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

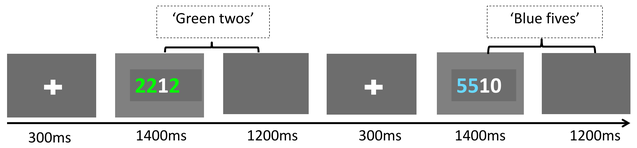
which elements are valid as input to create these complex conceptual representations.

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).

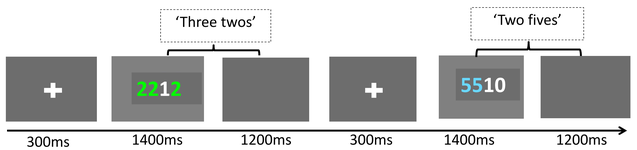
Materials and Methods

- 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.**

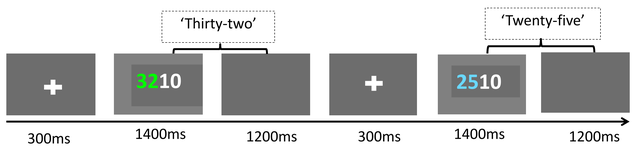
A. Color modification:
"Describe the colored digits"



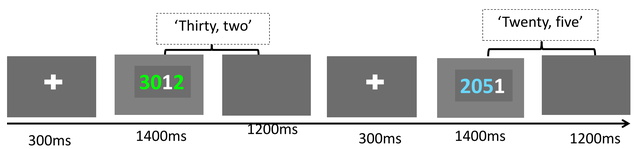
B. Numeral quantification:
"Name the quantity of colored digits and name the digits that are colored"



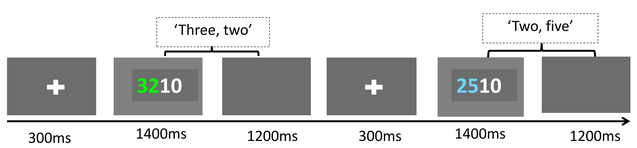
C. Complex number production task:
"Name the colored complex number"



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

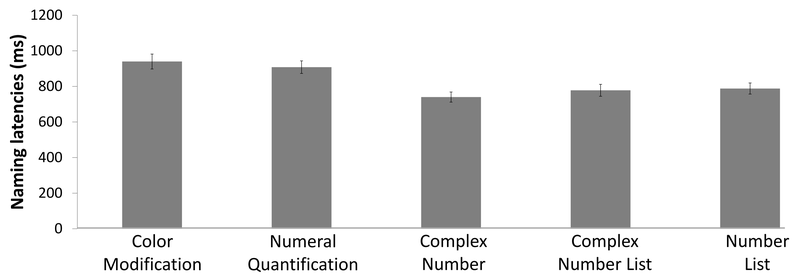


E. Number list production task:
"Name the colored digits individually"



Behavioral Results

1 x 5 ANOVA:



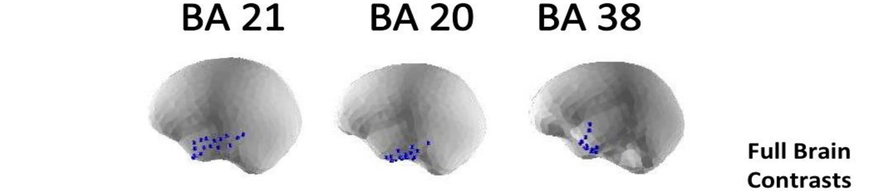
ROI analyses: LATL

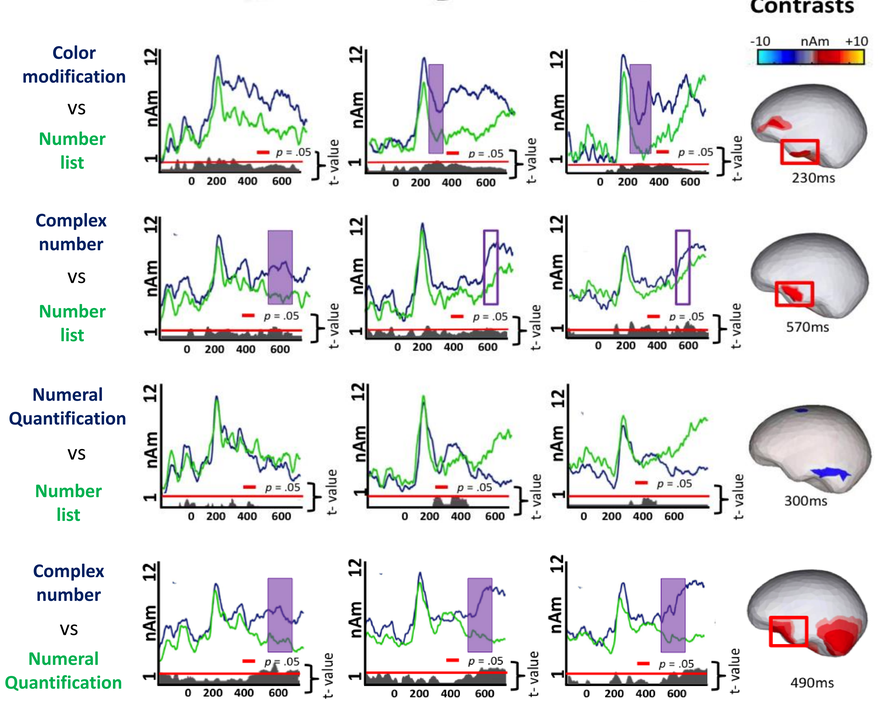
- Pairwise comparisons.

- Time intervals: 150:400 and 400:600ms.

- 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



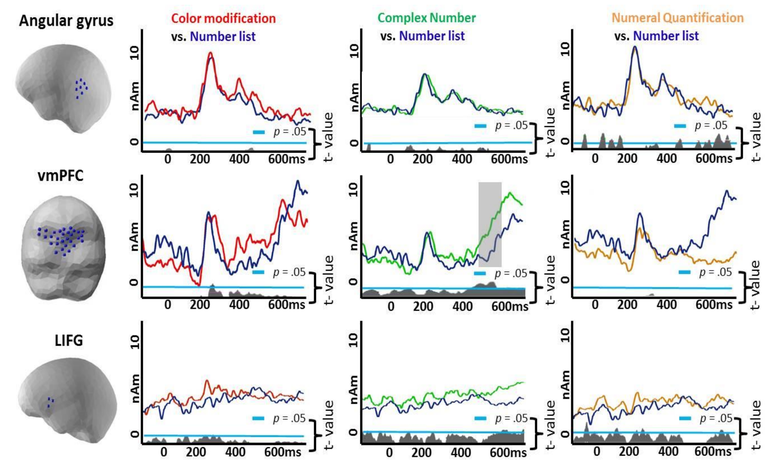


ROI analyses: Switching in Comprehension

- Pairwise comparisons:

- Time intervals: 150:400 and 400:600ms.

- Shaded regions indicate that the difference in activity between the two tested conditions was significant at a p = .05 value (corrected).



Conclusions

- 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.

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