Exploring the temporal dynamics and operational biases of noisy channel inferencing

[Authors]

Background. Noisy channel inferencing occurs when comprehenders perform string edits to the input based on contextual probabilities and the plausibility of original input versus the potential edit(s) [1,2,3]. For example, L1 English comprehenders may interpret “the mom gave the daughter to the money” as meaning “the mom gave the daughter the money” by performing a deletion of ‘to,’ resulting in a more plausible interpretation of the input. Recent work has begun to address the real-time processing consequences of this type of nonliteral interpretation formation. For example, Cutter et al. [4] show that readers are more likely to misinterpret implausible structures if they fixate less on regions where an insertion would be made to make that interpretation plausible. Since comprehenders are more likely to perform a deletion versus an insertion [5,6], reading behavior may be more likely to mitigate nonliteral interpretation formation in the more difficult insertion cases, namely DO implausible structures.

Current Study. The current study tests this by employing an English word-by-word moving window self-paced reading paradigm in combination with two types of binary offline probes: 1) Plausibility Judgments and 2) Lexical Memory Probes. Specifically, we were interested in observing the extent to which the type of edit needed to make a structure plausible influenced memory and acceptability judgements, and how this was further reflected in reading behaviors in critical sentence regions. 110 L1 English adults, recruited online for course credit, were tasked with reading 24 critical sentences (plus 24 filler sentences with different prepositions, either kept or omitted), each sentence followed by these two offline probes. We crossed Plausibility and Structure of the dative structure (PO vs. DO, Plausible vs. Implausible; see Table 1) in order to test differences between nonliteral interpretations that would require a deletion (PO implausible → plausible) or an insertion (DO implausible → plausible).

Results.

Data were fit to Bayesian hierarchical models with mildly informative priors, run on 4 chains for 7500 iterations (2500 warmup). Plausibility, Structure, and their interaction were entered as fixed effects (sum-coded), with length controls and additional fixed effects/interactions added where applicable, and a maximal random effects structure was used by item and by participant. We used 95% credible intervals as a heuristic for detecting effects. Only plausibility influenced sentence judgments, with implausible trials eliciting a lower rate of acceptability. Models revealed an interaction between Structure and Plausibility such that only implausible PO structures elicited a higher rate of lexical probe errors (i.e., deletion edit). Plausible DO structures elicited the longest mean probe response times (Fig 1), likely because confirming the absence of a word may be the most difficult task. Reading time analyses at the region following the preposition site also showed the longest reading times for implausible PO structures (Fig 2). Together, these results show that structures requiring deletion edits to become plausible lead to longer reading times and a higher likelihood of nonliteral interpretation formation. Longer spillover reading times led to a lower rate of acceptability only for plausible conditions, suggesting the longer reading times spent on implausible trials, where noisy-channel inferencing is made, is not experienced as heightened uncertainty by the comprehender. Together, these findings suggest that noisy-channel inferencing occurs automatically during sentence wrap-up processes and reconfirms evidence that deletion edits are more likely than insertion edits.

Table 1. Experimental items across conditions

Structure	Plausibility	Sentence
DO	Plausible	The mother gave the daughter the candle.
DO	Implausible	*The mother gave the candle the daughter.
PO	Plausible	The mother gave the candle to the daughter.
PO	Implausible	*The mother gave the daughter to the candle.

Did this sentence make sense?

Did you see the following word? 'to'

Figure 1. Lexical memory probe response accuracy and latencies across conditions

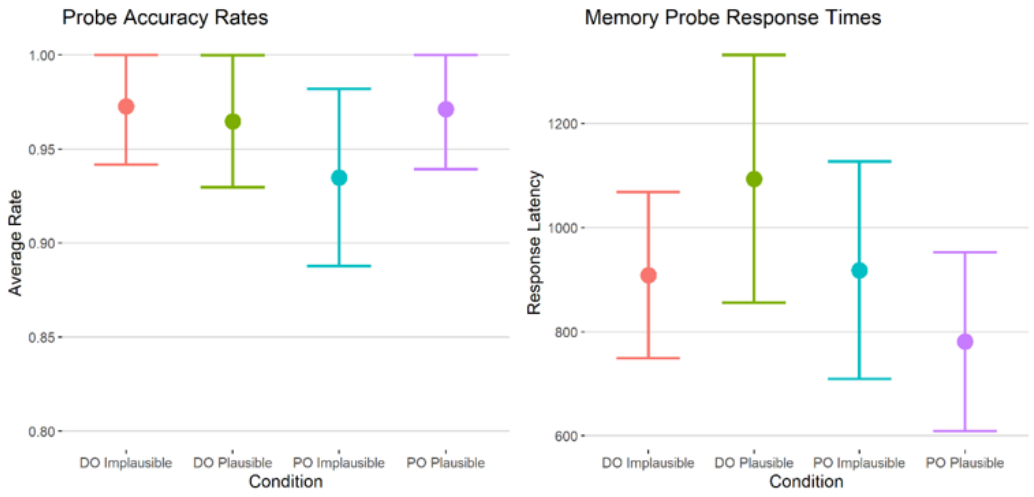
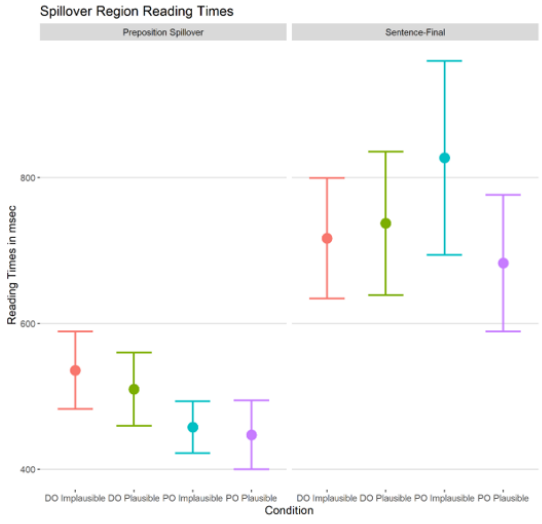


Figure 2. Reading times following preposition site across conditions



References

[1] Chen, S., Nathaniel, S., Ryskin, R., & Gibson, E. (2023). The effect of context on noisy-channel sentence comprehension. *Cognition*, *238*, 105503.

[2] Gibson, E., Tan, C., Futrell, R., Mahowald, K., Konieczny, L., Hemforth, B., & Fedorenko, E. (2017). Don't underestimate the benefits of being misunderstood. *Psychological Science*, *28*(6), 703-712.

[3] Ryskin, R., Futrell, R., Kiran, S., & Gibson, E. (2018). Comprehenders model the nature of noise in the environment. *Cognition*, *181*, 141-150.

[4] Cutter, M. G., Paterson, K. B., & Filik, R. (2024). Eye-movements during reading and noisy-channel inference making. *Journal of Memory and Language*, *137*, 104513.

[5] Xu, F., & Tenenbaum, J. B. (2007). Word learning as Bayesian inference. *Psychological Review*, *114*(2), 245.

[6] MacKay, D. J. (2003). *Information theory, inference and learning algorithms*. Cambridge university press.