Distinct neural signatures of semantic retrieval and event updating during discourse comprehension

Trevor Brothers[1,2], Sophie Greene[1], Gina Kuperberg[1,2]

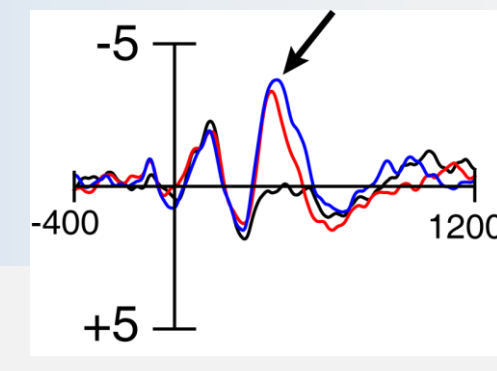1 Dept of Psychology, Tufts University, 2 Massachusetts General Hospital

Introduction

The **N400 response** (300-500ms) is often associated with the **retrieval** of semantic information from long-term memory. For example, during comprehension, words that are semantically unexpected elicit larger N400 responses relative to words that are predictable in context.

Currently, it is unclear to what extent the N400 response may also reflect the updating of discourse representations as readers encounter new information in a text.

A separate ERP component, the **late frontal positivity** (600-1000ms) is also sensitive to lexical predictability, but unlike the N400 response, this ERP component is:

• Not elicited in single word priming tasks (dog-cat) (Kutas, 1993)

• Not elicited to semantically anomalous words (Kuperberg, Brothers & Wlokto, 2020)

• Larger in rich, multi-sentence discourse contexts (Brothers et al., 2020)

Current theories suggest that the **late frontal positivity** either reflects:

1) The suppression of incorrect lexico-semantic predictions, or

2) The updating of discourse representations in light of new, unanticipated information

To isolate the neural signatures of **discourse updating**, we developed three-sentence scenarios containing critical words that were either *uninformative* or highly *informative* for re-interpreting the prior discourse (avg. constraint = 21%).

Participants also read a set of matched, high-constraint passages, in which the same critical words were either expected (54% cloze) or unexpected (0% cloze).

Low Constraint:
The way things were going, no one expected it to happen.
It left all of the onlookers completely speechless.
After the touchdown/commotion…

High Constraint:
The two football teams were tied at halftime.
Jack ran the ball into the end zone, scoring six more points.
After the touchdown/commotion…

	Length	Freq.	Concrete.	Cloze	LSA
LC_Info	6.6	3.8	4.1	>1%	0.02
LC_Uninfo	6.8	3.9	4.0	>1%	0.02
HC_Exp	6.6	3.8	4.1	54.0%	0.23
HC_Unexp	6.8	3.9	4.0	>1%	0.04

Participants (N=30) read 36 passages in each condition while answering occasional T/F comprehension questions. The first two sentences were self-paced, and the third sentence was presented RSVP (550ms per word). EEG was recorded continuously at the scalp from 32 electrodes sites, time-locked to critical word onset.

Discourse "Informativeness"

A separate group of participants provided a short summary of each discourse scenario, truncated either immediately before or after the critical word They then rated their "certainty" (1-5) about each event (e.g. "Santa preparing for Christmas").

Uninformative critical words did not increase event certainty, but *Informative* words increased both event certainty and the consistency of event descriptions across raters.
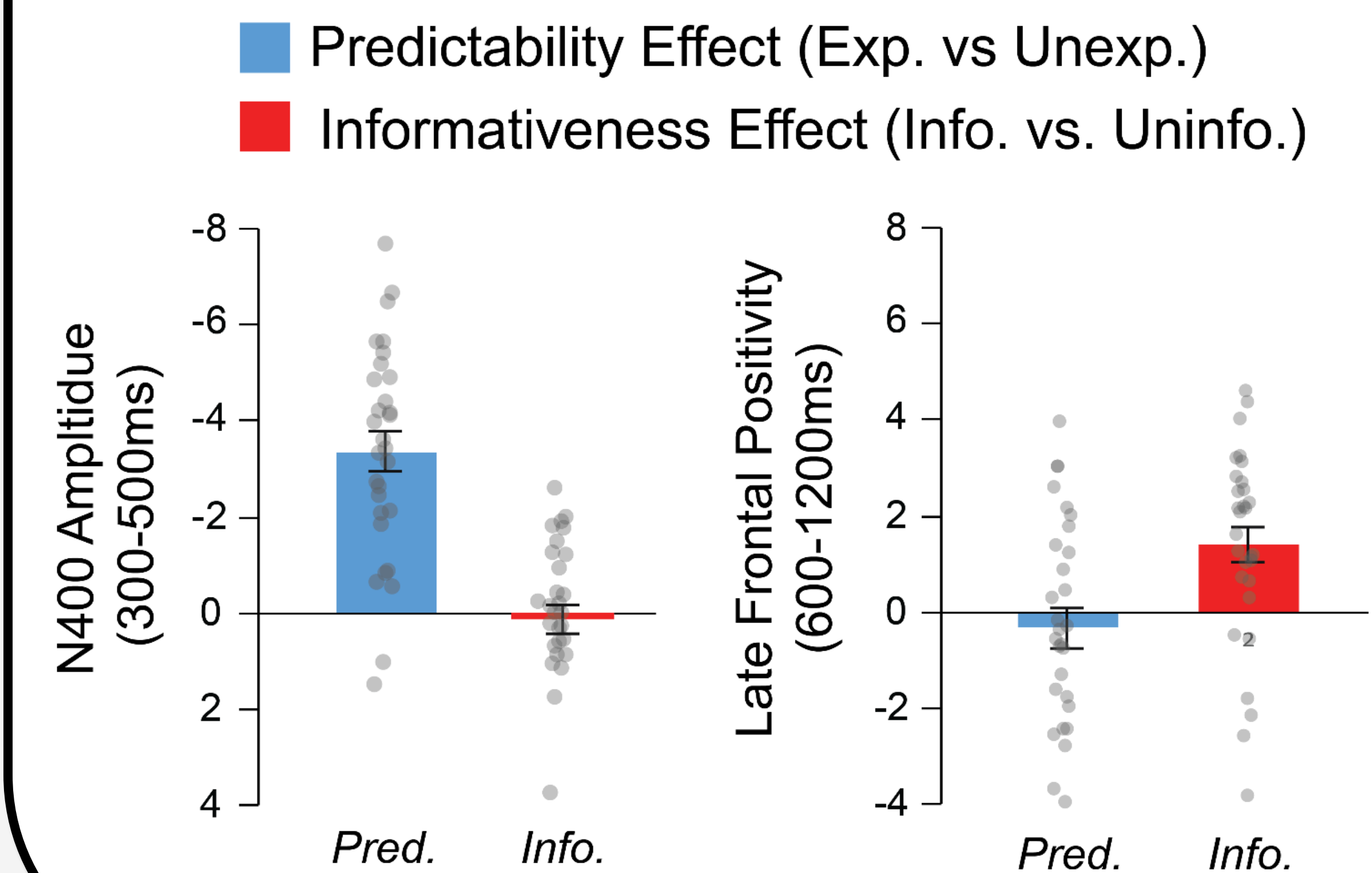
The special day was rapidly approaching.

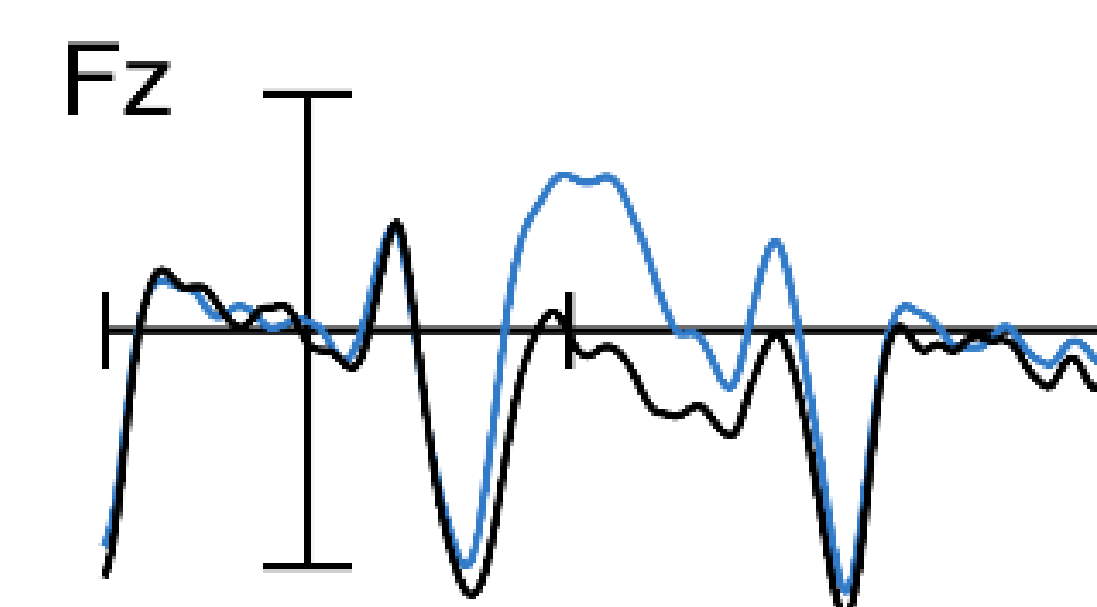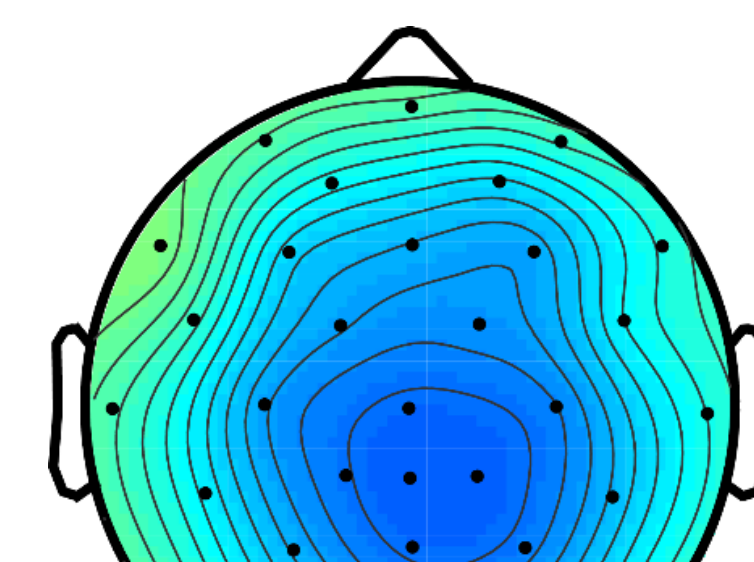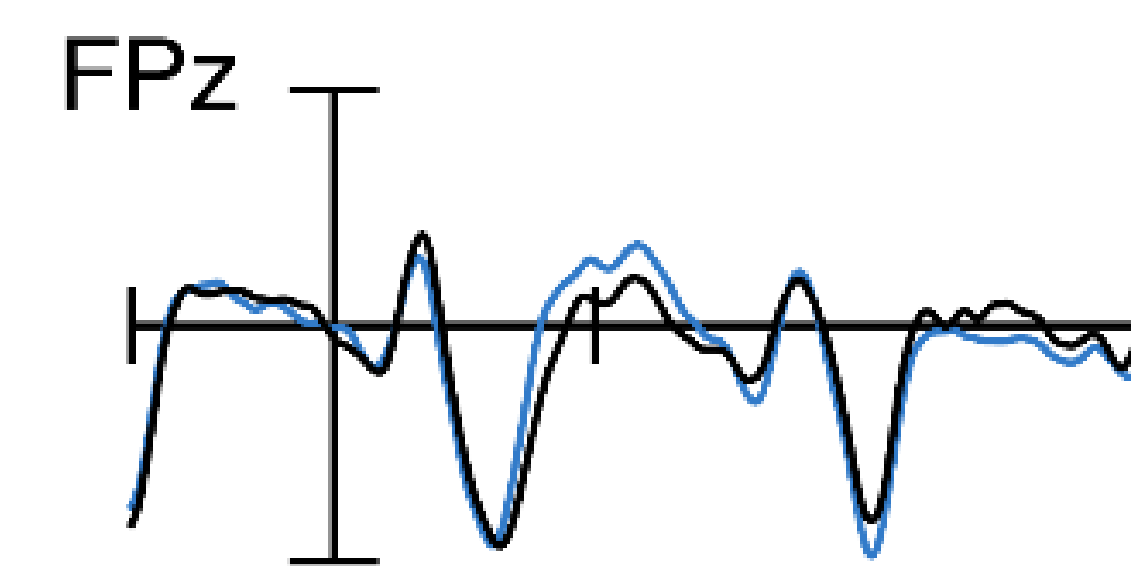*There was a lot of work to do, but luckily he had help.*
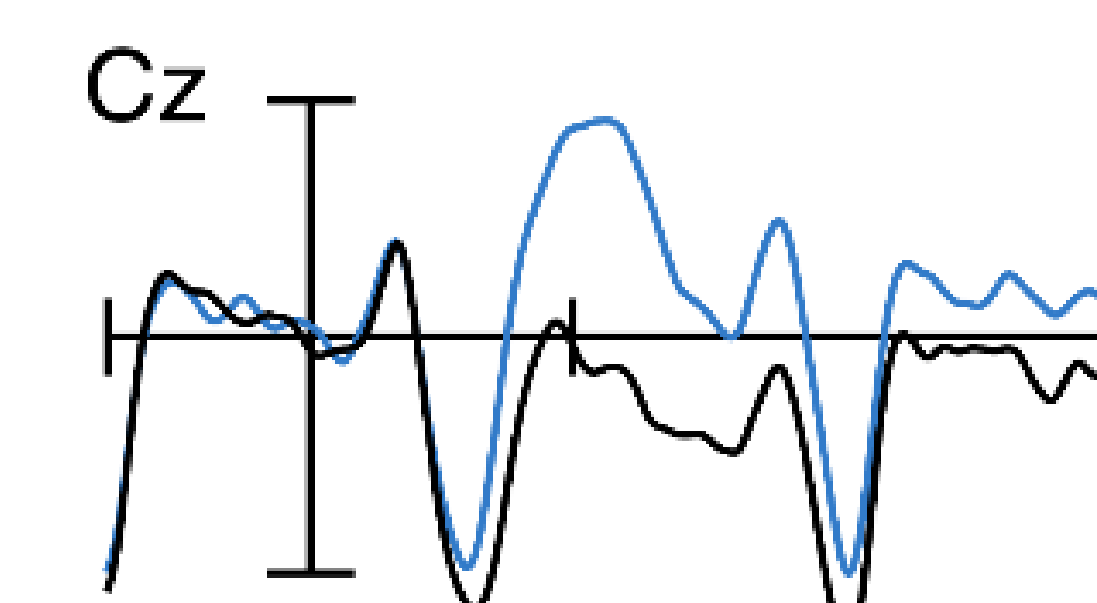
Luckily he could rely on his elves/speed…

High Constraint / Low Constraint

FPz

Fz

Cz

Pz

300-500ms

600-1200ms

-4µV

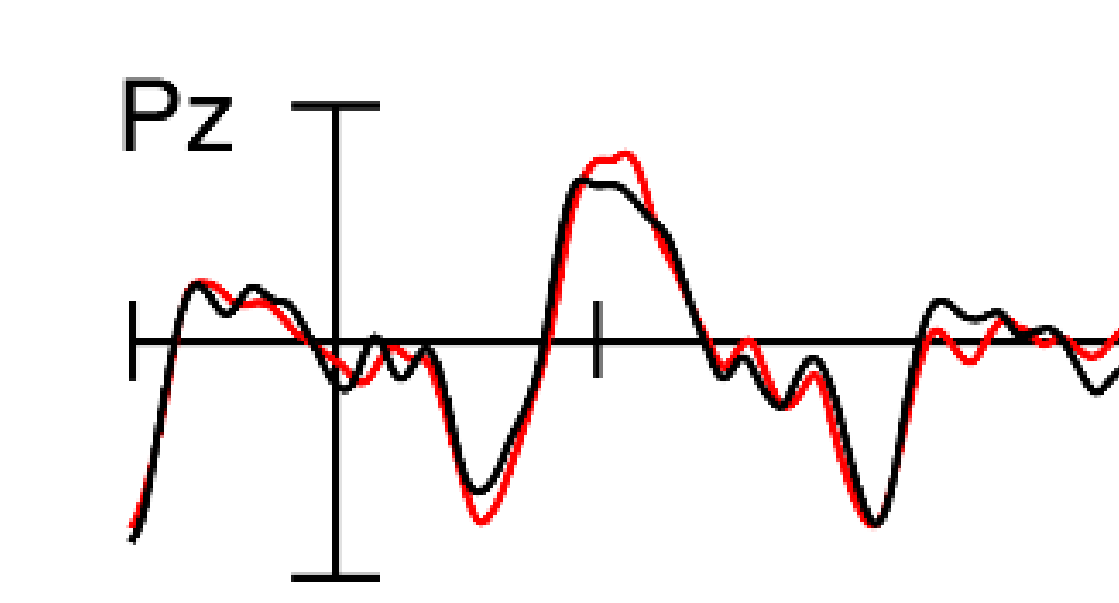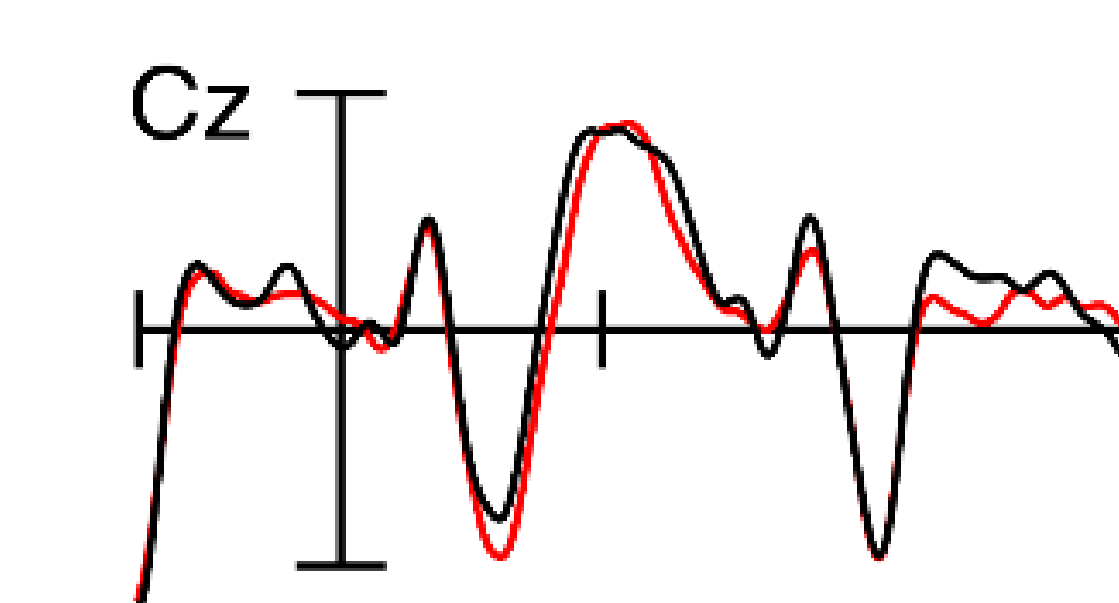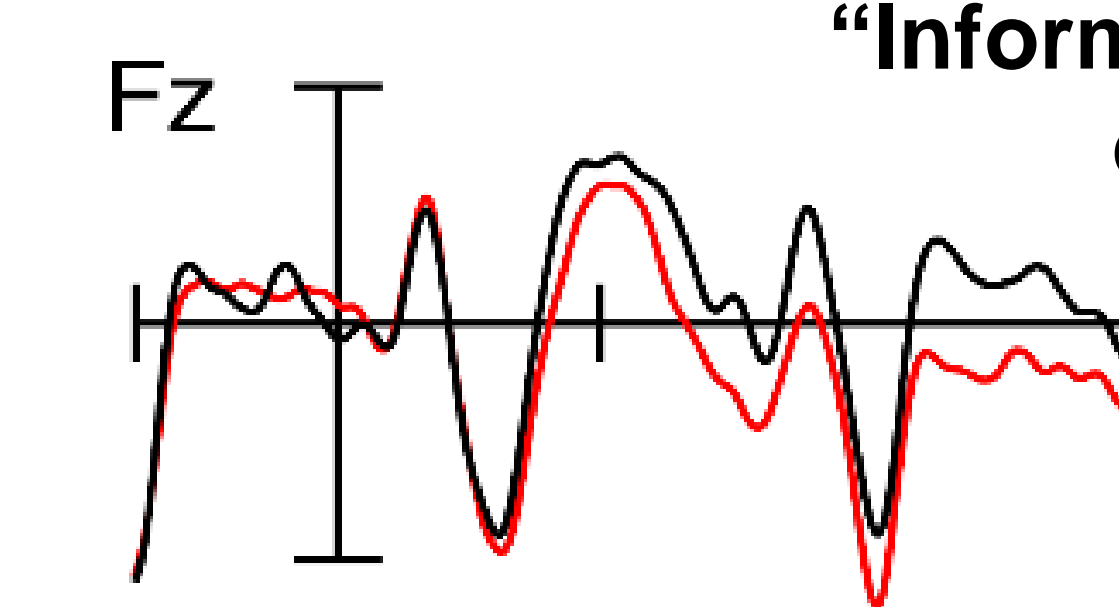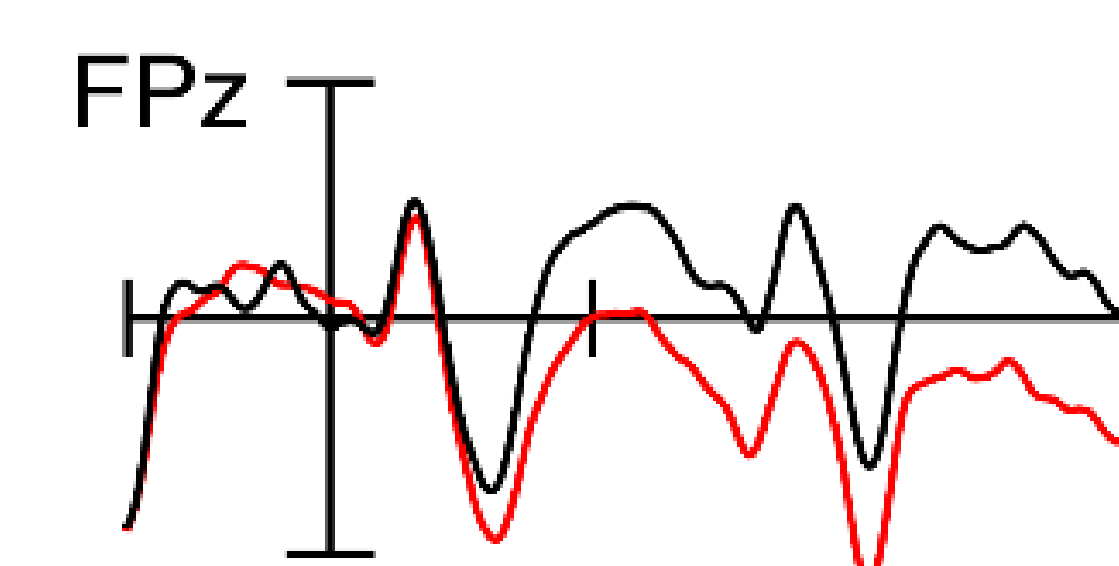400ms   1200ms
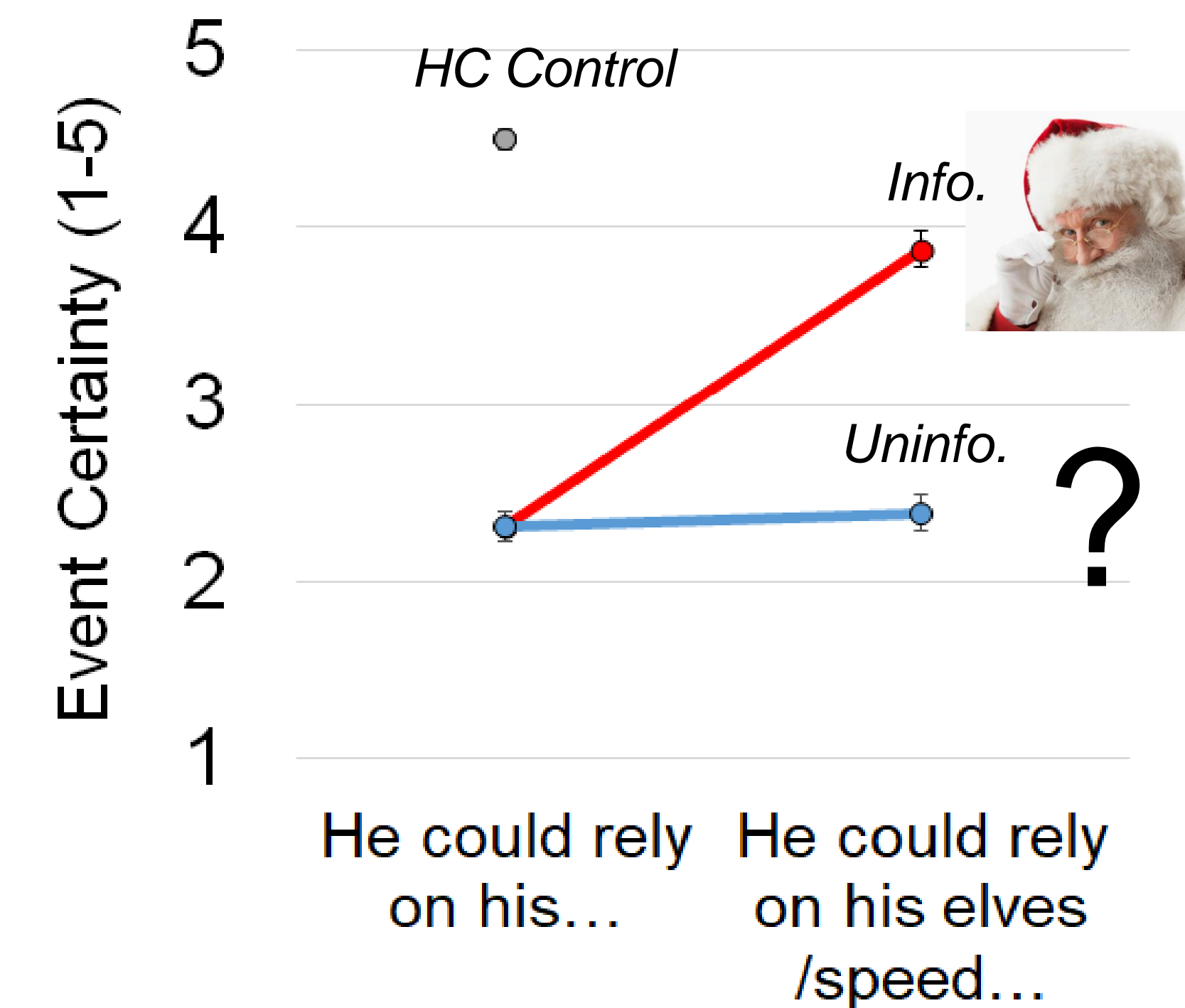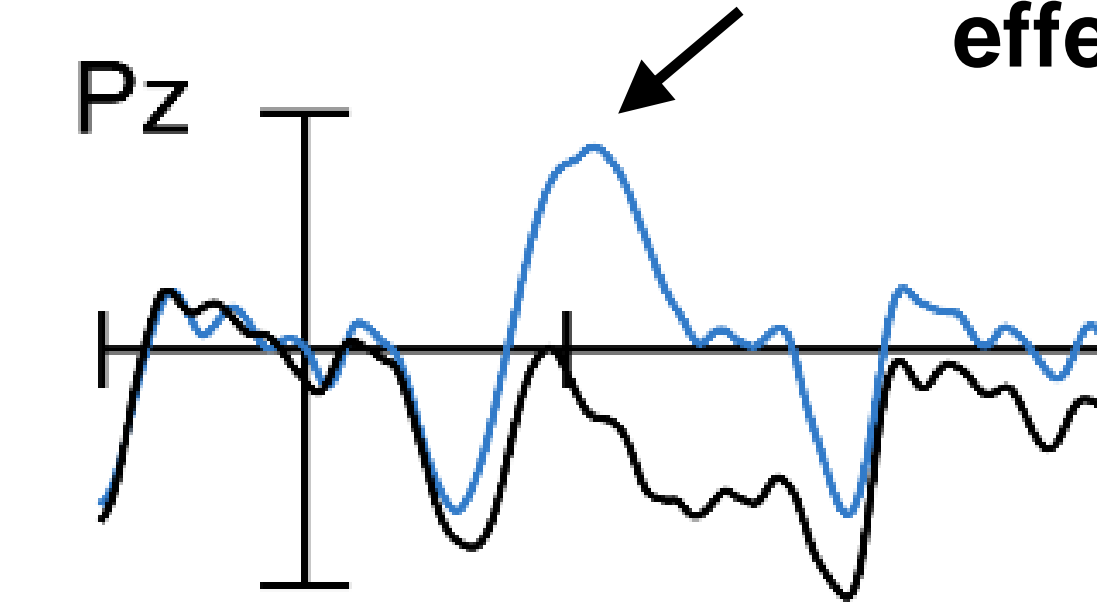
N400 predictability effect

Frontal "Informativeness" effect

Santa had a lot of work to do at the North Pole. Luckily, he had helpers to make all the toys.

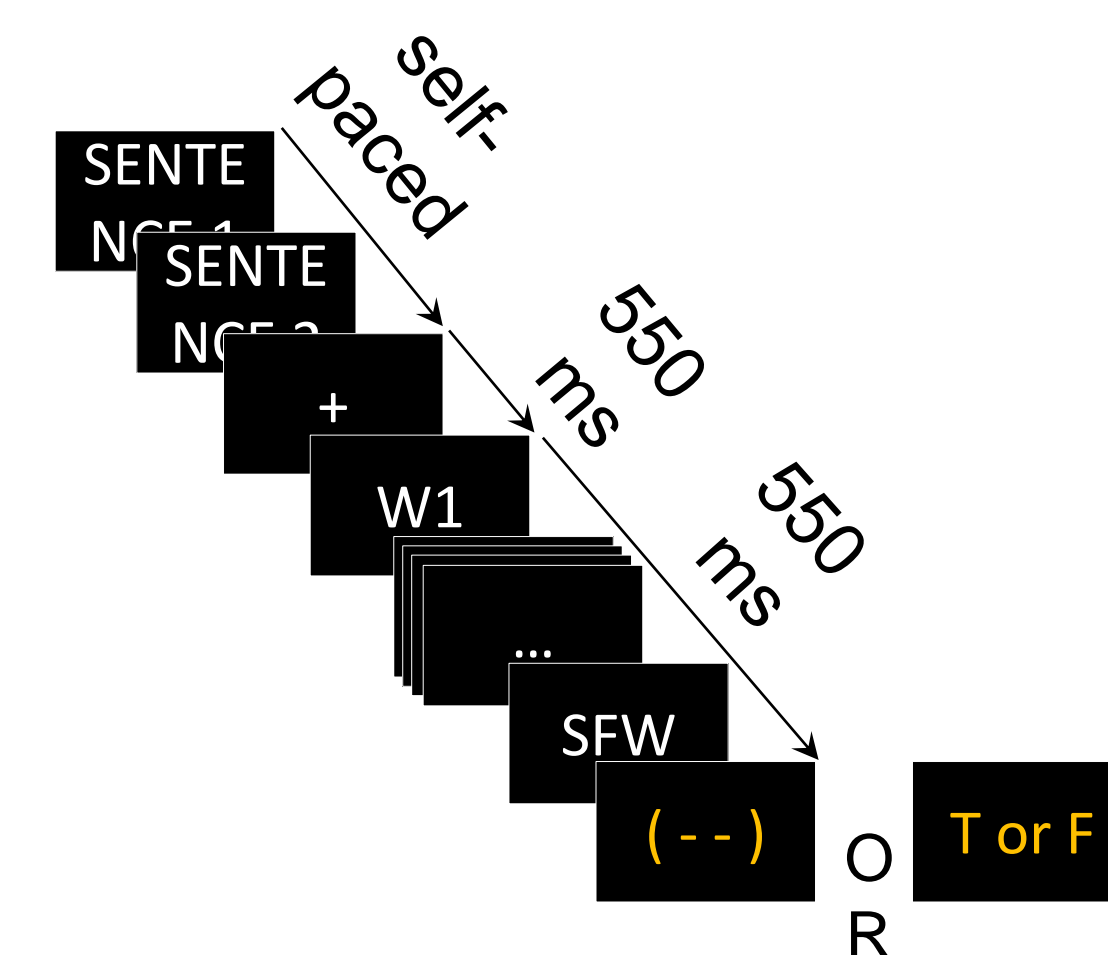He could rely on his **elves**/speed to get the job done.

The special day was rapidly approaching. There was a lot of work to do, but luckily he had help.

He could rely on his elves/**speed** to get the job done.

ERP Results

- Predictability Effect (Exp. vs Unexp.)
- Informativeness Effect (Info. vs. Uninfo.)

N400 Amplitude (300-500ms)

Late Frontal Positivity (600-1200ms)

Pred.   *Info.*

ERP Results

• In high constraint scenarios, the amplitude of the N400 was reduced for more predictable critical words.

• The amplitude of the N400 was not affected by discourse informativeness, with equally large N400s to for informative and uninformative continuations.

• Instead informative words generated a sustained positivity over frontal electrode sites, beginning approximately 300ms after word onset.

• These two manipulations (*predictability* and *informativeness*) showed different polarities and scalp topographies

Discussion

• These ERP results suggest there are distinct processing mechanisms underlying semantic retrieval and discourse updating, and that these two neural processes may be supported by distinct cortical regions.

• These findings support retrieval-based accounts of the N400

• They also suggest that the late frontal positivity observed in previous ERP studies (Federmeier, et al., 2007) is not specific to the violation of strong lexical predictions, but is instead reflects the updating of discourse representations

• Future work will investigate individual differences in discourse updating across readers, and the neuroanatomical locus these two distinct ERP effects.

Federmerier, Wlotko, Ochcoa-Dewald & Kutas (2007). Multiple effects of sentential constraint on word processing.
Kuperberg, Brothers & Wlotko (2020). A tale of two positivities and the N400: Distinct neural signatures are evoked by confirmed and violated predictions at different levels of representation
Kutas (1993). In the company of other words: Electrophysiological evidence for single-word and sentence context effects