

Introduction

- What is the neurobiology of our ability to create an infinity of conceptual representations from the basic building blocks of language?
- A broad methodologically diverse and internally consistent body of work strongly implicates the LATL as a basic site for semantic combination.
- However the work on semantic combination has been quite focused on one particular domain: the adjectival modification of nouns.
- When trying a different type of combination, del Prato and Pykkänen (2014) found that semantic composition but not numerical quantification elicit activity in this region.
- 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.
- Complex numbers are an interesting case as they can fulfill the place of the adjective and the noun.
- Additionally, it is an empirical question whether complex numbers are processed compositionally or holistically.
- The goal of the experiment:

Characterize which elements constitute valid input to create the type of complex conceptual representations that engage the LATL

AND

Define whether complex numbers undergo a composition process before being produced

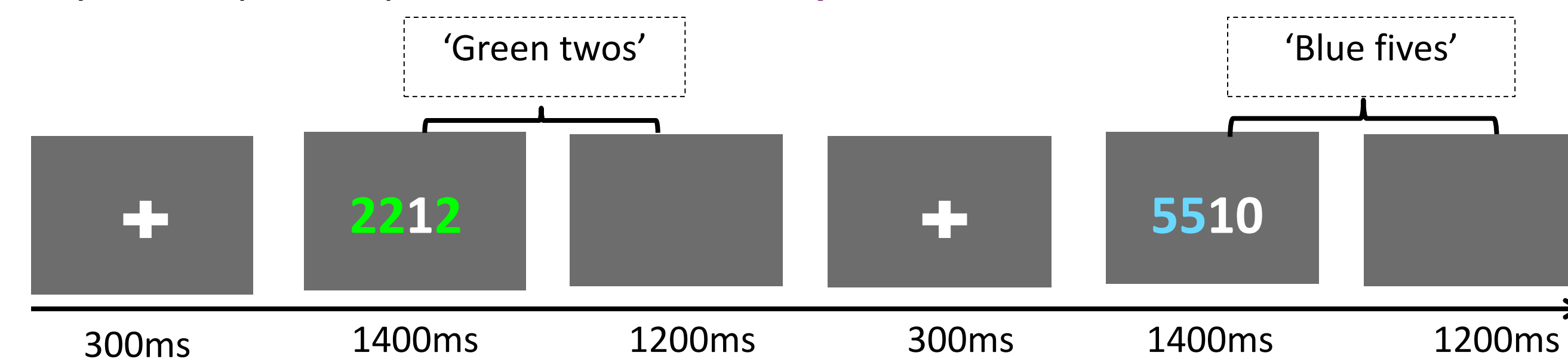
- MEG activity was analyzed in areas previously implicated in combinatory processes, including the left anterior temporal lobe (LATL), the ventro-medial prefrontal cortex (vmPFC), the left inferior frontal gyrus (LIFG) and the angular gyrus (AG).

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**.

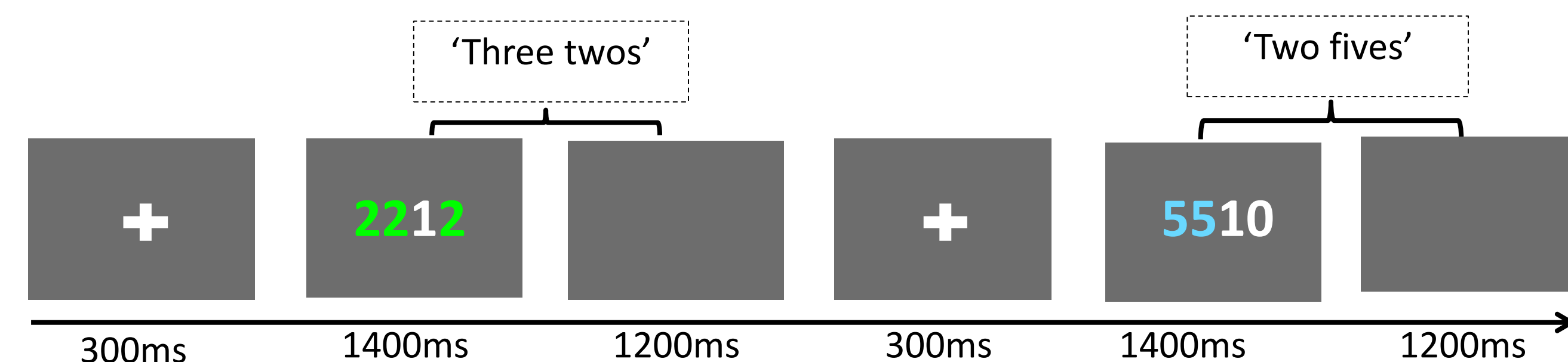
A. Color modification:

"Describe the colored digits"



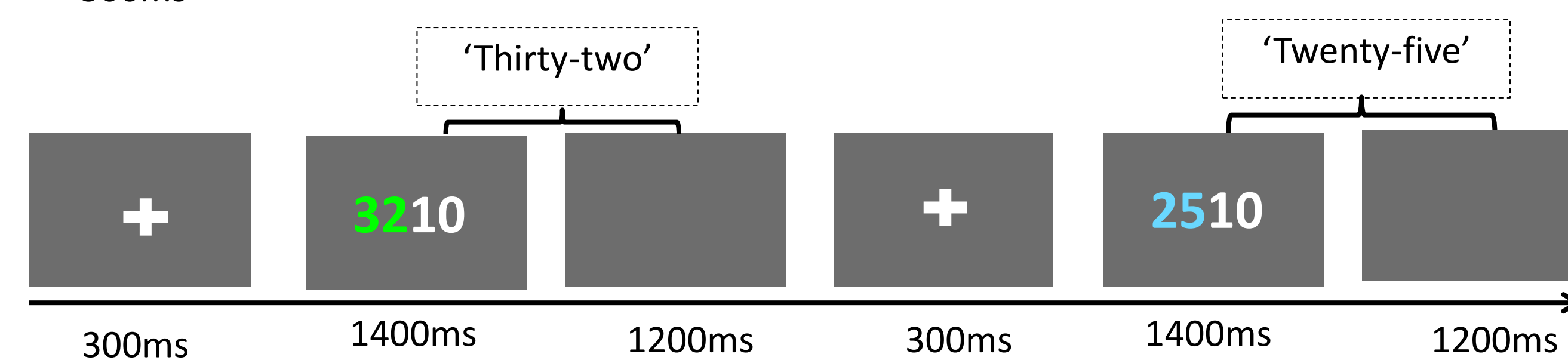
B. Numeral quantification:

"Name the quantity of colored digits and name the digits that are colored"



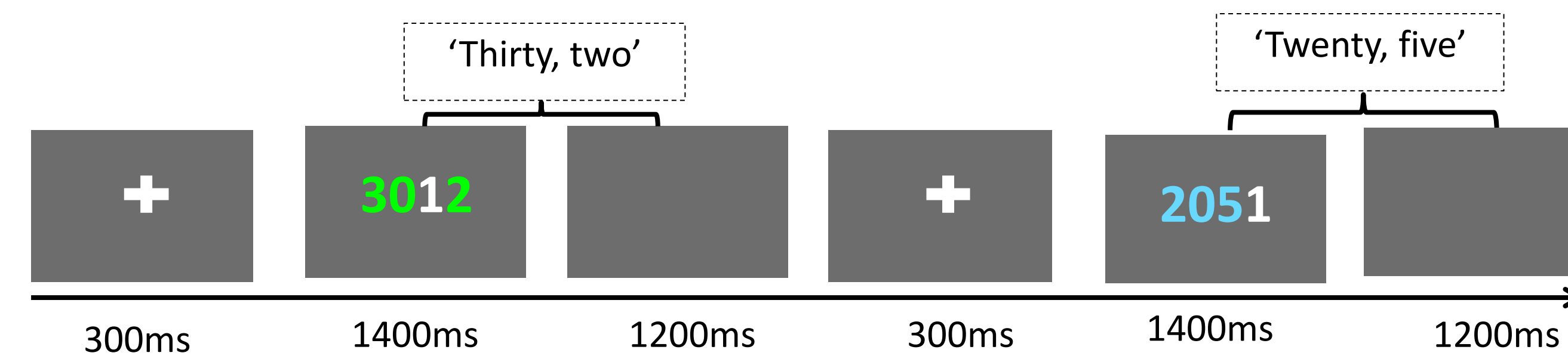
C. Complex number production task:

"Name the colored complex number"



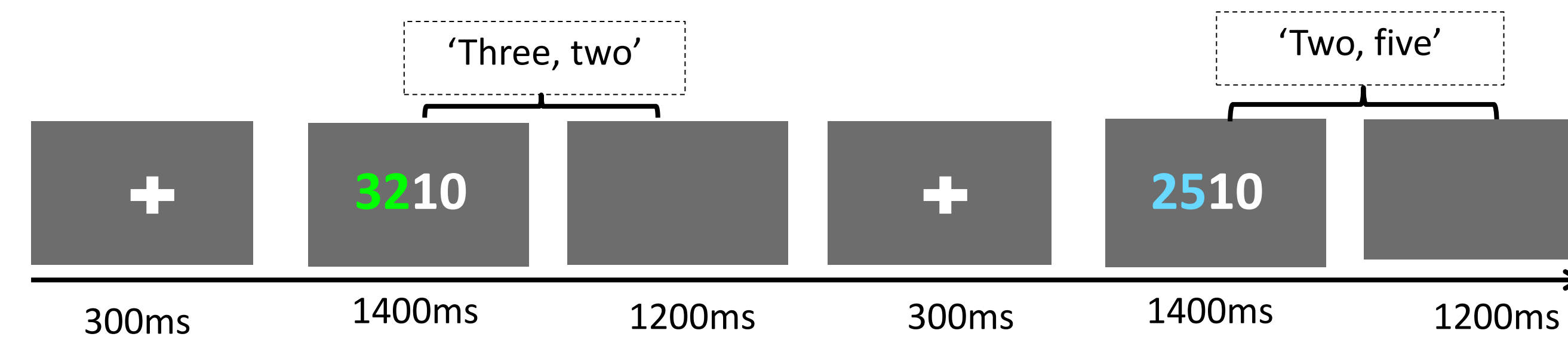
D. Complex number list task:

"Name the colored complex number on the left and the colored units digit on its right individually"



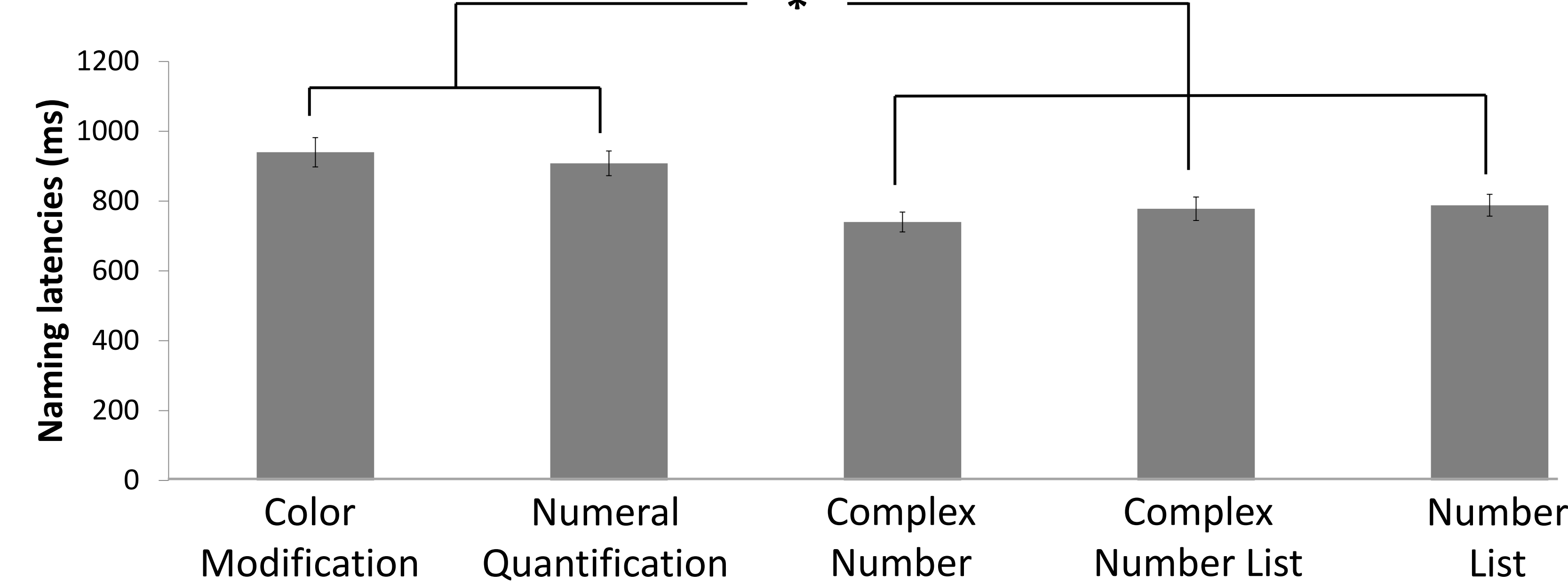
E. Number list production task:

"Name the colored digits individually"



Behavioral Results

1 x 5 ANOVA:



- Significantly longer naming latencies for conditions that involved naming a plural Noun Phrase.

ROI analyses: LATL

- **Pairwise comparisons:** 150:400 ms and 400:600 ms.
- **Shaded regions** indicate that the difference in activity between the two tested conditions was significant at a $p = .05$ value (corrected), while the **boxed region** indicates marginally significant effects ($p < .1$)

Composition effects in the LATL:

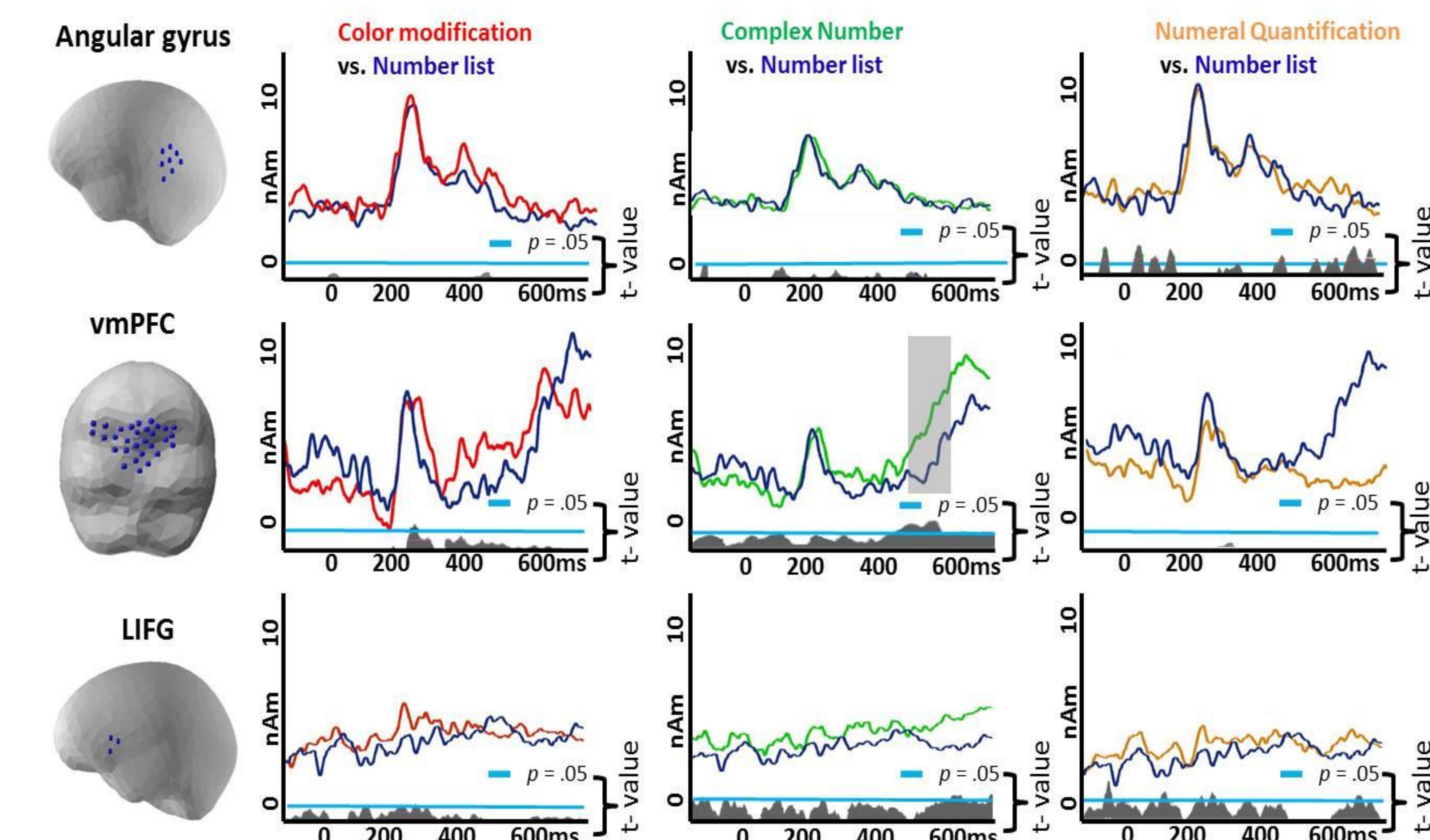
- Reliable combinatorial increases for Color Modification (150:400 ms) and Complex number composition (400:600 ms) over Number lists.
- No difference between Numeral Quantification and Number lists.

ROI analyses: Switching in Comprehension

- **Pairwise comparisons:** 150:400 ms and 400:600 ms
- **Shaded regions** indicate that the difference in activity between the two tested conditions was significant at a $p = .05$ value (corrected).

Results:

- vmPFC activity revealed trends towards increases for Complex numbers and color modification.
- Neither the AG or the LIFG showed reliable effects.



Conclusions

- While quantificational phrases failed to engage the LATL, both adjectival modification and complex numbers reliably engaged the LATL.
- The engagement of the LATL is determined by the computations underlying the performed combinatorial process as opposed to the nature of the input items.
- 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.



Contact: eb134@nyu.edu

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