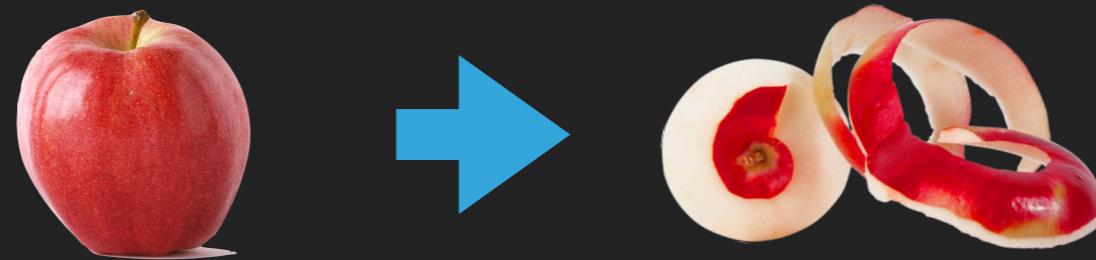


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# BOTTOM-UP INFLUENCES ON REPEAT OBJECT REFERENCE

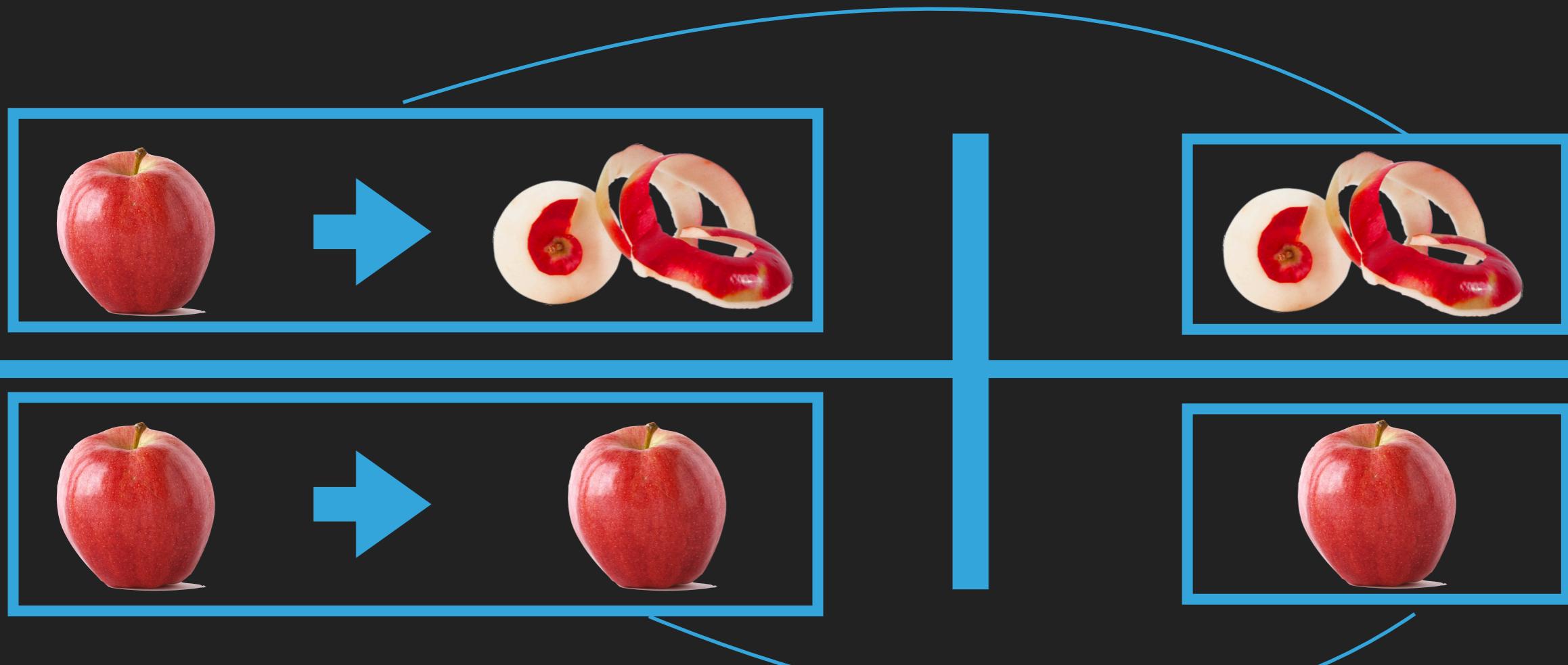
# COMPREHENSION & REPRESENTATION OF OBJECT CHANGE



- ▶ “The chef will peel the apple.”
- ▶ Intersecting Object Histories account: (IOH; Altmann & Ekves, 2019)
  - ▶ Understanding that a peeling event takes place requires maintaining the previous, un-peeled state of the apple
  - ▶ What are the implications of this maintenance?

# OBJECT STATE COMPETITION

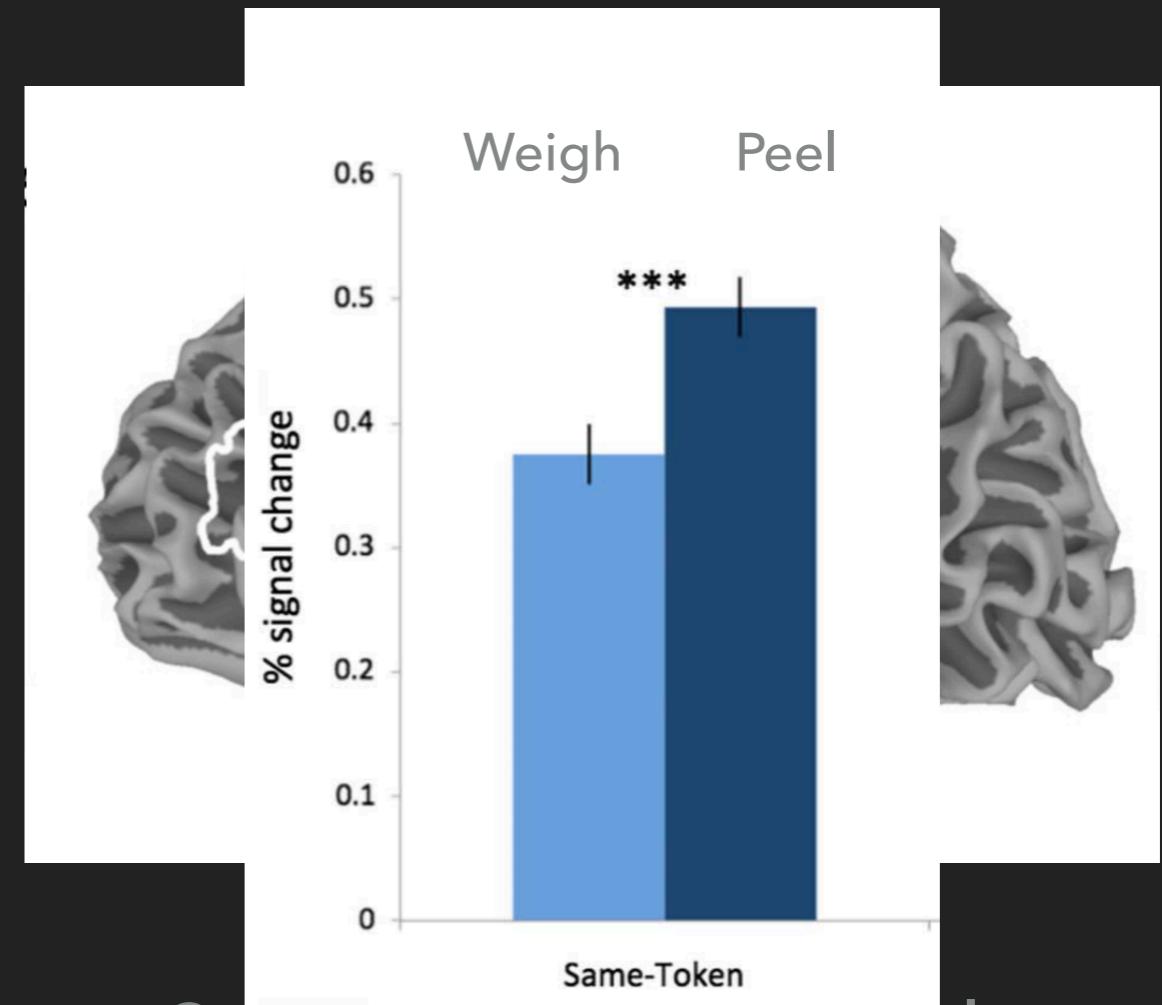
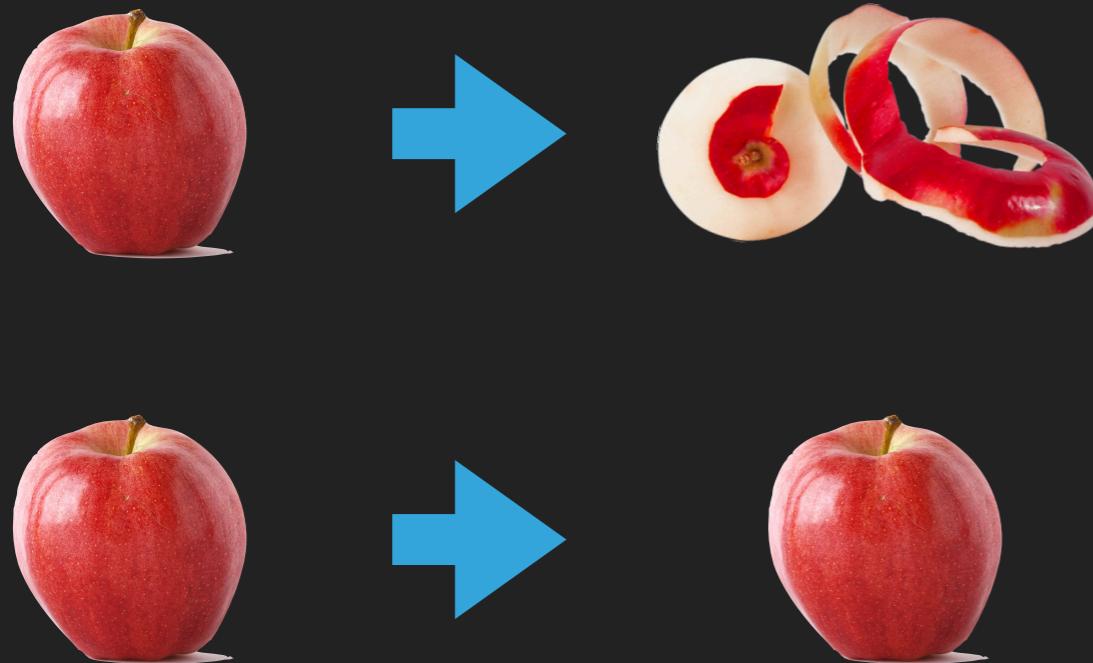
- ▶ The chef will **peel** the apple and then he will smell the apple.
- ▶ The chef will **weigh** the apple and then he will smell the apple.



- ▶ Competition is between two current episodic representations.

# OBJECT STATE COMPETITION

- ▶ The chef will **peel** the apple and then he will smell the apple.
- ▶ The chef will **weigh** the apple and then he will smell the apple.



Hindly et al., 2012; Stroop Sensitive Voxels Solomon et al., 2015

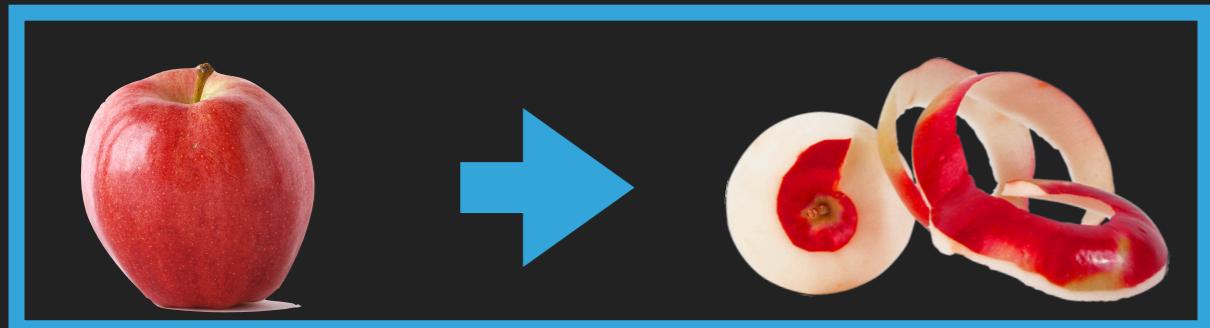
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# TOKEN-STATES, TOKENS & TYPES

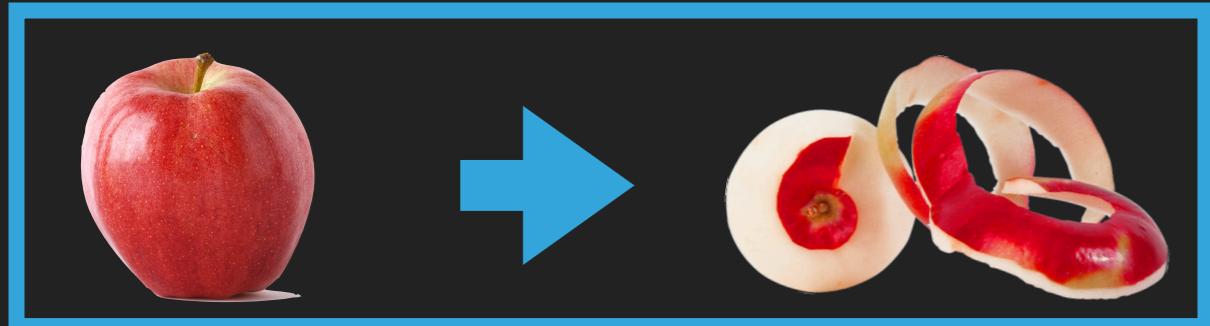
- ▶ Token: contextualized instantiation of an object
  - ▶ Two different peeled apples
- ▶ Token-state: state of a token at a particular time
  - ▶ An apple before and after peeling
- ▶ Type: category information, from experience with tokens
  - ▶ A canonical apple: red (can be green), rounded, sweet
  - ▶ Reading words activates canonical features (Yee et al., 2012)
- ▶ Tokens/token-states: episodic memory; Type: semantic memory

- ▶ The chef will peel the apple and then he will smell the apple.

## OBJECT STATE COMPETITION



## ALTERNATE, BOTTOM-UP THEORY



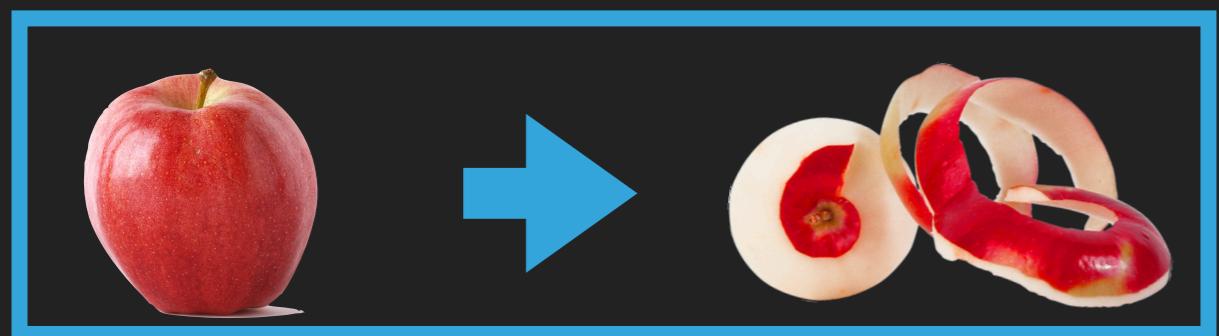
Semantic Mem.



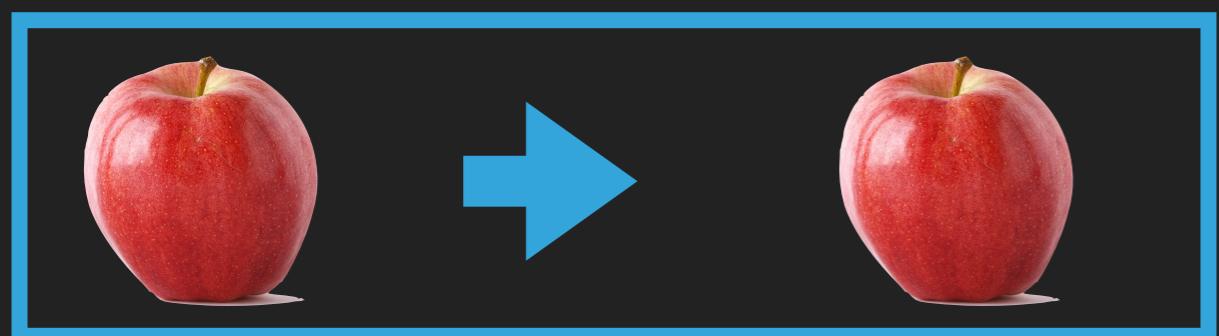
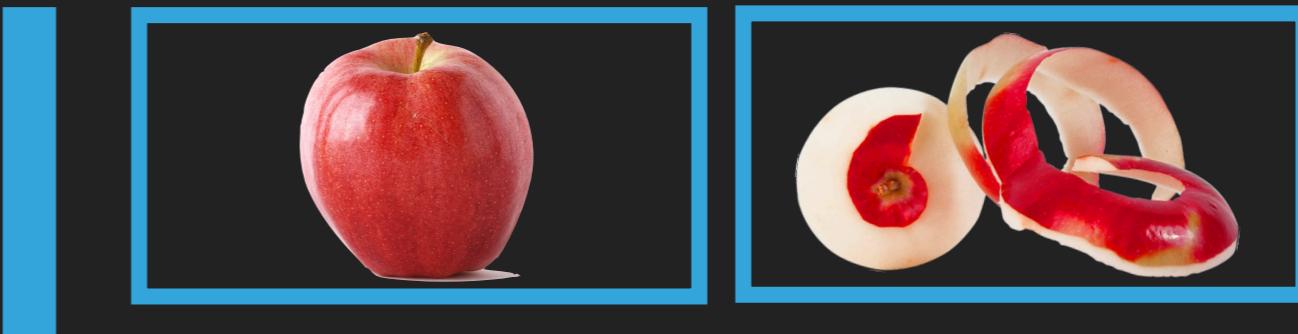
- ▶ Competition is between current representation and bottom-up, type information.

# EXPLAINING A STATE CHANGE EFFECT IN THE BOTTOM UP ACCOUNT

- ▶ The chef will **peel** the apple and then he will smell the apple.
- ▶ The chef will **weigh** the apple and then he will smell the apple.



Semantic Mem.



- ▶ Dissimilarity between current and canonical form drives effect

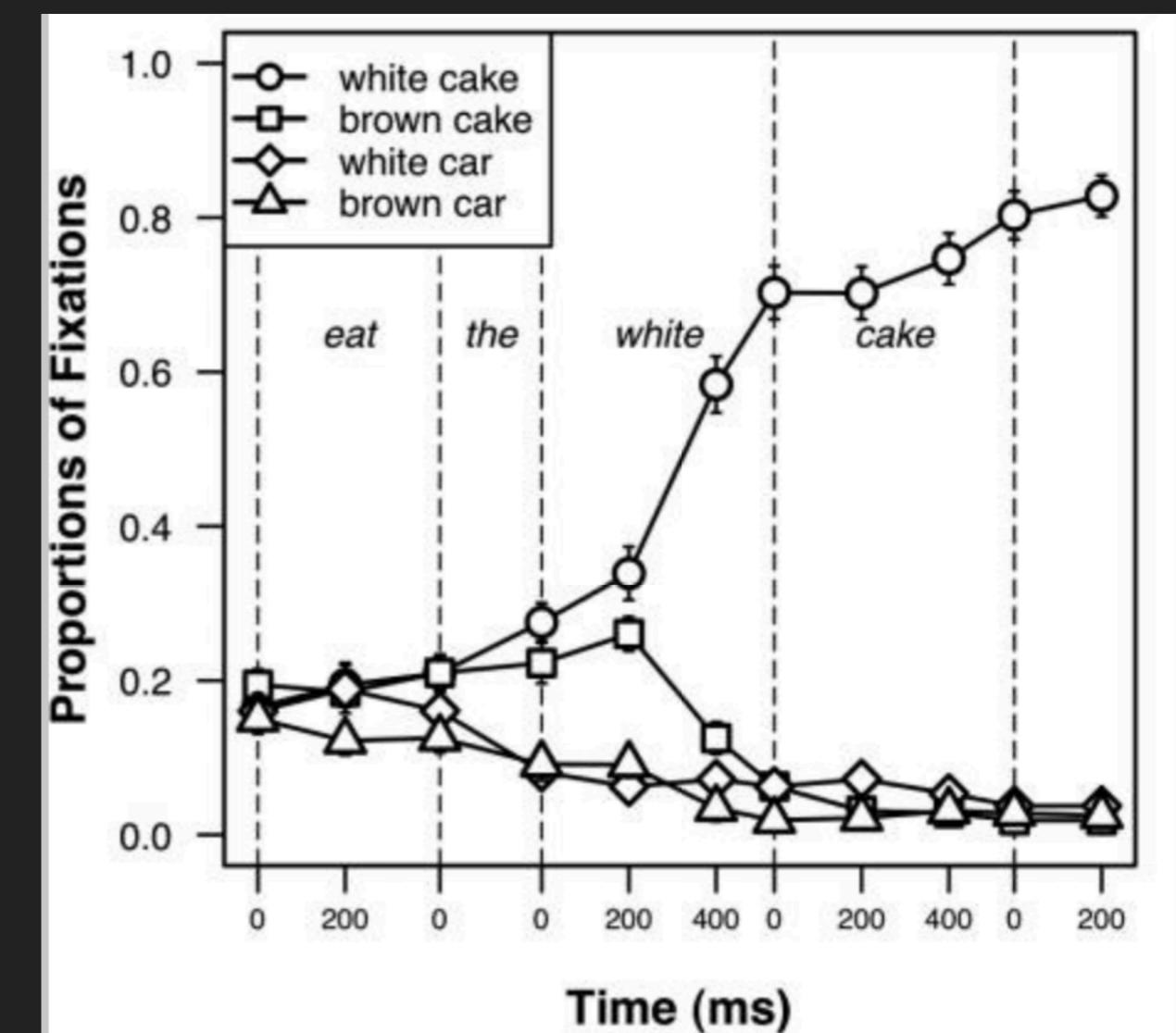
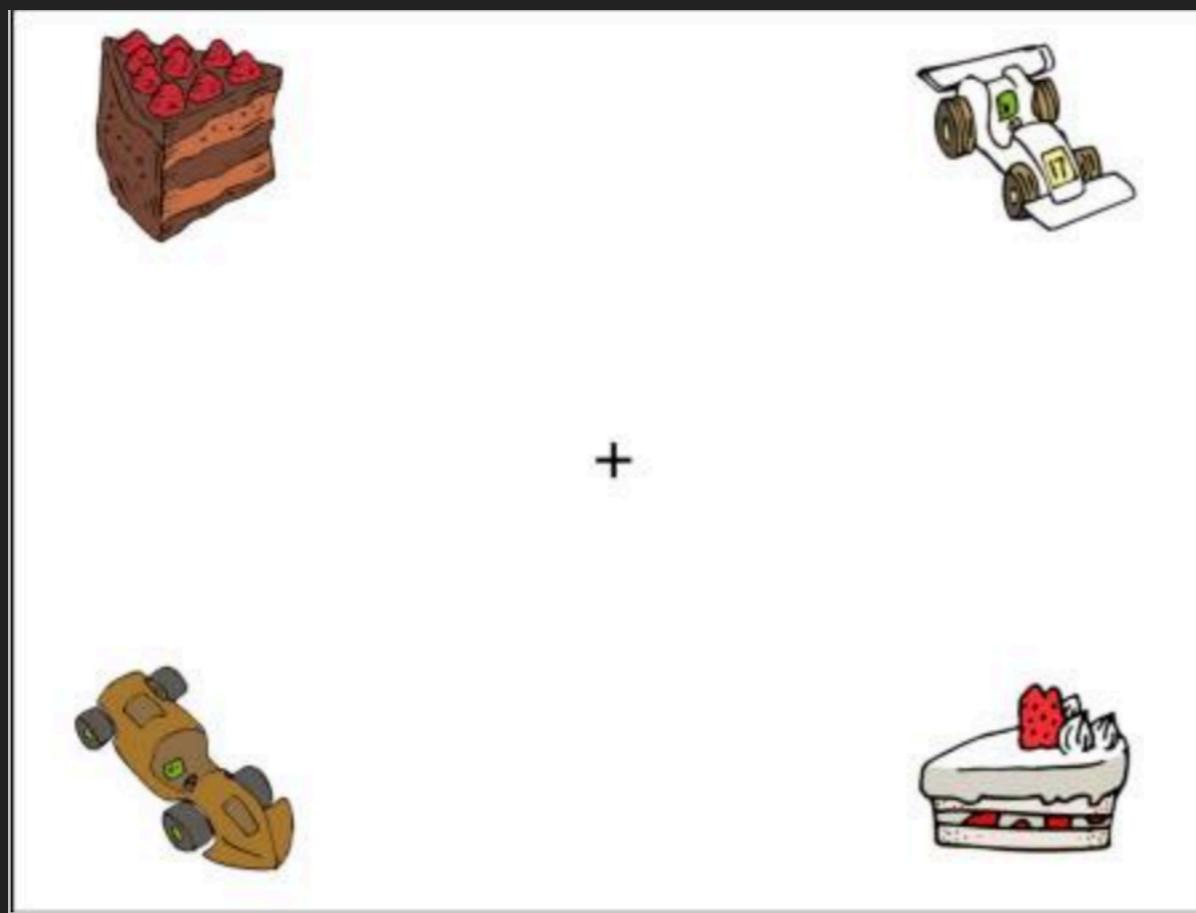
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# MOTIVATING WORK

- ▶ Local coherence effects
- ▶ Repeated name penalty

# LOCAL COHERENCE (KUKONA, CHO, MAGNUSON & TABOR, 2015)

- ▶ “The boy will eat the white cake.”
- ▶ Shows activation of local structure that is globally incompatible.



---

## REPEATED NAME PENALTY

- ▶ The cat is playing. The cat is in the living room.
- ▶ The cat is playing. It is in the living room.
- ▶ Some explanations
  - ▶ Discourse Prominence Theory (DPT); Gordon (93, 98)
  - ▶ Informational Load Hypothesis (ILH); Almor (99, 04)
  - ▶ Both of these suggest that repeat reference introduces new representation
  - ▶ Difficulty comes from integrating new & old representations

---

# TEASING APART SEMANTIC AND EPISODIC INFLUENCE

- ▶ The chef will **peel** the apple and then he will smell **the apple**.
- ▶ The chef will **weigh** the apple and then he will smell **the apple**.
- ▶ The chef will **peel** the apple and then he will smell **it**.
- ▶ The chef will **weigh** the apple and then he will smell **it**.
- ▶ It must refer to previous representation, no “bottom up” influence
- ▶ These conditions allow for direct test of competing hypotheses

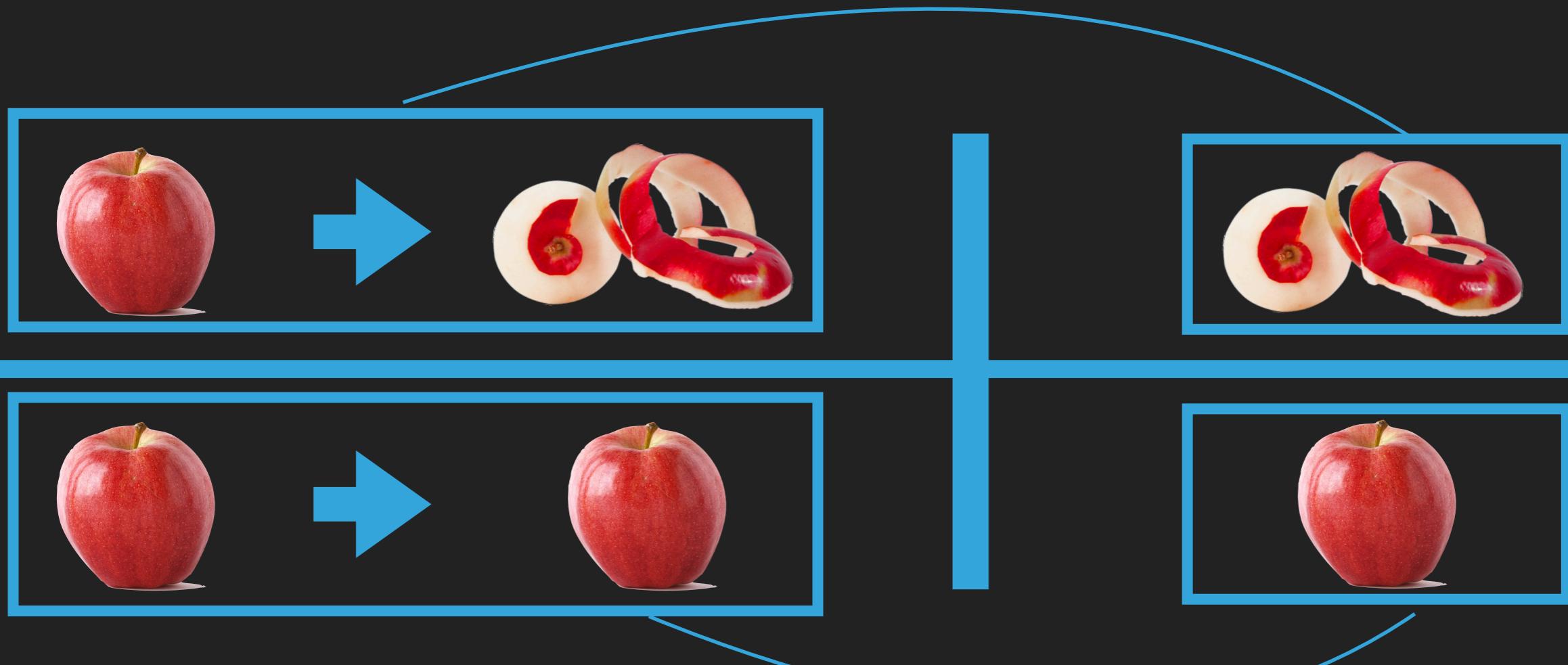
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## PREDICTIONS OF BOTH ACCOUNTS

- ▶ What does each account predict for pronoun conditions?
- ▶ Object State Competition
- ▶ Bottom-up Processing

## OBJECT STATE COMPETITION WITH PRONOUNS

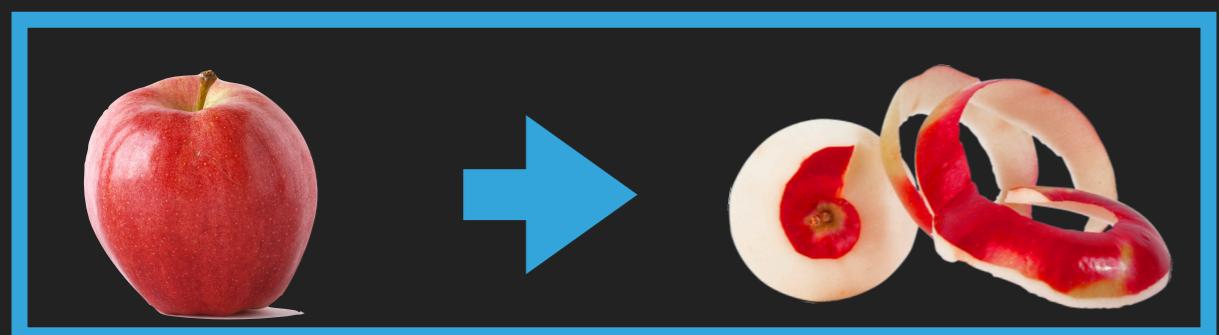
- ▶ The chef will **peel** the apple and then he will smell **it**.
- ▶ The chef will **weigh** the apple and then he will smell **it**.



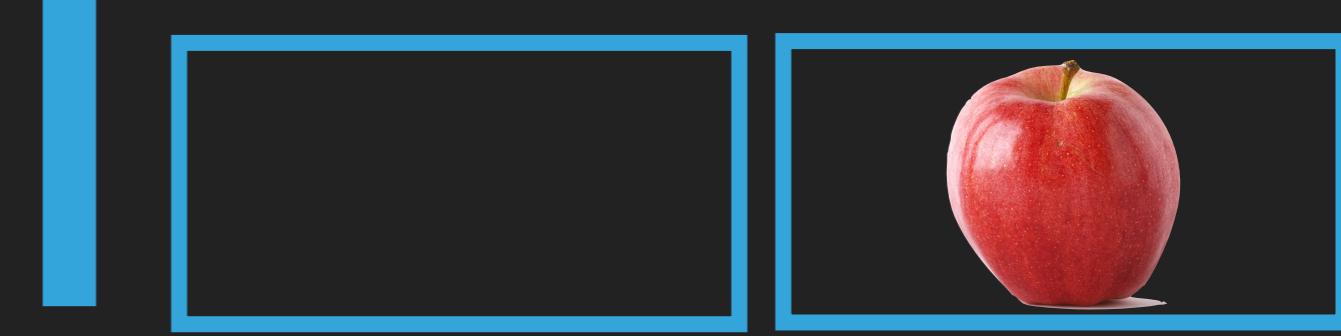
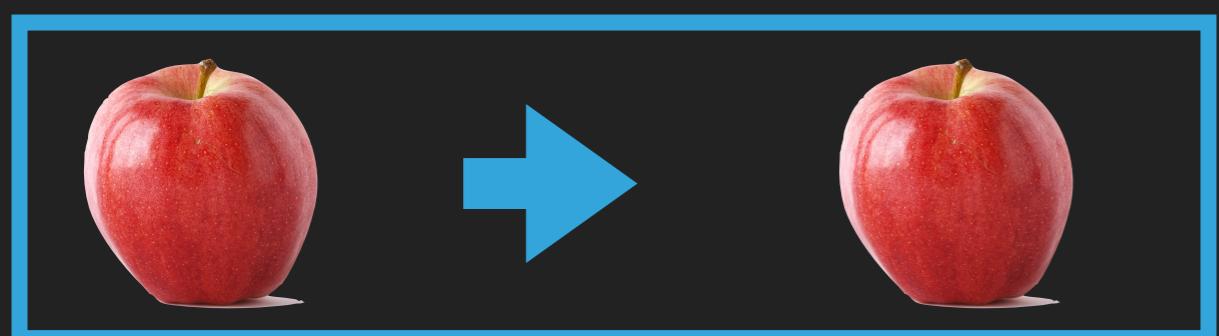
- ▶ Competition is still observed for state change.

## BOTTOM-UP ACCOUNT WITH PRONOUNS

- ▶ The chef will **peel** the apple and then he will smell **it**.
- ▶ The chef will **weigh** the apple and then he will smell **it**.



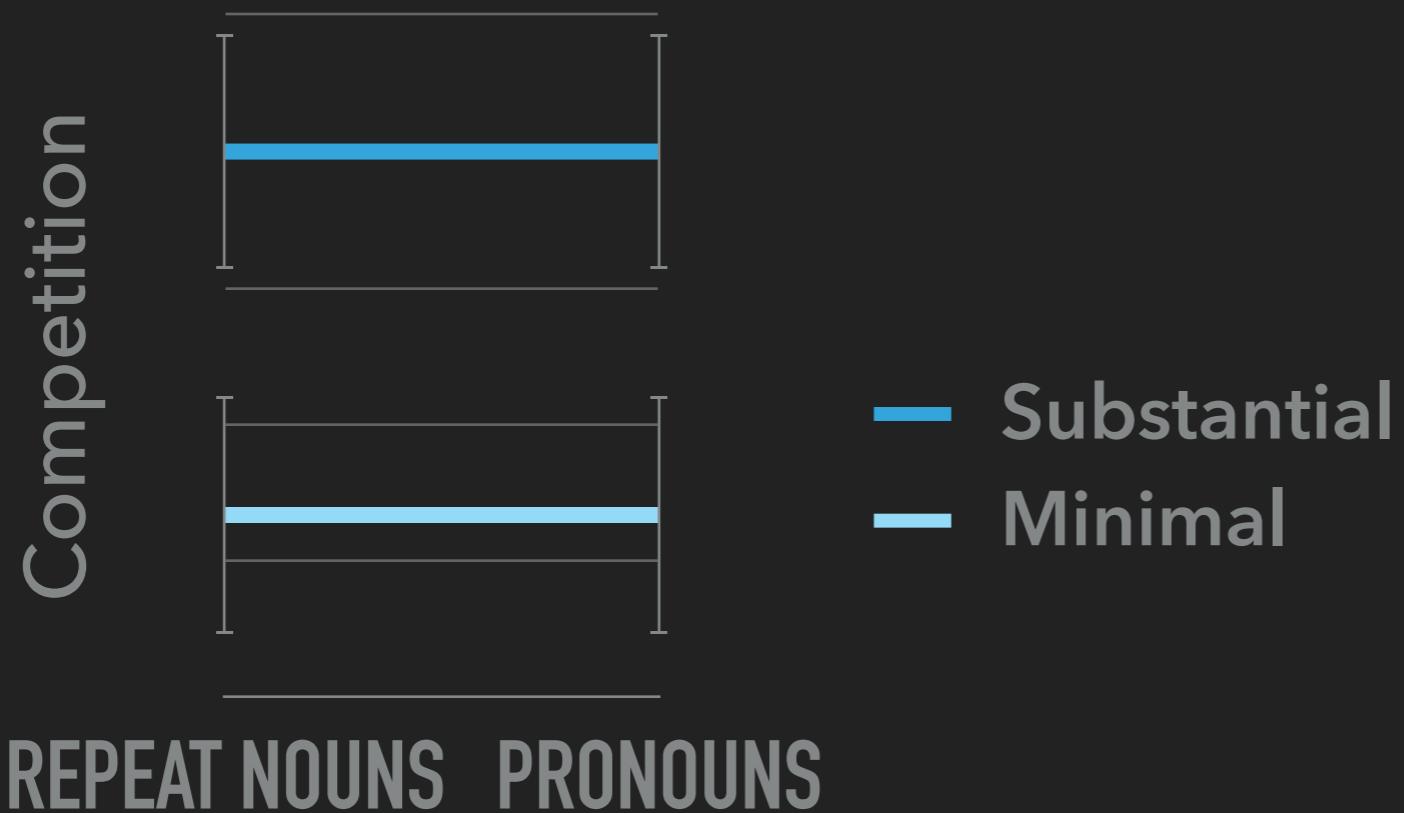
Semantic Mem.



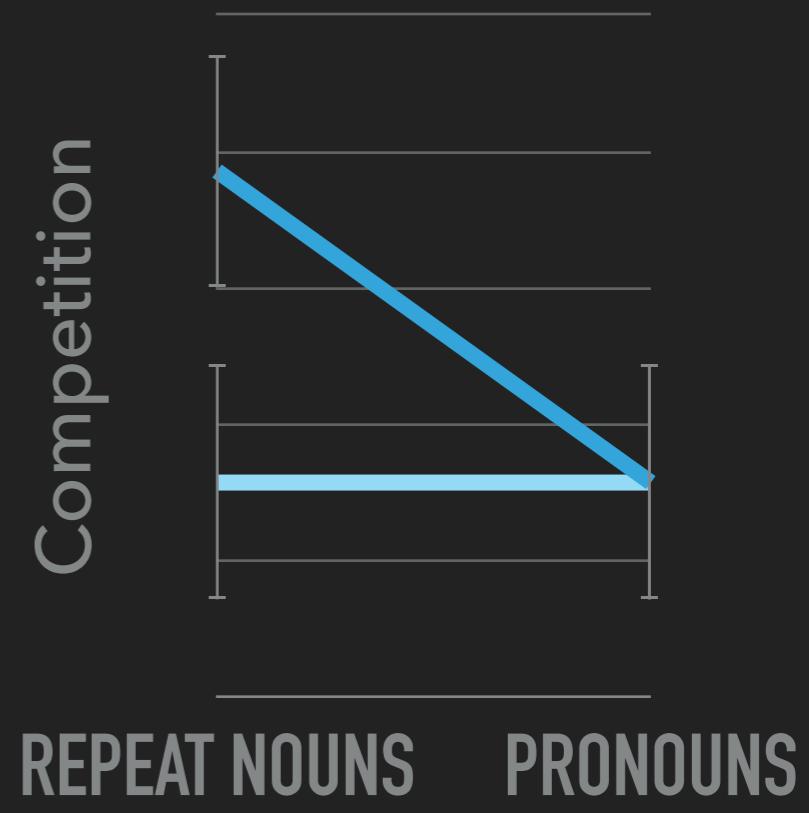
- ▶ No semantic interference: no competition.

# PREDICTIONS

► Object-state competition:



► Bottom-up Account:



- The chef will **peel** the apple and then he will smell **the apple**. (Sub/Rep)
- The chef will **weigh** the apple and then he will smell **the apple**. (Min/Rep)
- The chef will **peel** the apple and then he will smell **it**. (Sub/Pro)
- The chef will **weiah** the apple and then he will smell **it**. (Min/Pro)

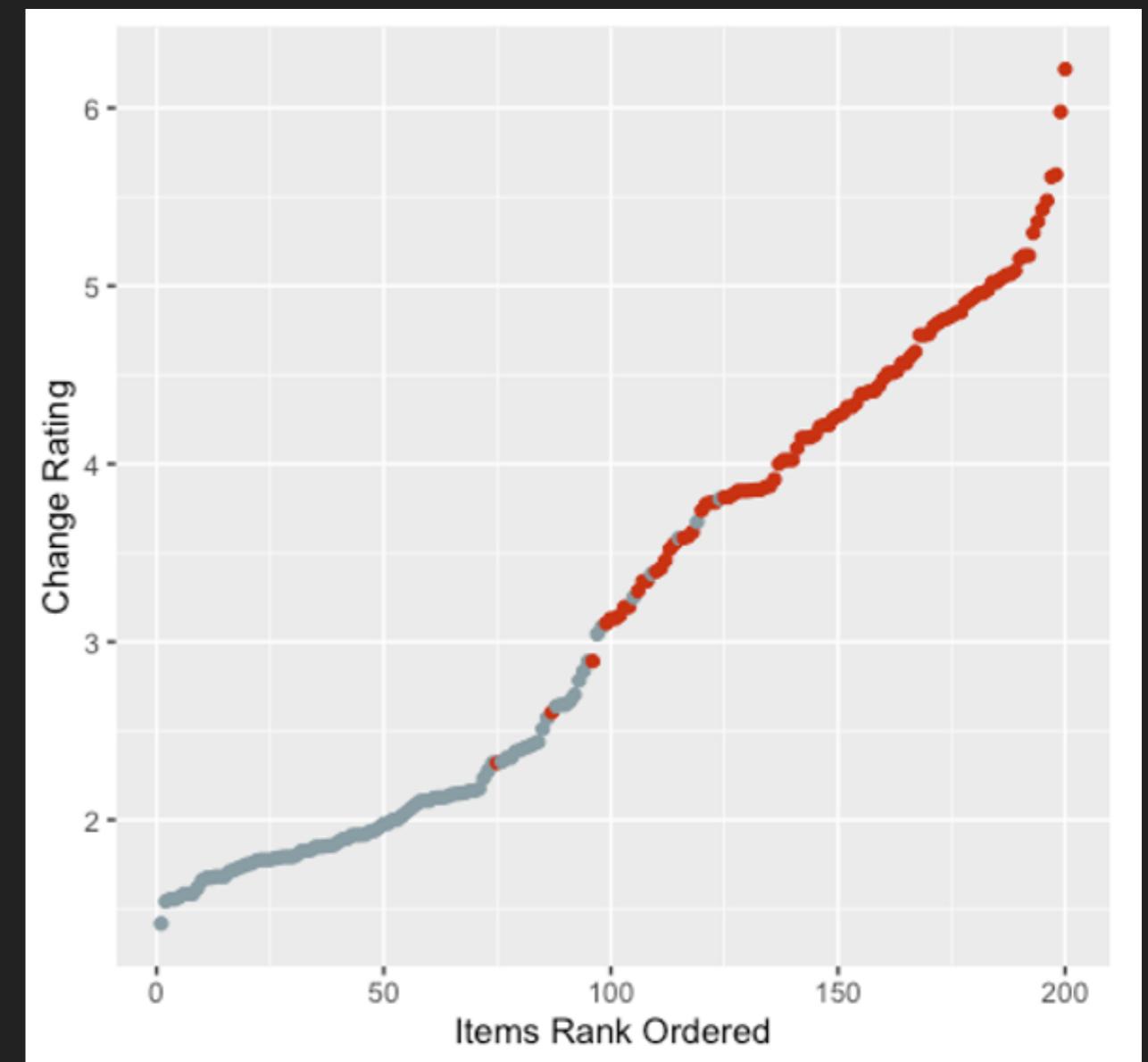
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# EXPERIMENTS

- ▶ fMRI
  - ▶ Test of competing hypotheses
  - ▶ Uses replicated effects
  - ▶ Localization of difference in “conflict” region
- ▶ EEG
  - ▶ Exploration of time course for state-change effects
  - ▶ Exploration of alpha & LIFG relationship

# ITEM NORMING

- ▶ “The chef will peel the apple.”
- ▶ Rated on
  - ▶ State Change
  - ▶ Imageability
- ▶ Amazon MTurk (200+ part.)

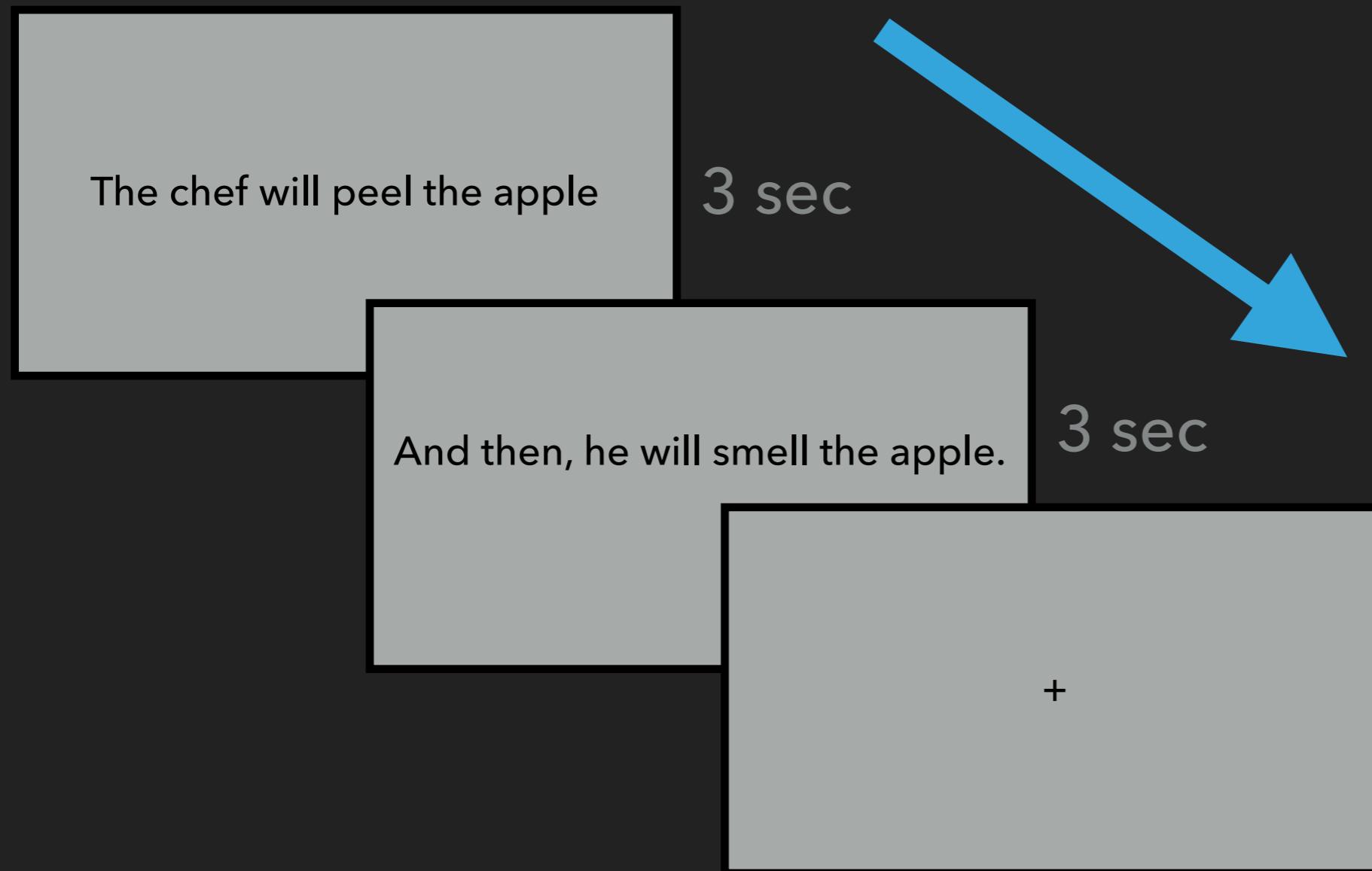


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# EXPERIMENT 1: FMRI

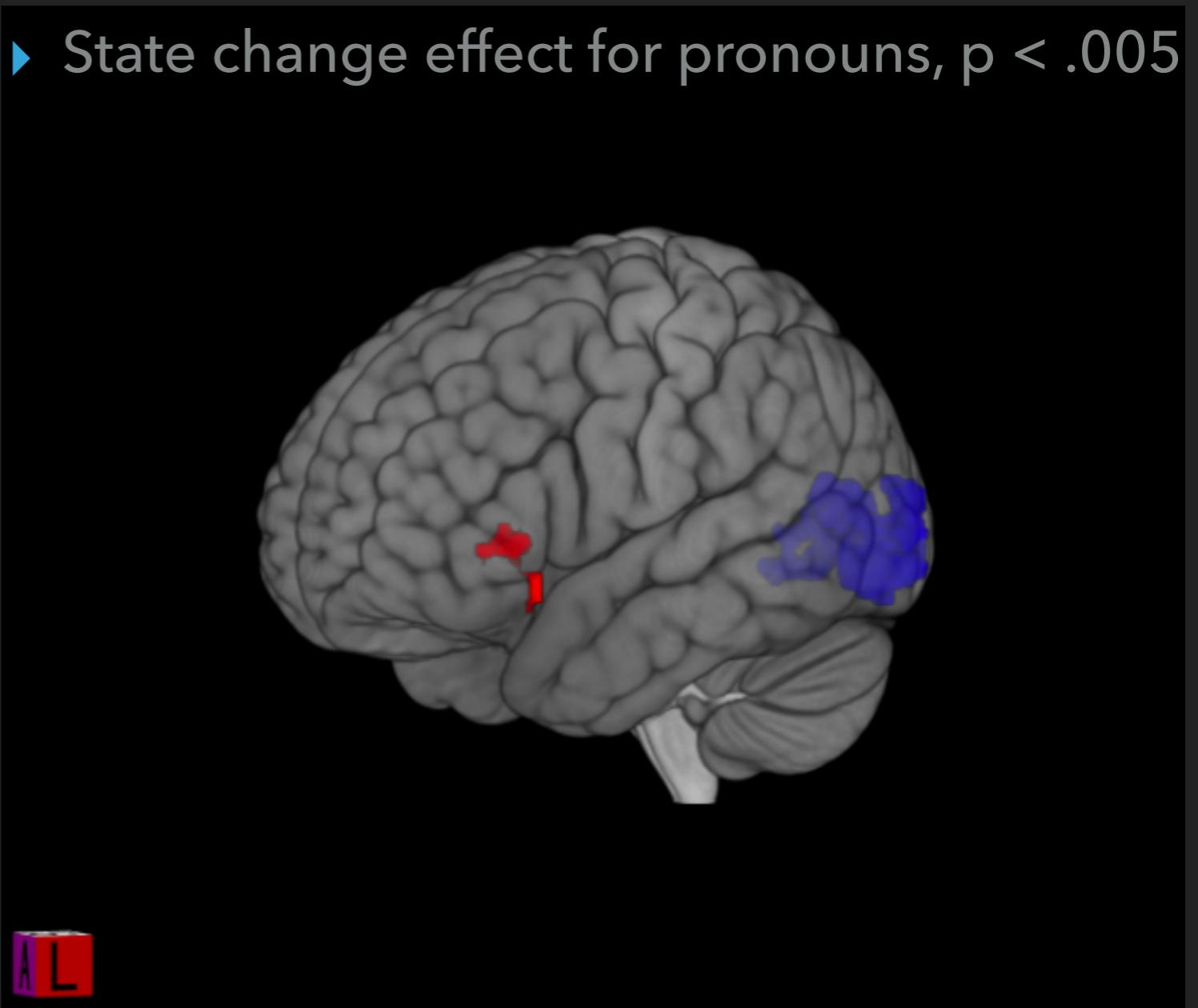
- ▶ 20 participants
- ▶ 2 (degree of change) x 2 (reference type) design
- ▶ 100 experimental trials
- ▶ 15 implausible “catch” trials: “The boy will eat the poster. And then he will laminate the poster.”
- ▶ Stroop localizer: indicate font color for RED vs **RED**
- ▶ Structure: Each sentence presented for 3 seconds (6 seconds overall), jittered fixation between trials, 5 runs

# TRIAL STRUCTURE



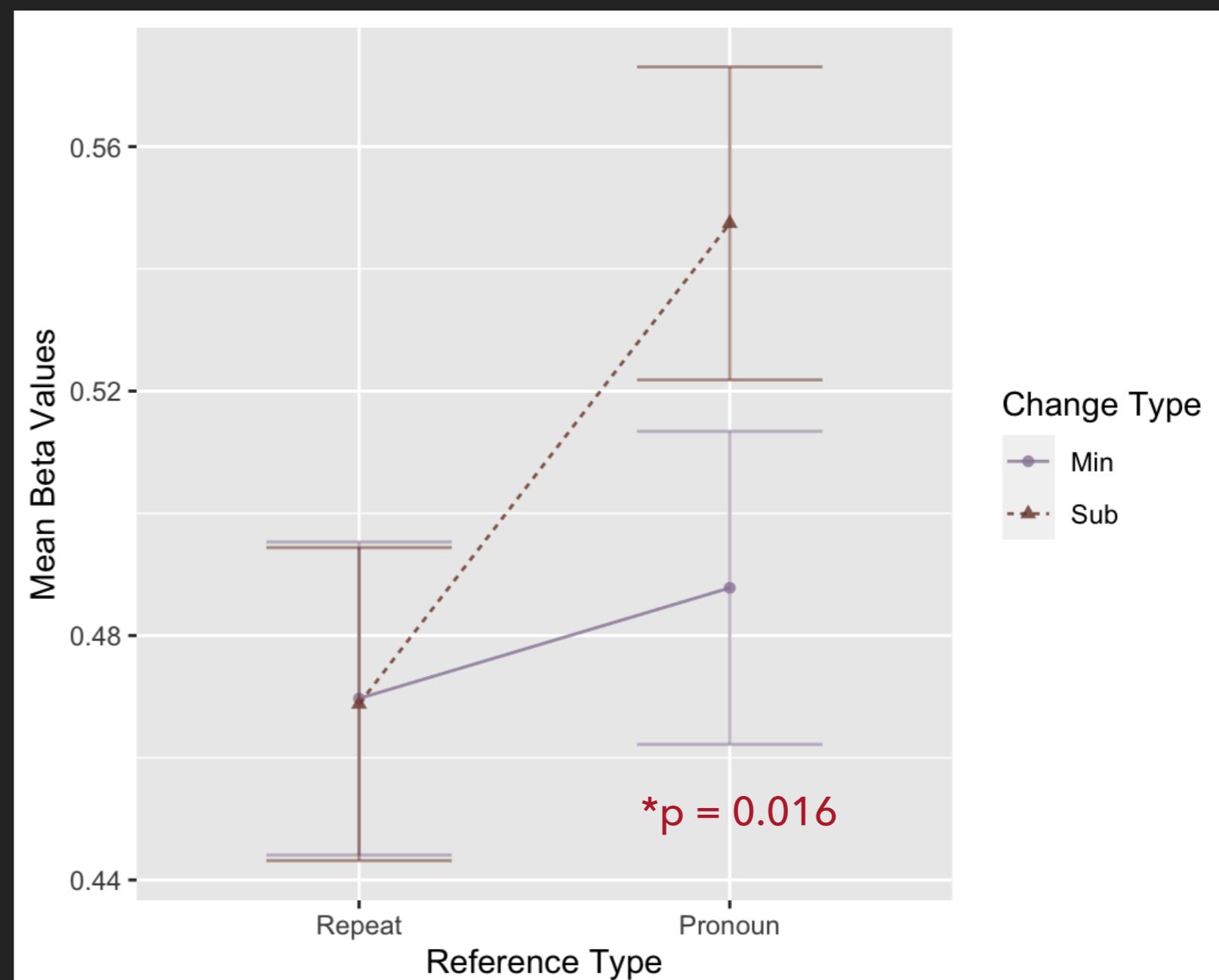
# SENTENCE TASK - WHOLE BRAIN

- ▶ Substantial Change - Minimal Change for Pronouns
- ▶ Prefrontal cluster survives correction for multiple comparisons
- ▶ **No state change effect for repeated nouns**



# SENTENCE TASK - ENTIRE VLPFC

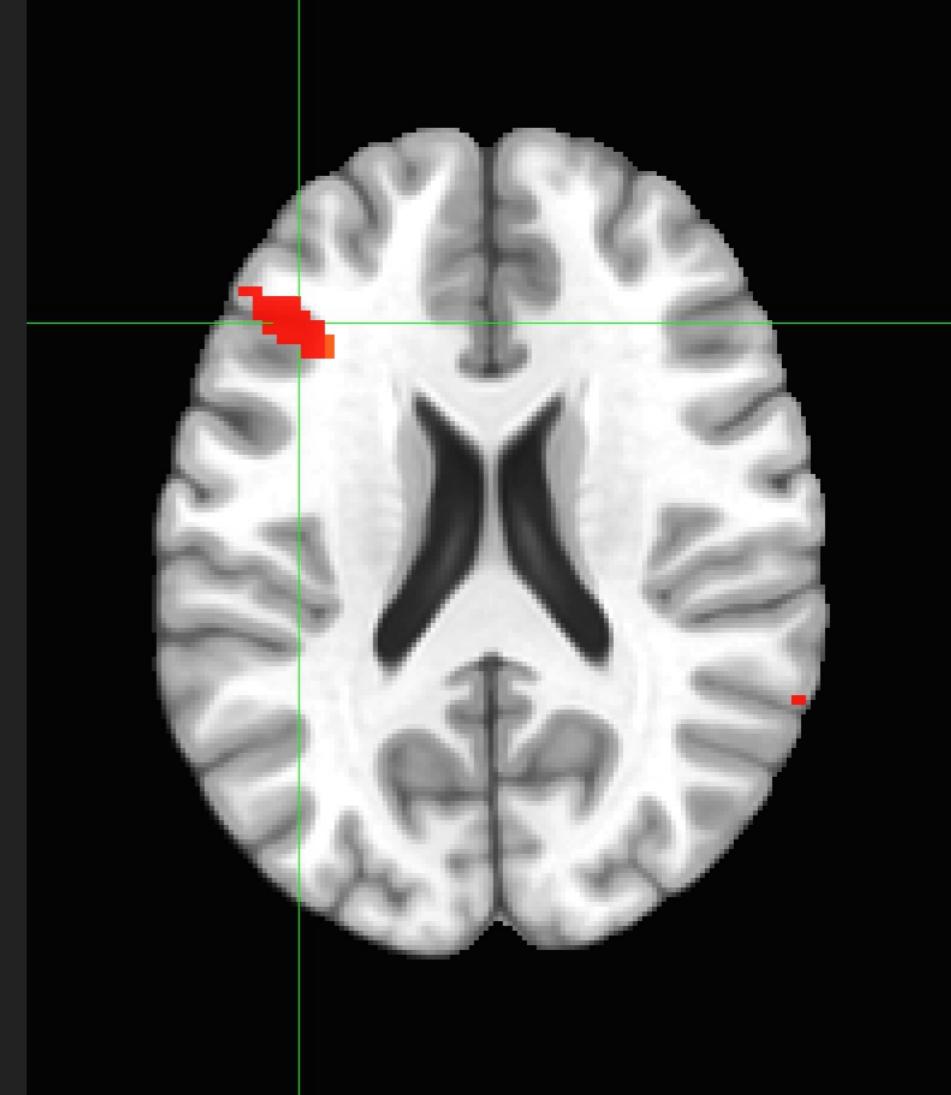
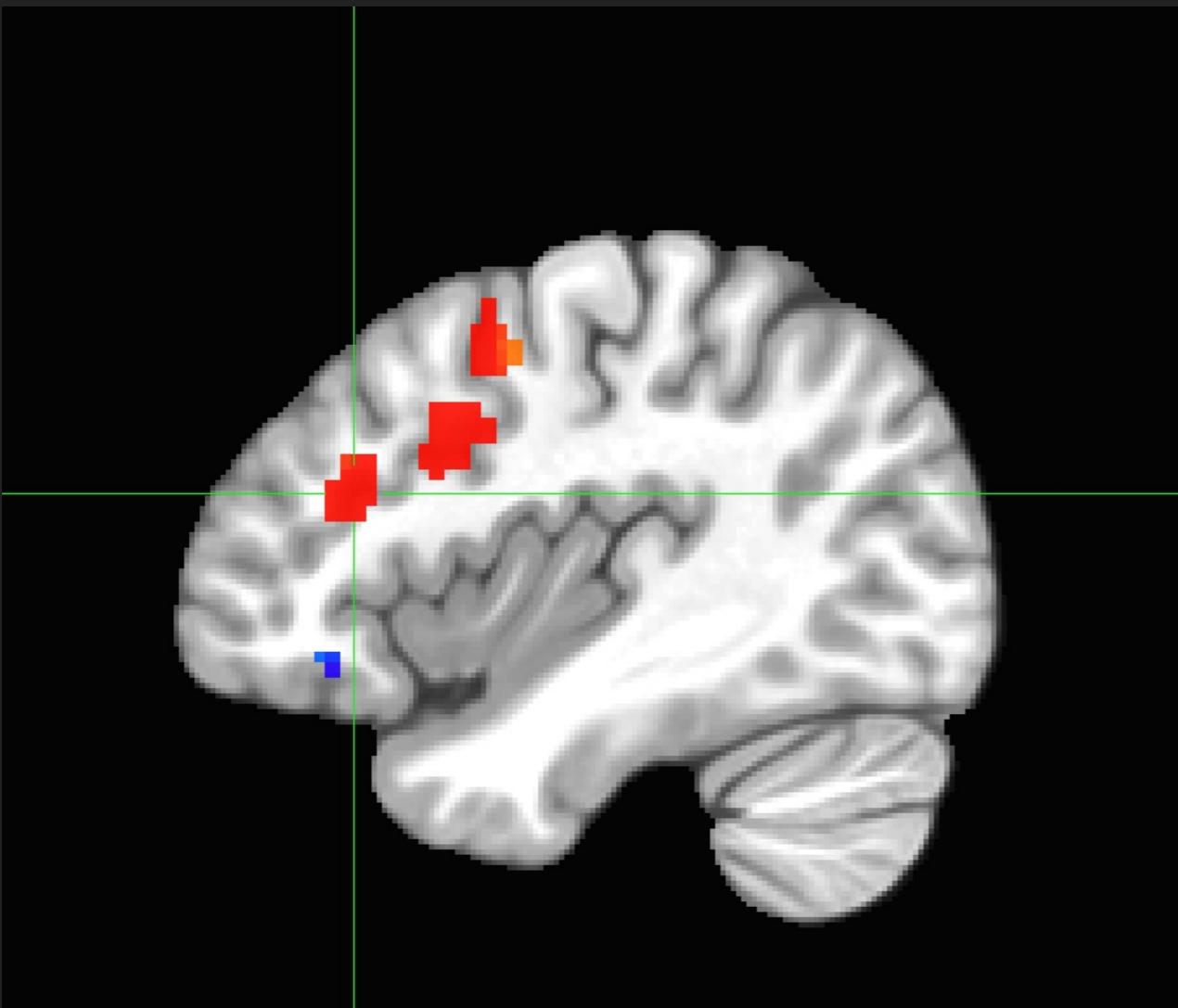
- ▶ Anatomical IFSa, BA44, 45 (e.g. Hindy & Solomon)
- ▶ Main effects:
- ▶ Pronoun>Repeat
- ▶ Sub>Min
- ▶ No interaction



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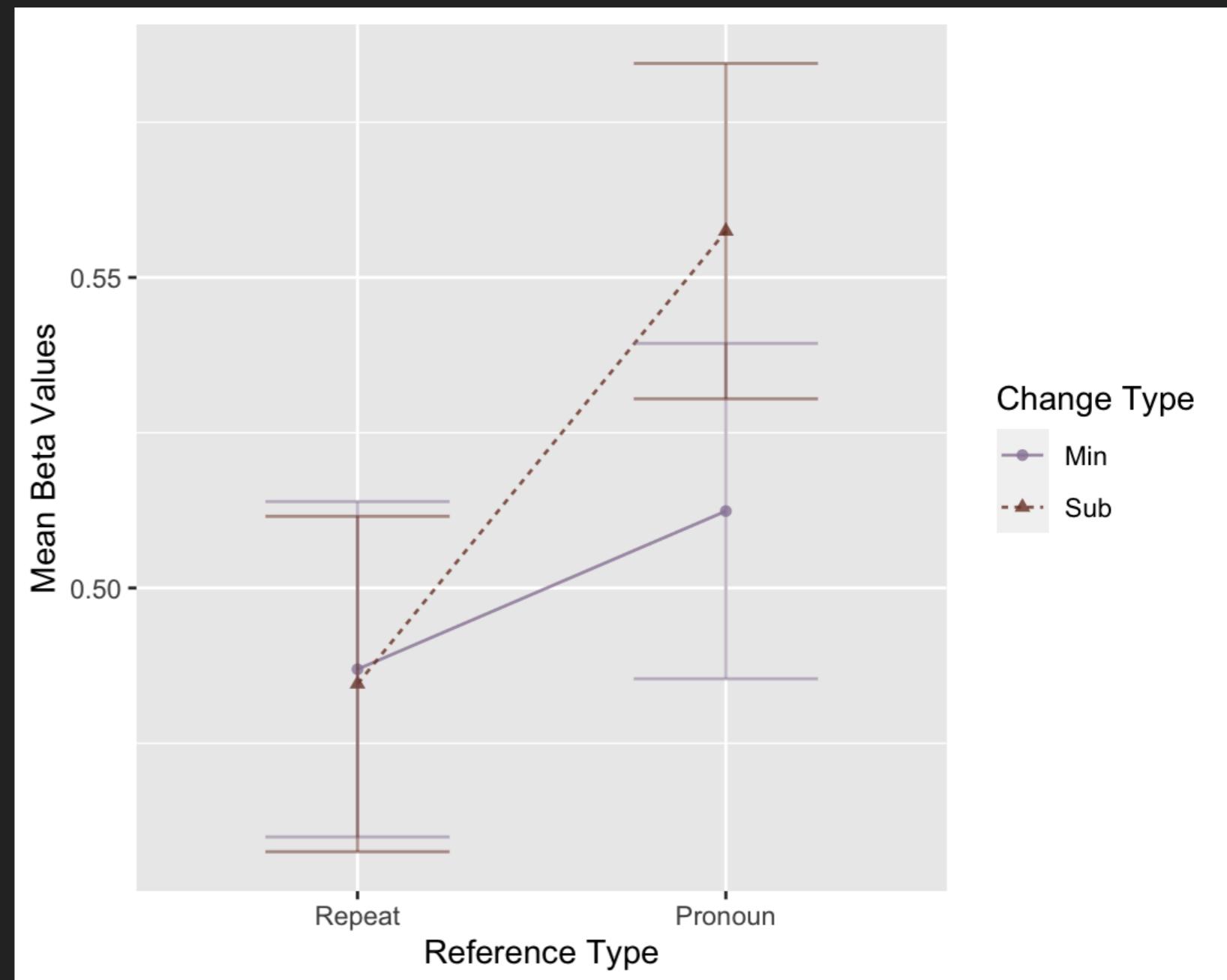
# STROOP CONFLICT EFFECT

►  $p < .0005$



# SENTENCE TASK - STROOP LOCALIZER

- ▶ within IFSa, BA44, 45  
(e.g. Hindy & Solomon)
- ▶ **10% most active**
- ▶ Main effect:
- ▶ Pronoun>Repeat
- ▶ No interaction



---

# FMRI

- ▶ State change effect shown for pronouns
  - ▶ Consistent trends, stronger effect with more VLPFC
- ▶ Don't replicate state change effect for repeated nouns
  - ▶ Could reflect heightened error sensitivity

The chef will peel the apple and then he will smell the apple.

The chef will peel the apple and then he will smell it.

---

## EXPERIMENT 1 DISCUSSION

- ▶ Intersecting Object Histories suggests competition between episodic states of an object in comprehension
- ▶ Previous work allowed for influence of semantic memory
- ▶ Replicate competition effect using pronouns
- ▶ Supports episodic token-state competition
- ▶ Suggestive of a more elaborate reference system in IOH wrt functional, neural, and cognitive subdivisions

---

## EXPERIMENT 1 CONCLUSION

- ▶ Supports competition between episodic states
  - ▶ High spatial resolution: “conflict” voxels
  - ▶ Low temporal resolution
- ▶ EEG increases resolution
- ▶ Provides converging evidence

---

# OBJECT-STATE COMPETITION IN EEG

- ▶ The chef will **peel** the apple and then he will smell **the** apple.
- ▶ The chef will **weigh** the apple and then he will smell **the** apple.
- ▶ Increase in left lateralized alpha power for **peel > weigh**  
(Prystauka, Master's Thesis)
  - ▶ Anticipatory effect at discourse final determiner
  - ▶ Potentially related to inhibitory processes related to resolving competition (e.g. Klimesch, Sauseng & Hanslmayr, 2007)
- ▶ Does alpha power (EEG) pattern like VLPFC activation (fMRI)?

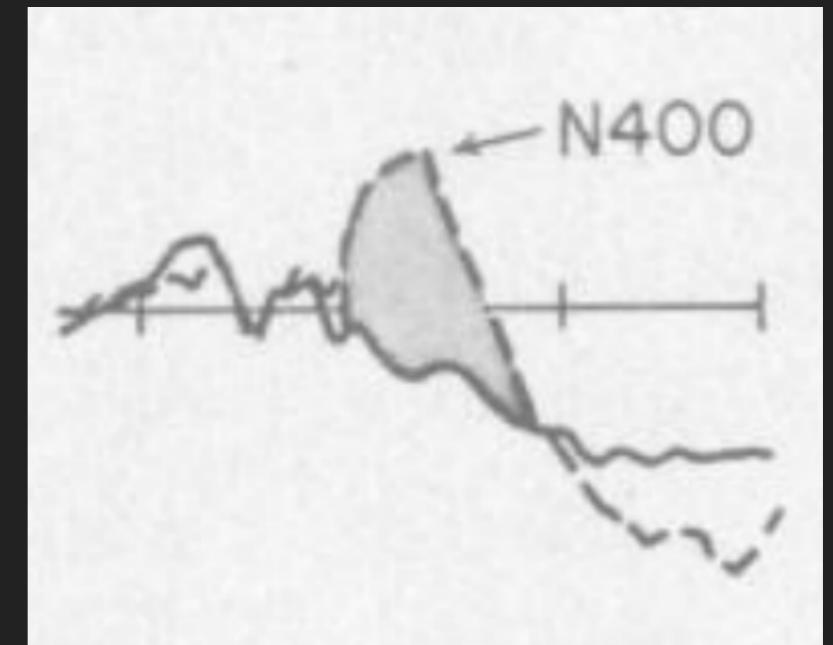
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## EXPERIMENT 2: EEG

- ▶ 19 participants included in analysis
- ▶ 2 (degree of change) x 2 (reference type) design
- ▶ 160 experimental trials
- ▶ 48 lexically ambiguous items: “tie the band/ribbon” (N400)
- ▶ 62 comprehension questions (yes/no; focused on agent and patient)
- ▶ RSVP: word by word reading (300ms on/off)
- ▶ ERP Detour ->

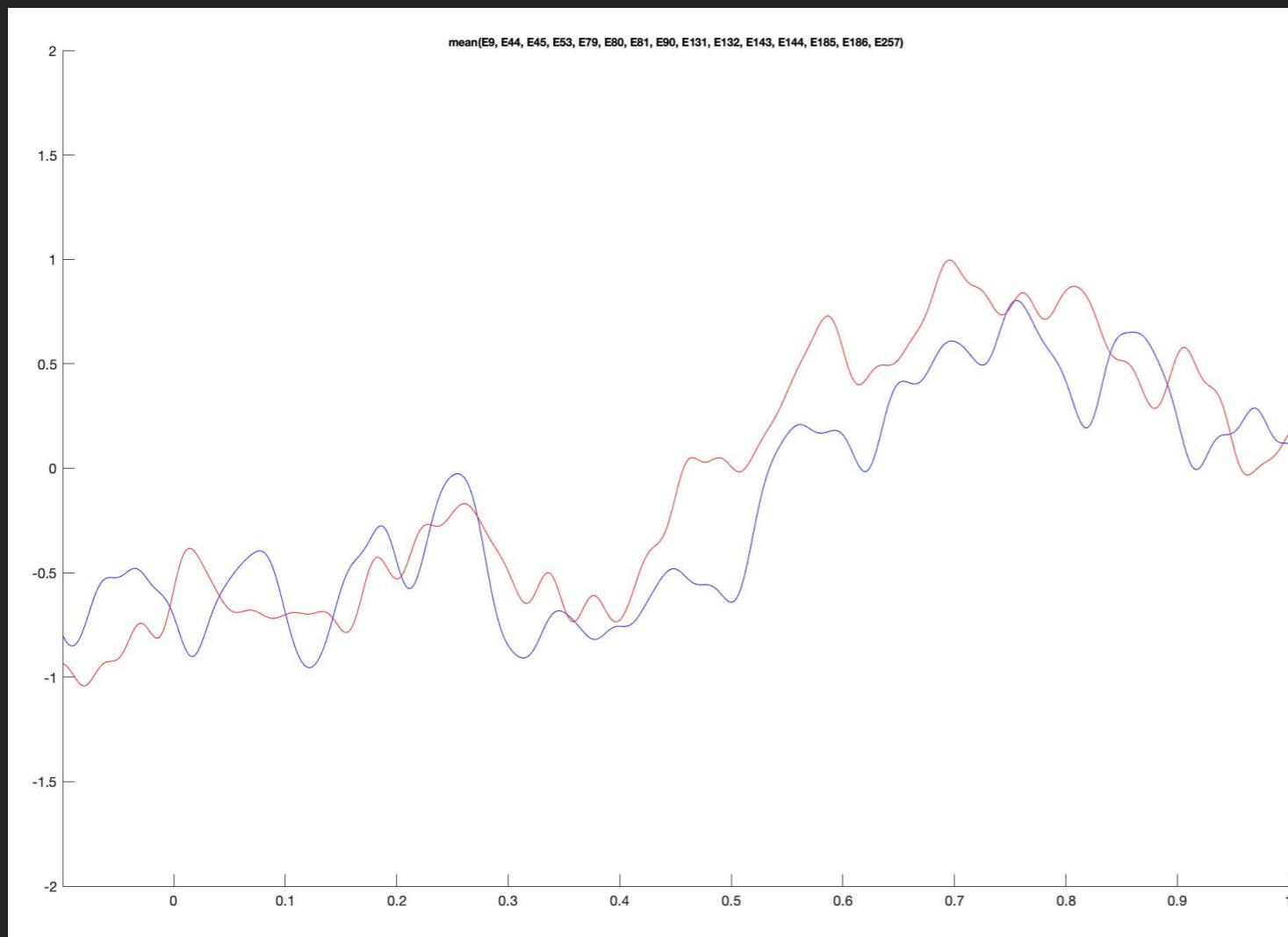
# ERP

- ▶ N400
  - ▶ Improbable/anomalous language (Kutas & Hillyard, 1980)
    - ▶ "Spread the warm bread with socks."
  - ▶ P600
    - ▶ Syntactically complex language (Kaan et al., 2000)
  - ▶ Retrieval and Integration; Expectations and Associations (Aurnhammer et al., 2021)

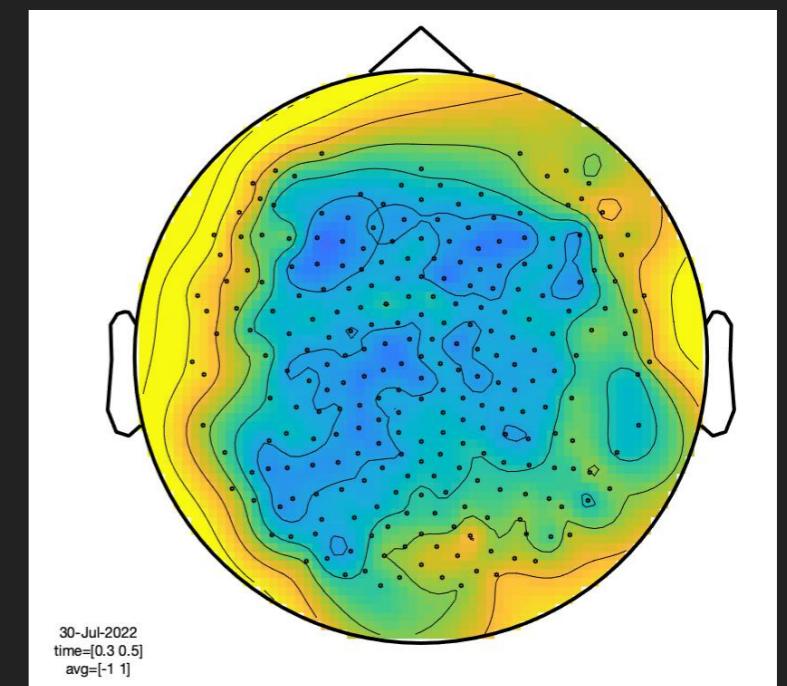


# N400 ERP

- ▶ N400 trending in the correct direction; not significant
- ▶ Blue line - Ambiguous; Red line - Unambiguous



Ambiguous - Unambiguous 300-500ms



---

## EXPERIMENTAL CONDITIONS

- ▶ No significant ERP effects
- ▶ Have visualizations in backup

# TIME FREQUENCY ANALYSIS

- ▶ State change difference for pronouns

- ▶ Alpha 7.5-12.5Hz

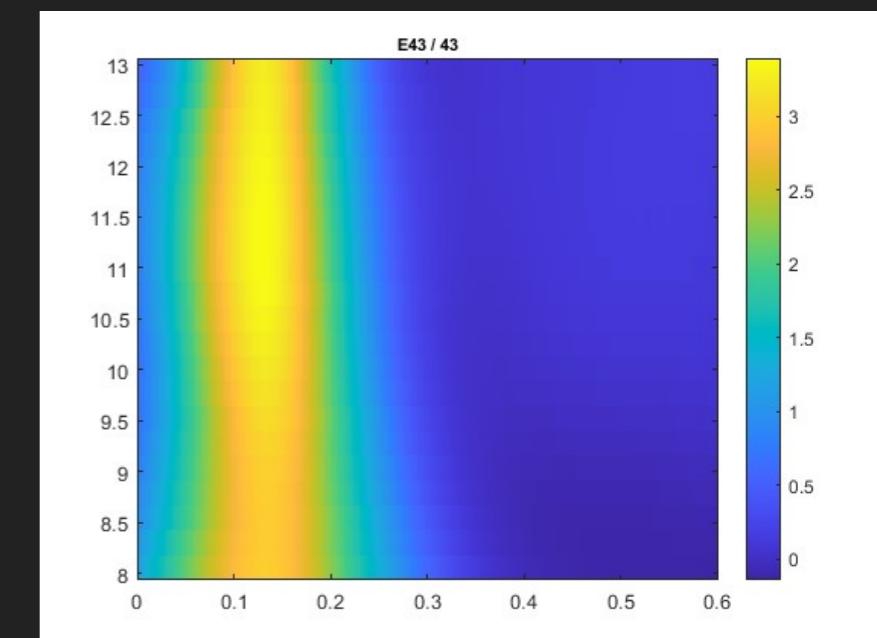
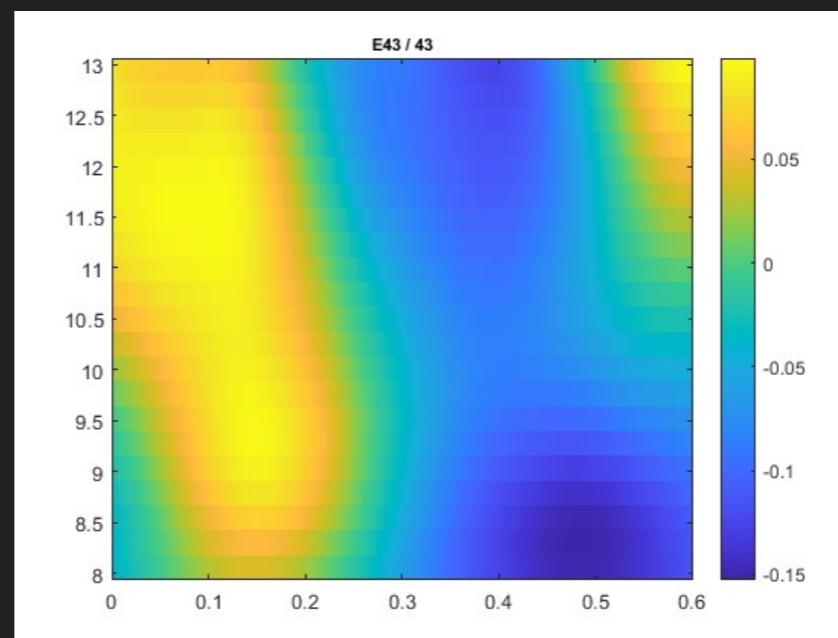
- ▶ Beta 12.5-30Hz

- ▶ Theta 4-7.5Hz

- ▶ Delta 0-4Hz

Substantial

Minimal



# TIME FREQUENCY ANALYSIS

- ▶ State change difference for pronouns

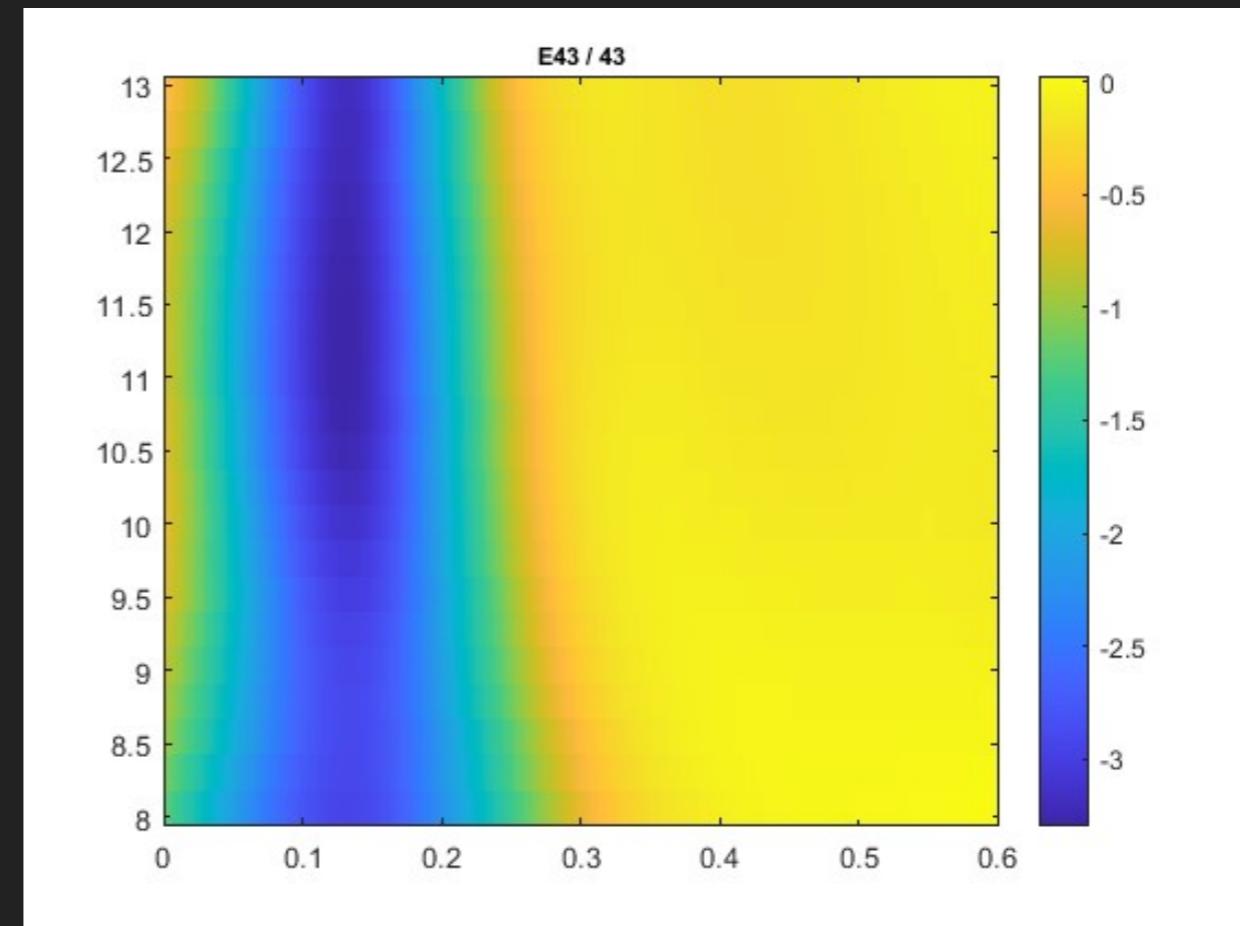
- ▶ ~~Alpha 7.5-12.5Hz~~

Substantial - Minimal Change

- ▶ ~~Beta 12.5-30Hz~~

- ▶ ~~Theta 4-7.5Hz~~

- ▶ ~~Delta 0-4Hz~~



# TIME FREQUENCY ANALYSIS

- ▶ State change difference for repeated nouns

- ▶ Alpha 7.5-12.5Hz

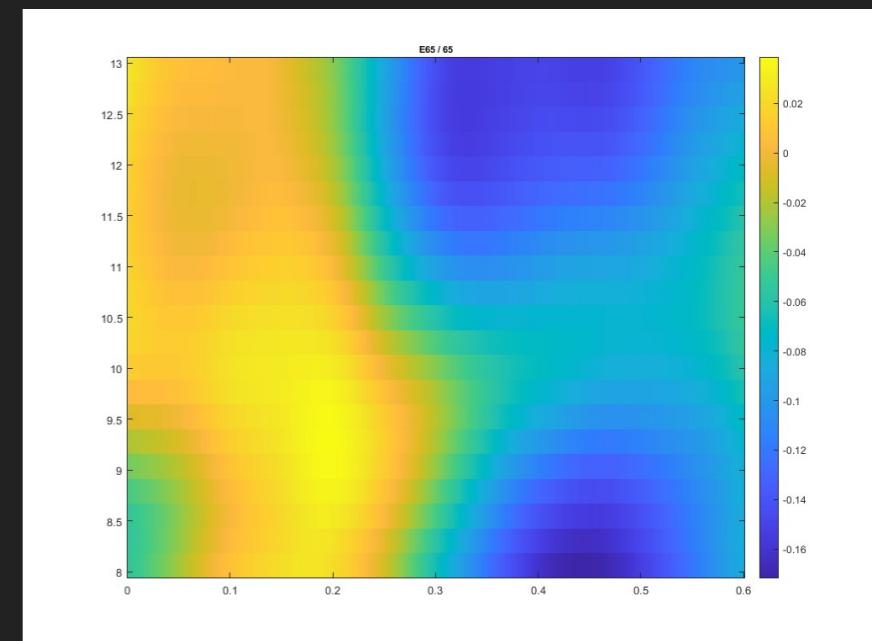
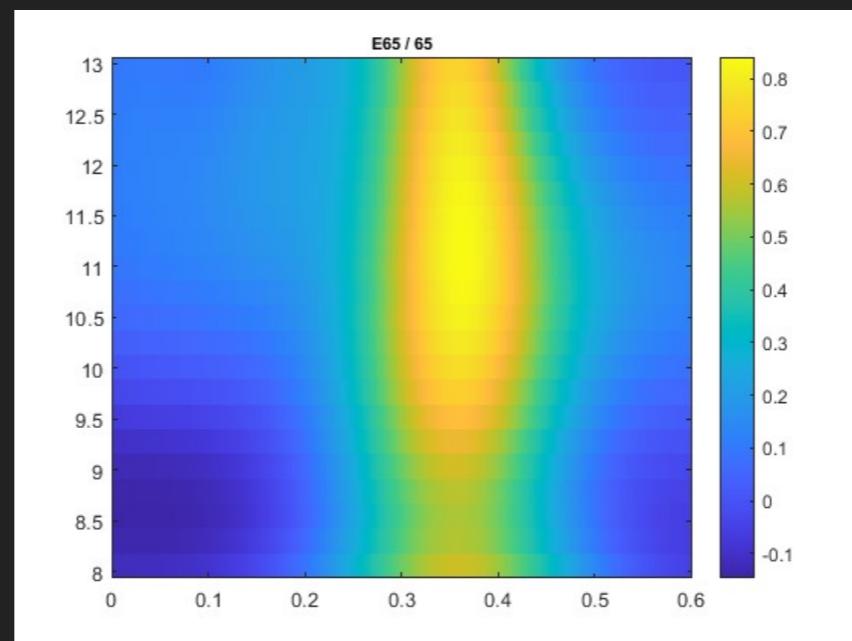
- ▶ Beta 12.5-30Hz

- ▶ Theta 4-7.5Hz

- ▶ Delta 0-4Hz

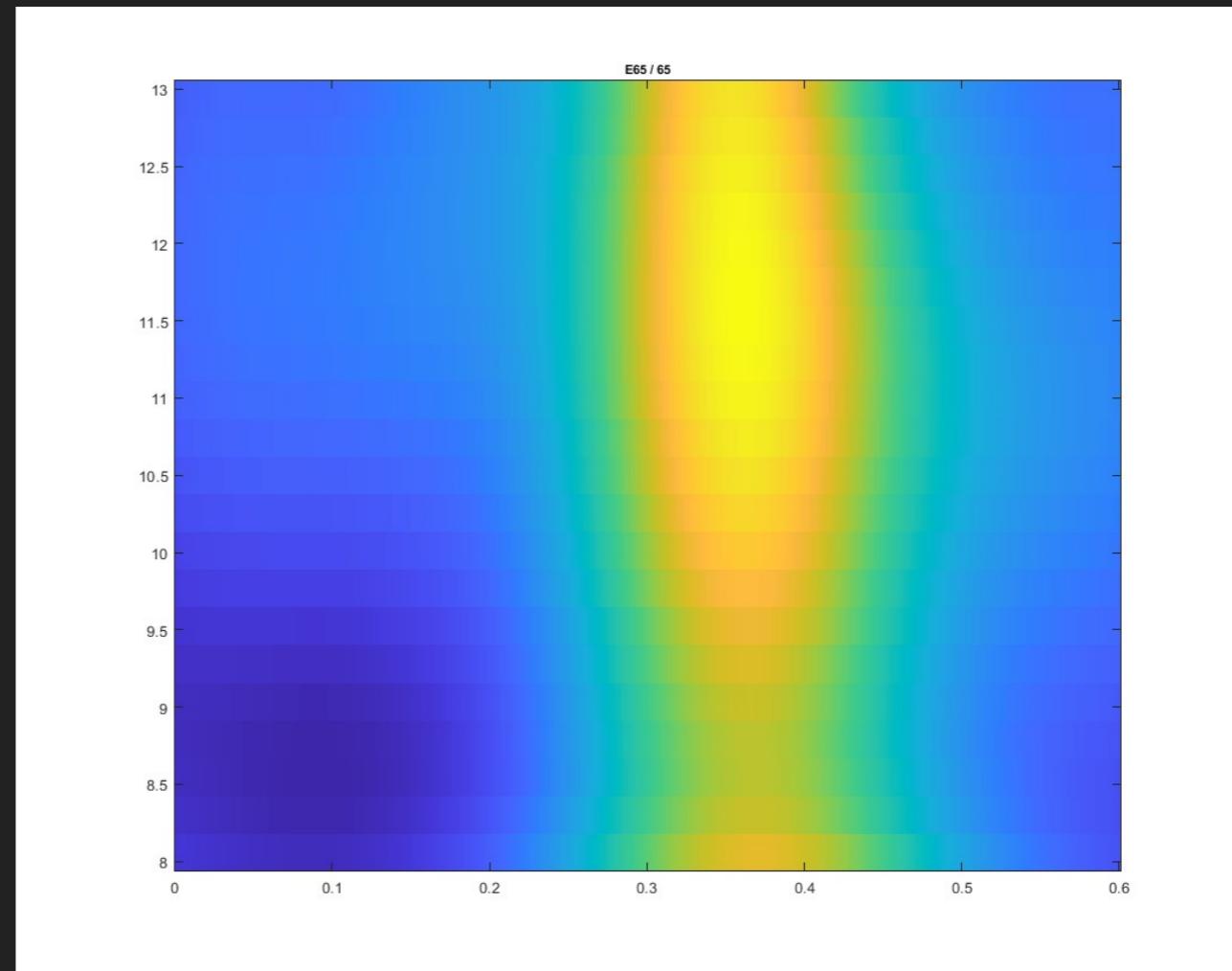
Substantial

Minimal



# TIME FREQUENCY ANALYSIS

- ▶ State change difference for repeated nouns
  - ▶ ~~Alpha 7.5-12.5Hz~~ Substantial - Minimal Change
  - ▶ ~~Beta 12.5-30Hz~~
  - ▶ ~~Theta 4-7.5Hz~~
  - ▶ ~~Delta 0-4Hz~~



---

## EXPERIMENT 2 CONCLUSION

- ▶ Did not observe any differences in time-frequency domain
  - ▶ Failed to replicate Prystauka (Master's Thesis)
  - ▶ Consistent with replication attempts
- ▶ No differences observed in ERPs

---

## GENERAL DISCUSSION

- ▶ Intersecting Object Histories - events as trajectories
  - ▶ Retrieval along trajectory reactivates nearby states
  - ▶ Previous support for this leaves open the possible influence of bottom-up effects causing competition
- ▶ Observed state change effect for pronouns in fMRI *must* be driven by episodic competition
- ▶ Strong support for IOH competition

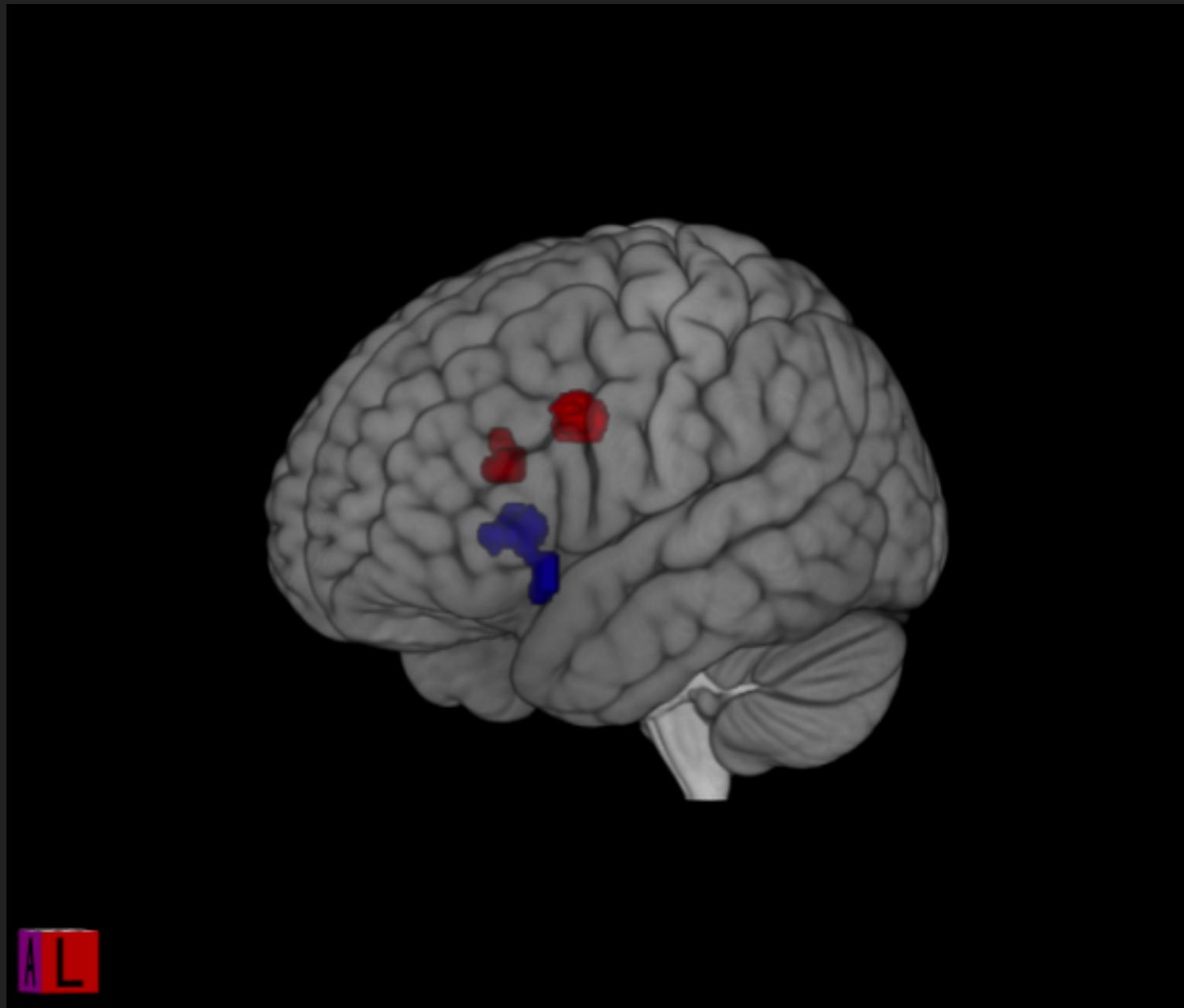
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## GENERAL DISCUSSION

- ▶ EEG results are inconclusive
  - ▶ Method seems to be unreliable
- ▶ Future Directions
  - ▶ Distinctions within cognitive control regions (e.g. Badre)

# SENTENCE VS STROOP REGIONS

- ▶ Blue: pronoun state change effect in sentence task
- ▶ Red: mismatch - match in Stroop task
- ▶ Non-overlapping peaks
- ▶ VLPFC Subregions:
  - ▶ Anterior: controlled retrieval
  - ▶ Posterior: competition  
(Badre & Wagner, 2007)



---

## GENERAL DISCUSSION

- ▶ EEG results are inconclusive
  - ▶ Method seems to be unreliable
- ▶ Future Directions
  - ▶ Distinctions within cognitive control regions (e.g. Badre)
  - ▶ Use this language to explore episodic memory systems

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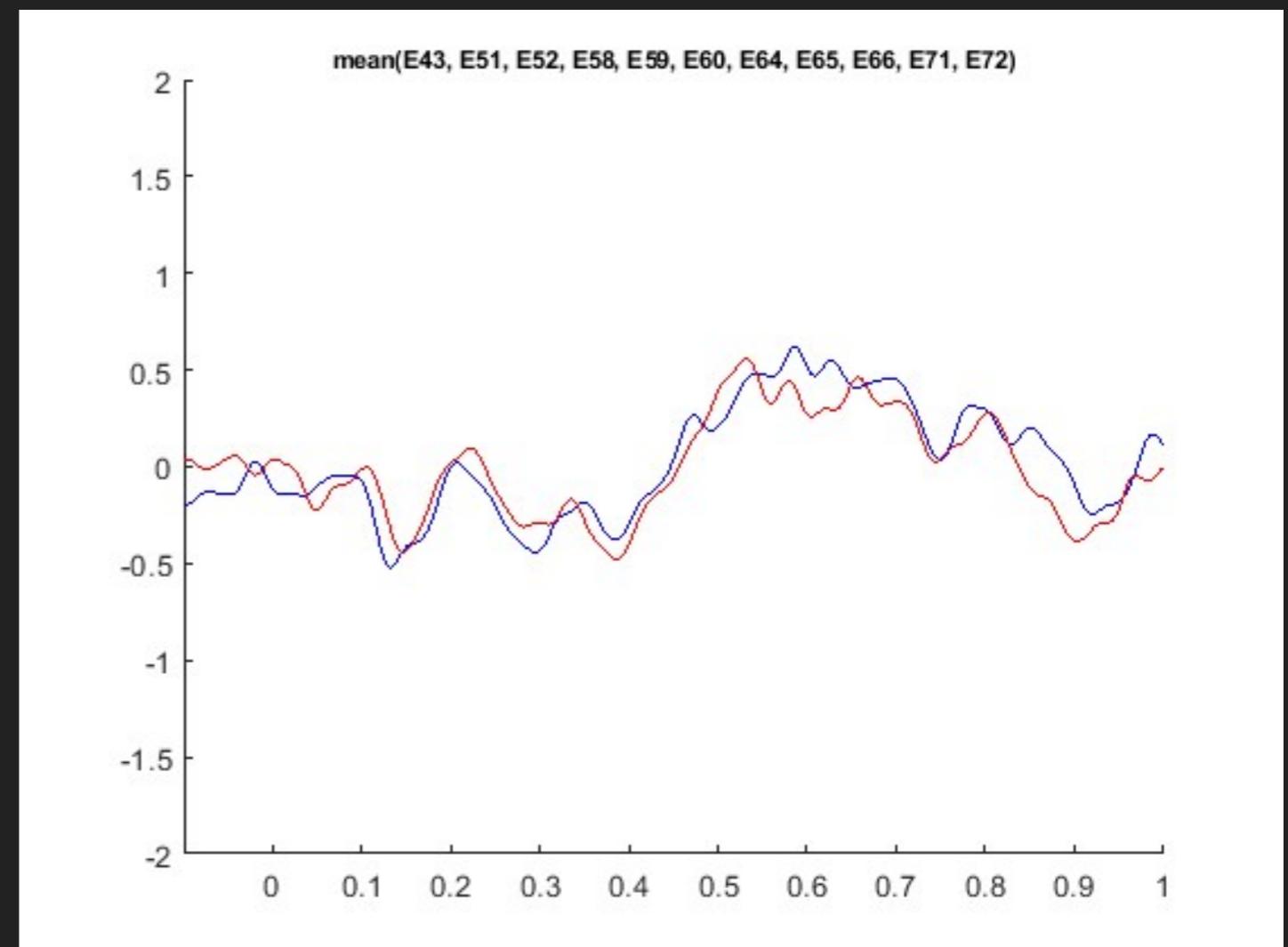
Thanks!

- ▶ Gerry Altmann
- ▶ Eiling Yee
- ▶ Whit Tabor
- ▶ Nicole Landi
- ▶ Altmann & Yee Labs
- ▶ BIRC
- ▶ IGERT, IBACS



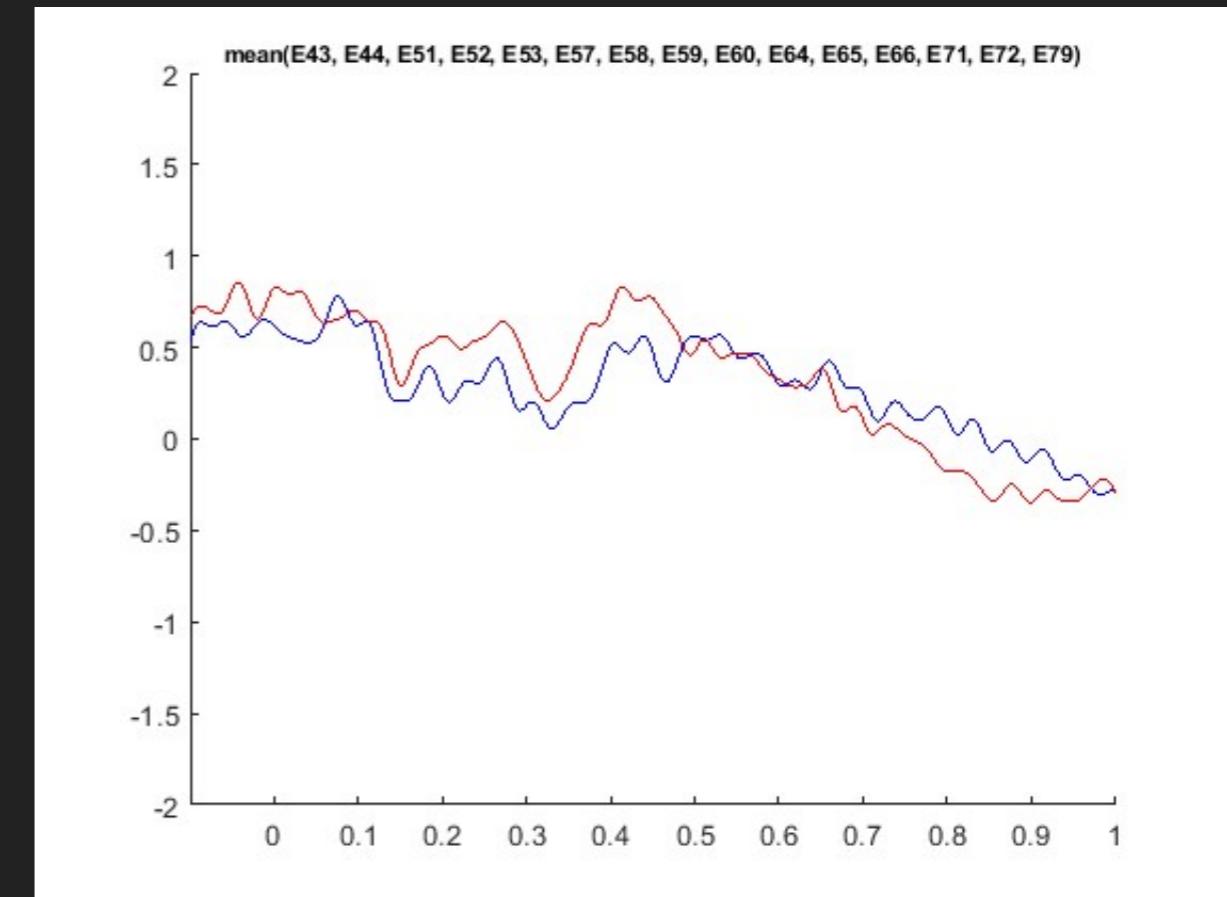
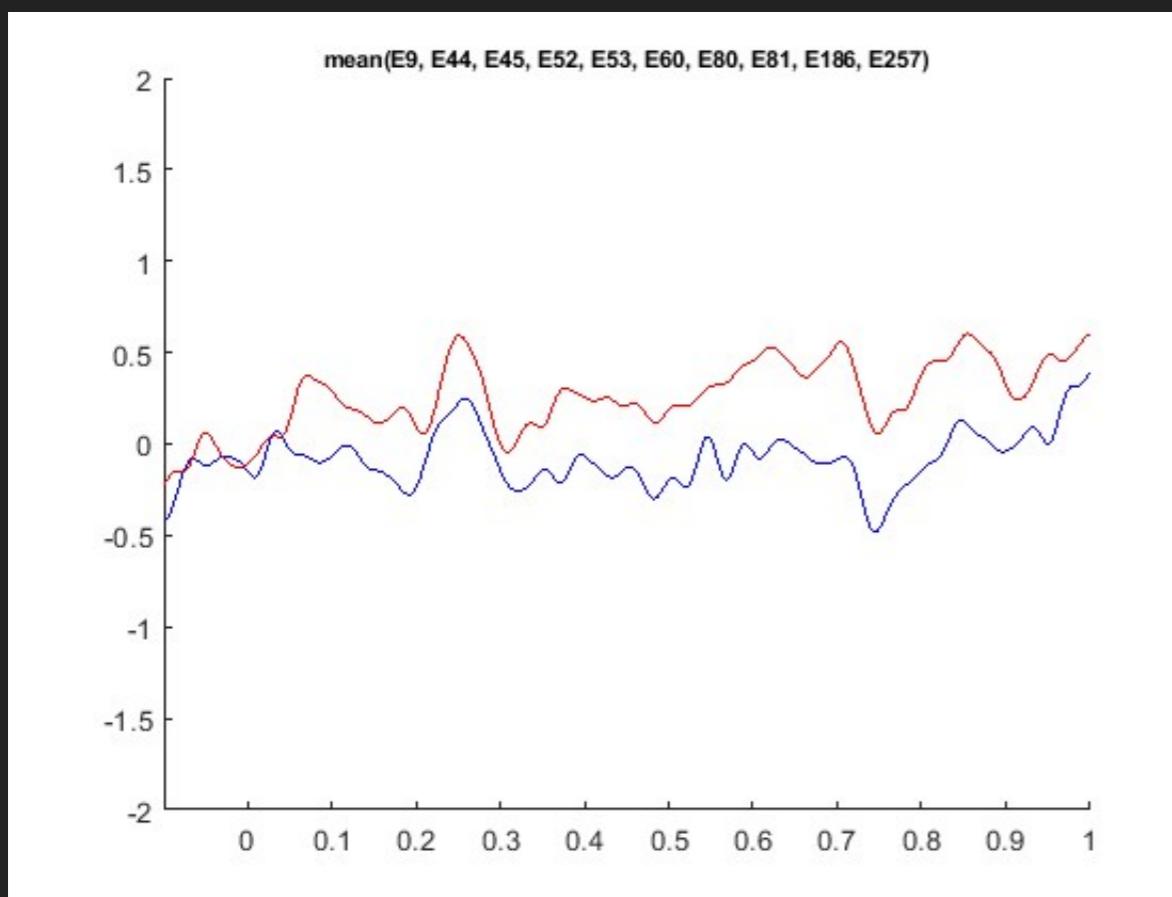
## ERP FIRST SENTENCE NOUN

- ▶ Collapsed across Pronouns and Repeated Nouns
- ▶ Blue - Substantial Change; Red - Minimal Change



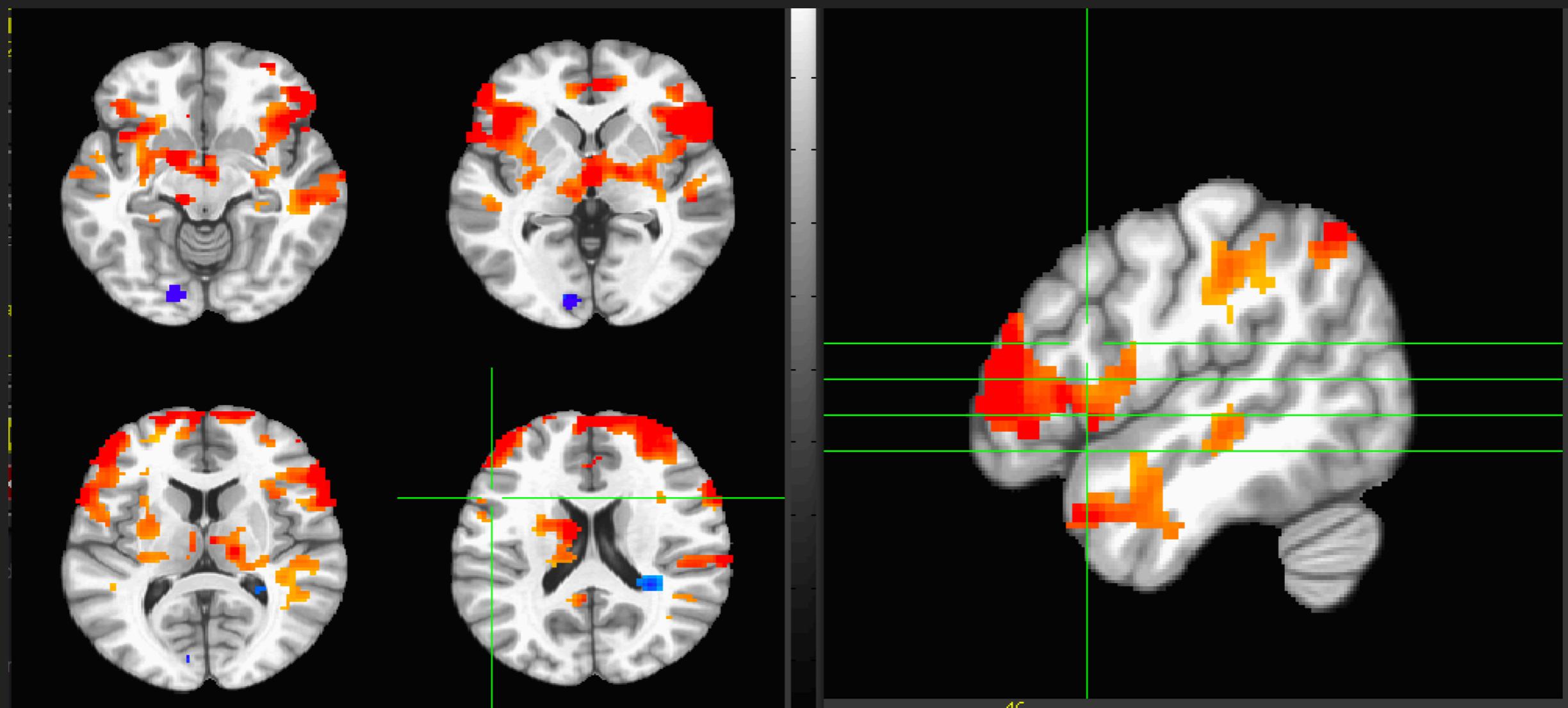
## ERP AT DETERMINER

- ▶ Repeated Noun Pronoun
- ▶ Blue - Substantial Change; Red - Minimal Change



## REFERENCE MAIN EFFECT

- ▶ Pronouns > repeated nouns



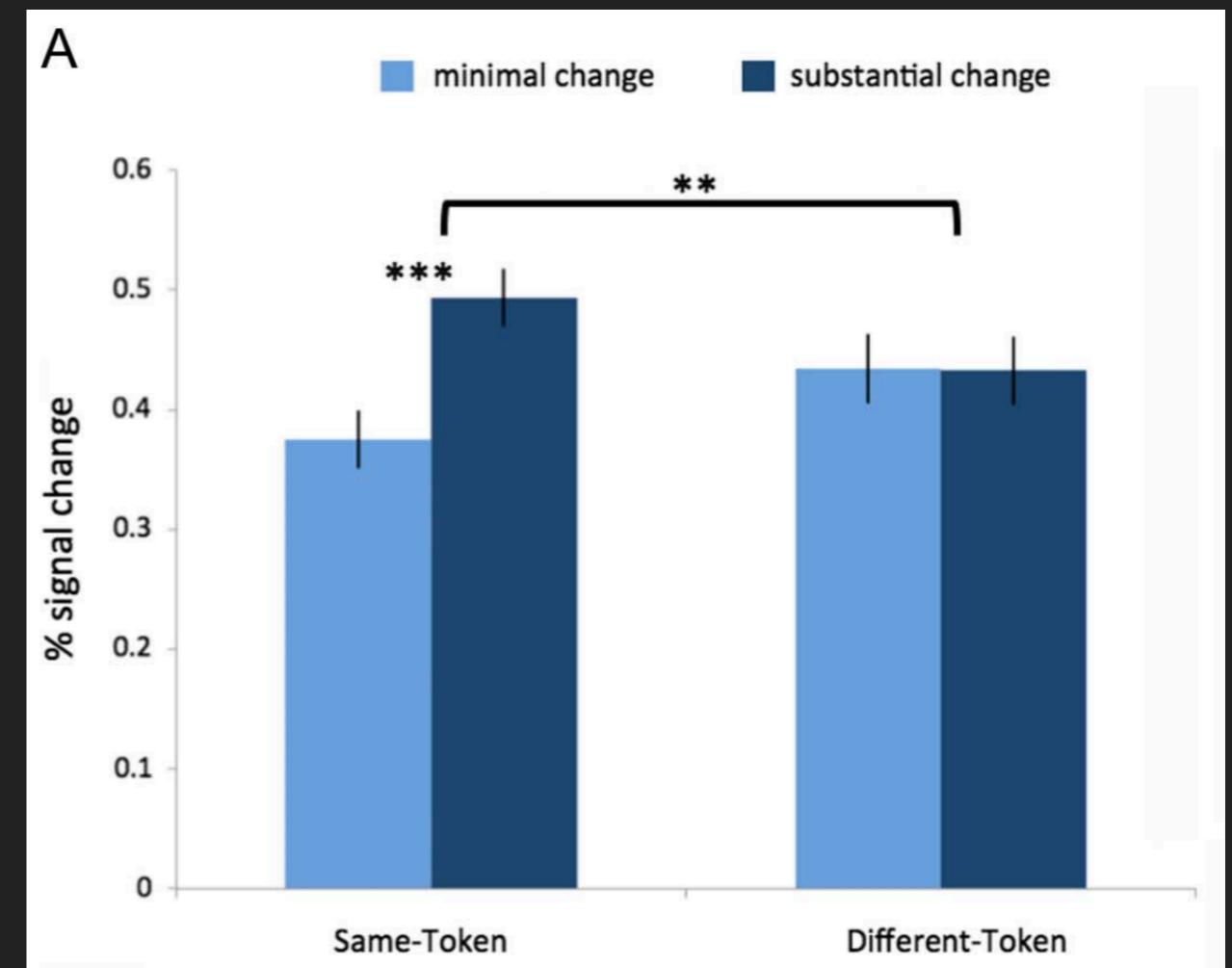
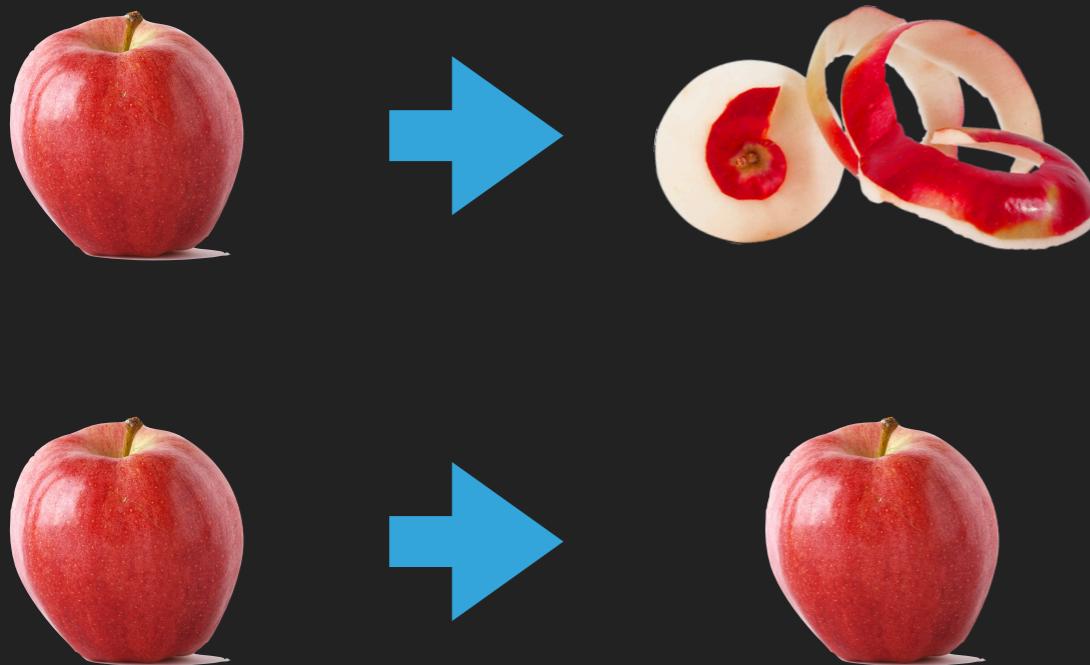
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## OTHER ANALYSES

- ▶ Change as amplitude modulated regressor
- ▶ Imageability concerns

# ANOTHER

- ▶ The chef will **peel** the apple and then he will smell another apple.
- ▶ The chef will **weigh** the apple and then he will smell another apple.



Hindy et al., 2012; Solomon et al., 2015

---

## EXPLORATORY FMRI PREDICTIONS

- ▶ Increased activation in temporal gyrus and intraparietal sulcus for repeated names > pronouns (Almor et al., 2007)
- ▶ Similarity of anaphor-antecedent modulates RNP (Almor, 1999; 2004): referring to a robin vs penguin as “the bird”