

## **MANIPULATING LEARNING CONSTRAINTS AND SIGNAL FEATURES IN ITERATED LANGUAGE LEARNING**

VERA KEMPE<sup>\*1</sup>, SHEILA CUNNINGHAM<sup>\*1</sup>, NIKOLAY PANAYOTOV<sup>\*1</sup>,  
NICOLAS GAUVRIT<sup>\*2</sup> & MONICA TAMARIZ<sup>3</sup>

<sup>\*</sup>Corresponding Author: v.kempe@abertay.ac.uk

<sup>1</sup>Division of Psychology, Abertay University, Dundee, Scotland, U.K.

<sup>2</sup>That Department, University Y, City, Country

<sup>3</sup>Department of Psychology, Heriot Watt University, Edinburgh, Scotland, U.K.

Iterated language learning (e.g. Kirby, Cornish & Smith, 2008) is a well-established methodology for studying emergence of linguistic structure in the laboratory. Yet there is considerable variation in implementation of the paradigm the effects of which have not been systematically scrutinized. For example, different training regimens can affect amount of learning thereby imposing different pressures on emergence of systematic signal-meaning associations. Also, differences in learning of visual vs. auditory signals (e.g. Raviv & Arnon, 2018) may not just be due to modality but to temporal differences affecting signal decay: the fading nature of sound may impose a memory burden not found in visual signals. We manipulated amount of learning, modality and temporal properties of the signals to examine the effects of these factors on the kinds of signal-meaning mappings that can emerge, while controlling for all other aspects of the methodology. We used binary sequences as signals to minimize potential influence of participants' prior knowledge and meta-linguistic awareness.

Both experiments alternated comprehension and production tasks to impose pressures to avoid ambiguity while also minimising effort: During comprehension, participants perceived the signals and had to choose the corresponding referents out of eight unfamiliar objects differing in size (large/small), shape (spiky/fluffy) and brightness (light/dark). During production, participants saw the referents and had to generate the corresponding signals, while being prevented from reusing the same signal for different referents. Crucially, amount of learning was manipulated by an adaptive procedure where transmission only took place once learners had reached a pre-defined accuracy threshold.

In Experiment 1, participants in 12 chains of 10 generations each learned to correctly associate either three (short training condition) or five (long training condition) meanings with signals comprising 4-6 bit binary auditory sequences of high and low tones of 500 ms each before being allowed to produce the signals that were then transmitted to the next generation. While compositional structure did not emerge, iconicity did: participants extended the length of those sequences that were associated with larger objects, but only in the short training condition.

In Experiment 2, participants in 12 chains of 10 generations each learned to associate 4-6-bit binary visual sequences comprising rows of blue and orange dots with the same meanings as in Experiment 1. In the stable condition, sequences appeared all at once before disappearing after a duration that was proportional to the number of dots in a sequence. In the fading condition, dots appeared one by one, with each dot fading away at a rate identical to the duration of tone presentation in Experiment 1. In all other respects, the procedure was similar to the short training condition in Experiment 1. As with auditory signals, there was a trend towards iconicity, but only in the stable condition. In the fading condition, participants tended to shorten all signals leading to overall greater learnability.

In sum, to simulate how memory constraints drive emergence of systematic mappings between signals and meanings in iterated language learning experiments training needs to aim at a ‘sweet spot’ where learning accuracy is high enough to retain crucial signal features yet also low enough to leave room for productive modifications. Our findings highlight the importance of carefully calibrating training regimens as well as the way in which modality-specific and temporal features can influence strategies of signal learning and signal use when trying to recreate language evolution in the laboratory.

### Acknowledgements

This research was funded by Research Incentive Grant #70700 of the Carnegie Trust for the Universities of Scotland.

### References

- 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*, 105(31), 10681-10686.
- Raviv, L., & Arnon, I. (2018). The developmental trajectory of children's auditory and visual statistical learning abilities: modality-based differences in the effect of age. *Developmental Science*, 21(4), e12593.