

## DENDROPHOBIA IN BONOBO COMPREHENSION OF SPOKEN ENGLISH

ROBERT TRUSWELL

*Linguistics and English Language, University of Edinburgh*  
*Edinburgh, UK*  
*rob.truswell@ed.ac.uk*

Fitch (2014) proposed the *Dendrophilia hypothesis* as a description of the ubiquity of hierarchical structures in human cognition:

‘Humans have a multi-domain capacity and proclivity to infer tree structures from strings, to a degree that is difficult or impossible for most non-human animal species.’ (Fitch, 2014, 352)

Part of Fitch’s supporting evidence concerns Fitch and Hauser’s (2004) demonstration that humans learn to recognize sequences of the forms  $(ab)^n$  and  $a^n b^n$ , while cotton-top tamarins can only learn the former. Fitch takes this to support the Dendrophilia hypothesis because  $(ab)^n$ , but not  $a^n b^n$ , can be generated in the limit by constituency-free finite-state grammars. However, this result has been disputed on empirical and theoretical grounds, e.g. Perruchet and Rey (2005), Jäger and Rogers (2012).

This paper gives a complementary source of evidence for Fitch’s hypothesis. We examine a corpus from (Savage-Rumbaugh et al., 1993) of 660 utterances directed in parallel to a bonobo, Kanzi, and a human infant, Alia, together with descriptions of their behavior in response to those utterances. Unlike grammar induction experiments such as Fitch and Hauser (2004), these strings are paired with interpretations. We can then infer aspects of a subject’s interpretation of an utterance from their behavior, and aspects of the grammatical representation of the utterance from that interpretation. I argue that Kanzi fails to respond to requests precisely where correct interpretation requires hierarchical constituency.

Kanzi’s overall performance across the corpus (71.5% ‘correct’ responses according to Savage-Rumbaugh et al.’s criteria) is comparable to Alia’s (66.6% ‘correct’). Usually, though, a correct response could be achieved through common-sense combination of the concepts expressed by individual words, without using syntactic information (Anderson’s 2004 *semantic soup* strategy). One such example, carried out correctly by Kanzi, is *Put the backpack in the car*: few other actions involving backpacks and cars suggest themselves.

In some cases (e.g. *Put the tomato in the oil / Put some oil in the tomato*), correct interpretation requires sensitivity to linear order, but not constituency. Kanzi's accuracy on 43 such sentences in the corpus (21 pairs, with 1 example repeated) is 76.7%, in line with his 71.5% overall accuracy. This suggests that Kanzi can make use of linear order information in his understanding of spoken English.

However, Kanzi responded correctly to only 4/18 sentences containing coordinated NP objects (22.2%). When asked to *Show me the milk and the doggie*, he shows only the dog; when asked to *Give the lighter and the shoe to Rose*, he gives Rose only the lighter. Kanzi ignores the first conjunct on 9/18 trials, and ignores the second conjunct on 5/18 trials.

Despite the small number of critical sentences, this represents a highly significant drop relative to both Kanzi's baseline accuracy ( $p < 10^{-4}$ ) and Alia's 68.4% accuracy on sentences containing the same construction ( $p < 0.01$ ). This, then, is a species-specific, construction-specific drop in performance.

I propose that Kanzi's performance dips precisely here (and not on many other constructions of comparable length) because correct interpretation of such sentences requires reference to hierarchical constituent structure. Specifically, unlike the previous examples, Kanzi must recognize that the object of *give* is the complex phrase *the water and the doggie*, and not just, for example, the next noun. Likewise, the patient of the action of giving should be the group of objects denoted by the complex phrase, not just the denotation of a single noun. Kanzi's generally impressive performance therefore only drops where reference to constituency is required, while Alia has no similar problem. In Fitch's terms, Kanzi is more dendrophobic than Alia.

## References

- Anderson, S. (2004). *Doctor Doolittle's delusion*. New Haven, CT: Yale University Press.
- Fitch, W. T. (2014). Toward a computational framework for cognitive biology: Unifying approaches from cognitive neuroscience and comparative cognition. *Physics of Life Reviews*, 11, 329-364.
- Fitch, W. T., & Hauser, M. (2004). Computational constraints on syntactic processing in a nonhuman primate. *Science*, 303, 377-380.
- Jäger, G., & Rogers, J. (2012). Formal language theory: Refining the Chomsky hierarchy. *Philosophical Transactions of the Royal Society B*, 367, 1956-1970.
- Perruchet, P., & Rey, A. (2005). Does the mastery of center-embedded linguistic structures distinguish humans from nonhuman primates? *Psychonomic Bulletin & Review*, 12, 307-313.
- Savage-Rumbaugh, E. S., Murphy, J., Sevcik, R., Brakke, K., Williams, S., Rumbaugh, D., & Bates, E. (1993). Language comprehension in ape and child. *Monographs of the Society for Research in Child Development*, 58, 1-252.