THE CUMULATIVE CULTURAL EVOLUTION OF CATEGORY STRUCTURE IN AN OPEN-ENDED MEANING SPACE

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This project represents a first step towards thinking about how iterated learning experiments deal with the problem of open-ended meaning spaces. Current studies tend to use meanings that are discrete, finite, pre-specified, and low-dimensional (e.g. Kirby, Cornish, & Smith, 2008). However, many of these properties are conspicuously absent in natural language, which is typified by open-ended meaning structure. While recent work has begun to explore the effects of continuous spaces (e.g. Perfors & Navarro, 2011), we present an experiment that explores the cumulative cultural evolution of category structure in a meaning space that is not just continuous, but contains no reoccurring items (every meaning is novel), is not specified by the experimenter *a priori*, and is high-dimensional.

Forty participants (4 diffusion chains of 10 participants) were tasked with learning the words for 48 triangles. The initial words were generated by randomly concatenating syllables from a finite syllabary, and the triangle stimuli were generated by randomly selecting three coordinates in a 480×480-pixel space, which allows for 6×10^{15} possible stimuli. These parameters model the linguistic property of discrete infinity, since a finite set of symbols is used to describe an essentially infinite set of meanings. The first participant in a chain was trained on a random mapping between signals and meanings, and subsequent participants were trained on the test output of the previous participant. No two participants ever saw the same stimuli in training. Participants were also tested on an additional set of 48

stimuli that were identical for all participants to allow us to measure the learnability of the languages and to test for the presence of structure. Transmission error was used as a proxy for learnability, and the correlation between string dissimilarity and triangle dissimilarity was used to measure the structure in the emergent languages.

The number of words used to describe the stimuli collapsed dramatically after only a few generations. Within a few more generations, systems emerged that arbitrarily divided the space into a small number of categories. Although our technique for uncovering the structure in the languages was able to consider multiple geometrical properties, the systems that emerged pertained primarily to the size and shape of the stimuli, ignoring features such as rotation and location. For example, in one chain, a reliable system emerged in which 'pika' was used for thin triangles, 'mamofudo' was used for large triangles, 'mamozuki' was used for approximately right-angled triangles, 'mamo' was used for isosceles triangles, and 'fido' was used for approximately equilateral triangles. The emergence of categorical structure in these languages contributed to their increased learnability. There were also signs of the emergence of sound-symbolic patterns in the signals.

The problem of creating an open-ended meaning space in an experimental scenario is still far from resolved, but we have developed a number of novel experimental, quantitative, and visualization methods to begin to explore this issue. The results showed that iterated learning can give rise to categorical structure, even when (a) items in the meaning space do not reoccur, and (b) there is no communicative pressure for expressivity. Although separate chains divided the space in subtly different, lineage-specific ways, participants showed biases for the size and shape properties of the stimuli. These results suggest that iterated learning amplifies cognitive biases, giving rise to the categorical structure we observe in human languages.

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References

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