Predictability shapes meaning resolution for lexicosemantic ambiguities

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Introduction

Sentence comprehension requires integration across multiple levels of representation.

As speech unfolds, **top-down predictions** inform processing of **bottom-up input**

semantics
words
morphemes
phonemes

However, incoming speech signals and corresponding linguistic units can be *unpredictable* and highly *ambiguous.*

Q1: Is the neural response driven by lexical- or sentence-level factors?
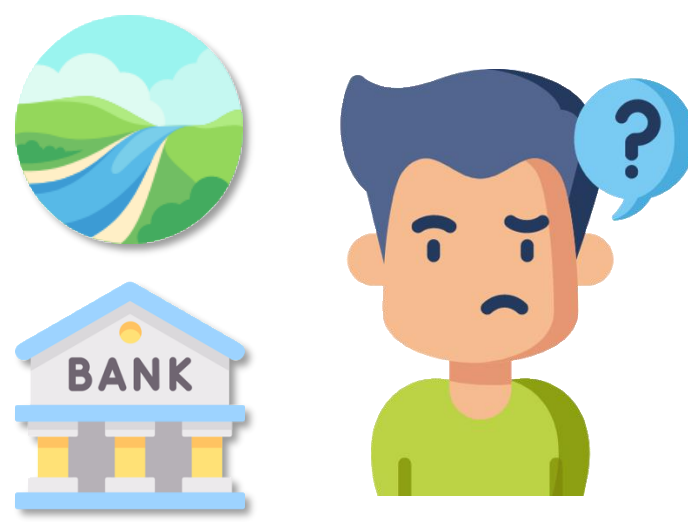*Q2: How does predictable context alter the processing of ambiguous words?*

Word Meaning Resolution

Lexicosemantic ambiguities

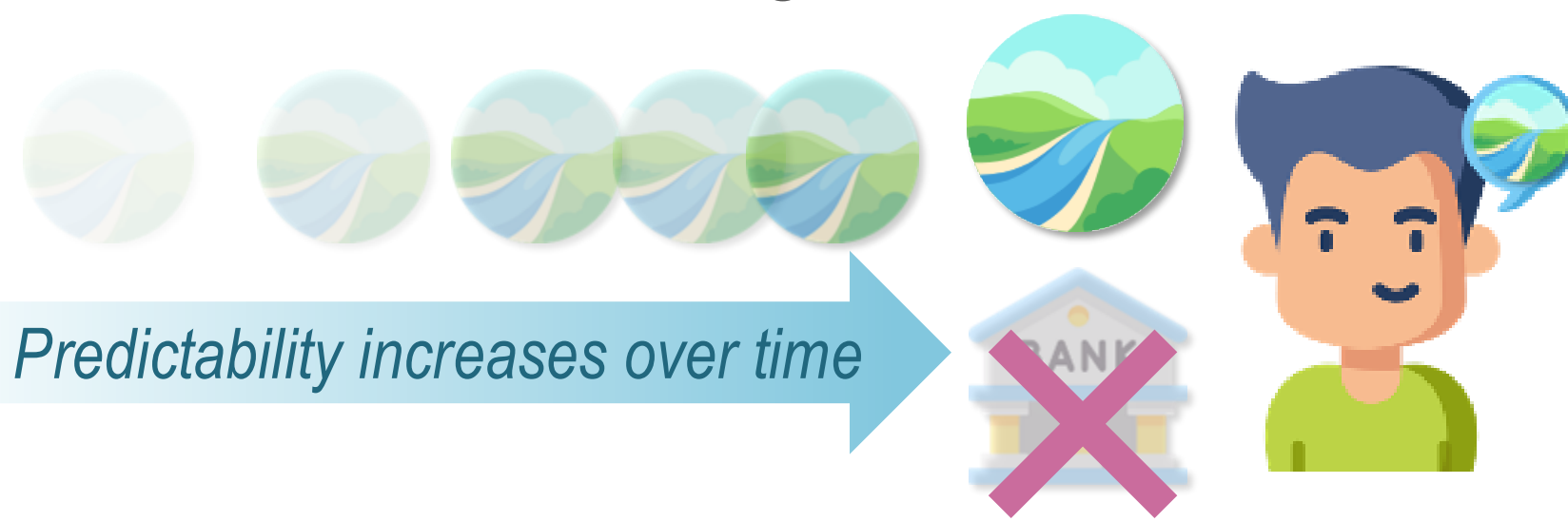→ word forms that map on to multiple meanings

In isolation — *"bank"* — vs — **In (predictable) context**

"While sailing down the river, she noticed the trees along the...x *bank*"

Predictability increases over time

What is required for meaning resolution?

(1) Meaning access: *lexicosemantic ambiguities* in unbiased contexts are associated with increased neural response amplitude relative to control words [1,2]
(2) Contextual support/predictability: *unpredictable words* are also associated with increases in neural response amplitude (e.g., larger N400). [3]

Methods

Participants: N=31
Task: auditory sentence comprehension
Data: MEG/EEG (Triux Neo), structural MRI (T1), web-based psych tests
Stimuli: 180 non-repeated sentence-final words.
ambiguous (AMB) words (cloze: m=0.64, sd=0.21),
selected-meaning synonyms (SMS), or **alternative meaning (ALT)** words.

While sailing down the river, she noticed the trees along the	bank	AMB	**congruent**	
The canoeists paddled to the other side and moored their boat on the opposite	shore	SMS		
After the ducks had finished swimming, they waddled up the muddy	cashpoint	ALT	**anomalous**	

Hypotheses and critical comparisons

Q1: Sentence-level factors
Semantic Congruency: ALT > (AMB^SMS)
Hypothesis 1: ALT (anomalous) will elicit larger amplitude response than congruent words in sentences.

Q1: Lexical-level factors & Q2: Ambiguity processing
Lexicosemantic (Un)Certainty: AMB <> SMS
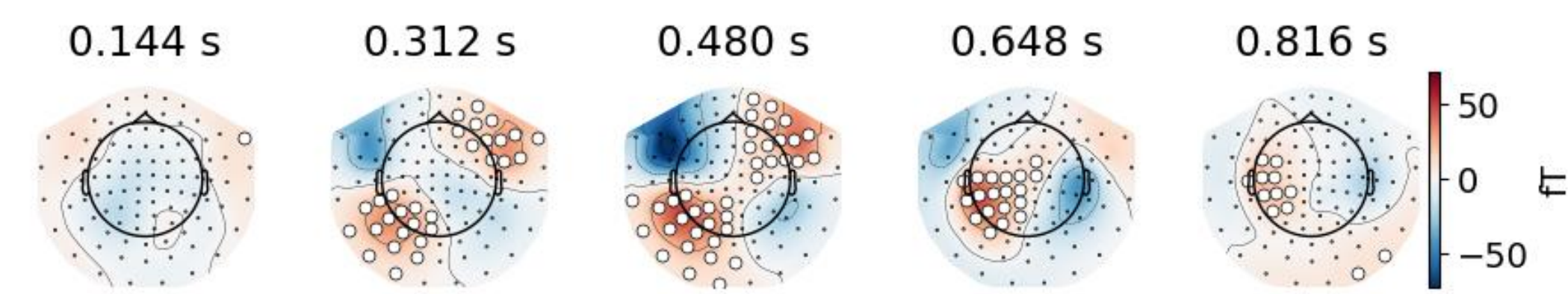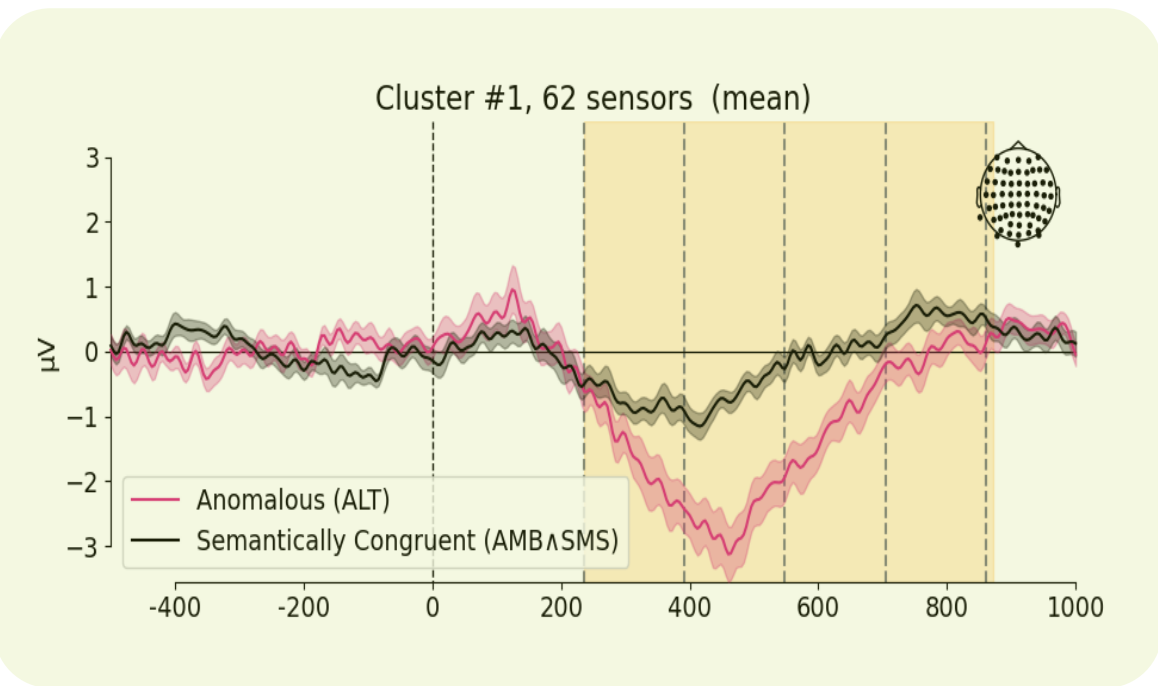Hypothesis 2a: Ambiguity effect: AMB > SMS
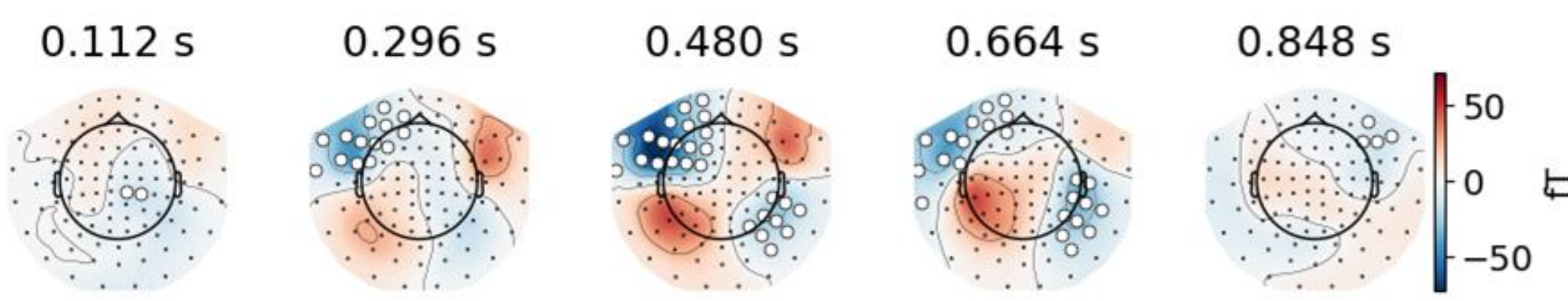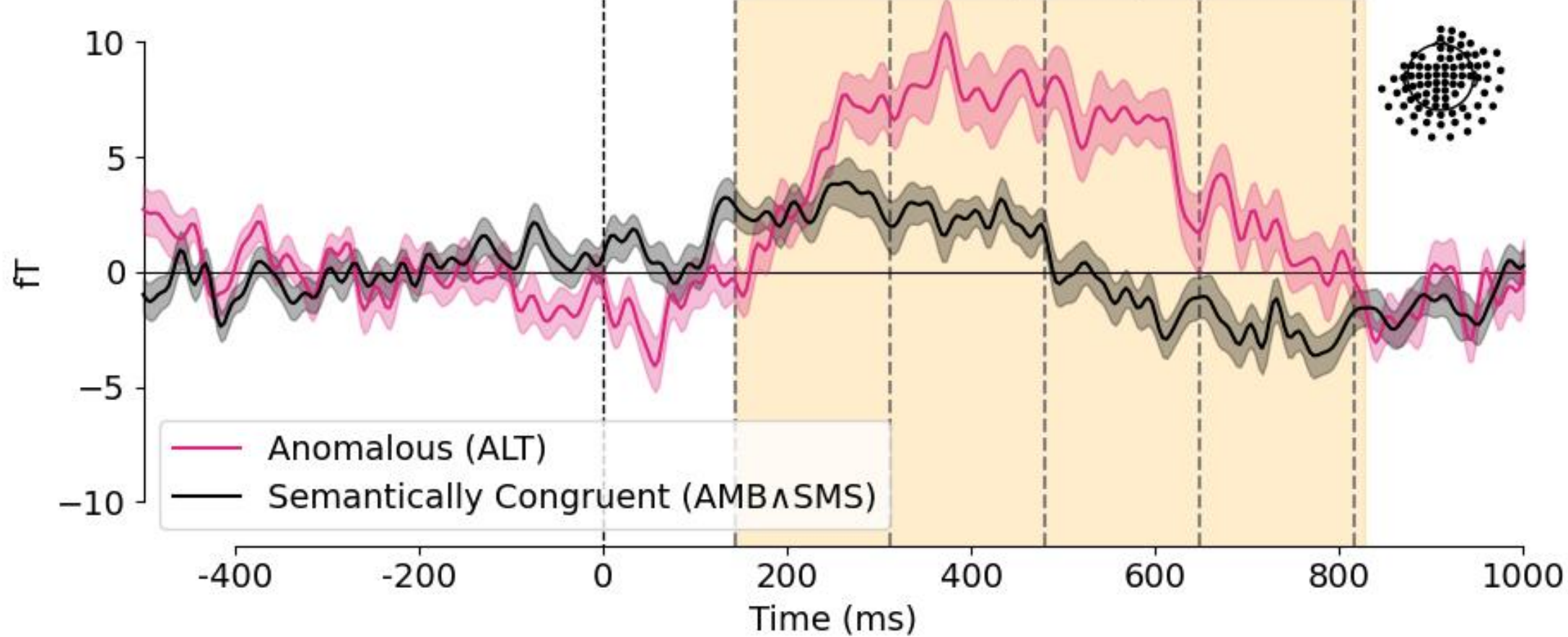Hypothesis 2b: Predictability effect: SMS > AMB

Results

Semantic Congruency:
Significant for all sensor types using 2D cluster-based permutation testing [4,5]. MEG magnetometers plotted with EEG below for demo of (m)N400.
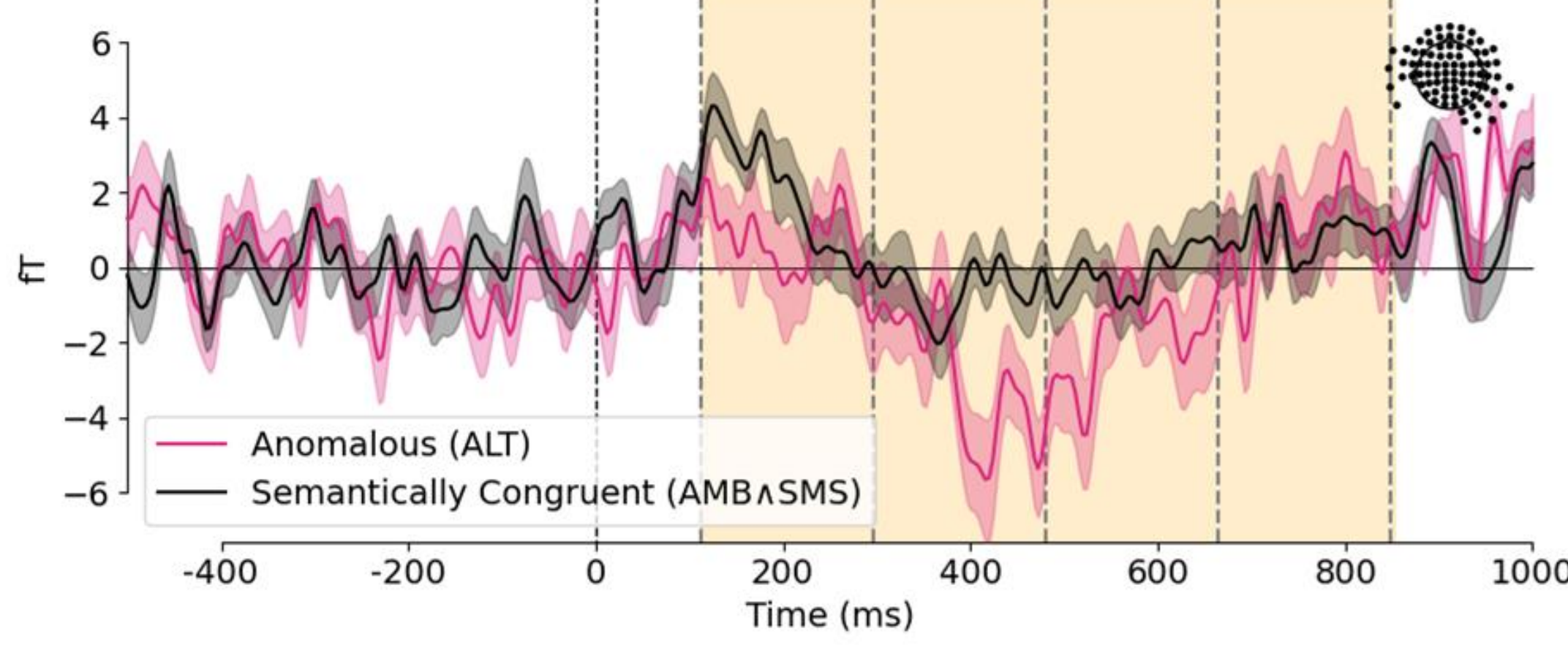
EEG: classic N400
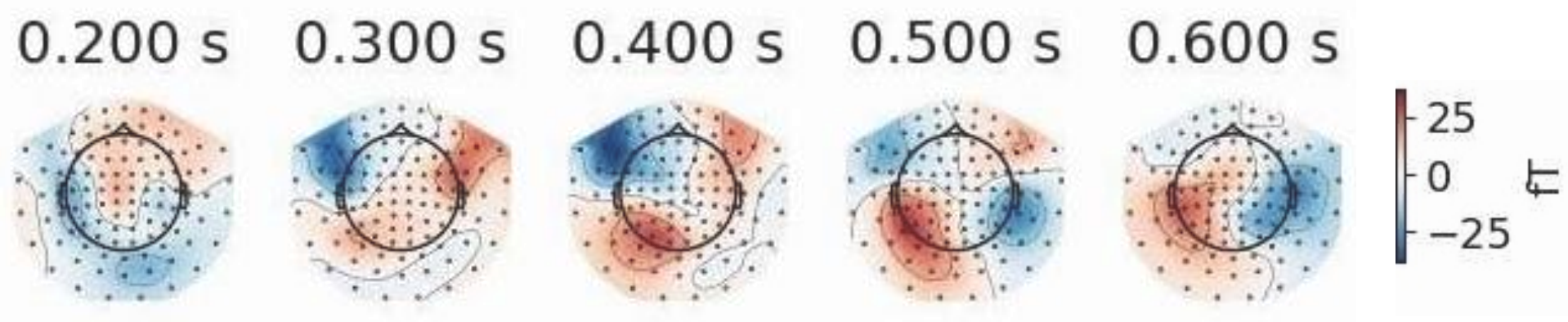

MEG magnetometers: Cluster #1, 85 sensors (mean)

0.144 s 0.312 s 0.480 s 0.648 s 0.816 s

— Anomalous (ALT)
— Semantically Congruent (AMB^SMS)

MEG magnetometers: Cluster #2, 85 sensors (mean)

0.112 s 0.296 s 0.480 s 0.664 s 0.848 s
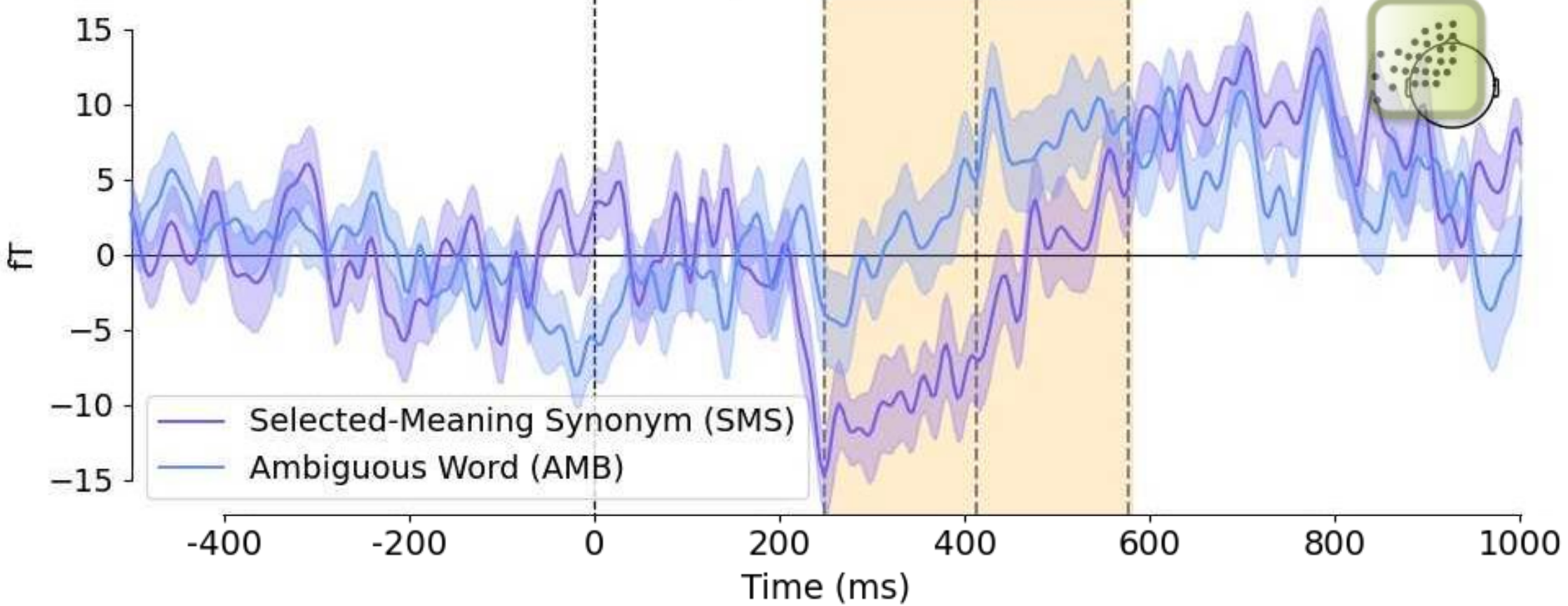
— Anomalous (ALT)
— Semantically Congruent (AMB^SMS)

Lexicosemantic (Un)Certainty
In predictable contexts, ambiguities behave like predictable words. Significant for MEG magnetometers only.

Difference between AMB vs SMS is driven by **sentence-level factors (e.g., cloze)**

0.200 s 0.300 s 0.400 s 0.500 s 0.600 s

Topography is consistent with mN400 pattern (like cluster 2, above right)

Cluster #1, 28 sensors (mean)

— Selected-Meaning Synonym (SMS)
— Ambiguous Word (AMB)

Discussion & Future Directions

AMB < SMS << ALT
A1: *Predictability due to sentence-level semantics (e.g., cloze)* drives differences in neural response amplitude.
A2: *Word meaning is highly flexible,* with **uncertainty** about word meaning reduced *in context*.

Results ***cannot rule out*** ambiguity effect caused by access of multiple meanings (exhaustive access [6])

Future directions: mixed effects modelling (lme4, R) with ambiguity, cloze probability, individual differences (vocabulary, fluid intelligence, and meaning resolution skill).

References: [1] Rodd et al., JML, (2002); [2] MacGregor et al., JoCN (2020); [3] Kutas & Federmeier, Ann. Rev. Pysch. (2011); [4] Gramfort et al. Frontiers in Neuroscience, (2014) [5] Maris & Oostenveld, J Neuroscience Methods [6] Onifer & Swinney, Mem & Cogn. (1981). Select images from Flaticon.com.