

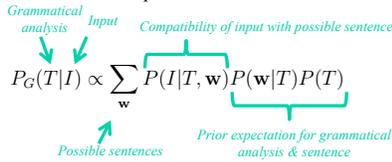


Background & Motivation

- Big question: *how do perceptual input and linguistic & world knowledge jointly guide the incremental grammatical analysis of a sentence in real time comprehension?*
- Specific question: *can prior grammatical expectations sometimes induce the comprehender to pursue an analysis of the sentence inconsistent with the surface input?*

Rational comprehension under uncertain input

- Levy (2008b) argued for a Bayesian/noisy-channel view of rational syntactic comprehension under uncertain input:

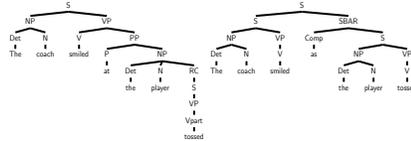


- Previous result (Levy, Bicknell, Slattery, & Rayner, 2009): if the current word is less compatible with the true preceding context than with a perceptually similar alternative context, the reader should be taken aback

The coach smiled *at* the player tossed the frisbee (and?) (as?)

The coach smiled *toward* the player tossed the frisbee

- One way of interpreting this result: comprehender can be distracted by an alternative grammatical analysis inconsistent with current input if its prior expectation is strong enough



- Leads to another question: *if prior expectations are strong enough, can a comprehender be induced to adopt a preferred grammatical analysis wholesale despite its conflict with surface input?*

References

Adams, B. C., Clifton, Jr., C., and Mitchell, D. C. (1998). Lexical guidance in sentence processing? *Psychonomic Bulletin & Review*, 5(2): 265–270.

Bolinger, D. (1971). A further note on the nominal in the progressive. *Linguistic Inquiry*, 2(4):584–586.

Bresnan, J. (1994). Locative inversion and the architecture of universal grammar. *Language*, 70(1):72–131.

Christianson, K., Hollingworth, A., Halliwell, J. F., and Ferreira, F. (2001). Thematic roles assigned along the garden path linger. *Cognitive Psychology*, 42:368–407.

Fodor, J. D. (2002). Psycholinguistics cannot escape prosody. In *Proceedings of the Speech Prosody Conference*.

Frazier, L. and Rayner, K. (1982). Making and correcting errors during sentence comprehension: Eye movements in the analysis of structurally ambiguous sentences. *Cognitive Psychology*, 14:178–210.

Hale, J. (2001). A probabilistic Earley parser as a psycholinguistic model. In *Proceedings of the Second Meeting of the North American Chapter of the Association for Computational Linguistics*, pages 159–166.

Hill, R. L. and Murray, W. S. (2000). Commas and spaces: Effects of punctuation on eye movements and sentence parsing. In Kennedy, A., Radach, R., Heller, D., and Pynte, J., editors, *Reading as a Perceptual Process*. Elsevier.

Levy, R. (2008a). Expectation-based syntactic comprehension. *Cognition*, 106:1126–1177.

Levy, R. (2008b). A noisy-channel model of rational human sentence comprehension under uncertain input. In *Proceedings of the 13th Conference on Empirical Methods in Natural Language Processing*, pages 234–243.

Levy, R., Bicknell, K., Slattery, T., and Rayner, K. (2009). Eye movement evidence that readers maintain and act on uncertainty about past linguistic input. *Proceedings of the National Academy of Sciences*, 106(50):21086–21090.

Tabor, W. and Hutchins, S. (2004). Evidence for self-organized sentence processing: Digging in effects. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 30(2):431–450.

Staub, A. (2007). The parser doesn't ignore intransitivity, after all. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, 33(3):550–569.

“Hallucinated” garden paths

- The NP/Z ambiguity is one of the best-studied garden-path phenomena in psycholinguistics (Frazier & Rayner, 1982; Mitchell, 1987; Ferreira & Henderson, 1993; Hill & Murray, 2000; Christianson et al., 2001; Adams et al., 2001; van Gompel & Pickering, 2001; Tabor & Hutchins, 2004; Staub, 2007):

While Mary was mending the sock fell off her lap.

Misanalyzed region (under 'mending')
Disambiguation region (under 'fell')

- It's commonly taken as given that placing a comma before the main-clause subject guides the parser to “close off” the subordinate-clause VP and eliminate the garden path:

While Mary was mending, the sock fell off her lap.

“With a comma after ‘mending’, there would be no garden path left to study.” (Fodor, 2002; see also Hill & Murray, 2000)

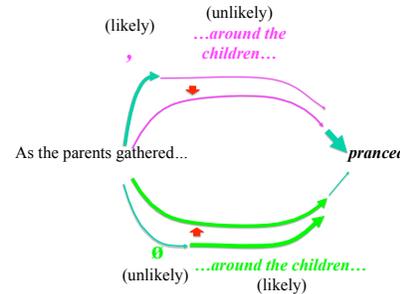
- In the present work, however, we'll see garden-path effects despite the presence of disambiguating commas:

As the parents gathered, around the children pranced a shiny-coated terrier.

Misanalyzed region (under 'gathered')
Disambiguation region (locus of boggle) (under 'pranced')

- Unlike traditional NP/Z sentences, we're introducing **locative inversion** into the main clause (Bolinger, 1971; Bresnan, 1994)

Analysis in uncertain-input model



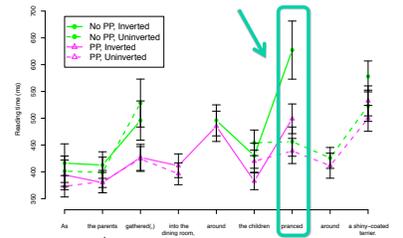
- Fidelity to input and prior grammatical/world-knowledge expectations trade off against one another to determine preferred grammatical analysis given input thus far
- Leads to high surprisal (Hale, 2001; Levy, 2008a) at *pranced*, which disconfirms the hallucinated garden path

Experiment 1

- Cross inversion w/presence of a postverbal PP (*into the dining room*) in subordinate clause

While the parents gathered, around the children pranced a shiny-coated terrier.
While the parents gathered, the children pranced around a shiny-coated terrier.
While the parents gathered into the dining room, around the children pranced a shiny-coated terrier.
While the parents gathered into the dining room, the children pranced around a shiny-coated terrier.

- This postverbal dependent PP fills the same thematic role as would the main-clause initial PP, thus should ameliorate hallucinated GP
- SPR result: boggle seen exactly where predicted!

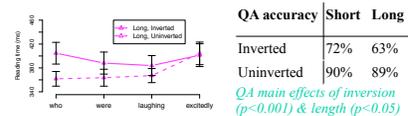


	+PP	-PP
Inverted	85%	76%
Uninverted	92%	93%

Interaction $p < 0.05$ on both RT and QA accuracy

Experiment 2

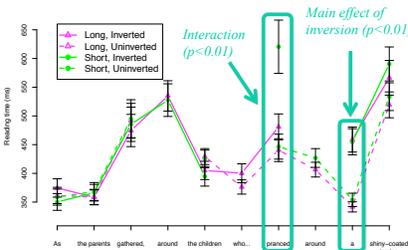
- Are the difficulty effects originating in the preposition *around*?
- Lengthen ambiguous region (Inversion x Length):
While the parents gathered, above the children (who were laughing excitedly) pranced a shiny-coated terrier.
While the parents gathered, the children (who were laughing excitedly) pranced above a shiny-coated terrier.
- Spillover disappears before disambiguation



	Short	Long
Inverted	72%	63%
Uninverted	90%	89%

QA main effects of inversion ($p < 0.001$) & length ($p < 0.05$)

- Hallucinated GP disambiguation effect at *pranced* remains ($p < 0.05$ in pairwise tests in both Short & Long conditions)



- N.b.: reverse digging-in effect (Tabor & Hutchins, 2004) at *pranced*! but disappears a word later.

Conclusions

- Comprehenders can ignore (*deletion overriding*) part of input in pursuit of grammatical analysis of a sentence
- This behavior can be understood in terms of rational comprehension under uncertain input
- Open questions:
 - Can we also find *insertion overriding*? Swap overriding?
 - What factors determine comprehenders' priors and noise models?