Structural correlates of language abilities: a surface-based region-of-interest morphometry study

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I.Introduction

Research on the neuronal substrate of expressive language has for a long time relied almost exclusively upon brain lesions studies. However, generalisation of these studies to healthy individuals is limited due to a lack of spatial resolution and potential for post-lesion neural reorganisation. With the development of new neuroimaging techniques, our understanding of normal cognitive function has greatly advanced. While a large number of studies have used functional imaging techniques to assess the relationships between brain activity and language skills, little is known about the relation between brain structure and language skills. The goal of the present study is to identify which cortical and subcortical regions, and which aspect of their structure, are correlated with language performance on two classical language tasks.

II. Method

2.1. Participants

21 healthy right-handed adults (10 males) participated in this study, which took place in Chicago (IL) (**table I**)

Table I. Participants caracteristics

	N	Minimum	Maximum	Mean	Std dev.
Age	21	20	36	25.0	4.4
Handedness	20	12	20	17.0	2.7
Education	21	12	22	15.4	2.7

2.2 Tasks

Participants underwent two language tasks:

(1) **Sentence generation**: generation of short sentences from a set of object pictures. The dependant variable is the percentage of correct sentences.

(2) **Verbal fluency**: production of as many animal and vegetables words as possible in 1 min (in two separate trials). The dependant variable is the number of correct words.

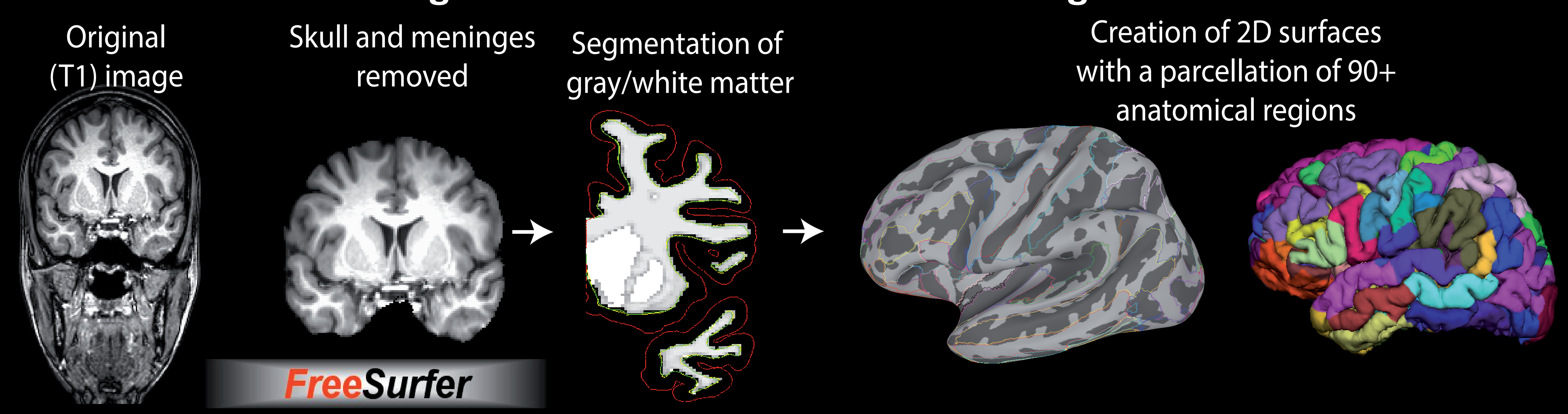
2.3 Image Acquisition and Analysis

For each participant, data were acquired on a 3T General Electric Signa HDx MR system (166 slices, 1mm3, 256 x 256 mm2 matrix).

2.4 Image Analysis

We used FreeSurfer to calculate the gray matter cortical thickness (CT) and surface of 88 cortical regions, and the grey matter volume of 8 subcortical regions in both hemispheres. The procedure is described in **figure 1**.

Fig. 1. Procedure for anatomical images



III. Results

Results on language tasks are reported in **table II**

The correlations between CT and surface of brain regions, and language scores are reported in **table III**. No correlations were found with the subcortical regions.

The correlations between the strucure of regions classically associated with language and language scores are presented in **figure 2** and **3**.

Table II. Language tasks results

	N	Minimum	Maximum	Mean	Std dev.
Verbal fluency	21	26.5	59.0	39.7	9.6
Sentence generation	19	67.5	100.0	86.4	7.9

Table III. Significant correlation between language tasks and brain regions structure

	Task	Structure	Anatomical Region	r	p
Left Hemi	Sentence generation	thickness	cingular gyrus isthmus	-.58	.009
		thickness	inf. par. gyrus supramarginal part	-.48	.039
		thickness	sup. frontal gyrus rostral part	.51	.025
		surface	post central sulcus	.60	.006
	Verbal fluency	thickness	inf. frontal gyrus orbital part	-.68	.001
		thickness	inferior frontal sulcus	-.58	.005
		surface	inf. frontal gyrus triangular part	.46	.035
Right Hemi	Sentence generation	thickness	cingular gyrus isthmus	-.47	.045
		thickness	frontomarginal sulcus	.64	.003
		surface	frontomarginal sulcus	.46	.048
	Verbal fluency	thickness	frontomarginal gyrus	.49	.023
		thickness	long insular gyrus	-.47	.034
		thickness	short insular gyrus	-.52	.015

Fig. 2. Correlation between Sentence Generation and brain structure

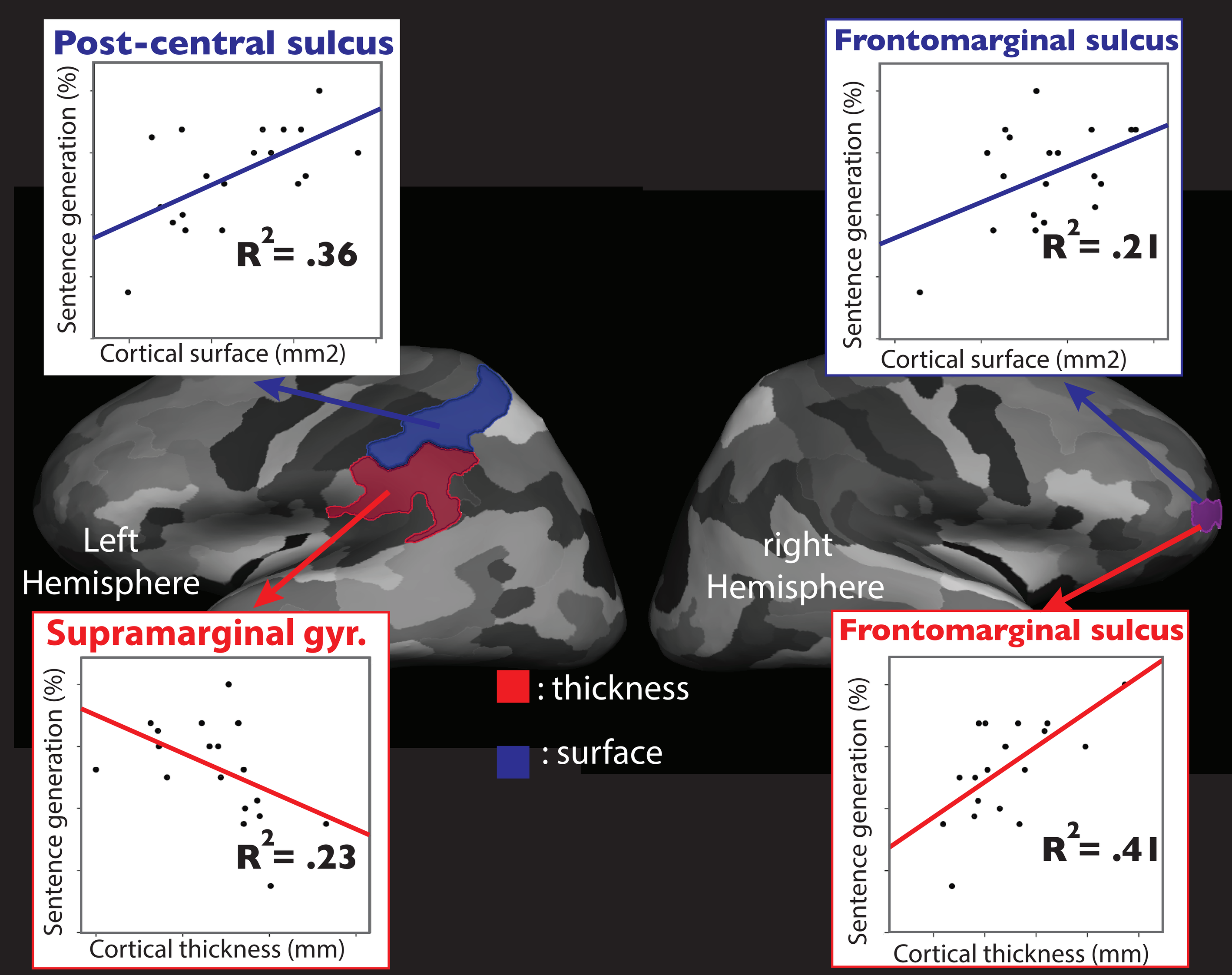
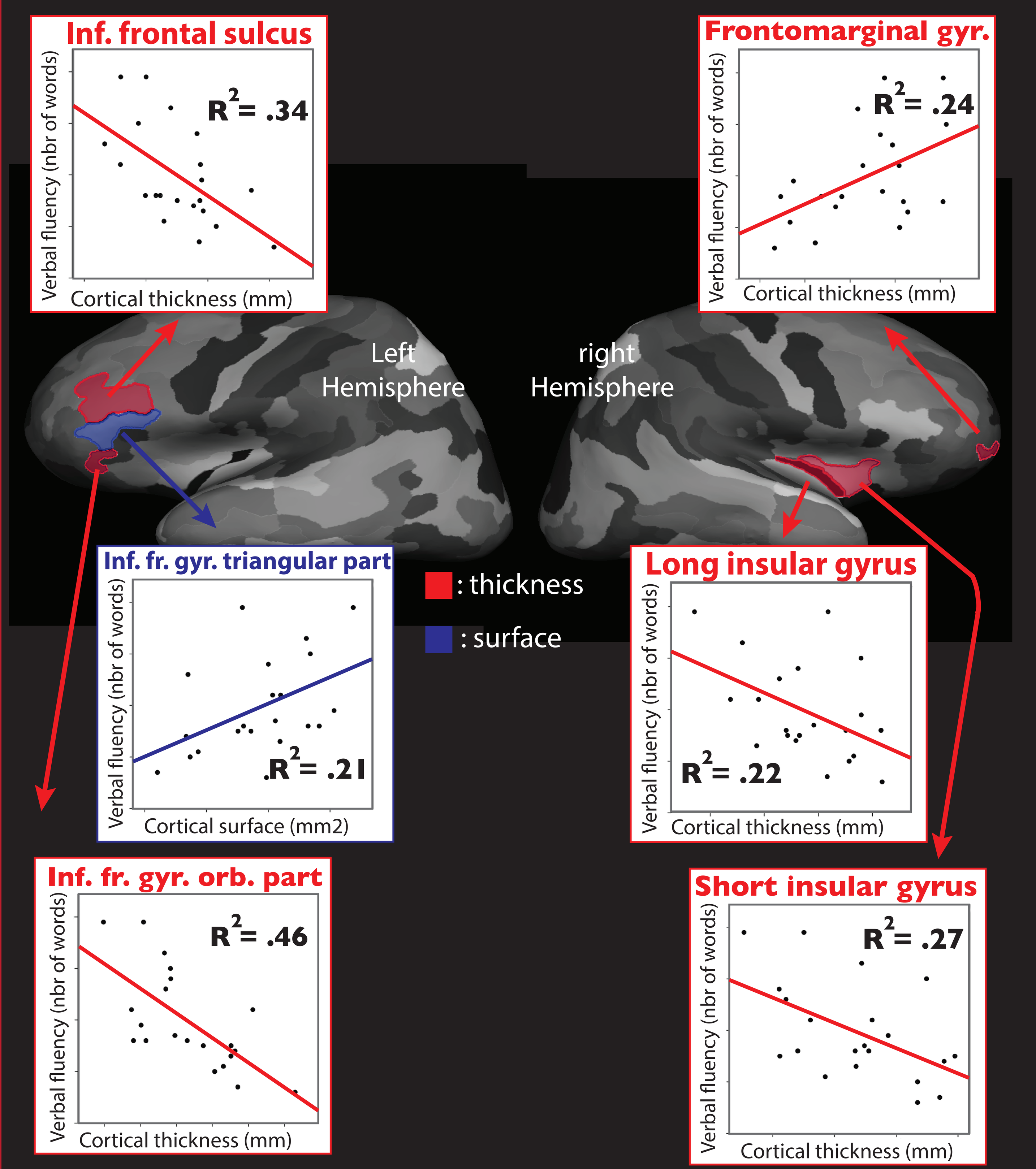


Fig. 3. Correlation between Verbal Fluency and brain structure



IV. Discussion

Generally, correlations were found between language tasks scores and several frontal, parietal and insular regions. This analysis highlighted the presence of task-related differences in the correlations of brain structure and measures of expressive language. Indeed, fluency scores tended to be correlated with regions located in the inferior part of the left frontal lobe while sentence generation scores showed correlations with the left inferior parietal cortex, post-central regions, and the right prefrontal lobe.

Importantly, CT was almost always negatively correlated with scores on both language tasks. This wasn't the case with the surface data, where positive correlations were predominant. A possible explanation is that thinner CT reflects a better pruning and/or myelinisation process during brain maturation associated with better language skills in term of production and comprehension, while wider cortical surface could be the result of a different mechanism, such as cerebral (structural) plasticity, in which a larger neuronal population is associated with better language skills.

V. Conclusion

Brain morphometric analysis is an interesting avenue for cognitive neuroscience research. The unique type of information it provides makes it a valuable tool for enhancing our understanding of the neuronal structure underlying language abilities.

IV. Acknowledgement

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NIH National Institutes of Health Turning Discovery Into Health