Developmental changes in the neural underpinnings of word learning

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INTRODUCTION

The school years are a critical time for word learning, an area of language development that is strongly tied to academic success. While recent research has expanded our understanding of developmental changes in the neural processes underlying sentence processing[1,2], we know less about the development of the neural networks supporting word learning. Additionally, the past developmental literature has focused on differences between children and adults instead of across children of different ages.

Purpose

This study combines event-related potentials (ERPs) and time frequency analysis (TFA) of the EEG to examine changes in the engagement of neural processes supporting word learning in school-age children (8-10 years old) and adolescents (13-15 years old).

METHOD

Participants

- Children (*N*=16, age=8-10)
- Adolescents (*N*=16, age=13-15)
- All right-handed monolingual English speakers

Auditory Word Learning from Context Task

- 50 sentence triplets with sentence-final target word
  - Sentence triplet supports the target word's meaning
    Her parents bought her a *chut.*
    The sick child spent the day in his *chut.*
    Mom piled the pillows on the *chut.*

Behavioral Task

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

EEG Processing

- Data epoched -500-1000 msec around target word
- Re-referenced to electrode sites near mastoid (T7, T8)

ERP Analysis

- 300-500 msec post-target word onset
- Repeated Measures ANOVA with Group (children, adolescents) as between-subjects and Sentence (1,2,3), Laterality (left, midline, right), Anterior-Posterior (frontal, central, posterior) as within-subjects

TFA analysis

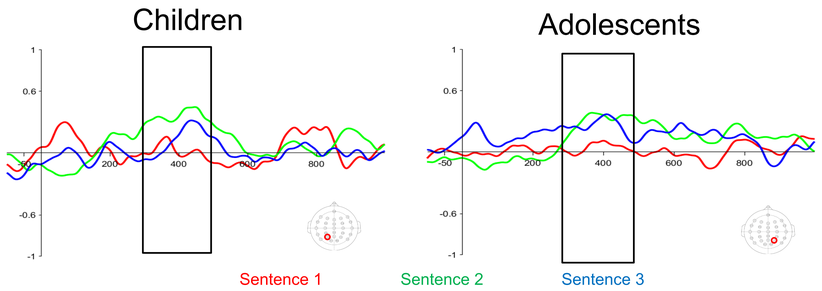
- Fieldtrip cluster-based permutation analysis[3,4]
  - Post-target word onset, 3-30 Hz

BEHAVIORAL RESULTS

Percent correct: Children = 68.9% (6.6), Adolescents = 79.5% (13.1)
$t(30)=6.1$, $p < 0.001$

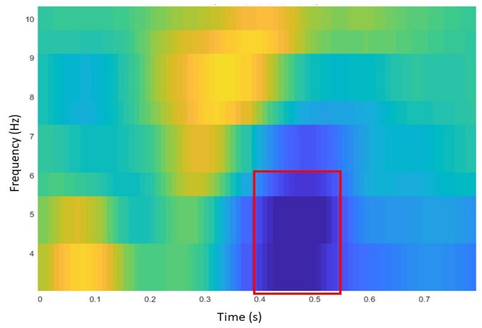
ERP RESULTS

RMANOVA 4-way interaction, $F(8,23)=2.93$, $p<0.05$

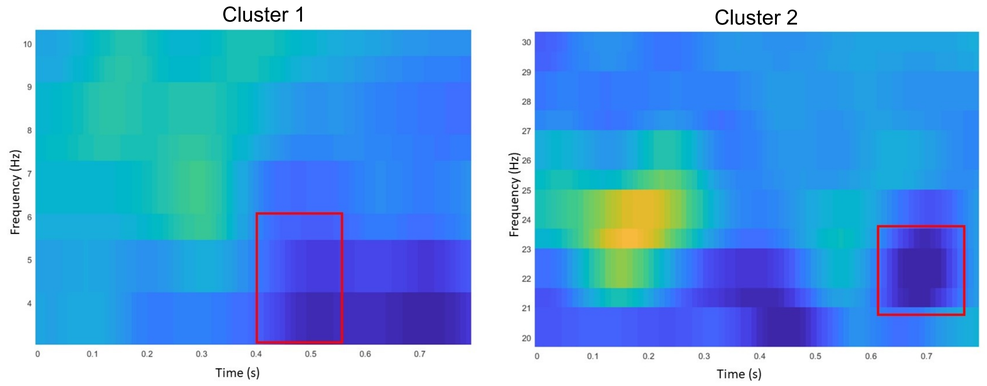


TFA RESULTS

Group (children, adolescents) x Sentence (1,3) interaction
Cluster effect 1*: Lower theta (3-6 Hz), ~400-470msec post-target word onset



Adolescents: Sentence 1 vs Sentence 3
Cluster effect 1**: Lower theta (3-6 Hz), ~400-550 msec post-target word onset
Cluster effect 2*: Lower beta (21-24 Hz), ~600-750 msec post-target word onset



FINDINGS

Behavioral

- Development of incidental word learning occurs throughout late childhood and early adolescence concurrently with changes in neural processing during word learning.

ERP

- Children: graduated attenuation of N400 amplitude; parietal sites
- Adolescents: N400 amplitude increased from sentence 1 to sentence 2, no change to sentence 3; central and parietal sites
- Suggests more efficient lexical semantic processing in adolescents

TFA

- No cluster effects within child group
- Theta:
  - Decrease during processing of sentence 3 versus 1 in adolescents ~400-500msec post-target word onset, which is greater than that seen in children
  - Suggests more effortful lexical-semantic retrieval in children versus adolescents[5-7]
- Lower Beta:
  - Decrease during processing of sentence 3 versus 1 in adolescents ~600-750msec post-target word onset
  - Possible interpretation as a response to syntactic or semantic violations[8-10] as participants dismiss potential meanings for the novel word with increased meaning information

CONCLUSIONS

Findings indicate continued improvement in incidental word learning throughout late childhood and a developing neural system related to semantic processing and retrieval and semantic and syntactic integration through the school years.

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