Noise in Phonology Affects Encoding Strategies in Morphology

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As with the evolution of a population's genetic variability, the evolution of human linguistic variability must be shaped by multiple interacting forces. The iterated learning paradigm (for overview, see Kirby, Griffiths & Smith, 2014) demonstrates that languages can evolve compositional structure when there is a learning bottleneck: Learners infer a linguistic system from limited input, requiring them to generalize beyond what they observe. Through this, linguistic patterns that are systematically structured become more frequent in the process of cultural evolution.

Besides the 'transmission bottleneck' (Hurford, 2002), the social composition of languages has been argued to be another force acting upon language structure. The 'Linguistic Niche Hypothesis' (Lupyan & Dale, 2010) proposes that morphological complexity is inversely correlated with population size. The mechanism behind this correlation is commonly assumed to be a learning difficulty of adult second language learners in acquiring specifically morphology (Bentz & Winter, 2013; Trudgill, 2011). However, crucially, the major share of evidence for the Linguistic Niche Hypothesis is correlational, leaving the underlying mechanism underspecified (Nettle, 2012).

An additional mechanism explaining the loss of morphological complexity in larger populations may be phonological variability. Adult learners introduce heterogeneity (effectively noise) into the phonological system (Nettle, 2012: 1833-1835). Larger populations harbor more pronunciation variants, paralleling the higher 'noise' present in large populations in the form of stochastic genetic variation. In a large population of speakers, noise is incorporated via contact with other dialects or because of second language learners with different accents. Because morphological markers generally rest on limited phonetic material, they are susceptible to ambiguity if phonological turnover in a population of speakers is high. Using a sequential strategy (i.e., different words/ word order changes) to mark the same contrast in meaning will be a more robust encoding strategy in high-noise signaling channels (Nettle, 2012).

A signal space in an iterated learning framework in principal has multiple dimensions by which they could evolve to preserve the structure of a meaning space. We wish to demonstrate clearly that ILM chains evolve so as to be robust to transmission noise by allocating important differences in meaning to the most reliable dimensions of transmission in signal space. We argue that perhaps the presence of noise causes the self-organization in encoding known as structure-preservation, as is also seen in genetic codes (Sella & Ardell, 2002).

Although effects of dimensionality and noise have been discussed (e.g., Little, Eryilmaz & de Boer, 2015), systematic quantitative study of how meanings get embedded in signal spaces of different sizes and structures in the ILM is still missing.

Integrating ideas from the evolution of the genetic code, we propose a computational architecture that addresses the role of noise in the ILM framework when dimensions of the signal space and population size are modulated. We aim specifically to demonstrate the transition from a morphological/paradigmatic to a syntagmatic/sequential strategy as phonological turnover increases. We predict that within parameter regions without added noise, ILM chains break evenly across these two orthogonal dimensions of compositionality. Under our hypothesis, the introduction of noise into the transmission of one of these dimensions will disrupt the stability of induction and expression and the languages will evolve robustness to this noise. We discuss our hypothesis in light of recent contradictory experimental results (Atkinson, Kirby & Smith, 2015),. Through our model, we attempt to demonstrate that noise in phonology biases against paradigmatic systems with morphological markers relying on minimal phonological elements. Rather than contradicting the Linguistic Niche Hypothesis, the proposed results from our study will provide an alternative mechanism for population-dependent effects on the evolution of language structure.

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