach was used to test the relationship between FA and WM, while controlling for single word processing ability.

Results

The left AF could only be segmented for 7 participants, and thus correlations with behavioral measures were not computed. For the remaining tracts, segmentation was possible for 13-24 participants. On the left, the only correlations with at least marginal significance were for single word semantic processing and FA values for the MLF and UF. On the right, FA values for the IFOF correlated with single word phonological processing, and FA values for the IFOF, ILF and UF correlated with semantic WM. In the multiple regressions controlling for single word processing, the relations between semantic WM and FA values remained marginally significant for the right ILF and UF (both *p*'s=.054) (Figure 1).

Conclusions

We did not observe expected relationships between WM and left hemisphere white matter tract integrity, though others have reported a relationship between left AF integrity and

verbal WM[6]; however, we had a limited ability to segment the left AF. Future work is needed to assess a larger sample of participants and analyze relationships between WM and subsections of the AF[8] as only certain subsections of the AF (*e.g.*, the direct segment, directly connecting temporal and frontal regions) may relate to phonological WM. The right ILF, and UF relations to semantic WM were a novel result and suggest possible reorganization to the right hemisphere[9]. To address these tracts' role prior to brain damage, we will investigate correlations between integrity of these tracts and WM performance in healthy age-matched individuals.

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Table 1. Bivariate correlations between FA values for left and right hemisphere tracts of interest and accuracy on semantic and phonological distractors in picture-word matching and semantic and phonological WM capacity.

		n[a]	Semantic distractors	Phonological distractors	Semantic WM[b]	Phonological WM[c]
Left Hemisphere Tracts	AF	7	--	--	**--**	**--**
	IFOF	13	.30 *.14*	.06 *.79*	.078 *.76*	.18 *.42*
	ILF	24	.09 *.67*	-.23 *.28*	-.10 *.69*	.20 .37
	MLF	16	**.35** **.095**	-.04 *.85*	.022 *.93*	.29 *.19*
	UF	15	**.48** ***.02***	.27 *.21*	.28 *.25*	.18 *.43*
Right Hemisphere Tracts	AF	19	-.14 *.51*	.21 *.33*	.10 *.70*	-.16 *.47*
	IFOF	23	.19 *.38*	**.53** ***.0075***	**.54** ***.022***	.29 *.19*
	ILF	24	.28 *.19*	.25 *.24*	**.54** ***.021***	.19 *.41*
	MLF	21	.22 *.30*	-.07 *.72*	-.051 *.84*	-.27 *.23*
	UF	24	.08 *.72*	.07 *.74*	**.41** ***.089***	.095 *.67*

* p values reported in italics

[a] n is the number for whom tract could be segmented. FA = 0 for those not segmented.

[b] Correlations computed after removing 5 individuals with d' < 2.0 on semantic distractors

[c] Correlations computed after removing 1 individual with d' < 2.0 on semantic distractors

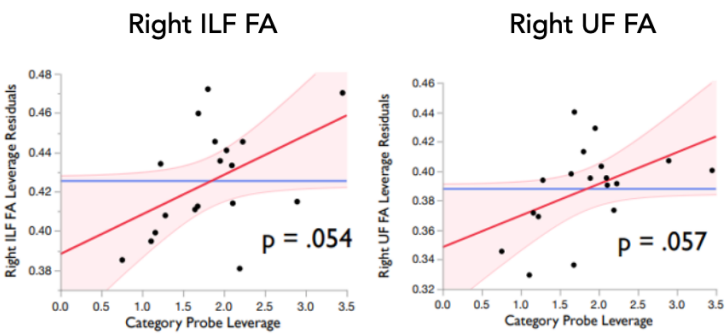

Figure 1. Leverage plots showing the relations between right hemisphere tract FA values (y-axes) and semantic WM (x-axes) after controlling for single word processing accuracy