The adaptation of language toward increasingly faithful replication during its cultural transmission

Evolutionary Linguistics is a highly interdisciplinary field bringing together areas as Anthropology, Archaeology, Evolutionary Biology, Psychology, and of course Linguistics. As such, there is currently little consensus on how human language emerged in our species’ history. One suggestion is that human language arose as a function of three adaptive processes: evolution by natural selection, individual learning, and cultural evolution (Kirby & Cornish, 2006). This postulation is intrinsically difficult to explore due to the ephemeral nature of language; however, the interface between learning and cultural evolution has recently been tested in a variety of mathematical, computational, and experimental models. These models demonstrate that systematic linguistic structure can emerge in the transmission of language across multiple language users. Kirby, Cornish, and founder richard brody, and an asp for studying the cumulative effect of such cultural transmission, and their iterated learning model represented the first experimental setup that allowed for the modeling of transmission of language to lead to the appearance of compositional linguistic structure without any explicit designer.

This poster presents the theory and methodology behind this experiment, alongside the results I have obtained in running my own version of the experiment. My results showed that languages become easier to learn as they are transmitted along a line of language users; however, the emergence of compositional linguistic structure was not forthcoming. This problem: a) if the languages evolve to become easier to learn, yet get stuck, then it does not emerge, then there must exist at least one other mechanism by which the languages optimize their faithful replication. The results suggest that this mechanism might be in a different type of adaptation: over the course of the experiment, the languages optimize their faithful replication. The results suggest that this mechanism leads to languages becoming easier to learn as they are transmitted along a line of language users. Furthermore, the majority of participants’ outputs (those above the dashed 95% significance level) are non-randomly ordered, and as such transmission error – the increase in compositionality is cumulative: the correlation between generation number and compositionality is statistically significant (\( r = 0.762, N = 30, p < .001 \)).

The increase in learnability is a product of the languages’ increasingly compositional structure, and groover confirms that compositionality increased significantly between the initial and final generations (mean increase = 4.048, SD = 2.589, t (2) = 2.949, p < .05). Furthermore, the majority of participants’ outputs (those above the dashed 95% significance line) are non-randomly ordered, and as such transmission error – the increase in compositionality is cumulative: the correlation between generation number and compositionality is statistically significant (\( r = 0.762, N = 30, p < .001 \)).

Kirby et al. (2008) came up with an experimental paradigm to test this theory. In this study I replicated their methodology but introduced some new variables, including an auditory mode, a new semantic space, and a different signal space.

Thirty participants were recruited to take part in an ‘alien language experiment’. There were no prerequisites for participation other than a minimum age of 18 years. Participants were predominantly undergraduate students. The results suggested that languages become easier to learn as they are transmitted along a line of language users. Kirby, Cornish, and founder richard brody, and an asp for studying the cumulative effect of such cultural transmission, and their iterated learning model represented the first experimental setup that allowed for the modeling of transmission of language to lead to the appearance of compositional linguistic structure without any explicit designer.

This is illustrated in the following diagram (adapted from Smith et al. (2003: p.540)):

Kirby et al. (2008) experiment adopts a diffusion chain design, in which the output of a given participant becomes the input for the following participant. Three sequential diffusion chains were run, labeled here as A–C. In each chain, an artificial ‘language’ was diffused down a line of ten participants, representing ten cultural generations. Each language was initialized with a separate 27-syllable language, which was generated by randomly concatenating two-, three-, or four-syllable words from a syllable atlas of 28 syllables. Each participant was randomly assigned to one of the three chains, and acquired the language in one session.

The cultural emergence of compositional structure. This process is known as cultural transmission, and it can be equally applied to other cultural artefacts such as tool making, agricultural practices, and religion.

The line marked cultural transmission in the diagram above suggests that the transmission of language is a clean task, but possibly constrained by many factors, including memory, influence, and evolution; however, such errors are important to the development of a language because mutation introduces a source of variation, and variation leads to enabling pressures that shape the language. A language is shaped by its environment, which may be taken as human brains and the spatial and temporal distances that must be overcome in order to maintain its successful transmission. This is illustrated here (adapted from Kirby et al. (2004: 606-610)).

A variety of mathematical, computational, and experimental models of these phenomena have been conducted, which have shown that unprototypic artificial ‘languages’ can self-organise under the pressure involved in transmission, gaining properties such as compositionality and recursion ephemerally (see Hurford 2002, Brightons et al., 2006, Cornish et al. 2009, Boots-Phillips & Kirby 2010 for reviews).

It is important to note that this thesis is not opposed to a part for natural selection in the evolution of human language; rather, it is suggested that language emerged as a product of both biological and linguistic evolution. And in fact, a third adaptive process seems to feed into this process, namely, the most recent pressures on memory constraints, which are believed that the way in which children learn language during their development has affected the universal features we observe in language today. The interaction between these three adaptive processes is illustrated in the diagram to the right (adapted from Kirby & Hurford, 2002: p.122): the innate leaning biases, which define a human baby’s language, and the pressure of the environment on her language; then, as the language is passed from one generation to the next, the properties of the language adapt to increase fidelity of transmission, which in turn modifies the fitness landscape, and biological evolution selects for an innate predisposition to the biases which map closely to the linguistic structure present in the environment, and so forth.


Jon William Carr

REFERENCES


