

# ERP Evidence for Parallel Probabilistic Lexical Prediction

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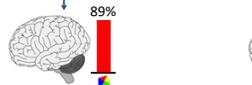
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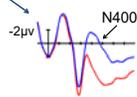
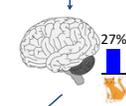
## Introduction

Comprehenders make *probabilistic predictions* about upcoming words

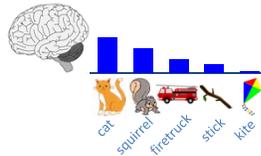
The day was breezy so the boy went outside to fly a...



Every time they went for walks Sylvia's dog Rex would break into a run as soon as he spotted a...



- N400 amplitude decreased in proportion to target noun cloze probability (Kutas & Hillyard, 1984; Delong, Urbach, & Kutas, 2005) ⇒ Lexico-semantic representations are pre-activated in proportion to their probability of occurring
- Specifically, we hypothesize that all possible continuation words are pre-activated in parallel in proportion to their probability



- Parallel prediction is widely assumed in computational models of language processing (Crocker & Brants, 2000; Gaskell & Marslen-Wilson, 1997; Hale, 2001; Jurafsky, 1996; Levy, 2005; McClelland & Elman, 1986; inter alia) and has supporting behavioral evidence (Smith & Levy, 2013; Staub et al., 2015; Zwitserlood, 1989; c.f. Kleinman, Runnqvist & Ferreira, 2015)
- ERP evidence for parallel lexical prediction specifically is sparse
  - Most experiments have conflated cloze with contextual constraint (but see Federmeier et al., 2007; Wlotko et al., 2018 who show that very low (0-3%) cloze words evoke the same amplitude N400, regardless of contextual constraint)

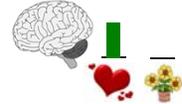
## Key question

Do medium-constraint target nouns receive facilitation in proportion to their cloze probability (even if they aren't the best completion)?

Parallel lexical prediction → Yes, all words pre-activated in proportion to their probability



Non-parallel prediction → No, only the best completion receives pre-activation



## Conclusions

- N400 amplitudes proportional to cloze, regardless of whether or not words are the best completion in context
- Supports a fully parallel account of lexical prediction
- Convergence between ERP and behavioral results (e.g. Smith & Levy, 2013)



## Materials

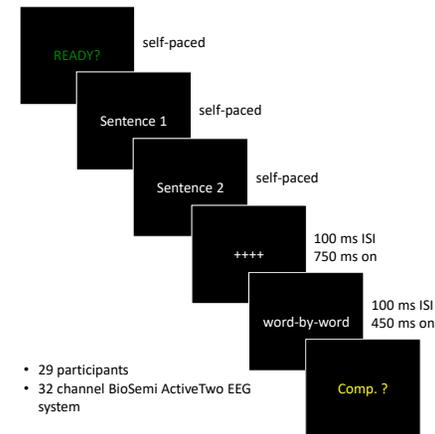
Experimental Materials	
<b>Constraining</b>	Stephen wanted to do something special for his girlfriend. He decided to make her a hand-made card. On it, he drew some... hearts (57%) / flowers (16%) (Best / SecondBest) ...and folded the paper.
<b>Unconstraining</b>	Malcom always doodled in class. He took out a fresh sheet of paper. On it, he drew some... hearts (4%) / flowers (3%) (Unexpected / Unexpected) ...and folded the paper.

- 3-sentence short story contexts provide (slightly) more natural context
- Matched final sentences
- Constraints in Constraining contexts span 36-92%

Filler Materials	
<b>Constraining</b>	Alexis was thrilled with her new garden. All of the flowers had bloomed overnight. In particular, she loved the... roses (61%) / rocks (0%) ...in the garden.
<b>Unconstraining</b>	Gracie had just moved a new city. She enjoyed exploring new sites. In particular, she loved the... roses (5%) / rocks (0%) ...in the garden.

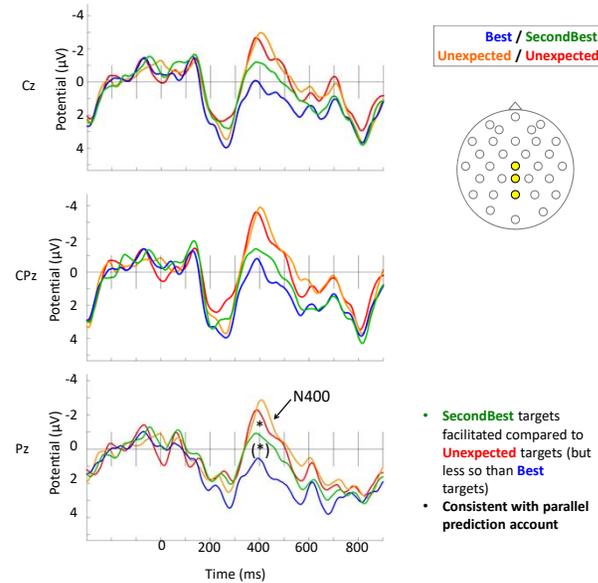
- Equal number of filler items which don't have good Second Best targets
- Constraints in Constraining contexts match constraints of experimental items

## Procedure



- 29 participants
- 32 channel BioSemi ActiveTwo EEG system

## Results

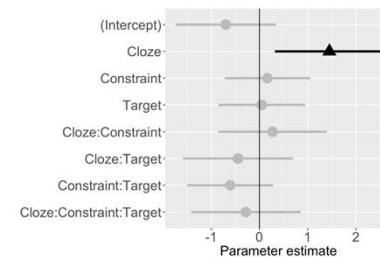


- SecondBest targets facilitated compared to Unexpected targets (but less so than Best targets)
- Consistent with parallel prediction account

Linear mixed effects regression to test graded effect of cloze on N400 amplitude

- Does the effect of cloze change depending on cell of the experimental design?
  - In particular, is the effect of cloze on N400 the same for SecondBest targets as for Best targets?
- Maximal random effects (by subjects and by items)
- All predictors standardized

N400 ~ Cloze \* Constraint \* Target  
Constraining v. Unconstraining    Best v. SecondBest



- N400 amplitude driven only by cloze probability
- In particular, SecondBest completions receive pre-activation in proportion to their probability, regardless of not being the most likely completion
- Supports parallel lexical prediction