LEARNING STRUCTURE-DEPENDENT PROCESSING FROM COMBINATORIAL MEANING

Hartmut Fitz (Max-Planck Institute for Psycholinguistics Nijmegen) & Franklin Chang (University of Liverpool)
hartmut.fitz@gmail.com

Knowledge of language includes syntactic principles which appear unlearnable given the language input children receive in development. The structure dependence of auxiliary fronting in complex polar questions is a paradigm case of such a principle (Chomsky, 1980).

English complex questions are formed by fronting the main clause auxiliary (*"Is the boy who is eating running?"*, structure-dependent movement), not the embedded clause auxiliary (*"Is the boy who eating is running?"*, structure-independent movement). Since these questions are rare in child-directed speech, it has been claimed that innate constraints are needed to remove structure-independent rules from the learner's hypothesis space (Berwick et al., 2011). Here we test whether structured meaning can be an alternative to innate syntactic constraints.

We adapted a connectionist model of language acquisition and sentence production (Chang, 2009) that learns from exposure to meaning-form pairs. Crucially, we assume that learners must be able to infer non-linguistic meanings, e.g., that the above sentence describes the two events RUNNING(BOY) + EATING(BOY). The EATING message is given and the RUNNING message is not known by the speaker (marked as a question). Over time, the model should learn to use this message structure to acquire the correct rule.

Model input consisted of simple and complex declaratives and questions with copulas, modal auxiliaries, and progressive verbs. No complex questions with auxiliaries in both clauses occurred in training. After 500K learning episodes, the model produced a diverse set of such questions with +95% accuracy from novel meanings. Model behavior was consistent with a range of findings concerning relative clause length, structure, and auxiliary type.

Errors during development were similar to those found in children who would often repeat auxiliaries (*"*Is the boy that is nice is happy?"*) in elicited production (Crain and Nakayama, 1987) and occasionally make embedded-auxiliary errors (*"*Can boys that run can jump?"*) (Ambridge et al., 2008). The model suggests how children could eventually learn to retreat from these errors and corpus evidence is provided to support this explanation.

From simple questions the model learned that features in the message signalled auxiliary movement, and from complex declaratives that different parts of a sentence depended on different message components. By combining these regularities that are present in child-directed speech, it was able to generalize auxiliary movement in a structure-dependent way. This is the first explicit computational model that learns to use message structure for subject-auxiliary inversion in the production of complex questions.

References

Ambridge, B., Rowland, C. E., and Pine, J. M. 2008. Is structure dependence an innate constraint? New experimental evidence from children's complex-question production. *Cognitive Science 32*, 222–255.

Berwick, R. C., Pietroski, P., Yankama, B., and Chomsky, N. 2011. Poverty of the stimulus revisited. *Cognitive Science 35,* 7, 1207–1242.

Chang, F. 2009. Learning to order words: A connectionist model of heavy NP shift and accessibility effects in Japanese and English. *Journal of Memory and Language 61*, 374–397.

Chomsky, N. 1980. On cognitive structures and their development. In M. Piattelli-Palmarini (Ed.), *Language and Learning: The Debate between Jean Piaget and Noam Chomsky*. London: Routledge and Kegan.

Crain, S. and Nakayama, M. 1987. Structure dependence in grammar formation. *Language 63,* 3, 522–543.