An event-related brain potential investigation of multi-level probabilistic expectations in sentence comprehension

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Introduction

Prediction during language comprehension occurs in a probabilistic manner at multiple levels of representation

Here we used event-related brain potentials (ERPs) to investigate how these multi-level predictions influence neural processing of incoming words in context

Design

Sentence contexts conveying events or states were strongly or weakly lexically constraining

Each context was completed with either the most expected word, an unexpected but plausible word, or an implausible word violating the coarse semantic constraints of the context

	Expected	Unexpected	Implausible
STRONG ***He liked lemon and sugar in his***	**tea.**	**sauce.**	**cash.**
WEAK ***The shirt was stained with***	**blood.**	**sauce.**	**cash.**

Sentence materials consisted of a subset of those used in prior studies manipulating lexical constraint [1,2]

Lists were counterbalanced so that across subjects, all critical words appeared as unexpected and implausible completions in both strong and weak constraint

Research Questions

(1) Does the degree of match or mismatch of an incoming word with semantic constraints of the context interact with lexical constraint, as indexed by the N400?

(2) Does the brain respond differently to lexically unexpected words that violate fine vs. coarse semantic constraints (i.e. plausible vs. implausible words)?

(3) Does a word that creates an impossible meaning representation lead to the semantic P600, even when it appears outside of the main verb-argument structure and when it does not necessarily violate animacy constraints?

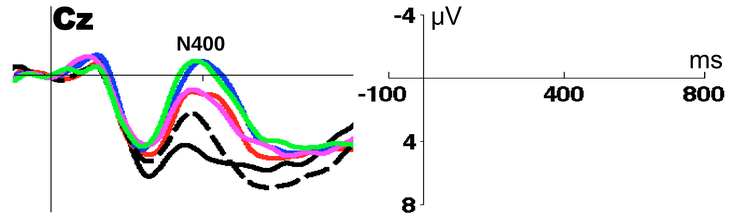
Results and Discussion

Semantic constraints

The **N400** was graded by the degree of semantic match with the prior context

Implausible > Unexpected Plausible > Weakly Expected > Strongly Expected
("Greater" is more negative, 300-500 ms, central-posterior sites)

For both types of semantically unexpected words, the N400 was insensitive to lexical predictability, highlighting the fact that it is primarily a reflection of semantic – as opposed to lexical – constraints [3]



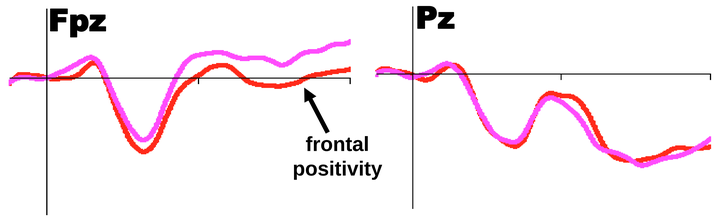
He liked lemon and sugar in his **tea / sauce / cash.**
The shirt was stained with **blood / sauce / cash.**

Violations of lexical predictions

Plausible but unexpected words that violated strong lexical constraints elicited a **late frontal positivity** (compared to these unexpected words in weak contexts), replicating past studies [1,4]

Unexpected Strong Constraint > Unexpected Weak Constraint
("Greater" is more positive, 600-800 ms, frontal and prefrontal sites)

The late frontal positivity likely reflects the violation of a high certainty lexical prediction, within a coherent meaning representation



He liked lemon and sugar in his **sauce.**
The shirt was stained with **sauce.**

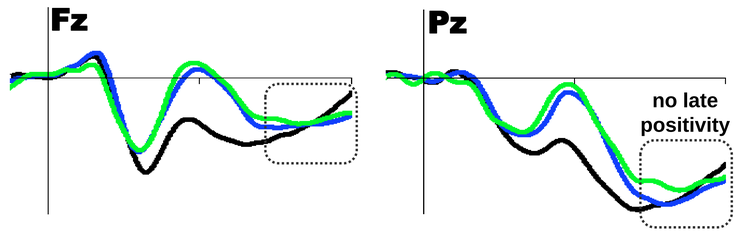
Implausible words within heterogeneous sentence structures

When the same words were highly implausible in their contexts, creating an impossible meaning, they did not elicit any late positivity in either strongly or weakly constraining contexts (compared to expected words, here collapsed over constraint), unlike in past studies showing a **semantic P600** for animacy violated nouns [5,6] and verbs [7]

Implaus. Strong Constraint ≈ Implaus. Weak Constraint ≈ Expected
(600-800 ms, frontal or posterior sites)

Contexts were defined solely on the basis of lexical constraint, and did not necessarily strongly constrain for a single, specific semantic-syntactic structure

Future work will examine the role of sentence structure and word position in determining whether and what late ERP effects are evoked by unexpected words



He liked lemon and sugar in his **tea / cash.**
The shirt was stained with **blood / cash.**

Methods

- 36 right-handed native English speaking volunteers participated
- Participants performed an acceptability judgment task
- 168 sentences included 21 per condition and 21 implausible filler sentences in both strong and weak constraint (counterbalanced)
- Sentences presented word-by-word w/ 450 ms duration, 100 ms ISI
- ERPs recorded with 32 Biosemi active electrodes, continuously sampled at 512 Hz with a bandpass filter of DC – 104 Hz

References & Acknowledgements

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