Neural representation of linguistic feature hierarchy reflects language proficiency

Giovanni Di Liberto **Jinping Nie**

Jeremy Yeaton, Bahar Khalighinejad, Shihab Shamma,

***Nima Mesgarani**

COLUMBIA | Zuckerman Institute

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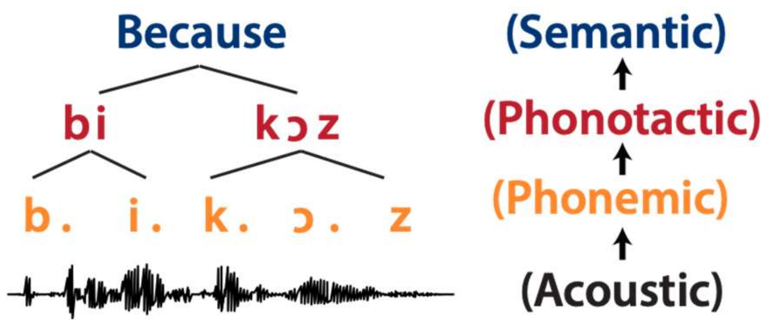
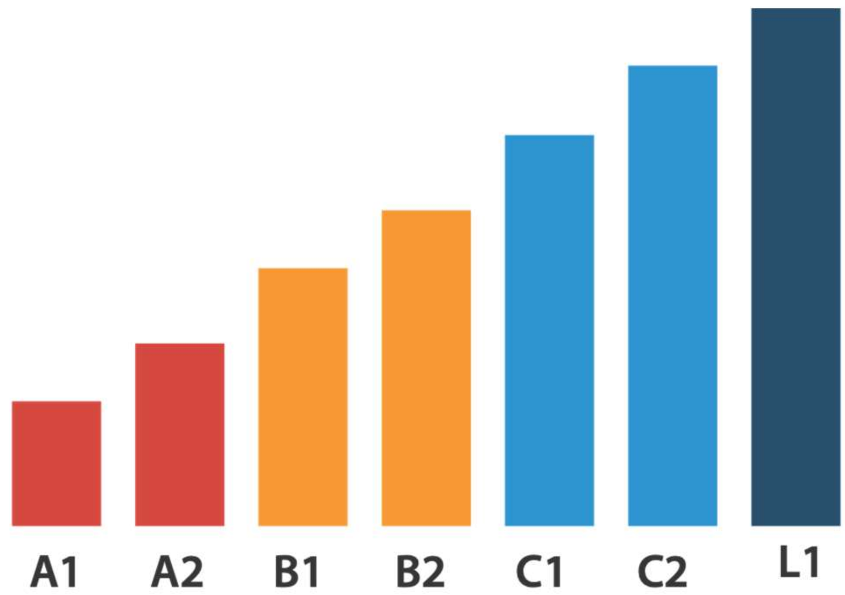
Speech processing hierarchy



- Learning a new language requires learning new sounds (**phonemes**), new sound combinations (**phonotactics**), and new words (**semantic**)
- Language acquisition is cumulative; proficiency can be quantified (e.g., Basic, Independent, Proficient)
- How does language proficiency change the neural representation of linguistic feature hierarchy?

Native (L1) and non-native (L2) English speaking subjects

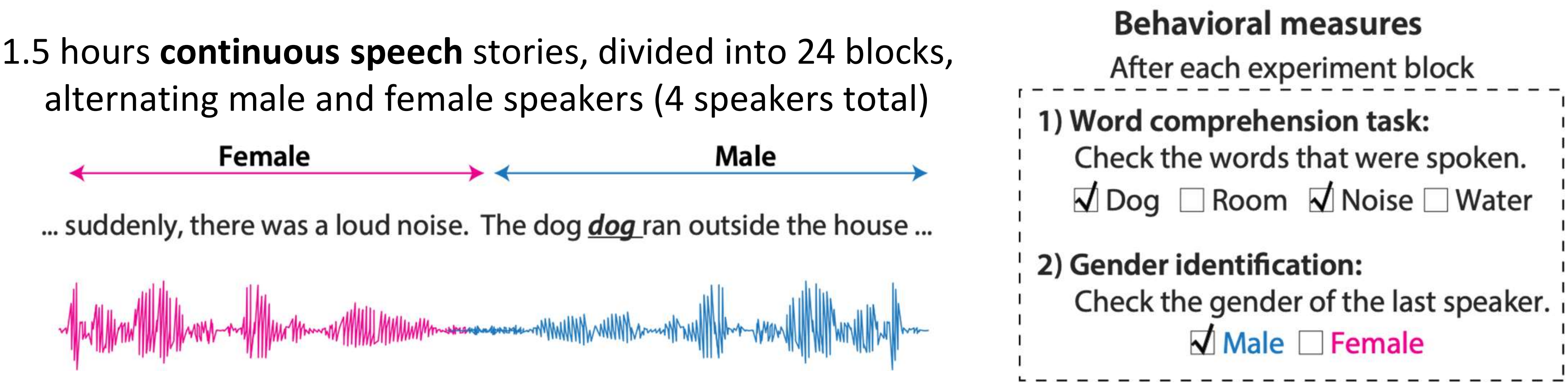


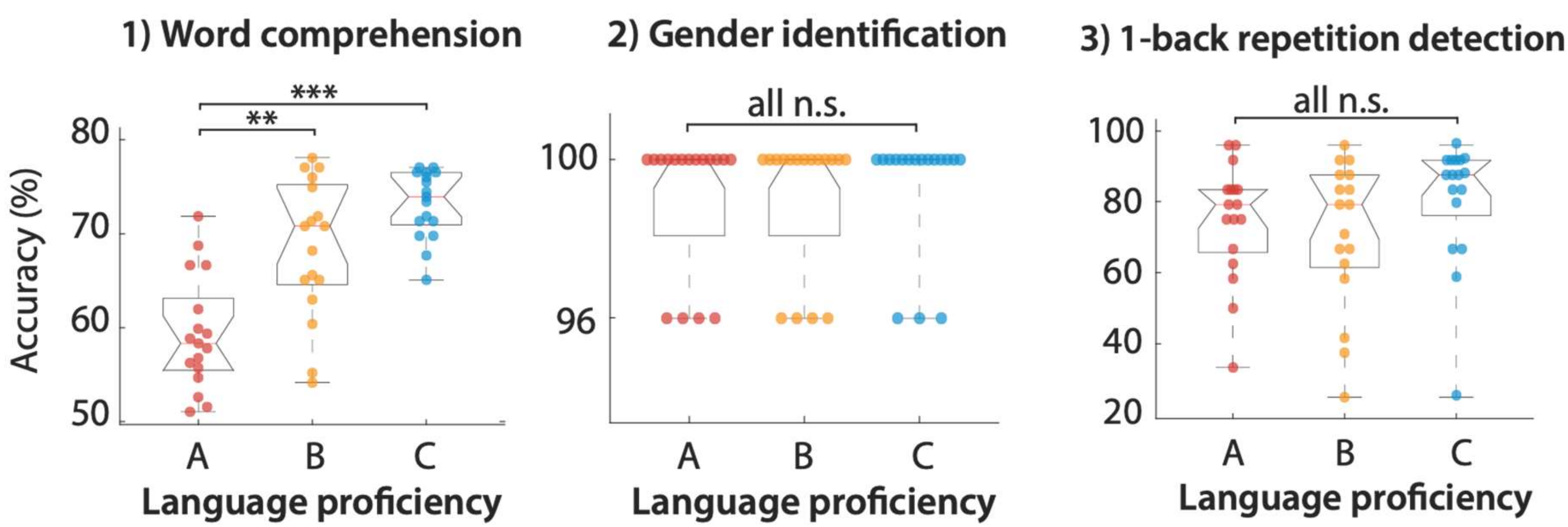
Language proficiency: Basic | Independent | Proficient | Native

Number of subjects: 17 | 16 | 16 | 22 | 71 total

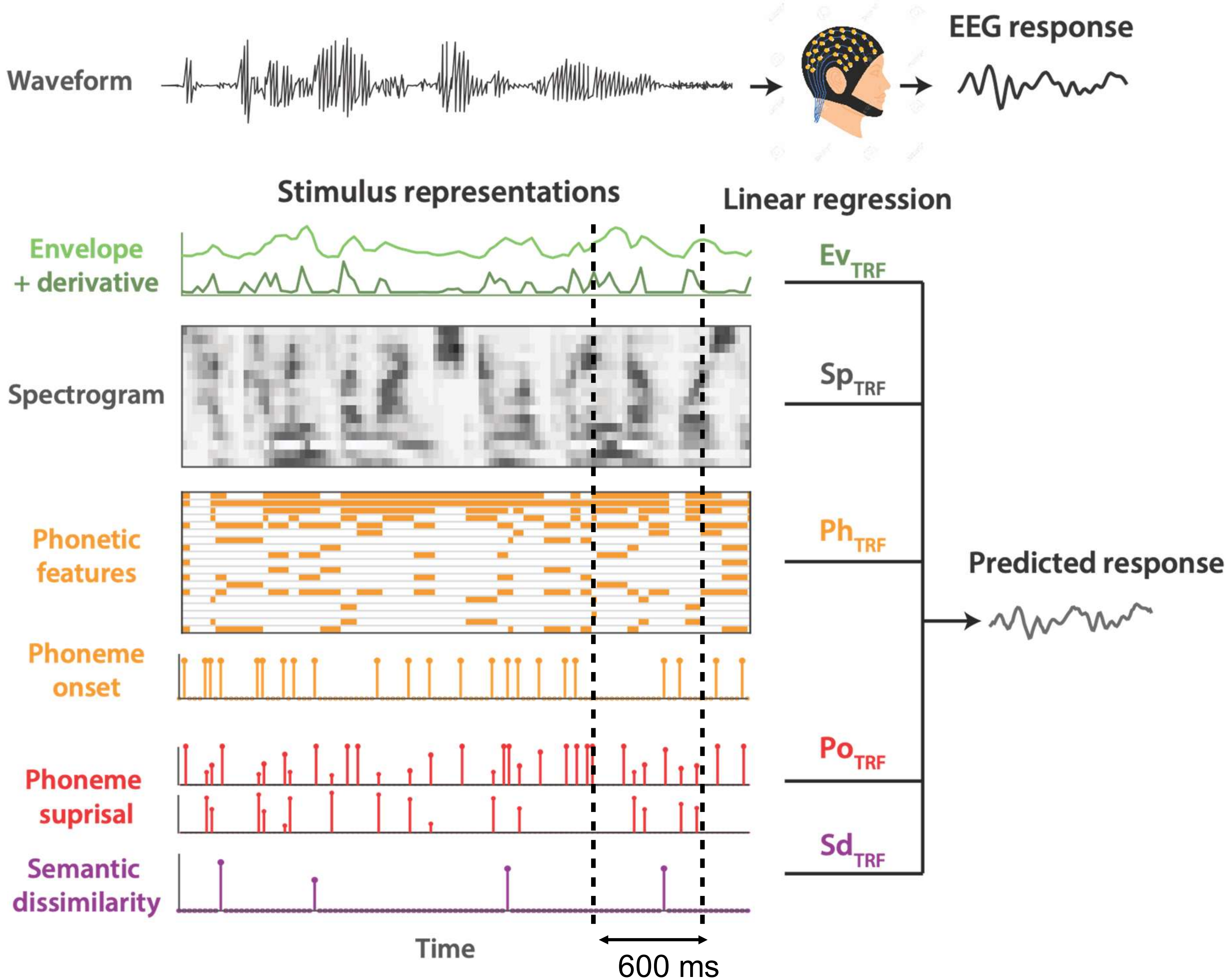
- L1: 22 Native English speakers
- L2: 49 Native Mandarin speaker with instructed English acquisition
- No significant difference between age and time in the US

Experimental procedure





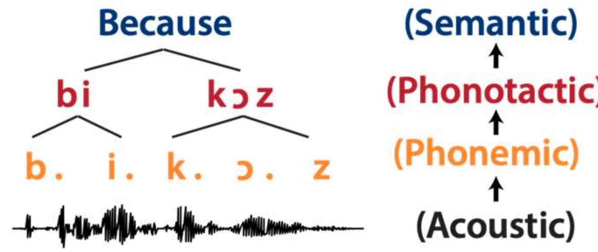
Similar task engagement



Regression weights (a.k.a TRF) show the contribution of each feature to the response

Lalor ' 2009, Di Liberto ' 2016,2019, Broderick ' 2018, Brodbeck ' 2018

Hypotheses



With increased language proficiency in L2 subjects, the neural representation of:

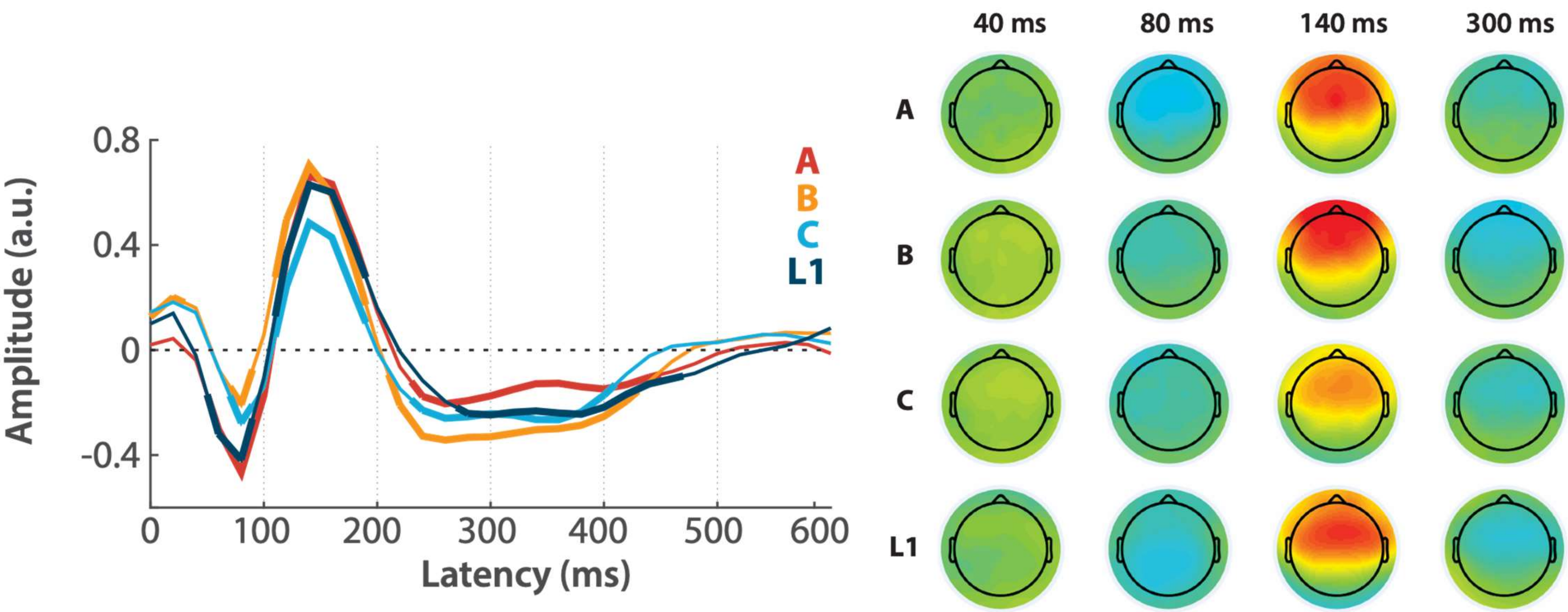
1. Low-level acoustic attributes will not change

2. English phonemes will be more similar to L1 (learned **phonetics**)

3. Phonotactics will approach L1, but not entirely to preserve L2 phonotactics (learned **phonotactics**)

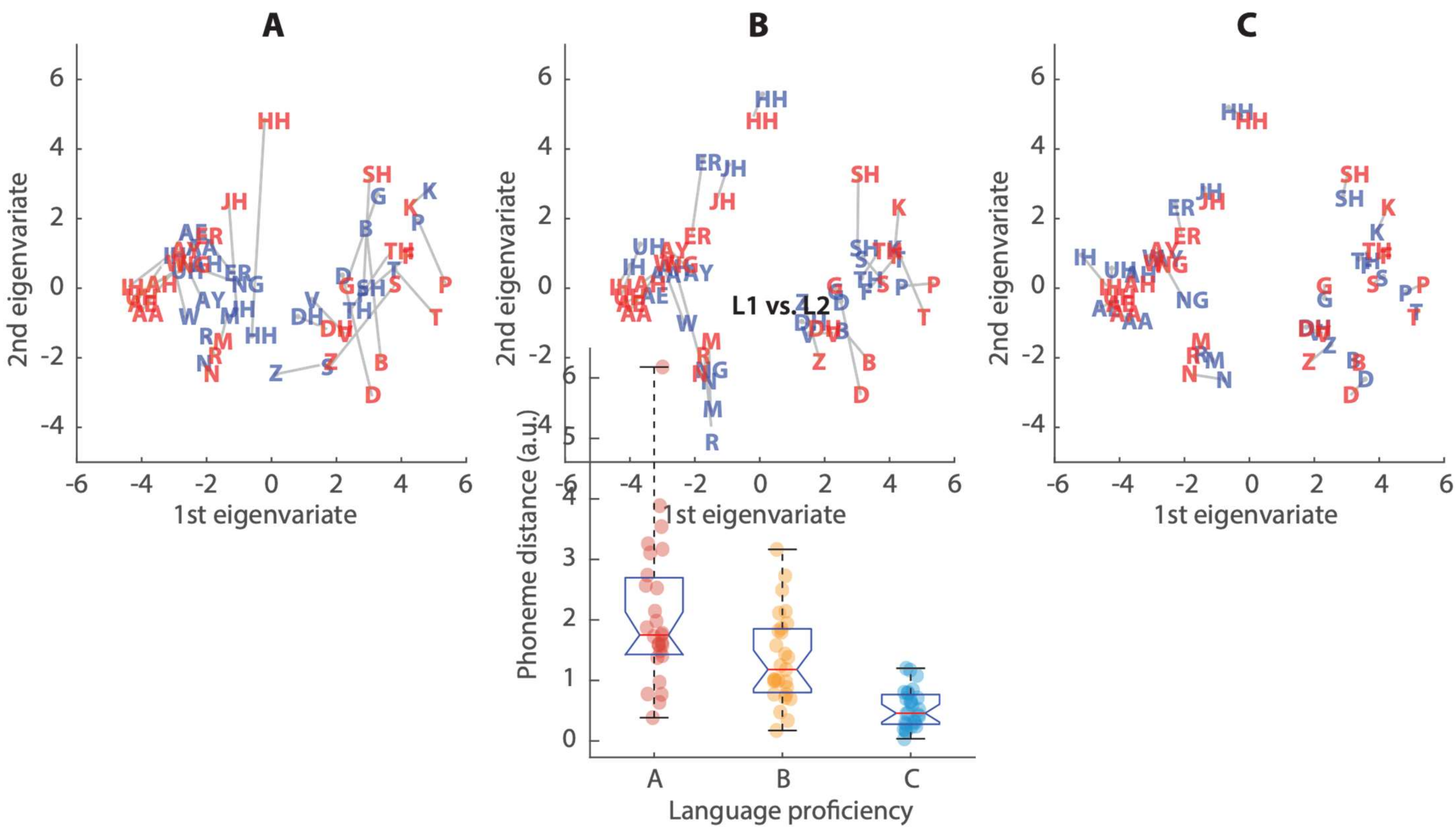
4. Semantic dissimilarity becomes more pronounced (learned **words**)

Envelope TRF



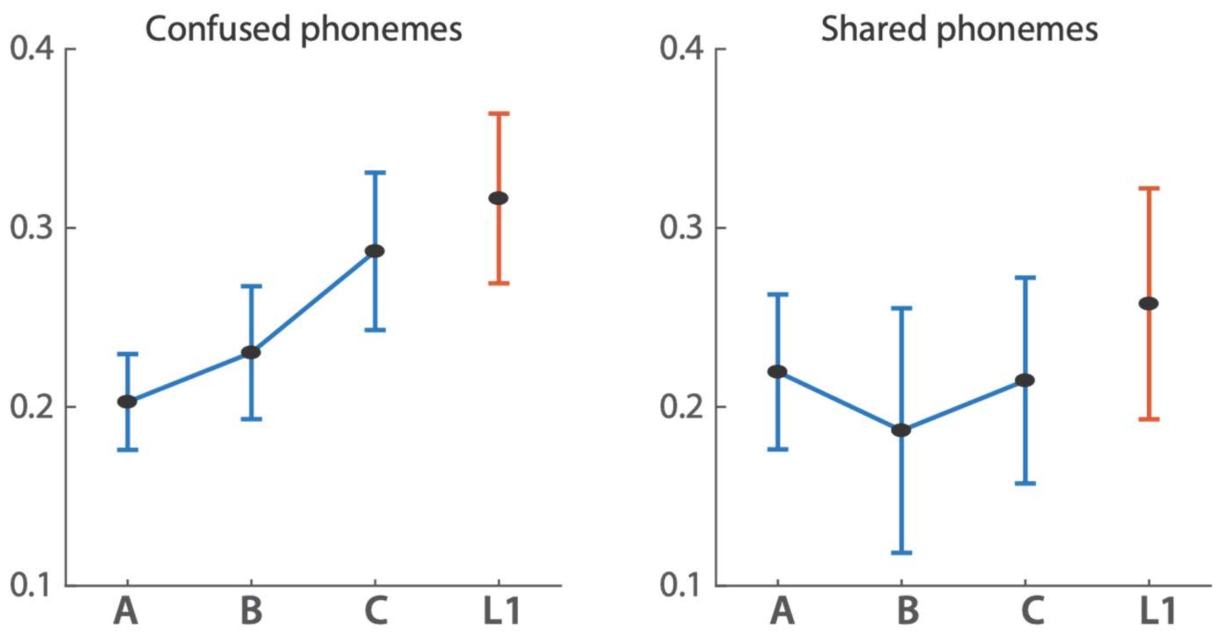
- Reflects the processing of basic acoustic features
- No significant change with proficiency

Phoneme TRF

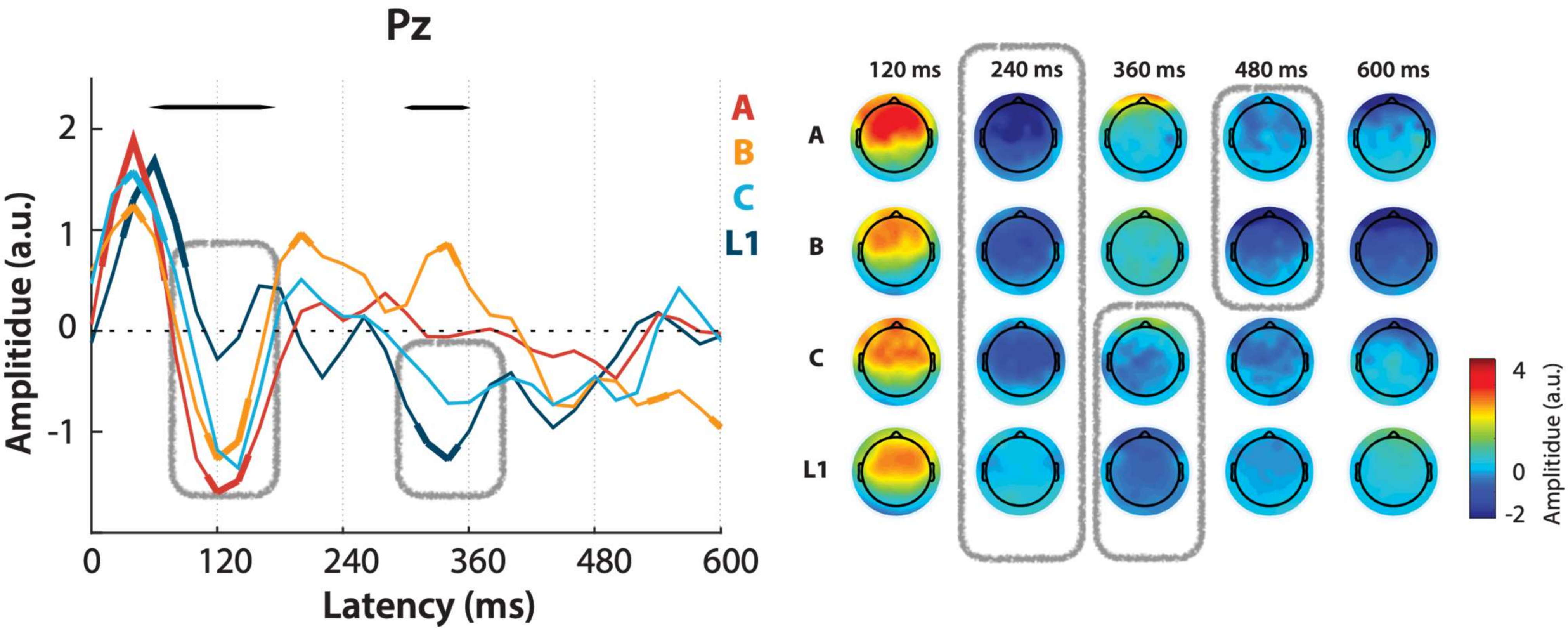


Proficiency shifts the neural representation of phonemes toward L1

Increased phoneme similarity to L1 is higher for English-only phonemic contrasts

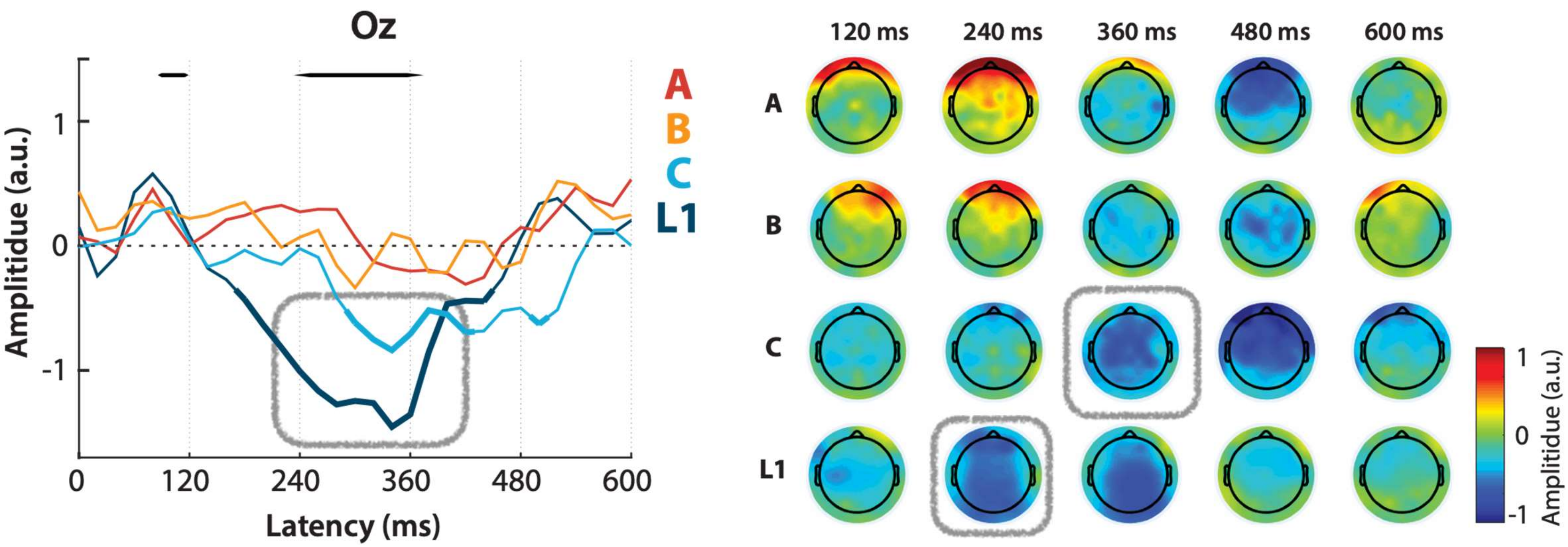


Learning new phoneme sequences: phonotactic TRFs



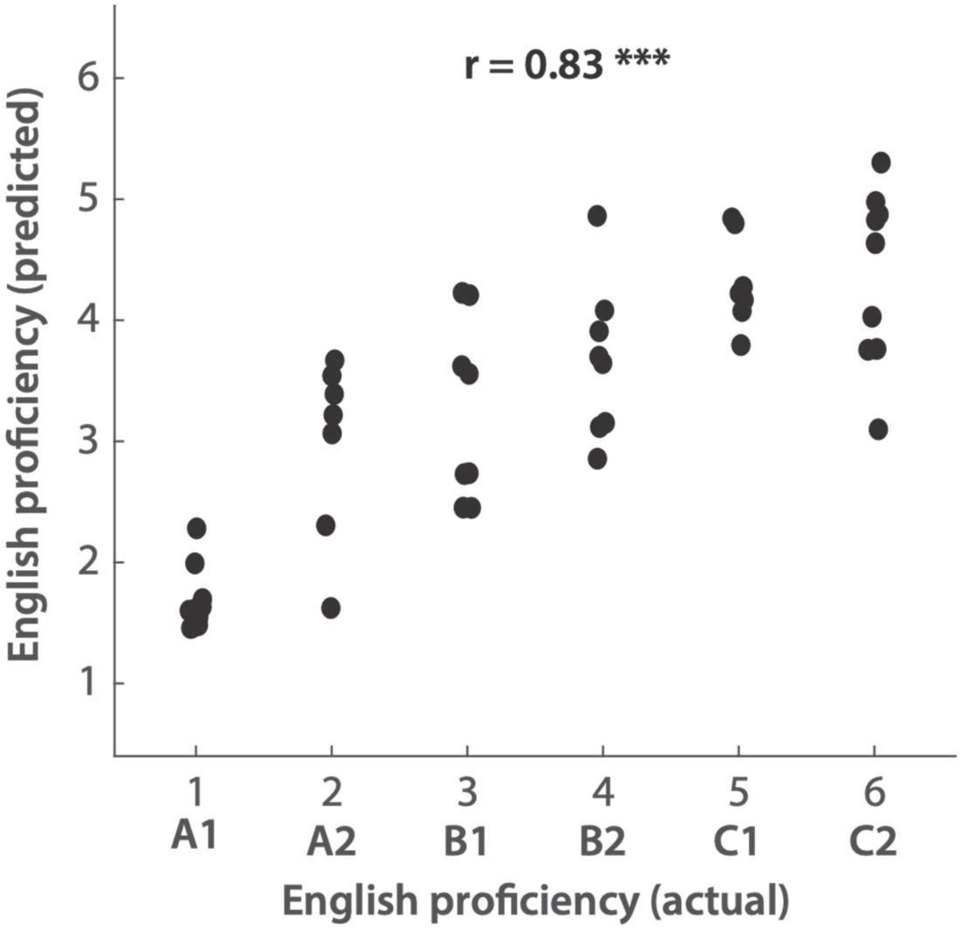
- Early negative in all **L2** subjects, but not in **L1** (~240 ms)
- Late Negative for **L1 & C** (~360ms), and even later for **A & B** (~ 480 ms)

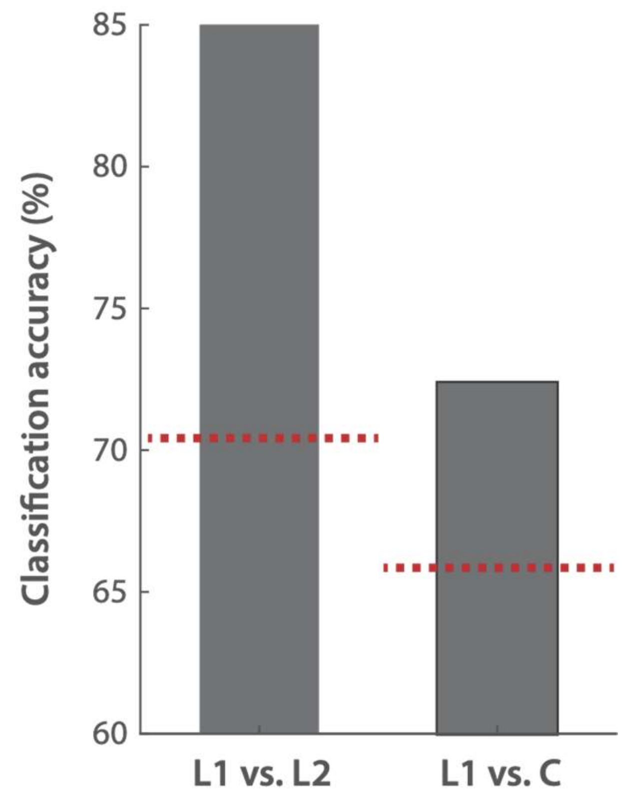
Semantic dissimilarity TRF



- Early negative in **L1** subjects (~240 ms), Later in **C** (~360 ms)
- Weaker in **A & B**

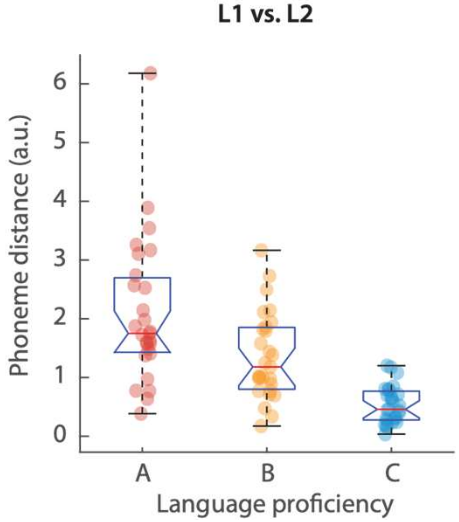
Predicting language proficiency from TRFs

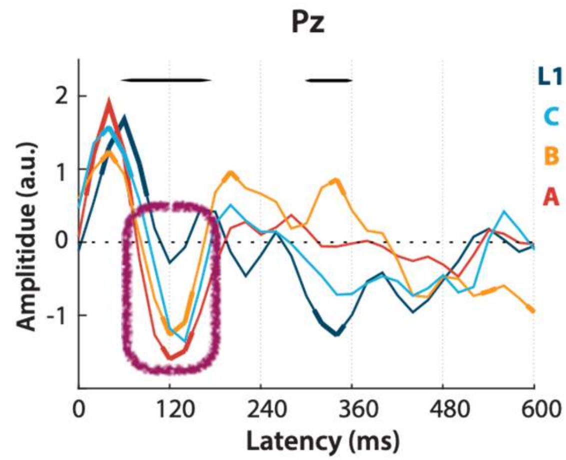


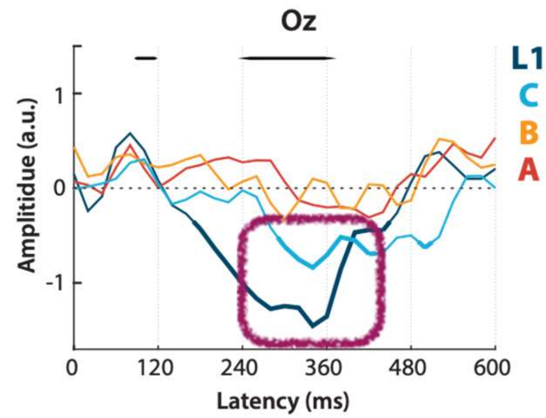


Language proficiency is highly predictable from EEG
High classification accuracy for **L1 vs. L2**, but also **L1 vs. C**

Proficiency changes the encoding of linguistic hierarchy in EEG responses to continous speech



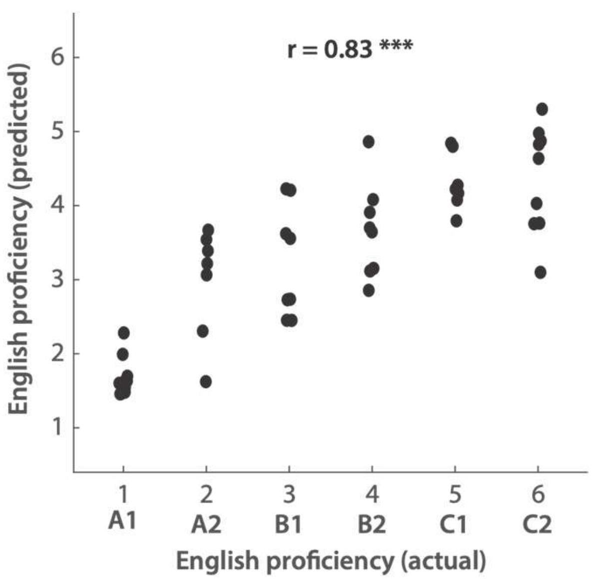




phonemes

phonotactics

semantic



- **Objective measure of proficiency & nativeness**
- **Age of acquisition, frequency of exposure, etc.**