DOES LEARNING FAVOUR COMMUNICATIVE EFFICIENCY?

KENNY SMITH[*1] and JENNIFER CULBERTSON[1]

[*]Corresponding Author: kenny.smith@ed.ac.uk
[1]Centre for Language Evolution, University of Edinburgh, UK

Natural languages are well-designed for communication, exhibiting structural properties which optimally trade off communicative function and efficiency (e.g. Zipf, 1949; Piantadosi et al., 2012; Jäger, 2007). These properties of language are typically explained as a consequence of modifications made by speakers during language use; in these accounts, learning plays no role in structuring languages to be communicatively optimal, and indeed simplicity biases in learning can erode communicative utility if unchecked (Kirby et al., 2008; Silvey et al., 2015).

However, several recent papers purport to show an improvement in communicative function through learning alone (e.g. Fedzechkina et al., 2012; Carstensen et al., 2015). Fedzechkina et al. (2012) show that participants trained on an artificial language featuring variable case marking will restructure that language in ways which would increase its communicative function, despite never using the language to communicate. They train participants over 4 days on an artificial language for describing events in which animate agents perform actions on animate or inanimate patients. The training language has variable word order, meaning that utterances are potentially ambiguous if the patient of an event is animate (but not if it is inanimate, since inanimates are never agents in their stimuli). The training language features case marking which, where it occurs, serves to eliminate this ambiguity: 60% of objects are case-marked, but animates and inanimates are equally likely to be case marked, yielding a distribution of case markers which is not communicatively optimal. Fedzechkina et al. found that learners increased the frequency of case marking on animate patients, and reduced it on inanimate patients. This results in a more communicatively efficient system, suggesting that learning may in fact play a critical role in structuring languages to be communicatively optimal, a result which runs contrary to the accounts reviewed above.

In Experiment 1 we replicated Fedzechkina et al.'s experiment and result (see Figure 1): we found that participants preferentially marked animate patients at later days. However, this replication highlighted a surprising feature of their stimuli: animates which are agents are never patients, and vice versa. By day 4 our participants were therefore able to correctly interpret sentences involving two animates with near-perfect accuracy even if the object was not case-marked; nonethe-

DOI:10.12775/3991-1.115

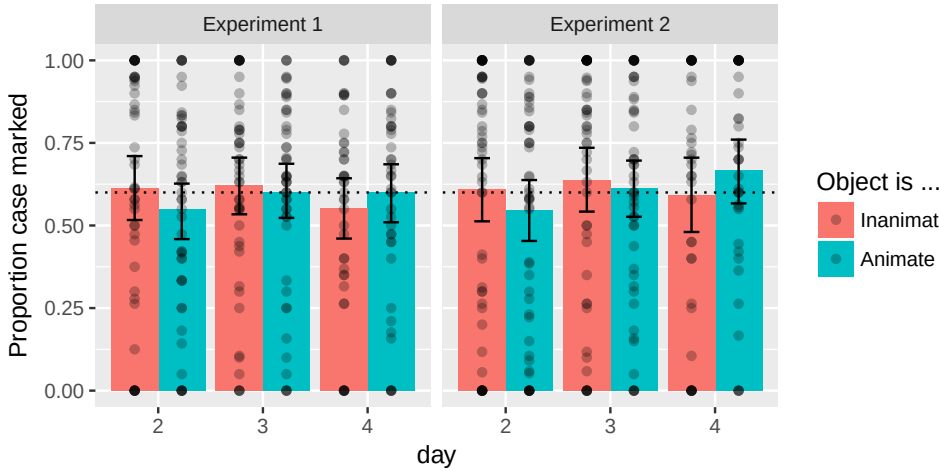

Figure 1. Proportion of case-marked objects in participants' productions in both experiments across days (testing occurred on days 2–4 only). The dashed line indicates frequency of case marking in the input, for both animate and inanimate patients; error bars indicate 95% CIs on the mean; individual points indicate by-participant means. Note the developing tendency to case-mark animate objects more often than inanimate objects, present in both experiments (as indicated by a significant day x animacy interaction in Experiment 1, and no interaction featuring Experiment across the full data set).

less they exhibited the pattern of case-marking that is putatively driven by the ambiguity of unmarked animate patients. We re-ran the experiment with a modified set of stimuli where all animates served as agents *and* patients, which should increase the utility of differential case marking. While Experiment 2 showed a modest increase in case marking on all objects, there was not a significantly stronger tendency to casemark animates (see Figure 1). Experiment 2 also featured an additional test on Day 4 where participants used the language to communicate with their alien language tutor; here, where communicative utility matters, we again saw an overall increase in case marking, but not preferentially on animates.

Overall, our results cast some doubt on the Fedzechkina et al.'s claim that biases in learning favour communicative utility: while their result is robust, this interpretation is at odds with results elsewhere in the literature, and makes predictions which do not appear to be borne out in their paradigm. We are currently exploring whether restructuring of the input in this case might be due to biases in learning which favour conditioning of variation (cf. Hudson Kam & Newport, 2009): their results may represent an artifactual case where biases in learning yield languages which are coincidentally better for communication. Thus, even if learning does not directly drive communicative function, it nevertheless plays an important explanatory role in accounting for the design of natural languages.

Acknowledgements

This project has received funding from the European Research Council (ERC) under the European Unions Horizon 2020 research and innovation programme (grant agreement 681942).

References

Carstensen, A., Xu, J., Smith, C. T., & Regier, T. (2015). Language evolution in the lab tends toward informative communication. in . In *Proceedings of the 37th annual meeting of the cognitive science society.* Austin, TX: Cognitive Science Society.

Fedzechkina, M., Jaeger, T. F., & Newport, E. L. (2012). Language learners restructure their input to facilitate efficient communication. *Proceedings of the National Academy of Sciences, USA*, *109*, 17897–17902.

Hudson Kam, C. L., & Newport, E. L. (2009). Getting it right by getting it wrong: When learners change languages. *Cognitive Psychology*, *59*, 30-66.

Jäger, G. (2007). Evolutionary game theory and typology. a case study. *Language*, *83*, 74–109.

Kirby, S., Cornish, H., & Smith, K. (2008). Cumulative cultural evolution in the laboratory: an experimental approach to the origins of structure in human language. *Proceedings of the National Academy of Sciences, USA*, *105*, 10681-10686.

Piantadosi, S. T., Tily, H., & Gibson, E. (2012). The communicative function of ambiguity in language. *Cognition*, *122*, 280-291.

Silvey, C., Kirby, S., & Smith, K. (2015). Word meanings evolve to selectively preserve distinctions on salient dimensions. *Cognitive Science*, *39*, 212-226.

Zipf, G. K. (1949). *Human behaviour and the principle of least effort : an introduction to human ecology*. Cambridge, MA: Addison-Wesley.