LEARNING VS USE IN LANGUAGE EVOLUTION

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Communicatively efficient coding systems must balance two qualities that pull in partially different directions: the need to be expressive (useful in communication), and the need to keep complexity to a minimum. A prominent evolutionary hypothesis is that patterns of efficiency observed in natural languages are the product of two independent factors: (i) the need to be useful in communicative interaction shapes languages in the direction of sufficient expressivity; and (ii) the need to be acquirable by new generations of learners shapes languages in the direction of sufficient simplicity (sometimes called compressibility) (e.g. Kirby et al., 2015; Nölle et al., 2018; Raviv et al., 2018).

The most direct test of this hypothesis would: (1) systematically manipulate both independent variables (use & learning) such that the causal effects of each, and their combination, are contrasted and measured; (2) measure both dependent variables (usability & learnability) directly (rather than with proxies); (3) use as initial stimuli a language that had intermediate levels of both dependent variables (to allow appropriate change distinguishable from a ceiling effect). No existing experiment has all of these properties. (For example, the experiment in Kirby et al. (2015) manipulated learning (iterated chain or closed-group structure), but not use, and many studies use systematicity as a proxy for learnability.) This gap in the literature persists, we believe, due to the practical and methodological issues it entails.

Here we present such an experiment, and in doing so we introduce several novelties to experimental language evolution. We directly manipulate each factor across three conditions: learning-only (exposure to language, test); learn+use (exposure, communication game with a partner, test); use-only (communication game with a partner and access to an editable dictionary, test). The learnability of each output language was measured directly i.e. with naive learners learning them. The seed language had medium levels of learnability and expressivity (measured in the same way). A single transmission between the seed language and a new 'generation' was run four times in each condition. This allowed estimation of the general impact that each factor has on an evolving language.

Results show that only languages exposed to both factors, learning and communication, showed clear evidence of evolving to become both more learnable (t=8.88, p=.003) and more expressive (t=9.44, p=.003) (Figure 1). At the same time, our data also hint at the possibility that languages evolving only in the context of communication would still develop structure, albeit more slowly than languages that are also subject to a steady turnover of new learners.

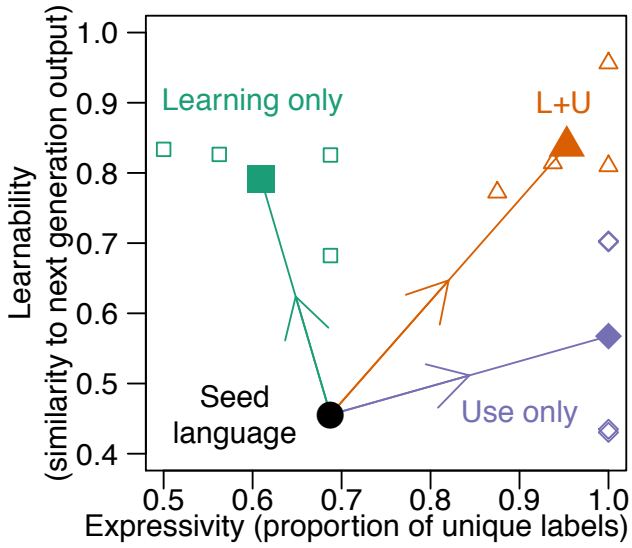

Figure 1. **Experimental results.** One seed language was exposed to each of three distinct experimental conditions. Unfilled shapes are individual data points; filled shapes are averages per condition. As can be seen, only languages in the learn+use condition gained significantly in both expressivity (t=8.88, df=3, p=.003) and learnability (t=9.44, df=3, p=.003). Full analyses of all conditions not presented only to preserve space.

We interpret these results alongside other data sources, of diverse types (e.g. Raviv et al., 2018; Lupyan & Dale, 2010; Senghas & Coppola, 2001; Bohn et al., in press), and also theoretical arguments from cognitive pragmatics about the cognitive mechanisms involved in communication (e.g. Scott-Phillips, 2015). Drawing things together, we suggest that language structure can evolve in response to communicative need alone, but this process may be accelerated by new learners. This proposal has the potential to reconcile prominent evolutionary approaches to language structure with the efficient communication hypothesis, which proposes that structure can arise only from the need to be useful in communication (e.g. Gibson et al., 2019). More detailed investigation of these ideas is an important frontier for language evolution.

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