Comprehending Structural Priming: A Connectionist Learning Account

Franklin Chang [1], Gary Dell [2], and Kathryn Bock [2]

[1] Max Planck Institute for Evolutionary Anthropology, [2] University of Illinois at Urbana-Champaign

Abstract

Structural priming is a tendency to reuse previously produced sentence structures. It provides good evidence for syntactic representations in language use, and is informative about how experience with other structures influences those representations. A new connectionist model that does language learning is shown to be better able to explain a variety of structural priming results (compared to previous models), suggesting the same language learning mechanism can support syntax acquisition and structural priming.

The Mechanism underlying Structural Priming: 3 Critical Findings

1. Structural priming can be long-lasting, suggesting that it is form of implicit learning (Bock & Griffin, 2000)
2. Comprehension-to-production and production-to-production are similar in magnitude (Bock, 2002, March)
3. Structurally similar but lexically and semantically different sentences can prime one another (Bock & Loebell, 1990)

- These critical findings suggest that priming is supported by an implicit learning mechanism that is shared between production and comprehension and has the ability to abstract away from lexical and conceptual content.

Previous Work

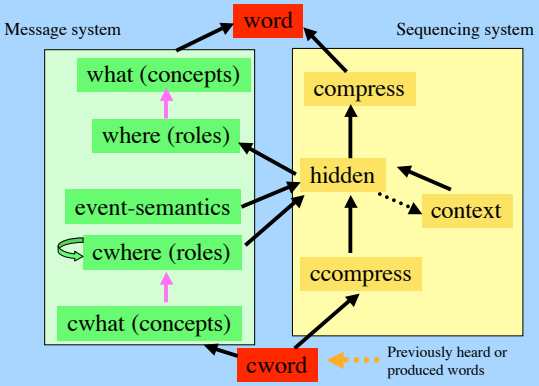
Connectionist models generalize based on overlap in unit-specific representations (which in language models tend to be words and concepts) (Fodor & Pylyshyn, 1988; Marcus, 1998). For example, a connectionist model of sentence production requires overlap between prime and target MESSAGES to get structural priming (Chang, Dell, Bock, & Griffin, 2000). These issues make it difficult to account for critical findings 2 and 3 above.

Chang (2002) developed a novel model architecture (Dual-path) that allows a connectionist model to generalize more abstractly by developing separate representations that can be combined in novel ways.

Sentences Types use to Train Model

Event Type	Example	Actions
Inanimate Intransitive	A bottle break,-s.	open, close, break, fall
Animate Intransitive	A girl walk,-ed.	dance, sleep, laugh, play, go,walk,run,jump
Locative	A man goes near the cafe.	go, walk
Presentational	This is jumping.	any verb
Transitive	Mary eat,-s a crossiant.	hit, carry, push, touch
Theme-experiencer	The cake amuse,-ed Mary	scare, surprise, amuse, annoy
Cause-motion	The woman pour,-ed the water on the car.	put, hit, carry, push, touch
Double Object Dative	The girl give,-s Mary a crossiant	give, send, throw, feed
Benefactive Dative	Fred is bake,-ing a cake for Mary	make, bake, build, mold, hit, carry, push, touch, scare, surprise, amuse, annoy
Change	The woman fill,-ed the bottle with water.	fill, cover, soak, bathe
Spray-load Alternation	The boy spray,-ed water on the wall.	spray, load, brush, heap

Dual-path Model Architecture (Chang, 2002)



The dual-path architecture separates content from structural relationships, allowing abstract syntactic representations to be learned and used. The message is in weights between *where* (role) and *what* (concepts) units.

Testing Structural Priming

We took a fully trained model and presented the prime with learning turned ON. Then we gave the model the target message, and allowed it to choose a structure to convey it. This was repeated with 10 models that were trained on different input sets. Results averaged over 10 models, and t-tests applied to priming difference (all results significant at 0.05).

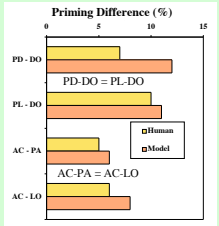
In previous models (Chang et al., 2000; Rohde, 2001 March), during prime processing both the prime message and the prime's words were processed. Here, we only presented the prime's words (without the prime message), thus simulating only the comprehension of the prime. The equivalence of comprehension-to-production and production-to-production priming (critical finding 2) occurs because in both cases, the prime is comprehended, and this comprehension is the cause of the priming (Branigan, et al. 2000).

Priming involves Structures

Priming does not require meaning or open-class lexical overlap (Bock & Loebell, 1990).

Structure	Example
Double Object Dative (DO)	John gives the dog the cake
Prepositional Dative (PD)	John gives the cake to the dog
Prepositional Locative (PL)	John pushes the cake to the dog
TARGET EVENT	Sally passes a beer to Mary

Active Transitive (AC)	John carries Mary
Passive Transitive (PA)	Mary is carried by John
Intransitive Locative (LO)	Mary is walking by John
TARGET EVENT	The dog touched the cat.



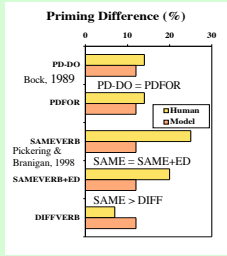
These results suggest that the model uses abstract structures that are shared between prepositional datives and prepositional locatives, as well as passives and locatives (supporting critical finding 3).

Insensitivity to Closed Class Items

Structural priming is insensitive to closed-class elements (Bock, 1989; Pickering & Branigan, 1998).

Prime Structure	Example
Double Object Dative (DO)	John gives the dog the cake
Prepositional Dative(PD)	John gives the cake to the dog
Benefactive Dative (PDFOR)	John makes the cake for the dog
TARGET EVENT	Sally passed a beer to Mary

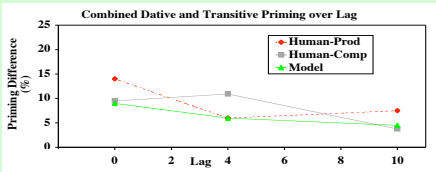
Same Verb	John passes the cake to the dog
Same Verb + Past Tense	John passed the cake to the dog
Different Verb	John gives the cake to the dog
TARGET	Sally passed a beer to Mary



These results suggest that the model is able to use structural frames to activate the appropriate closed-class element, but these elements are separate from the syntactic structure (further support for critical finding 3).

Priming Over Lag

Structural priming lasts over a lag of 10 intervening sentences (Bock & Griffin, 2000; Bock, 2002, March).



Priming in the model was present over 10 intervening sentences, and similar to both comprehension and production results (supporting critical finding 1 and 2).

Conclusions

- The Dual-path architecture constrains language learning such that abstract syntactic representations are developed.
- By only using the prime word sequence, we show that distributional sequence learning could be the common mechanism for both comprehension-based and production-based priming.

References

Bock, K. (1989). Closed-class immanence in sentence production. *Cognition, 31*(2), 163-186.

Bock (2002, March) Persistent structural priming from comprehension to production. Presented at the CUNY Conference on Human Sentence Processing, New York, NY.

Bock & Griffin (2000) The persistence of structural priming: Transient activation or implicit learning? Journal of Experimental Psychology: General, 129, 177-192.

Bock & Loebell (1990) Framing sentences. Cognition, 35, 1-39.

Branigan, H. P., Pickering, M.J., & Cleland, A.A. (2000). Syntactic co-ordination in dialogue. Cognition, 75, B13-25

Chang (2002) Symbolically speaking: A connectionist model of sentence production. Cognitive Science, 26, 609-651.

Chang, Dell, Bock, & Griffin (2000) Structural priming as implicit learning: A comparison of models of sentence production. Journal of Psycholinguistic Research, 29, 217-229

Fodor, J. A., & Pylyshyn, Z. (1988). Connectionism and cognitive architecture: A critical analysis. *Cognition, 28*, 3-71.

Marcus, G. F. (1998). Rethinking eliminative connectionism. *Cognitive Psychology, 37*, 243-282.

Pickering, M. J., & Branigan, H. P. (1998). The representation of verbs: Evidence from syntactic priming in language production. *Journal of Memory and Language, 39*, 633-651.

Rohde, D. L. T. (2002 March). *Syntactic and semantic processing in a connectionist model of complex sentence comprehension and production.* Poster presented at the 15th Annual CUNY Conference on Human Sentence Processing, New York City.

Presented at the CUNY Sentence Processing Conference, 2003, MIT, Boston, MA