

THE CULTURAL CO-EVOLUTION OF LANGUAGE AND MINDREADING

MARIEKE WOENSDREGT

KENNY SMITH, CHRIS CUMMINS, SIMON KIRBY

*Centre for Language Evolution, School of Philosophy, Psychology & Language Sciences
University of Edinburgh, Edinburgh, United Kingdom
m.s.woensdregt@sms.ed.ac.uk*

One defining feature of human language is its heavy reliance on reasoning about the mental states of others (e.g. Scott-Phillips, 2014). The development of such mindreading skills was a crucial step in hominin evolution because it allowed for the expression and recognition of communicative intentions, thereby paving the way for the cooperative information sharing that we find in humans today. The ability to recognize and infer communicative intentions also plays an important role in language development on an ontogenetic time-scale, as evidenced by studies correlating mindreading skills and word learning (e.g. Parish-Morris, Hennon, Hirsh-Pasek, Golinkoff, & Tager-Flusberg, 2007).

This relationship between language and mindreading may be reciprocal; the acquisition of language has been shown to unlock further levels of mindreading development in the individual (e.g. Lohmann & Tomasello, 2003; Pyers & Senghas, 2009). Furthermore, Heyes and Frith (2014) have argued that mindreading is a skill that has developed (partly) through cumulative cultural evolution - just like language (Kirby, Tamariz, Cornish, & Smith, 2015).

In this paper we present a computational model that investigates the implications of such a bidirectional interaction between the capacities of language and mindreading. This new agent-based model builds on previous models of cross-situational word learning (Siskind, 1996), but extends this framework by allowing agents to learn a way of inferring an interlocutor's communicative intentions, simultaneously with learning the lexicon.

In the model, agents communicate (probabilistically) about objects that are proximate to them. The learner's task is to establish the relations between the words and the objects (i.e. the lexicon), and the perspective of the speaker, which may be the same as the learner's own or may differ. The communicative intentions of the speaker are a product of the context that the agents find themselves in and the speaker's perspective (which renders some objects more salient than others). Utterances in turn are a product of a speaker's communicative intention

and lexicon.

The data that a learner has access to in order to learn a speaker's lexicon and perspective consists of the speaker's word use in context. From these two observable variables the learner has to infer two unobservable variables simultaneously: the speaker's lexicon and their perspective. This learning happens through Bayesian inference, where accumulating evidence allows the learner to weigh different combinations of lexicon and perspective hypotheses against each other - based on the likelihood of the incoming data given a specific hypothesis.

Although a speaker's utterances are as much a product of their perspective as they are of their lexicon, simulations with this model show that given consistent input, a learner is able to infer both the correct lexicon and the correct perspective from scratch, by reciprocally bootstrapping the learning of the one variable with partial knowledge of the other. The learning trajectory that is revealed in these simulations is one where acquiring a bit of the lexicon helps the learner infer the speaker's perspective, which in turn allows the learner to acquire the rest of the lexicon.

We will discuss the dynamics of this model on two different levels: exploring the emergence of language and mindreading capacities both within individual agents and across generations of a population. This model thus gives insight into the effects of an individual-level interaction of cognitive capacities on population-wide dynamics such as establishing and maintaining a stable signalling system; thereby connecting proximate and ultimate causes of language evolution.

References

- Heyes, C. M., & Frith, C. D. (2014). The cultural evolution of mind reading. *Science (New York, N.Y.)*, 344(6190), 1243091.
- Kirby, S., Tamariz, M., Cornish, H., & Smith, K. (2015). Compression and communication in the cultural evolution of linguistic structure. *Cognition*, 141, 87–102.
- Lohmann, H., & Tomasello, M. (2003). The role of language in the development of false belief understanding: A training study. *Child Development*, 74(4), 1130–1144.
- Parish-Morris, J., Hennon, E. a., Hirsh-Pasek, K., Golinkoff, R. M., & Tager-Flusberg, H. (2007). Children with autism illuminate the role of social intention in word learning. *Child development*, 78(4), 1265–87.
- Pyers, J. E., & Senghas, A. (2009). Language promotes false-belief understanding: Evidence from learners of a new sign language. *Psychological science*, 20(7), 805–812.
- Scott-Phillips, T. (2014). *Speaking our minds: Why human communication is different, and how language evolved to make it special*. Palgrave MacMillan.
- Siskind, J. M. (1996). A computational study of cross-situational techniques for learning word-to-meaning mappings. *Cognition*, 61(1-2), 39–91.