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INTRODUCTION

- ❖ Past research in adults, including professional mathematicians has revealed the existence of a highly reproducible network of regions responsive to mathematics in the human brain.
 - ❖ This network is mainly composed of bilateral regions in the intraparietal sulcus and posterior inferior temporal gyrus, dissociated from language-responsive areas.
- ❖ In healthy adults, it is engaged for a wide range of math activities from processing numbers and arithmetic calculation to reflection on complex statements with math content.
 - ❖ Here, we explore math-related activation after substantial recovery from acalculia and severe math reasoning difficulties consecutive to widespread brain damage.
- Patient profile:

 - Young adult
 - High-level math training before the accident
 - Severe leuco-encephalopathy
 - Acquired (secondary) acalculia

METHOD

Participants:

- Patient scanned with fMRI at chronic stage (1.5 year after the accident, at the end of a 9-month intensive custom cognitive rehabilitation course).
- Control group: 14 professional mathematicians, previously scanned.

Auditory task: Participants were asked to perform fast intuitive semantic judgments on spoken mathematical and non-mathematical statements (classify them as true, false).

Experiment 1: simple facts spanning various domains and solving strategies

Examples:

1) Rote algebraic facts:	$(a+b)(a-b) = a^2 - b^2$
2) Algebraic calculation:	$(x-1)(x+1) = x^2 - 1$
3) Trigonometry:	$\sin(x+3\pi/2) = -\cos x$
4) Complex numbers:	$Re(e^{in/4}) = Im(e^{in/4})$
5) Euclidean geometry:	The section of a sphere by a plane is always a point
6) General knowledge:	Rock'n'roll is a musical style characterized by a slow tempo

fMRI acquisition and analysis

- High resolution multiband fMRI acquisition: TR = 1.5 s, voxel size = 1.5*1.5*1.5 mm³
- Standard pre-processing with 2 mm smoothing
- Structural analyses and functional first-level GLM with SPM12.
- Comparisons between the patient and the control group with Crawford modified t-tests.

Alerting sound

“a plus b by a minus b is equal to a square minus b square”

Statement presentation	Response	Resting period	
1 s	mean = 4.1 ± 0.7 s	2.5 s	7 s

RESULTS

Patient’s behavioral dissociation between verbal and symbolic math problems

Neuropsychological assessment

- Visuo-spatial difficulties, dysexecutive syndrome, and attentional deficits, no aphasia but secondary acalculia.
- Note: Custom cognitive rehabilitation that involved the deployment of verbal strategies.

Experiment 1

- The patient struggled with most symbolic math statements.
- The patient performed similarly to the control group only on geometry (i.e., the statements involving language the most).

Category	% correct
Rote facts	~65
Algebra	~35
Trigo	~55
Complex	~55
Geometry	~95
Nonmath	~65

Category	% correct
Rote facts	~95
Algebra	~90
Trigo	~60
Complex	~85
Geometry	~85
Nonmath	~90

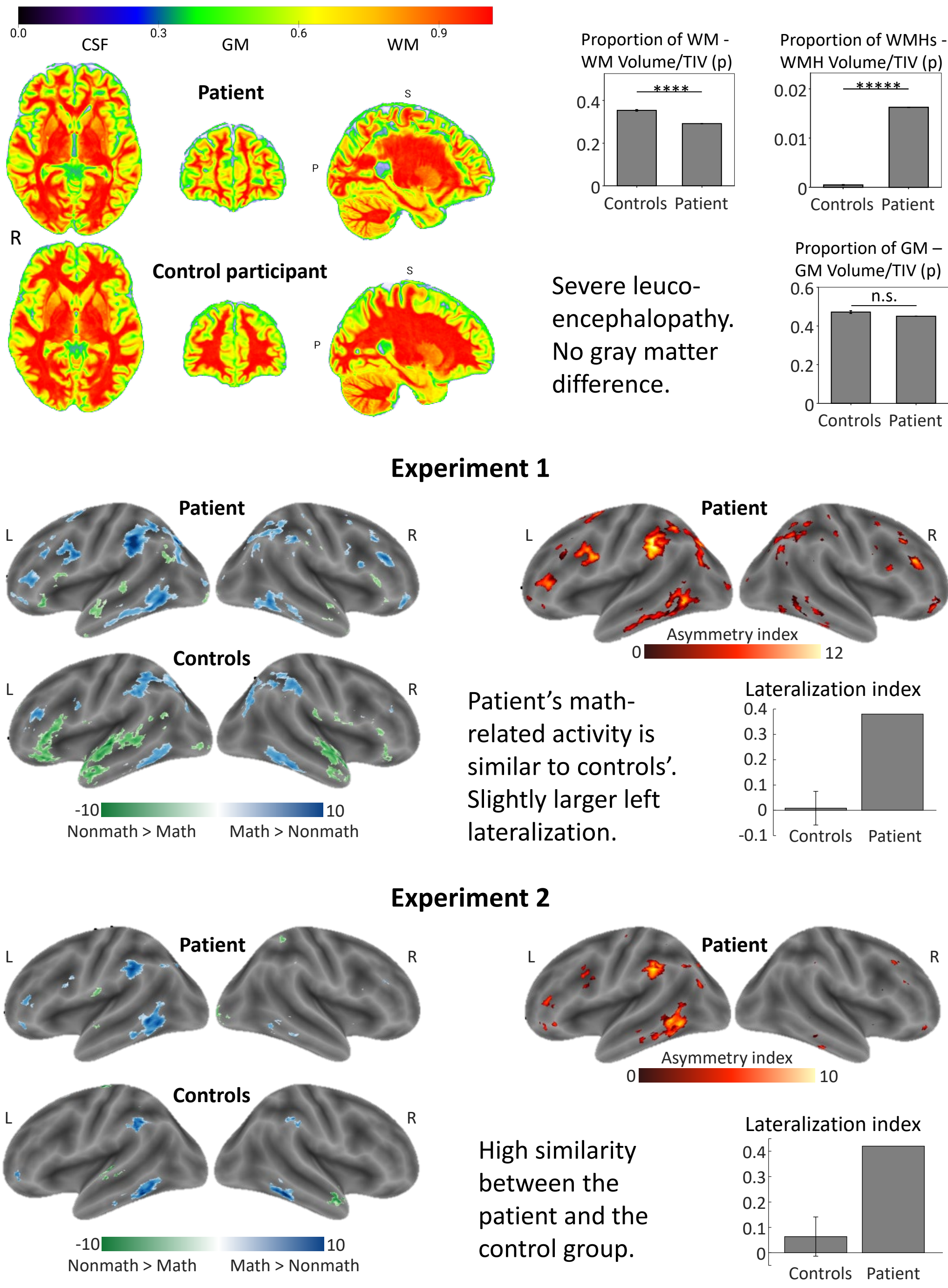
Experiment 2

- The patient achieved high performance (significantly above chance and almost as high as the control group) on all verbal math statements (except the ones involving negation).

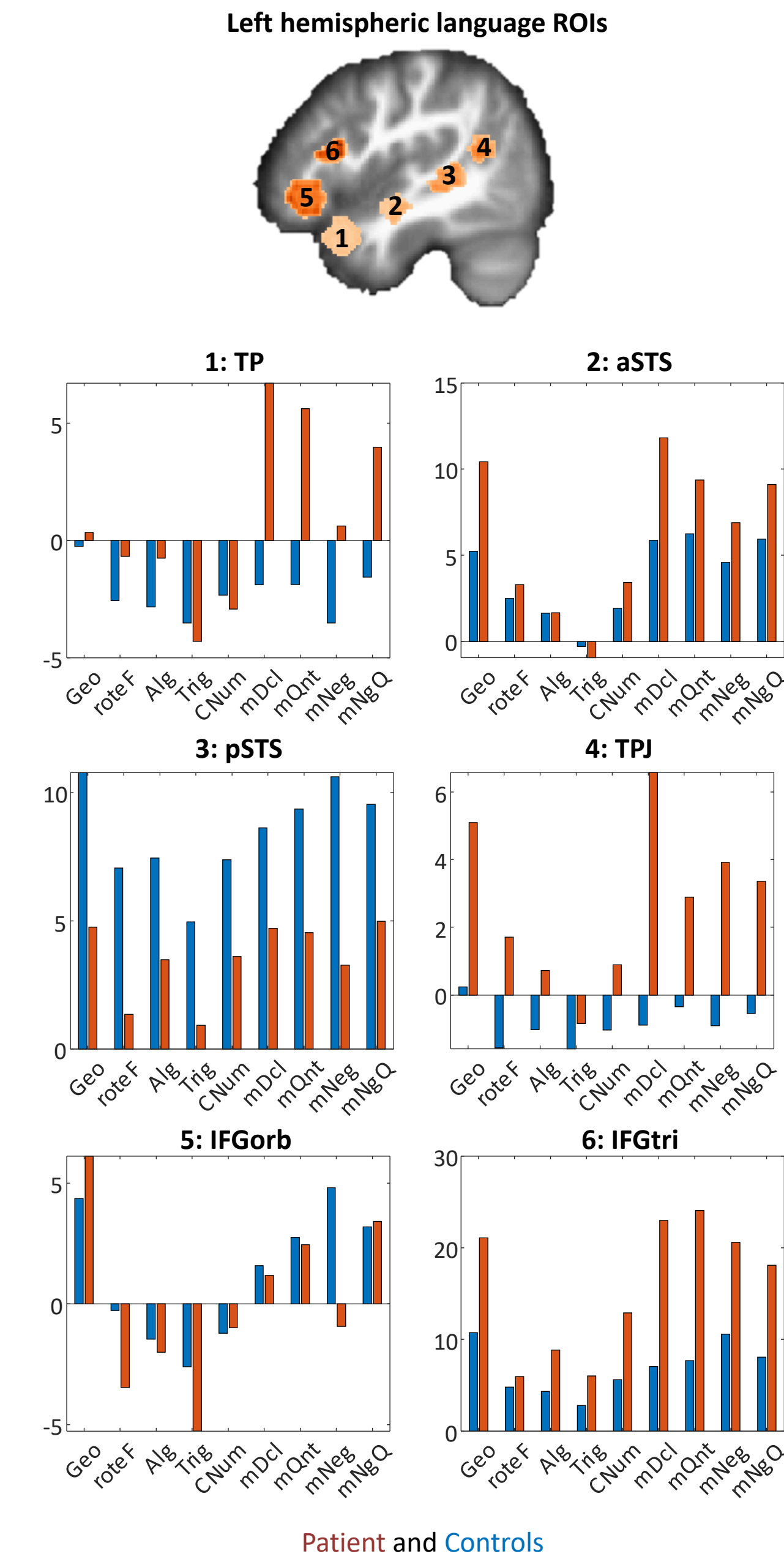
Category	% correct
Decl	~85
Quant	~85
Neg	~55
Neg quant	~85

Category	% correct
Decl	~95
Quant	~95
Neg	~90
Neg quant	~85

Major anatomical but minor functional differences



Language regions tend to be engaged for math reflection more by the patient than by the control group of mathematicians



CONCLUSIONS

- ❖ This study reports the exceptional case of a patient with high premorbid math competence, who suffered from acquired acalculia consecutive to a severe leuco-encephalopathy, and recovered substantial math skills through the deployment of verbal strategies.
- ❖ Our fMRI findings highlight the robustness of the math-responsive functional network despite major structural brain damage.
 - ❖ They also suggest that if the math- and language-responsive networks are functionally dissociated, they
- interact with each other, as the later seems to support the functional restoration of the former.

 - ❖ Without drawing general implications from a single-case study, the present results support the development of verbal compensatory strategies in other clinical contexts.

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