Changes in neural oscillations provide insight into the engagement of cognitive processes during word learning

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INTRODUCTION

Unlike most other linguistic domains, vocabulary acquisition continues throughout adulthood. Adults learn most of their new vocabulary by using the surrounding linguistic context to infer a new word's meaning. The relative contribution of different cognitive processes to word learning from linguistic context is not well understood, however. By using time frequency analysis of the EEG, we can identify how different frequency bands typically associated with cognitive processes are engaged during word learning in adults.

Purpose

This current study examines changes in three frequency bands related to word learning from context: a) theta (4-8 Hz), associated with semantic processing and working memory (e.g., Bastiaansen et al., 2002a; 2002b) b) alpha (8-12 Hz), associated with attention (e.g., Klimesch, 1999), and c) lower beta (12-20 Hz), associated with memory search (e.g., Shahin et al., 2009).

METHOD

Participants

- 21 right-handed monolingual English speakers
- M_{AGE} = 20.76, *SD*= 1.67, Range = 19-25

EEG Equipment

- Neuroscan EEG System, 62 electrode cap

EEG Analysis

- Data epoched -500 msec before to 1000 msec after the target word
- Data were Fourier transformed, magnitude squared, and normalized
- Power spectrum data averaged across trials and subjects and computed using the log power values minus the baseline
- Within EEGLAB, statistical significance (p<0.05) determined using random permutation statistical analysis
- Only statistically significant clusters of 3 or more electrodes were considered in interpretations

Auditory Word Learning from Context Task

- Sentence triplets
- Target word in sentence-final position

Behavioral Task

- Participants asked to identify the target word's meaning after each triplet.

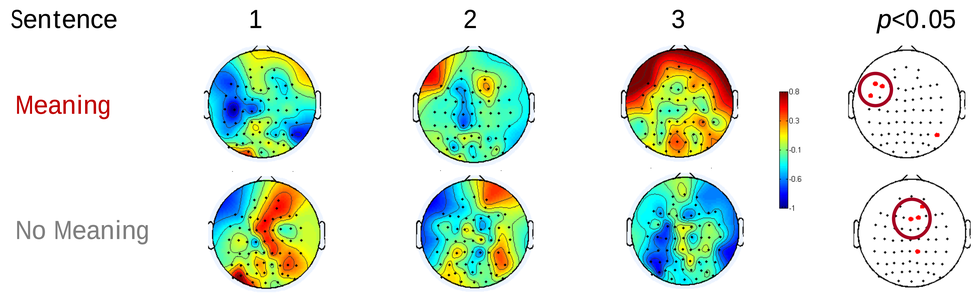
EXAMPLE STIMULI

Conditions (50 triplets each)	Sent #	Example triplet (target in italics)
Meaning sentence triplet supports the target word's meaning	1	Her parents bought her a *chut.*
	2	The sick child spent the day in his *chut.*
	3	Mom piled the pillows on the *chut.*
No Meaning sentence triplet does not provide support for learning the target word's meaning	1	His favorite toy of all time is the *vik*.
	2	He had a lot of food on his *vik.*
	3	Before bed, I have to take a *vik.*

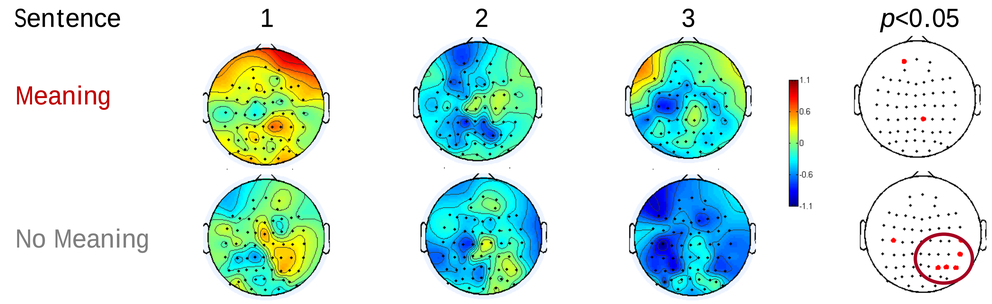
FINDINGS

Behavioral: **Meaning**: 84.1% (SD=6.7%); **No Meaning**: 91.3% (SD=4.6%)

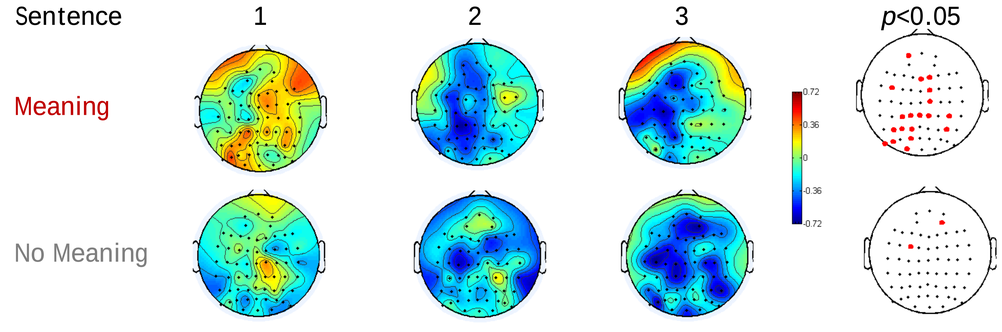
THETA (4-8 Hz)



ALPHA (8-12 Hz)



LOWER BETA (12-20 Hz)



RESULTS

Theta

- Increase in power over left frontal electrodes with each presentation in the Meaning condition
- Decrease in power change over right-central electrodes for No Meaning condition
  - Suggests engagement of semantic processing during word learning when contextual support for the word's meaning is available (e.g., Bastiaansen et al., 2002a; 2002b)

Alpha

- Decrease in power across right occipito-parietal locations for No Meaning condition
  - Suggests that more attention is required when the novel word's meaning remains unknown (e.g., Klimesch, 1999)

Lower Beta

- Widespread decrease in power for Meaning condition
  - Suggests engagement of memory search (Shahin et al., 2009), likely to review prior contextual information and potential word meaning

CONCLUSIONS

These findings indicate that different cognitive processes are engaged dependent on whether contextual information supports learning a new word's meaning. When the meaning is available, semantic processing and memory search are engaged. Conversely, when meaning is not readily available, attentional processes are more strongly engaged.

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