# ERP correlates for the meaning and structure of ambiguous phrases in context

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It is known that context influences language comprehension[1]. What remains less clear is how nearby local context and long-distance global context differentially impacts the incremental comprehension of the current word[2,3,4]. According to the Minimalist Hypothesis, global context is only used when there is a local incongruency that needs to be resolved[2]. In contrast, the Multiple Cause Intensified Retrieval Hypothesis (MIR) claims that global context can be used regardless of local congruence[5]. The current study uses EEG to investigate the relative roles of local and global context in meaningfully ambiguous phrases. The Minimalist Hypothesis predicts that global context effects would only occur when the local context is incongruent with the critical words. In contrast, the MIR Hypothesis predicts that global contextual information will impact reading regardless of local incongruencies.

24 native English-speaking undergraduates read 160 sentences in a 2 Global Context (Left Branching Biasing, Right Branching Biasing) x 4 Ambiguous Phrase (Right Branching Biased, Left Branching Biased, Distinct Unbiased, Equivalent Unbiased) design (Table 1). Critical words were the 2nd and 3rd words of the phrases (i.e., *commuter* and *ship* from *wrecked commuter ship*), while the 1st and 1st+2nd words served as the local context respectively (i.e., *wrecked* and *wrecked commuter*). The phrases are preceded by global contexts that correspond to the possible interpretation of the ambiguous phrase. Global contexts are designed to influence the ease of integrating the critical words with immediately preceding local context. For example, a global context '*ship of wrecked passengers'* facilitates the processing of '*wrecked commuter*', because *wrecked* explicitly integrates with a similar word to *passenger*.

Participants read sentences word-by-word at the center of the screen while their EEG was recorded. Comprehension questions appeared after ~25% of the trials to verify participation. In the ERP analysis, mean amplitudes were generated from 300-500ms and 500-800ms post-stimuli onset along midline electrodes (i.e., Fz, Cz, Pz). Separate analyses of 2nd and 3rd word ERPs were conducted using Repeated Measures ANOVAs. At the 2nd word (Figure 1), there was a main effect of Global Context without a main effect of local context or interaction. Critical words preceded by incongruent Right Branching Biasing Context elicited a larger N400 and an anterior negativity than those preceded by the congruent Left Branching Biasing Context. Specifically, reading *wrecked passenger* in the preceding global context facilitates the reading of *wrecked commuter.* At the 3rd word (Figure 2), there was a main effect of Local Context reflecting increased sensitivity to local incongruencies. The critical 3rd word in the Left Branching Biased condition (i.e., *furry tiger* + **painting**) elicited a larger N400 than the Right Branching Biased condition (i.e., *wrecked commuter* + **ship**). Specifically, readers expect the 3rd word *ship* following an anomalous constituent *wrecked commuter*, while the 3rd word *painting* is more surprising following a semantically valid constituent *furry tiger.*

The results inform when readers use global and local context during disambiguation. They are consistent with the MIR Hypothesis and prior work showing that global context cues can suppress sensitivity to local cues[3,4]. They are inconsistent with the Minimalist Hypothesis, because global context effects were found regardless of local semantic congruency at the 2nd word. While local inconsistencies between the critical word and its local context occur at both the 2nd and 3rd word, the results suggest that readers are sensitive to local incongruencies only at the 3rd word when the Global Context effect fades. It shows that discourse-level context effects influence immediate parsing, followed by effects of local cues. This supports 'Top Down' models of sentence processing where long-distance context plays a key role.

**Table 1 Stimuli:** *Structurally ambiguous with different semantic properties. Norming data shows that they differ regarding two properties: 1) how different are the two possible interpretations in meaning; 2) are people biased towards one interpretation without context.* Word-length and bigram frequencies ($1^{st}+2^{nd}$, $2^{nd}+3^{rd}$, $1^{st}+3^{rd}$ bigrams) of the ambiguous phrases were matched.

| Ambiguous Phrase | Structures | Meanings |
|---|---|---|
| Left Branching Biased: *furry tiger painting* | [furry [tiger painting]] | tiger painting that is furry |
| | **[[furry tiger] painting]** | **painting of a furry tiger** |
| Right Branching Biased: *wrecked commuter ship* | **[wrecked [commuter ship]]** | **commuter ship that is wrecked** |
| | [[wrecked commuter] ship] | ship for wrecked commuters |
| Distinct Unbiased: *tall wheat tractor* | **[tall [wheat tractor]]** | **wheat tractor that is tall** |
| | **[[tall wheat] tractor]** | **tractor for tall wheat** |
| Equivalent Unbiased: *automatic copying machine* | **[automatic [copying machine]]** | **copying machine that is automatic** |
| | **[[automatic copying] machine]** | **machine for automatic copying** |

**Figure 1 Global Context:** Waveform and Topography showing N400 (F(1,23)=11.951, p<.01 from 300-800ms) and anterior negativity (F(1,23) = 6.257, p<.05 from 300-800ms) for Right Branching Global Context in comparison to Left Branching Global Context. The critical word is *commuter* from *wrecked commuter ship*.
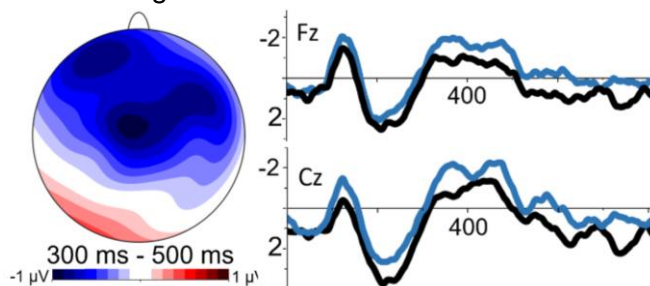
Critical word *commuter* is preceded by either:
**Right Branching Global Context:** *passenger ship that is wrecked*
**Left Branching Global Context:** *ship for wrecked passengers*



**Figure 2 Local Context:** *Waveform and Topography from 300-500ms showing that inconsistent Left Branching Biased condition is significantly more negative than consistent Right Branching Biased condition (p = .033 with Holm-Bonferroni correction for multiple comparisons).* The critical $3^{rd}$ word is in bold and the local context includes preceding words.
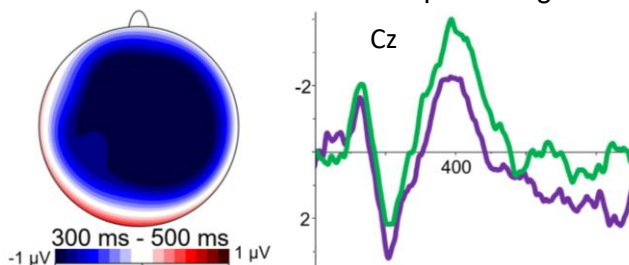
**Critical $3^{rd}$ word in bold:**
Left Branching Biased: *furry tiger **painting***
Right Branching Biased: *wrecked commuter **ship***

**[1]** Van Berkum, J. J. (2008). Understanding sentences in context: What brain waves can tell us. *Current directions in psychological science*, *17*(6), 376-380. **[2]** McKoon, G., & Ratcliff, R. (1992). Inference during reading. Psychological Review, 99, 440–446. Meyer, D. E., & Schaveneveldt, R. W. **[3]** Van Petten, C., Coulson, S., Weckerly, J., Federmeier, K. D., Folstein, J., & Kutas, M. (1999). Lexical association and higher-level semantic context: An ERP study. *Journal of Cognitive Neuroscience Supplement*, *46*. **[4]** Camblin, C. C., Gordon, P. C., & Swaab, T. Y. (2007). The interplay of discourse congruence and lexical association during sentence processing: Evidence from ERPs and eye tracking. *Journal of Memory and Language, 56*(1), 103-128. **[5]** Van Berkum, J. J. (2009). The neuropragmatics of 'simple' utterance comprehension: An ERP review. In *Semantics and pragmatics: From experiment to theory* (pp. 276-316). Palgrave Macmillan.