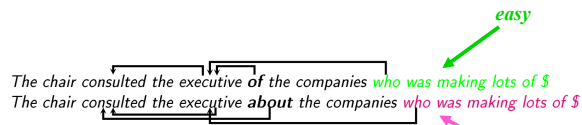


Background & Motivation

- Big picture: theories of processing complexity can be based on...
 - Memory storage & retrieval operations (Gibson 1998, 2000; Lewis 1996; Gordon et al., 2001, 2004; Lewis & Vasishth, 2005; Lewis et al., 2006)
 - Probabilistic expectations (Hale 2001, Levy 2008)
- Gibson & Breen (2005^{***}) concluded from a series of self-paced reading studies that there was evidence for complexity associated with **processing discontinuous dependencies**:
 - Extraposition of a relative clause (RC) from subject across a verb (G&B expt 2):



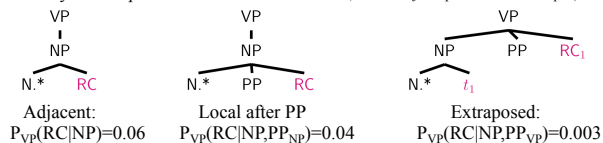
- Extraposition of RC from object across a PP (G&B expts 3 & 4):



- G&B expts 3&4 suggest that this difficulty is unlikely to be reducible to dependency locality or retrieval interference
- The results could be due to...
 - Derivational complexity of the extraposed structure—more transformational steps (Fodor, Bever & Garrett 1974)
 - A constraint-based cost (MacDonald, Pearlmuter & Seidenberg 1994) for the extraposed RC rule higher than that of the unextraposed RC
- Here, we will refine the interpretation of these results by suggesting that **the processing cost of these discontinuous dependencies is derived from probabilistic expectations over upcoming structure**

Expectations and extraposition

- It's not just that extraposed RCs are *rare*; they are rare in such a way that they're *unexpected* in the above contexts (*estimated from parsed Brown corpus*):



Manipulating extraposed RC expectations

- If extraposed RCs are hard because they're unexpected...
- ...then making them more expected should make them easier
- Recent work (Wasow et al., 2005; Jaeger, 2006; Levy & Jaeger, 2007) has found that premodifier type can affect expectation for (in-situ) RCs

a barber... low RC expectation
the barber... higher RC expectation
the only barber... very high RC expectation

- **If** premodifier-induced expectations are carried over past the continuous NP domain, we may be able to manipulate extraposed RC expectations the same way*

Experiment Design

- We crossed RC expectation (low/high) with RC extraposition (extraposed/unextraposed)
- Example sentence: *The chairman consulted...*

Expect	Extr	
low	-	... <i>the</i> executives about the company <i>which</i> was making...
low	+	... <i>the</i> executives about the company <i>who</i> were making...
high	-	... <i>only those</i> executives about the company <i>which</i> was making...
high	+	... <i>only those</i> executives about the company <i>who</i> were making...

- We disambiguate the RC attachment weakly through the relative pronoun, and completely at the auxiliary verb (number marking on *was/were*; balanced across items)
- We predict an **interactive effect**: high RC expectation (“only those”) will facilitate RC reading, but **only** in the extraposed condition

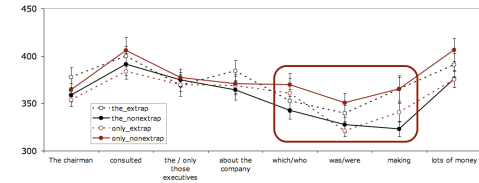
Method

- Word-by-word self-paced reading
- 36 native English-speaking Boston undergrads participated^{***}

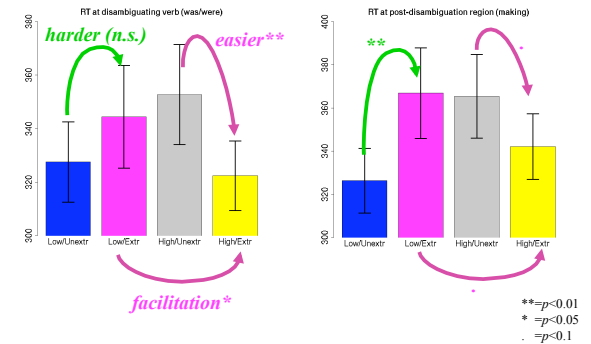
- *this prediction depends on the assumption that high RC expectation from premodifiers is not (strongly) negatively correlated with extraposition.
 - We don't have, enough annotated corpus data to test this explicitly
 - But there is no reason to expect such a correlation

Results

- The differences across conditions show up in the RC onset:



- The interaction is significant (all p 's < 0.05) at the disambiguating verb (*was/were*) and also at the next region (*making*)



- When an RC is less expected, there is a processing penalty for the extraposed variant
- When an RC is more expected, the extraposed variant is easier
- Equivalently, increasing expectation for an RC facilitates processing of that RC despite its extraposition

Conclusions

- Syntactic expectations are not limited to the continuous-constituent/dependency domain (a novel finding)
- Strong expectations for an RC can facilitate extraposed RC processing
- The processing constraint associated with phrasal adjacency seems to be entirely reducible to syntactic expectations
- Probabilistic expectations at many levels of representation play a broader role than previously realized
- Broader outlook: couple expectation-based comprehension with a theory of weight effects in production (Wasow, 2002) to explain distribution & processing of discontinuous dependencies