Predictive Pre-Activation During Language Comprehension Is Preserved in Older Adult Readers
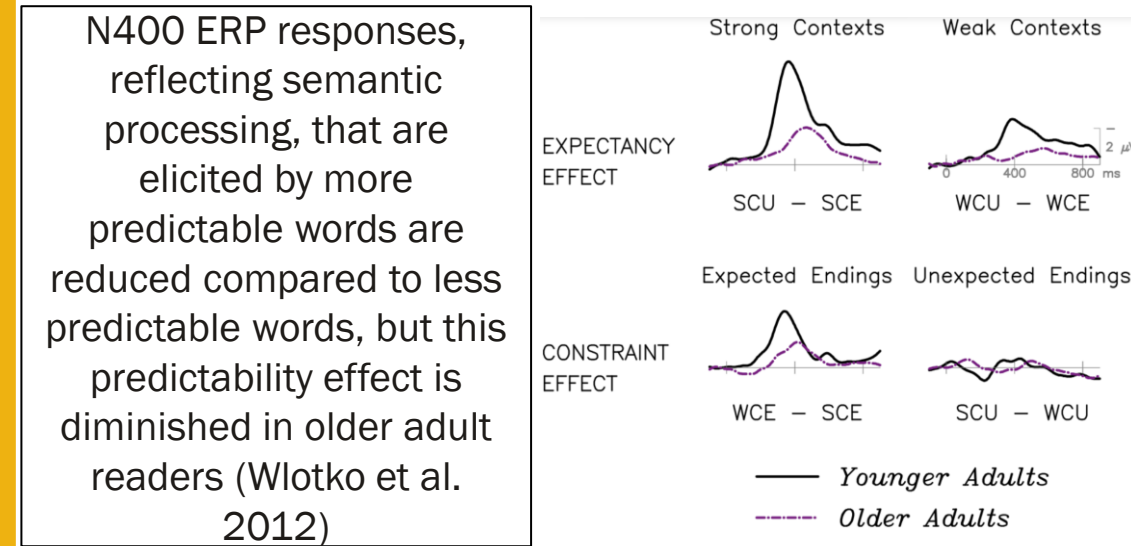
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Introduction

• Individuals can predict features of upcoming words during language comprehension in order to facilitate processing (Federmeier, 2022; Kuperberg & Jaeger, 2016)

• Older adults may not engage in predictive processing, or may not benefit from predictable information to the same degree that younger adults do (Cheimariou et al., 2018; Federmeier, 2007)

N400 ERP responses, reflecting semantic processing, that are elicited by more predictable words are reduced compared to less predictable words, but this predictability effect is diminished in older adult readers (Wlotko et al. 2012)

Strong Contexts   Weak Contexts

EXPECTANCY EFFECT   SCU – SCE   WCU – WCE

Expected Endings   Unexpected Endings

CONSTRAINT EFFECT   WCE – SCE   SCU – WCU

— Younger Adults
-- Older Adults

• Recent eye-tracking work suggests older adult readers do predict upcoming words (Milburn et al., 2023; Zhang et al., 2022)

• Most studies examine consequences following predicted or unpredicted targets, rather than the formation of predictions / pre-activation of upcoming words

The Present Study

We used the Representational Similarity Analysis (RSA) method to test the hypothesis that predictive pre-activation of word features during reading is preserved in older adult readers. This method has previously provided evidence of rapid neural pre-activation of upcoming features (Hubbard & Federmeier, 2021). We conducted RSA on EEG data from younger and older adult readers as they read sentences with predictable and unpredictable endings, and compared neural pre-activation across age groups.

Methods

Re-analysis of data from Federmeier et al. (2017), 31 young adults, as well as combined data from Wlotko & Federmeier (2012) and Wlotko et al. (2012), 41 older adults

• Subjects read 140 sentences that were either strongly constraining (SC; final word cloze > 67%) or weakly constraining (WC; final word cloze < 42%)

• Rapid serial visual presentation (RSVP) of words; 200 ms on screen, 300 ms off screen (500 ms per word)

Don't   touch   the   wet   paint.
500 ms   500 ms   500 ms   500 ms   500 ms
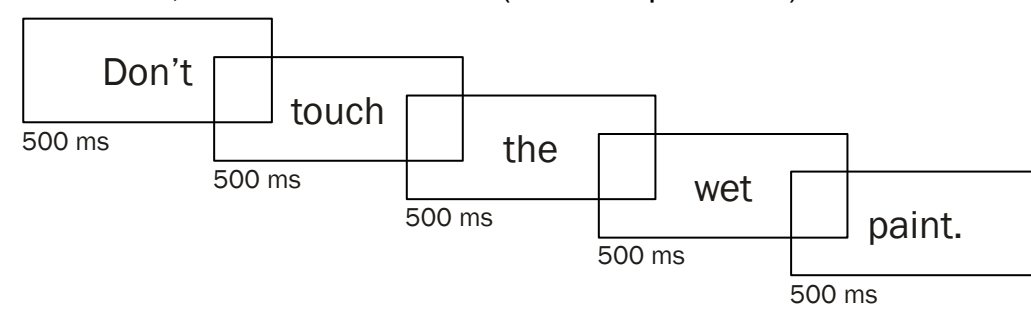
EEG Pre-Processing

• 26 EEG channels in geodesic arrangement over the scalp
• Bandpass filtered, 0.2-40 Hz
• Ocular artifacts corrected with AMICA (Palmer et al., 2015)

• Additional removal of large artifacts / abnormal data
• Baseline correction with Stitched z-score baseline (Ciuparu & Muresan, 2020)

Spatial RSA Results

Are Spatial Patterns of Neural Activity Similar Across Time?

Strongly Constraining (SC)
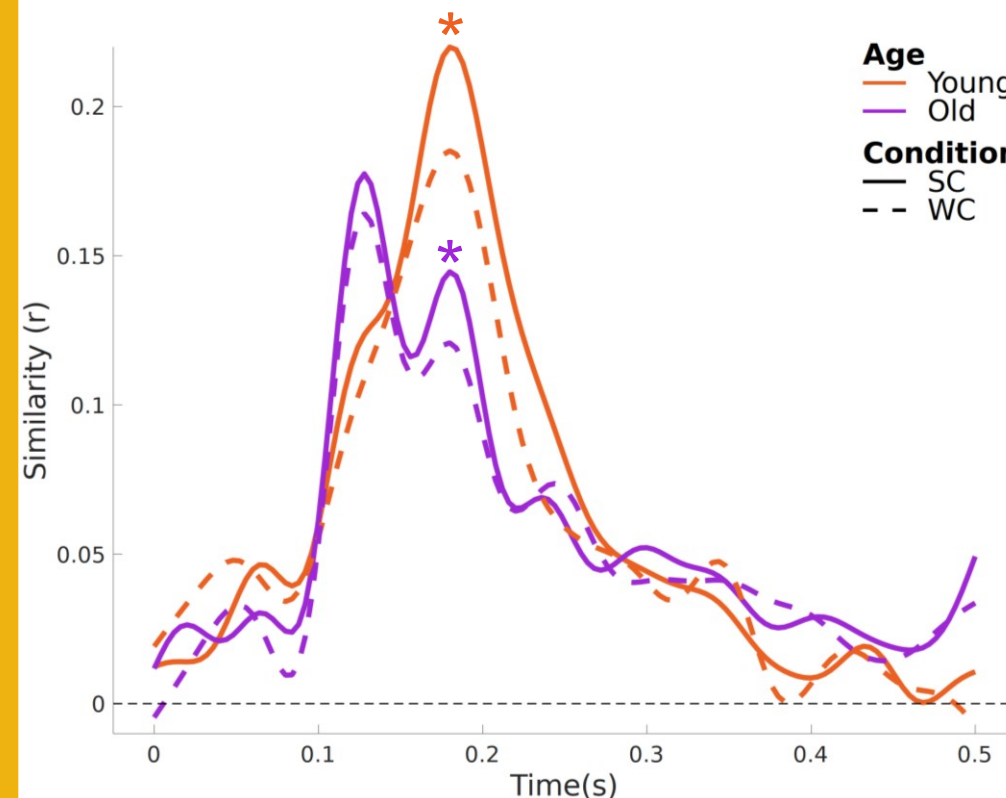Father carved the turkey with a ⚡knife

Weakly Constraining (WC)
In the distance they heard the ⚡ sound

Pre-final word   Final word

Time

We expect pre-final and final word neural similarity to be greater for more predictable final words

Low Predictability
High Predictability

Similarity

$$\begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_n \end{bmatrix} \quad r \quad \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_n \end{bmatrix}$$

Vector of channel amplitudes

Correlation time series

Averaged across SC and WC sentences

Average Similarity Across Conditions

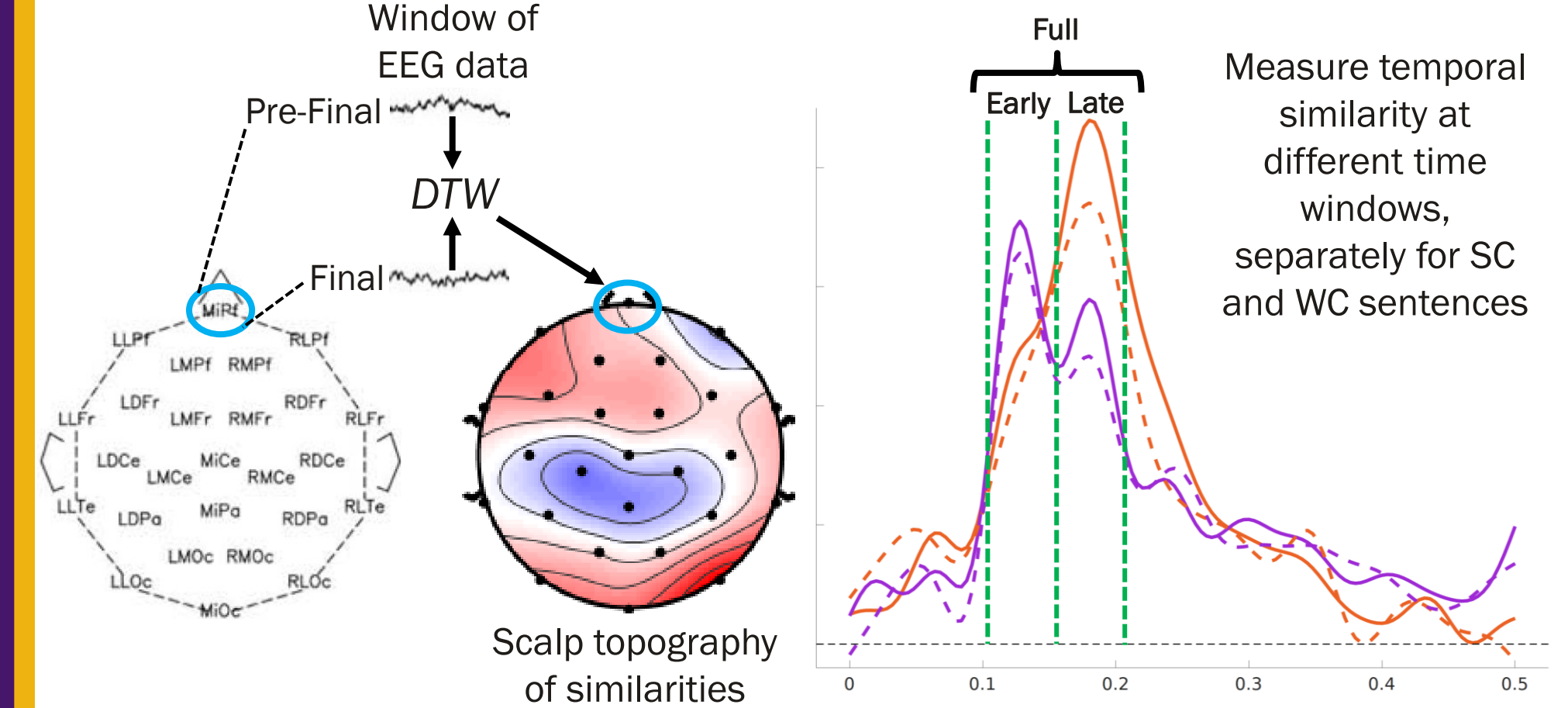Age: Young / Old
Condition: SC / WC

Similarity (r) vs Time(s)

Both younger and older adult readers exhibit greater pattern similarity for predictable sentence endings (no significant interaction w/ age)

Item-Level Relationship with Predictability

Similarity (r) vs Cloze Probability

Old / Young
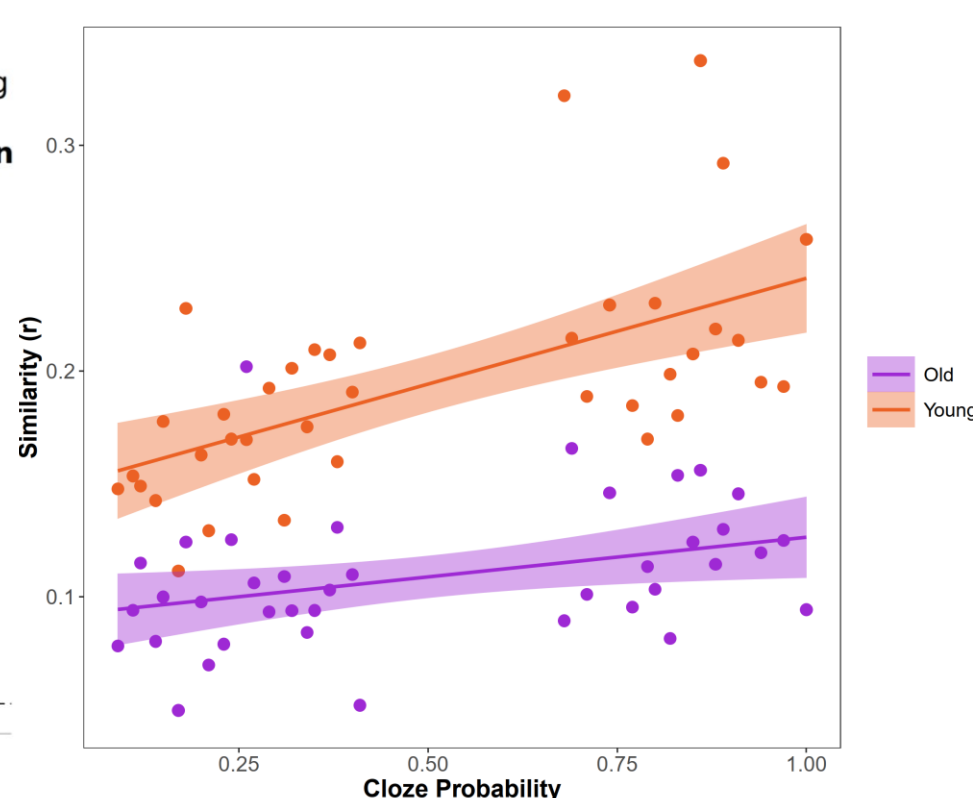
Mean similarity is related to cloze probability for both younger and older adult readers (no significant interaction w/ age)
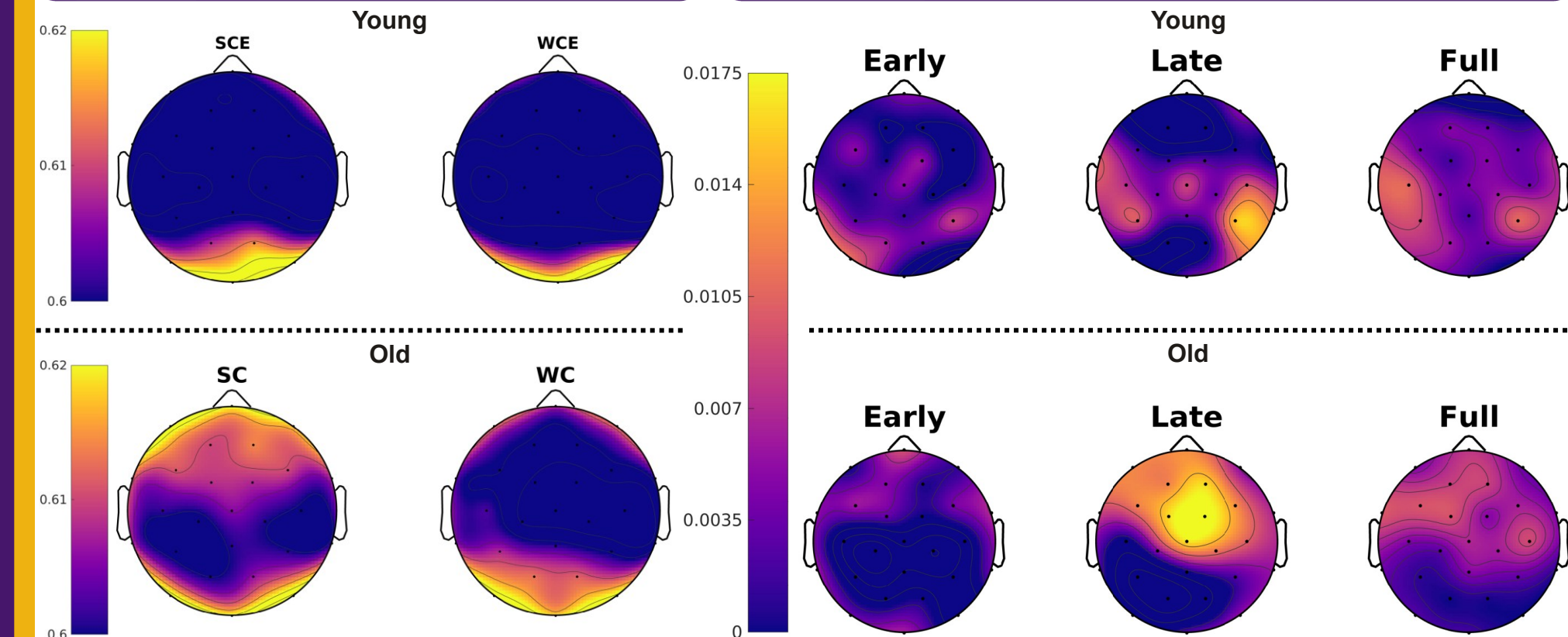
Temporal RSA Results

Are Temporal Patterns of Neural Activity Similar Across Space?

Window of EEG data
Pre-Final
Final
DTW

LLPf RLPf
LMPf RMPf
LLFr LDFr LMFr RMFr RDFr RLFr
LDCe LMCe MiCe RMCe RDCe
LLTe LDPa MiPa RDPa RLTe
LMOc RMOc
LLOc RLOc
MiOc

Scalp topography of similarities

Full
Early Late

Measure temporal similarity at different time windows, separately for SC and WC sentences

Similarity in Late Time Window

Young: SCE / WCE
Old: SC / WC

Older adults exhibit greater temporal similarity in frontal channels specifically for SCE endings, not found for younger adults

Condition Differences Across Time Windows

Young: Early / Late / Full
Old: Early / Late / Full

Increased similarity for SC endings in frontal channels specifically in the late time window for older adult readers, no differences for younger adults

Conclusions

• Spatial RSA identified an early (150-250 ms) increase in neural pattern similarity that was modulated by predictability for both younger and older adult readers

• Overall neural pattern similarity was reduced for older adult readers compared to younger adults, but the relationship between neural similarity and cloze probability was preserved

• Older adults also exhibited an earlier peak (100-150 ms) in the spatial RSA time-course, but this earlier response did not differ based on predictability

• Temporal RSA of the EEG time-course where the spatial RSA peak was found revealed an occipital topography of similarity for both age groups, but older adults exhibited increased temporal similarity in frontal channels, specifically for more predictable words

• Older adults do seem to pre-activate features of upcoming words during reading similarly to younger adult readers, but may rely on compensatory neural substrates, potentially including frontal cortical structures, to support prediction