A processing model of the strong and weak island distinction

Marisa Ferrara Boston
Cornell University

CUNY Conference, Stanford University
March 24-26, 2011

Strong and weak islands...

This work demonstrates that varying difficulties in **activation** and **interference** explain strong and weak islands, confirming previously argued processing accounts [7].

Strong islands, like complex noun phrases (CNPs), do not permit extraction [10,12,6]:

✗ What do you really need to find *someone you can intimidate with*?

Weak islands, like wh-islands (WHIs), permit some extraction [10,12,5]:

✓ Which employee did Albert learn *whether they dismissed*...?

Although exceptions exist [12], experimental data confirms this pattern for standard cases. A computational model tests these results.

...vary cross-linguistically.

In Swedish, extractions from strong islands are not difficult [2]:

✓ Ett ben som jag ser *en hund som gnager på*.

Other languages, like German, confirm the English pattern [1]:

✗ Wen trifft Petra *die Leute, die entlassen?*

A parser attributes difficulty...

A Nivre dependency parser [9] builds non-projective analyses of experimental sentences (Figure 1).

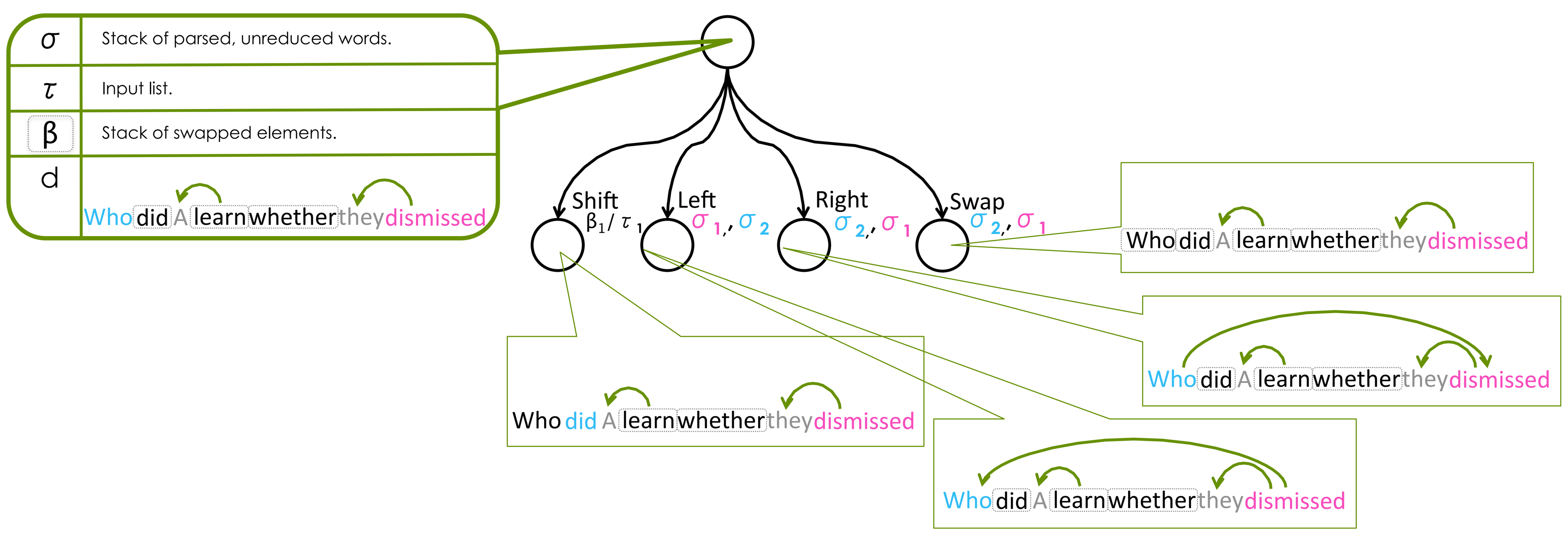

Figure 1: Parser states include σ, τ, β, and d. Shift, Left, Right, and Swap transitions lead to new states.

Aspects of the parser's memory state (Figure 2) determine probabilities and surprisal values [4] for analyses (Figure 3).

Activation		Activation + Interference	
Distance	$\sigma_1 - \sigma_2$	DLT	$\text{intervenors}_{\text{nominal}}(\sigma_2 \ldots \sigma_1)$ [3]
Retrieval Activation	baselineActivation(σ_2) [8]	Stacks	σ_1 (+ σ_2) (+ σ_3) + β_1
		Retrieval	retrievalTime(σ_2) [8]

Figure 2: Feature definitions.

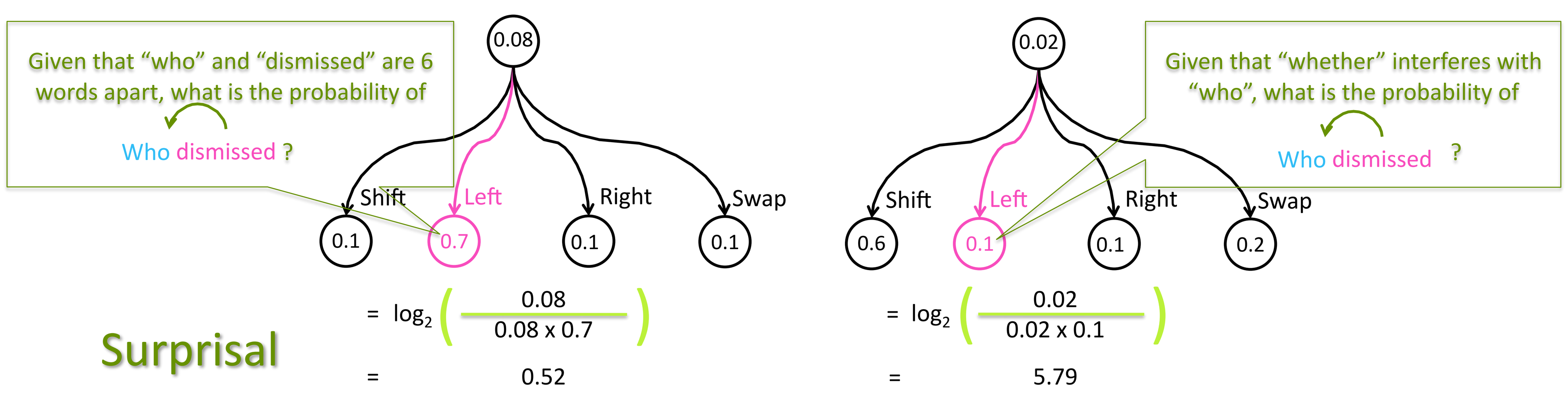

Figure 3: Probabilities based on activation or interference produce different surprisals.

Hypothesis: Increased surprisal at the verb indicates increased processing difficulty integrating the *wh*-filler and verb across an island for that memory theory.

...to activation and interference...

Surprisals from probability models that incorporate activation theories exhibit human-like (non)difficulty patterns for English [6] and Swedish [2] strong islands. For weak islands [5,11], combination theories provide better models (Figure 4).

		Human	Act	Act + Int
Strong Islands	Who do you really need to find *someone you can intimidate*?	42	52	55
	Which theory do you really need to find *someone you can intimidate with*?	36	53	54
	What do you really need to find *someone you can intimidate with*?	35	70	72
	Ett ben som jag ser *en hund som gnager på*. (A bone which I see a dog who is-gnawing on.)	0	1.7	1.5
	Vad ser jag *en hund som gnager på*? (What see I a dog who is-gnawing on?)	0	1.7	2.3
Weak Islands	Who did Albert learn that they dismissed...	232ms	23	21
	Which employee did Albert learn *whether they dismissed*...	244ms	22	21.9
	Who did Albert learn *whether they dismissed*...	256ms	22	22.3
	Who thinks...	1.23	0.2	0.9
	Who wonders...	0.71	0.2	0.95
	What do you think that John bought?	-0.23	33	33
	What do you wonder *whether John bought*?	-0.73	33	36

Figure 4: Activation and combination theories model acceptability and reading times.

This result holds for German and other English results [1,11], confirming processing accounts like [7,5].

...but embedding calls this into question.

Alexopoulou & Keller [1] find that increased island embedding produces less processing difficulty in English and German strong islands. This result is not modeled by either activation or combination theories (Figure 5).

		Human	Act	Act +Int	↑Parallel
English	Who will we fire?	0.38	12	10	2.8
	Who does Jane think that *Mary meets the people that will fire*?	-0.18	65	68	6.6
	Who does Mary meet *the people that will fire*?	-0.23	43	48	6.7
German	Wen entlassen... (Who sack...)	0.56	0.4	0.9	0.9
	Wen denkt Barbara, dass *Petra die Leute trifft, die entlassen*? (Who thinks Barbara that Petra the people meets that sack)	-0.44	55	52	3.9
	Wen *trifft Petra die Leute, die entlassen*? (Who meets the people that sack)	-0.52	24	22	4.0

Figure 5: A parallel architecture models this result, but the strong/weak island distinction breaks down.

Increasing parallelism within the parser allows activation, interference, and combination theories to exhibit this behavior.

Conclusion

A computational model recasts the strong and weak island distinction in terms of activation and interference, challenging the assumption that strong and weak islands are only distinguished via overt grammatical constraints.

However, this result breaks down if increased embedding of islands reduces processing difficulty for humans.

[1] Alexopoulou, T. & F. Keller. 2003. Linguistic complexity, locality and resumption. In WCCFL 22 Proceedings, pages 15–28.
[2] Allwood, J. 1982. The complex NP constraint in Swedish. In E. Engdahl and E. Ejerhed (Eds.) *Readings on unbounded dependencies in Scandinavian languages*, pages 15–32.
[3] Gibson, E. 2000. Dependency locality theory: A distance-based theory of linguistic complexity. In A. Marantz, Y. Miyashita, & W. O'Neil (Eds.), *Image, language, brain: Papers from the First Mind Articulation Symposium*, pages 95–126.
[4] Hale, J. T. 2001. A probabilistic Earley parser as a psycholinguistic model. In *Proceedings of NAACL 2001*, pages 1–8.
[5] Hofmeister, P., & Sag, I. A. 2010. Cognitive constraints and island effects. *Language* 86, pages 366–415.
[6] Keller, F. 1996. How do humans deal with ungrammatical input? Experimental evidence and computational modeling. In D. Gibbon (Ed.) *Natural language processing and speech technology: results of the 3rd KONVENS Conference*, pages 27–34.
[7] Kluender, R. 1998. On the distinction between strong and weak islands: A processing perspective. *Syntax and Semantics* 29, pages 241–279.
[8] Lewis, R., & Vasishth, S. 2005. An activation-based model of sentence processing as skilled memory retrieval. *Cognitive Science* 29, pages 1–45.
[9] Nivre, J. 2009. Non-projective dependency parsing in expected linear time. *Proceedings of the ACL 2009*, pages 351–359.
[10] Ross, J.R. 1967. *Constraints on variables in syntax*. MIT Dissertation.
[11] Sprouse, J., Wagers, M., & Phillips, C. To appear. A test of the relation between working memory capacity and syntactic island effects. *Language*.
[12] Szabolcsi, A. & M. den Dikken. 2002. Islands. In L. Chang and R. Sybesma (Eds.) *The Second GLOT International State of the Article Book*, pages 123–241.

mfb74@cornell.edu