Longitudinal evidence for prefrontal and temporal learning systems during adult L2 acquisition

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Introduction

Learning to speak a second language (L2) was shown to recruit a number of brain regions (1) including:

a) the **canonical language network**, but also
b) low-level brain regions involved in **perception and articulation** of new speech sounds and writing systems, and
c) brain networks involved in **cognitive control** (2) and reward learning.

It is still unclear which brain regions are involved (3) in which phases (4) of **L2 learning in adults**. L2 learning success is equally difficult to define since it comprises a **number of different skills**.
Instead of explicitly testing L2 knowledge in different domains, we can also **infer** it **from** more **naturalistic production**.

Methods

Participants

- **56** Arabic mother tongue speaker (48 m ; age = 24.3 ± 4.5 years)
- Intensive **German language course** 3 months – 5 h x 5 days a week

Behavior

Specific tasks with explicit sentence judgment for syntax and semantics.

Analysis of text production for naturalistic measures of:
a) Lexical knowledge (mean word length);
b) Syntactic knowledge (syntactic level);
c) Overall proficiency (mean clause length)

Imaging

- Siemens 3T PRISMA MRT
- High resolution diffusion MRI (dMRI) 1.3 mm isotropic; 60 directions, b=1000, SMS 2, GRAPPA 2, 3 averages, 21 min
- **Two MRI time points**: beginning and after 3 months

Analysis

- dMRI preprocessing, (FSL)
- Single subject & group **FA template** (ANTS)
- FA normalization and 4mm smoothing
- Whole brain **V**oxel-**B**ased **S**tatistics (SPM)

References

1. Li, P. et al. (2014), Neuroplasticity as a function of second language learning: Anatomical changes in the human brain. *Cortex.*
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3. García-Pentón, L., et al. (2016) The neuroanatomy of bilingualism: how to turn a hazy view into the full picture. *Language, Cognition and Neuroscience.*
4. Pliatsikas, C. (2019) Understanding structural plasticity in the bilingual brain: The Dynamic Restructuring Model. *Bilingualism: Language and Cognition.*

Discussion

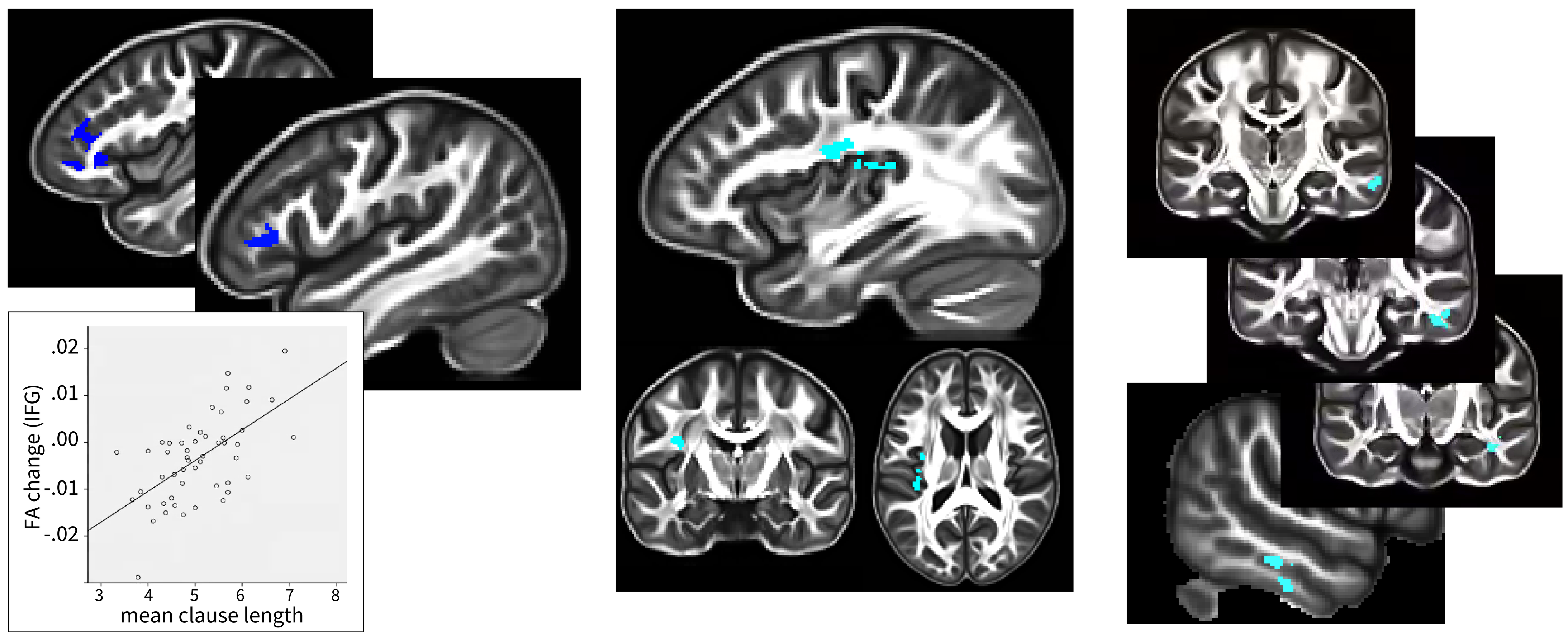
For successful language learning in an initial stage, the **three types of brain areas** showed plastic changes, **correlating to the complexity** of the text production of the participants. On the one hand, participants showed changes in the **left IFG and dorsal stream**, areas associated with both **word learning and the acquisition of hierarchical language rules**. We also find the **right MTG/ITG, involved in lexical and conceptual processing**. Additionally, we find areas implied in the **reward learning circuit** in the **medial and orbital PFC**.

Finally, we find **supplementary motor** areas involved in **speech planning**, probably important for **inner speech** and monitoring in less proficient learners.

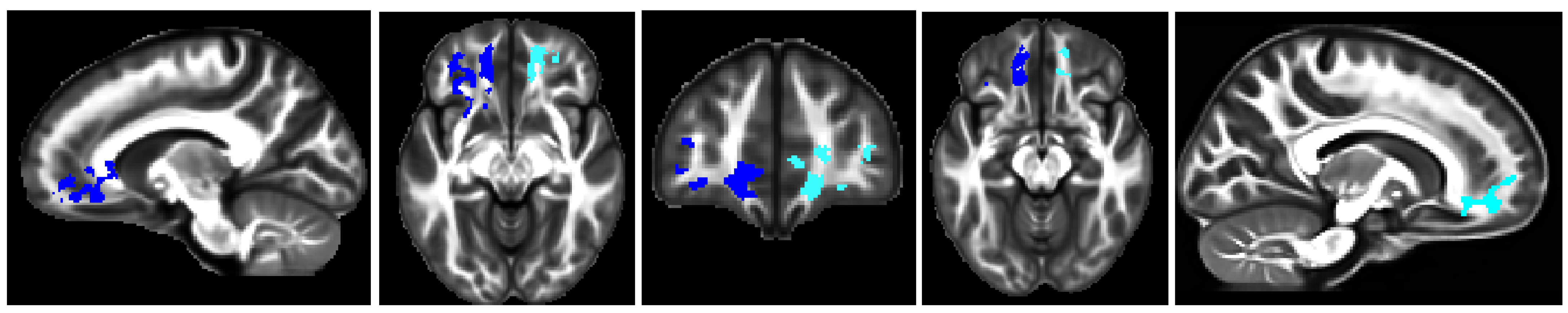
We need to now observe the **progression of these learners** and accompanying **brain changes** to assess which changes are **sustained during learned** and which ones are lost as well as to establish which further areas are recruited in **later stages of learning**.

Results

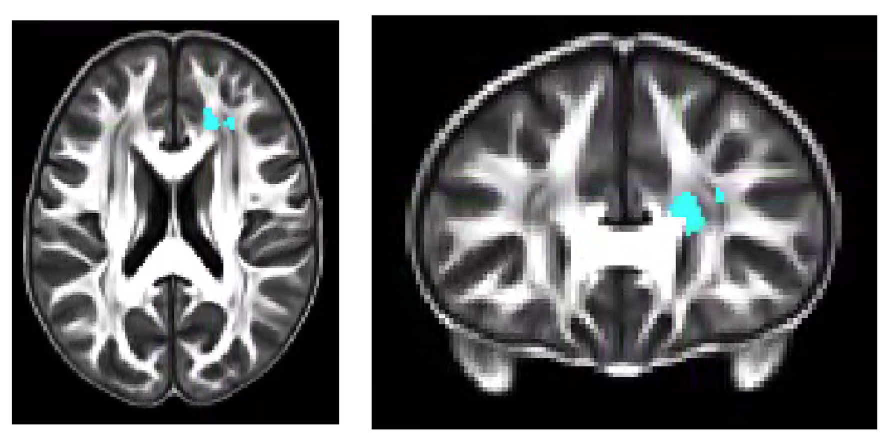
1 **Positive correlation** between **mean clause length** and **FA** in the
- left **IFG**; left **SLF/AF**; right **MTG/ITG**;



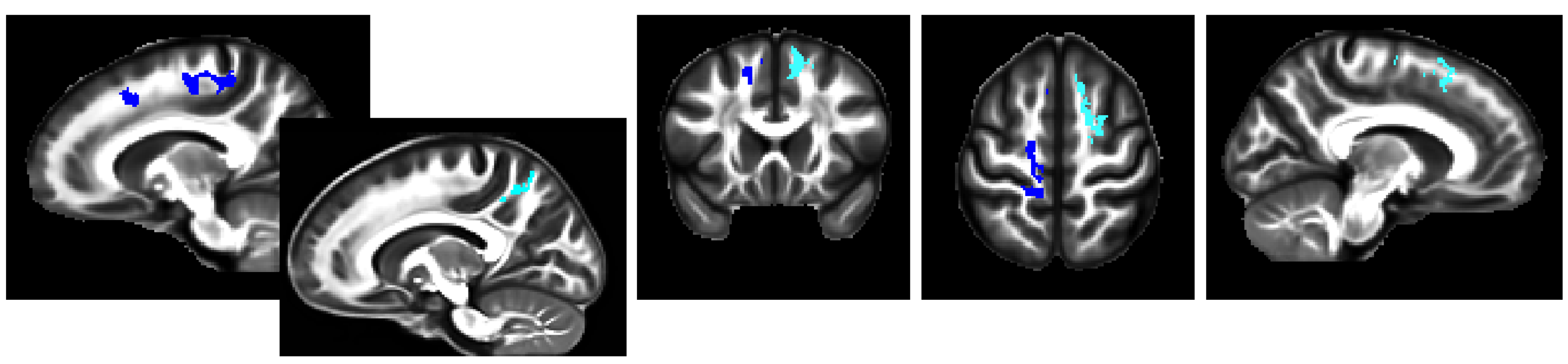
2
- bilateral **orbitofrontal** cortex



3
- **prefrontal** interhemispheric connections



4
- bilateral **SMA/pre-SMA** and left pre-cuneus



- At an early learning stage, explicit **syntactic and semantic** measures are highly **correlated**, probably not possible to distinguish them.

- We focus on a more **holistic** measure of learning success: **complexity** in production measured by **mean clause length**.