Composition of Complex Numbers:
Delineating the computational role of the left anterior temporal lobe
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Introduction

1- What is the neurobiology of our ability to create an infinity of conceptual representations from the basic building blocks of language?

2- A broad methodologically diverse and internally consistent body of work strongly implicates the LATL as a basic site for semantic combination.

3- However the work on semantic combination has been quite focused on one particular domain: the adjectival modification of nouns.

4- When trying a different type of combination, del Prato and Pylkkänen (2014) found that semantic composition but not numerical quantification elicit activity in this region.

5- Thus three possibilities arise:

  a) The combination of two clear content words is required.
  b) The modification by a content word is required.
  c) The computations underlying numerical quantification in particular are not a valid combinatorial process.

6- The goal of the experiment:

Characterize which specific computations engage the LATL
AND
which elements are valid as input to create these complex conceptual representations.

7- MEG activity was analyzed in areas previously implicated in combinatory processes, including the left anterior temporal lobe (LATL), the ventro-medial prefrontal cortex (vmPFC), the left inferior frontal gyrus (LIFG) and the angular gyrus (AG).

Materials and Methods

- 25 right-handed English native speakers.

- Continuous MEG data acquired during experimental session, 208 sensor array.

- Acquisition recording band 0-200Hz, sampling rate of 1000 Hz.

- Five conditions partitioned by block; pre-empted with **condition-specific instruction.**
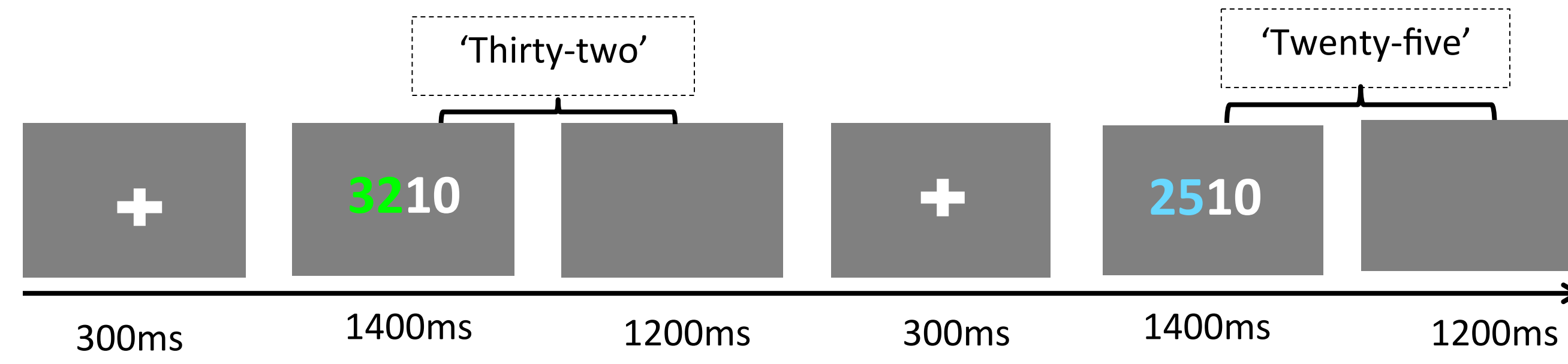
A. Color modification: "Describe the colored digits"

'Green twos' | 'Blue fives'
2212 | 5510
300ms | 1400ms | 1200ms | 300ms | 1400ms | 1200ms
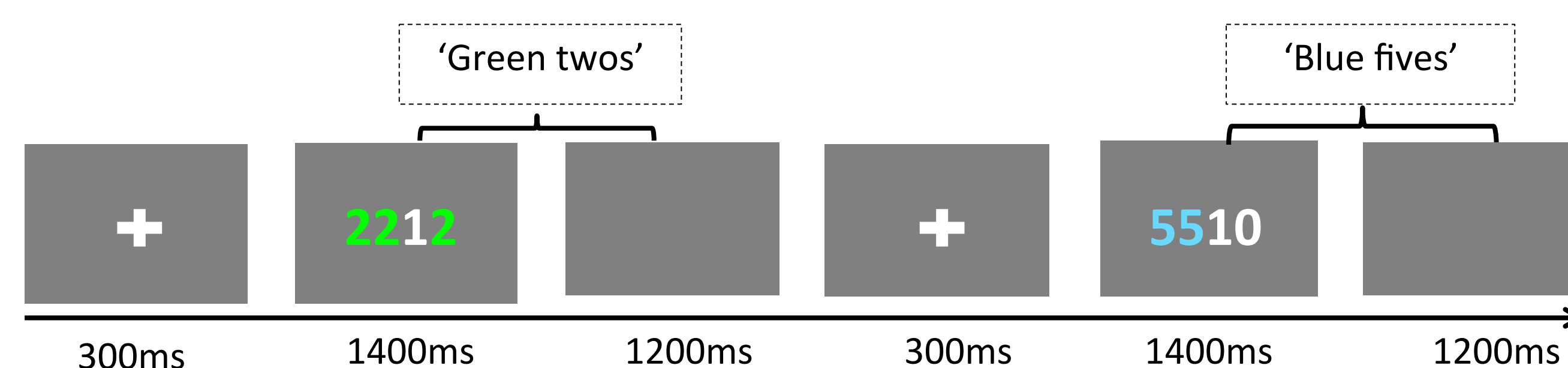
B. Numeral quantification: "Name the quantity of colored digits and name the digits that are colored"

'Three twos' | 'Two fives'
2212 | 5510
300ms | 1400ms | 1200ms | 300ms | 1400ms | 1200ms
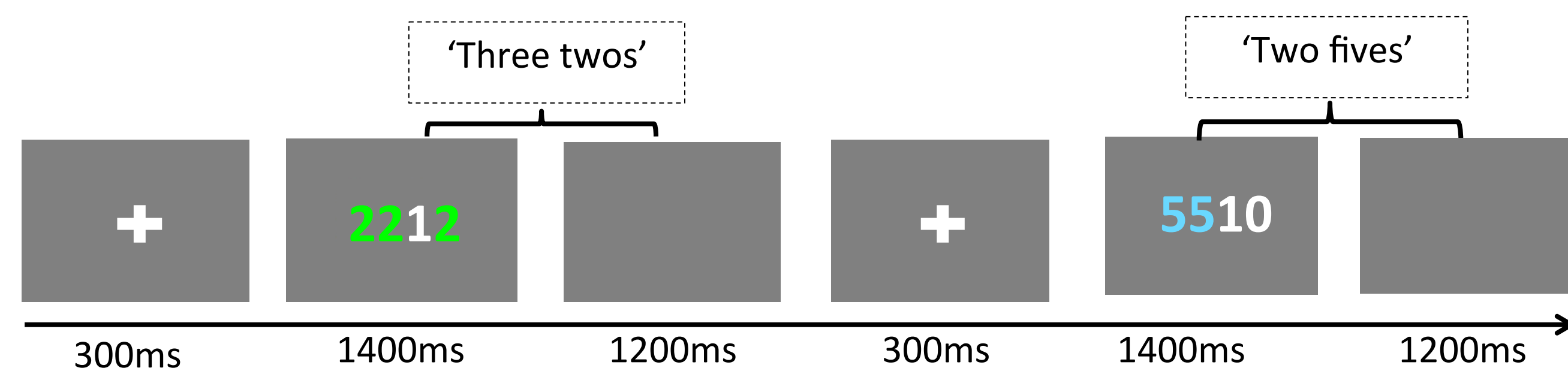
C. Complex number production task: "Name the colored complex number"

'Thirty-two' | 'Twenty-five'
3210 | 2510
300ms | 1400ms | 1200ms | 300ms | 1400ms | 1200ms

D. Complex number list task: "Name the colored complex number on the left and the colored units digit on its right individually"

'Thirty, two' | 'Twenty, five'
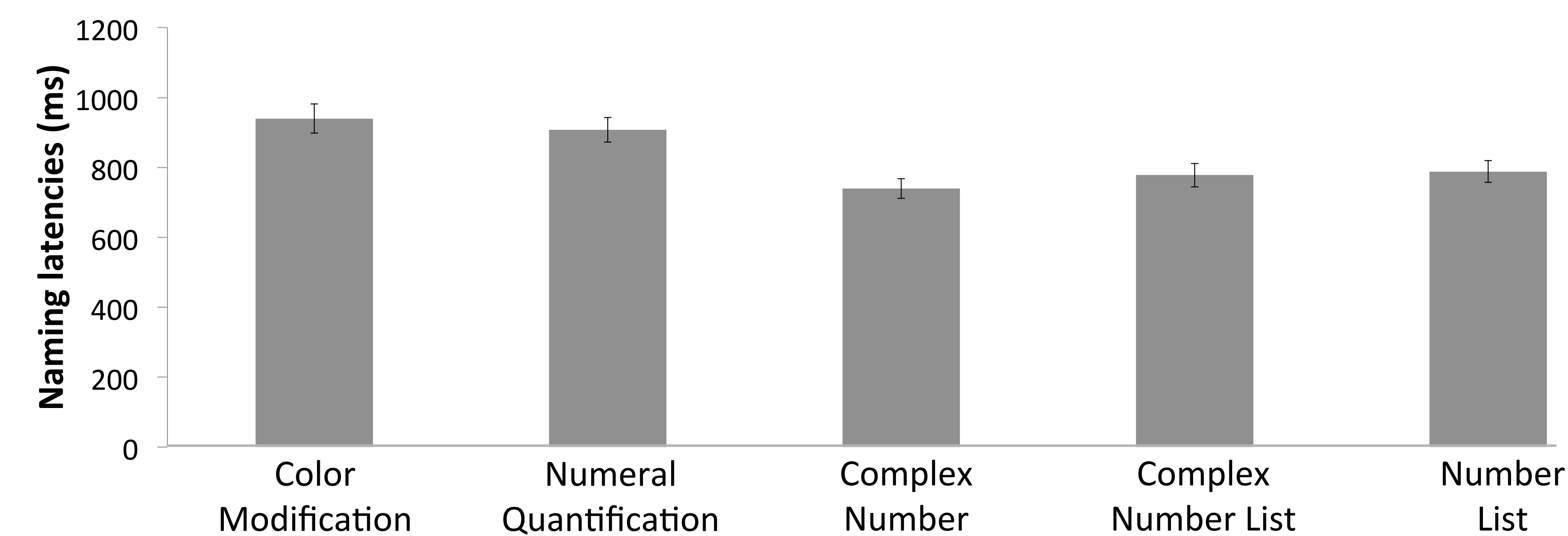3012 | 2051
300ms | 1400ms | 1200ms | 300ms | 1400ms | 1200ms
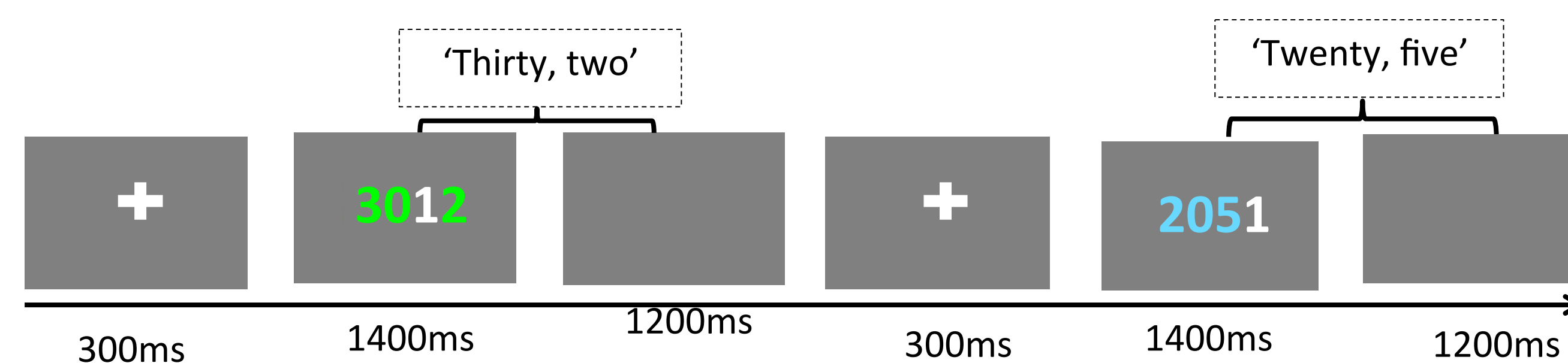
E. Number list production task: "Name the colored digits individually"

'Three, two' | 'Two, five'
3210 | 2510
300ms | 1400ms | 1200ms | 300ms | 1400ms | 1200ms
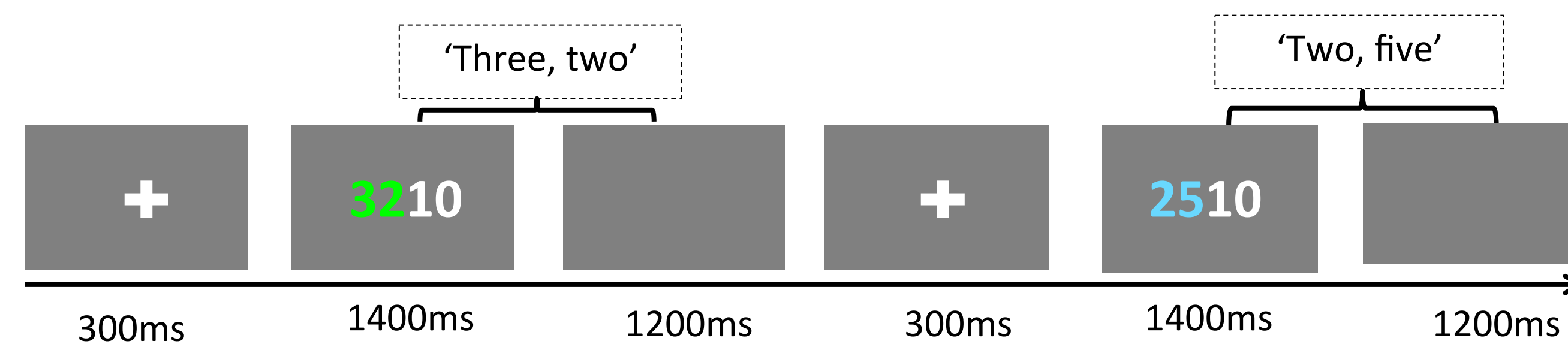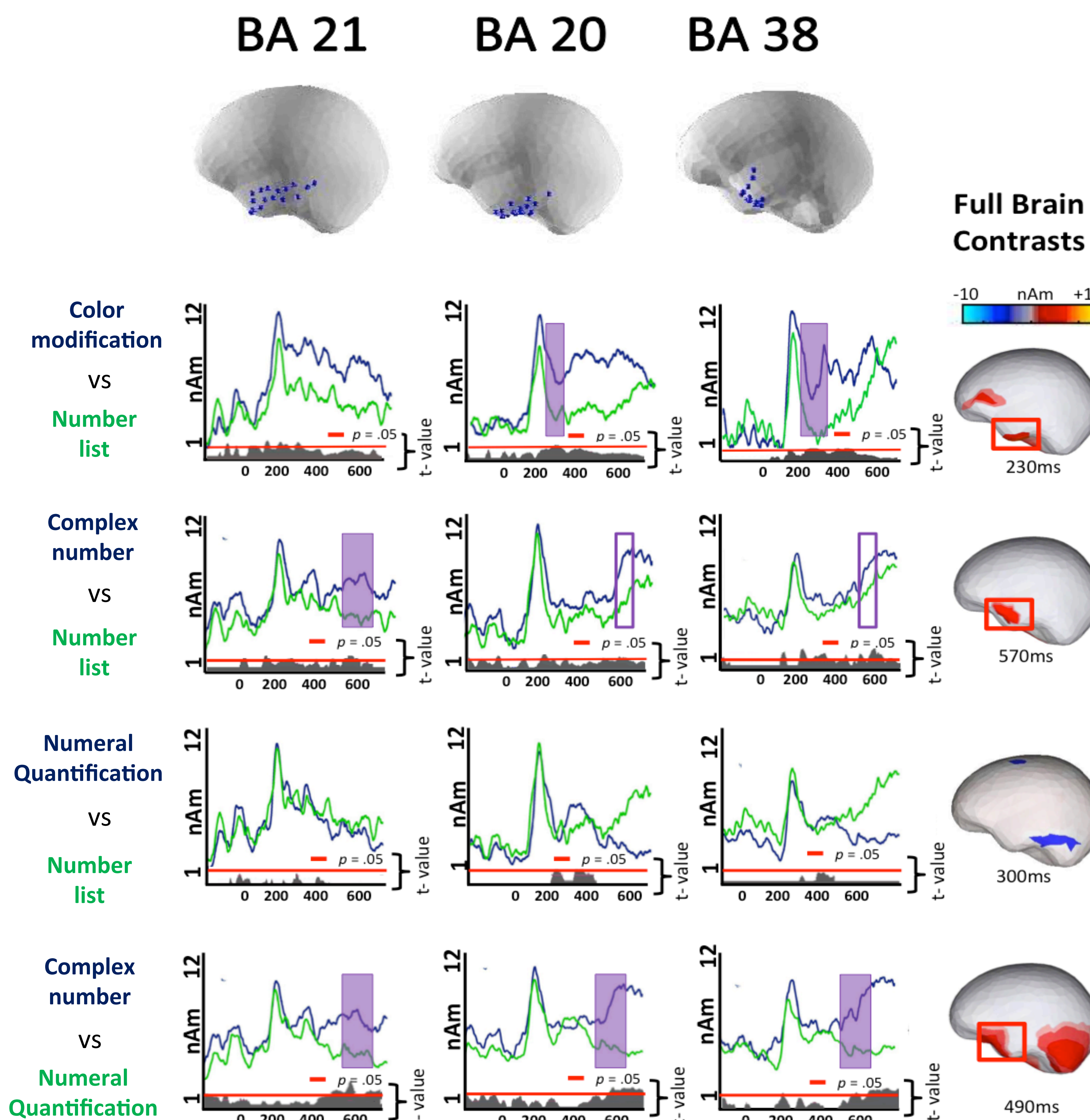
Behavioral Results

1 x 5 ANOVA:

ROI analyses: LATL

- **2 x 2 ANOVA:** Domain (Language/Category) x Switch: (Switch/Non-switch).
- **Time intervals:** 300:500 and 500:700ms.
- **Main effect of Switch**: p = 0.002

Composition effects in the LATL

BA 21   BA 20   BA 38

Color modification VS Number list — 230ms
Complex number VS Number list — 570ms
Numeral Quantification VS Number list — 300ms
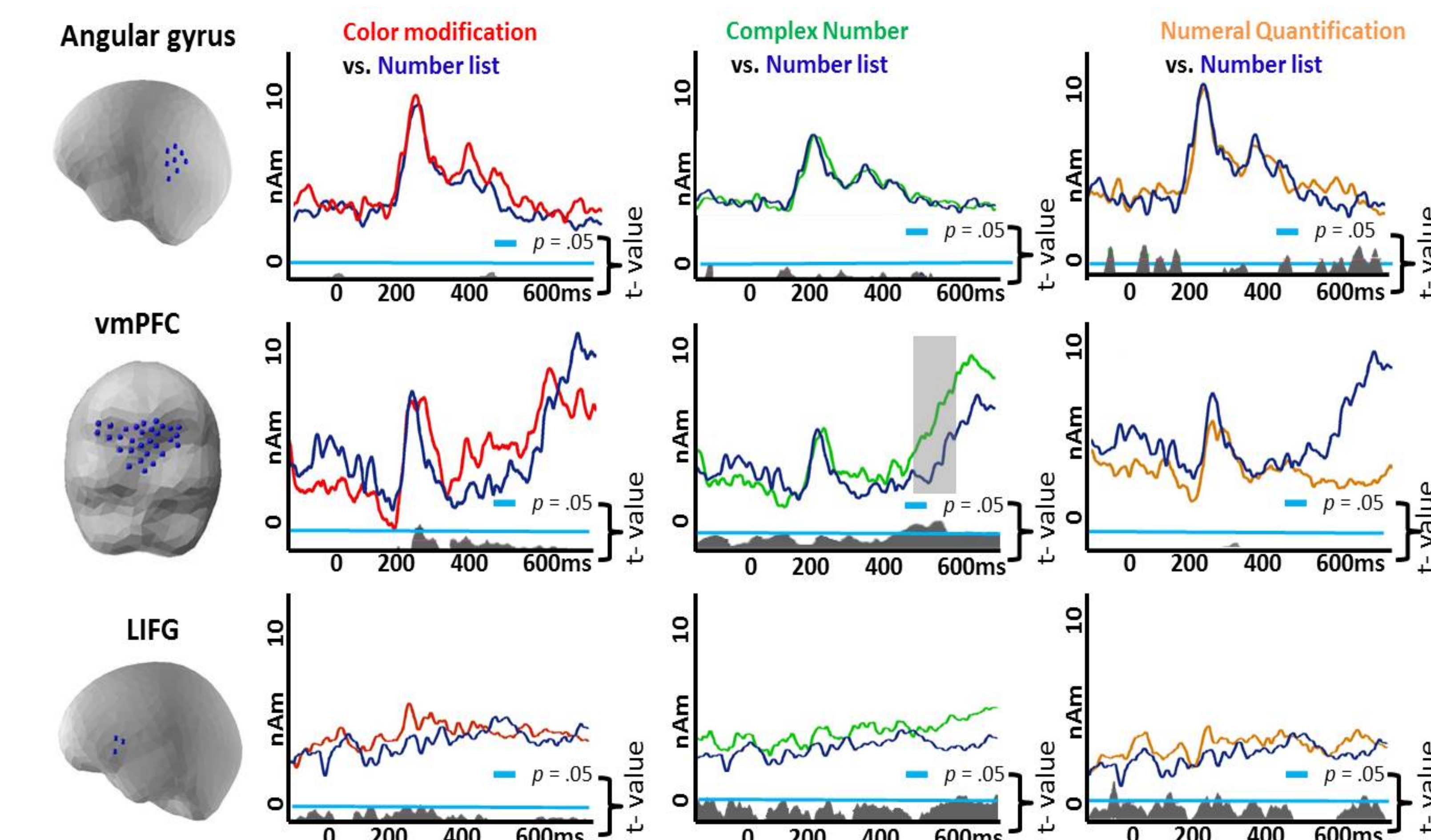Complex number VS Numeral Quantification — 490ms

ROI analyses: Switching in Comprehension

- **2 x 2 ANOVA:** Domain (Language/Category) x Switch: (Switch/Non-switch).
- **Time intervals:** 300:500 and 500:700ms.
- **Interaction**: p = 0.01

Angular gyrus / vmPFC / LIFG
Color modification vs. Number list / Complex Number vs. Number list / Numeral Quantification vs. Number list

Conclusions

- This finding suggests that the LATL is not a general purpose combiner of meanings but rather specializes in some version of conceptual combination.

- This conceptual combination is potentially delimited to situations where one combining element characterizes a property of the other.

- The finding of combinatorial activity for our complex number condition conforms to theories suggesting that complex numbers undergo a composition process before being produced as opposed to being holistically processed and retrieved.

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