THE ADVANTAGE OF EXTREME MEANINGS IN CULTURAL EVOLUTION

FAUSTO CARCASSI[*1], MARIEKE SCHOUWSTRA[1], and SIMON KIRBY[1]

[*]Corresponding Author: fausto.carcassi@gmail.com
[1]Centre for Language Evolution, University of Edinburgh, UK

Gradable adjectives are used to convey that an individual has a property to a degree greater (or to a degree lower) than some threshold. For instance, "Mary is tall" conveys that Mary's height is greater than some threshold on the scale of heights. These thresholds can in principle be anywhere, but a remarkable connection has been shown between the thresholds' positions and the structure of the underlying scale. Namely, if the scale is bounded adjectives tend to be at the maximum or minimum of the scale. This tendency is surprising because generally, communication is more accurate when categories have roughly the same size (Jäger, Metzger, & Riedel, 2011). Various models for adjectival semantics attempt to explain the boundary-minded behaviour of adjectives like 'full' by appeal to online pragmatic considerations (Lassiter & Goodman, 2015), long-term communicative efficiency (Qing & Franke, 2014), the saliency of extreme points and its role in referential language use (Kennedy, 2007; Potts, 2008; Franke, 2012).

We present an account of extreme thresholds, defined as thresholds positioned at a scale's border, that does not make assumptions about specific cognitive preferences, but rather only appeals to the mechanisms of learning. We claim that extreme thresholds have an advantage in cultural evolution because they produce data that can be learned with a greater accuracy than data produced by non-extreme thresholds. Once a population stumbles upon an extreme language, the language is transmitted with high fidelity and tends to persist in the population. We support this explanation with a computational model that combines Iterated Learning (IL) as a model of cultural evolution (Kirby, Griffiths, & Smith, 2014; Kirby, Tamariz, Cornish, & Smith, 2015) and Rational Speech Acts (RSA) as a model of pragmatic communication (Goodman & Frank, 2016).

The language in the model consists of three signals: s_σ (silence), s_+ (positive polarity adjective like "full"), and s_- (negative polarity adjective like "empty"). Each signal conveys that a degree d_o falls in a certain part of the relevant scale. s_σ is compatible with the whole scale, leaving the position of d_o unspecified. s_+ [s_-] conveys that d_o is greater [lower] on the scale than a value θ_+ [θ_-]. Agents are pragmatic speakers that, given an observation, tend to produce the signal s that is

most useful for the listener. The utility of s is calculated as the expected distance between the listener's guess and the speaker's observation, given s. This causes the speakers to allow *pragmatic slack* (Lasersohn, 1999), i.e. speakers sometimes use signals that are not literally compatible with the observation. Pragmatic slack is regulated by a λ parameter for each signal; the greater the λ parameter, the less pragmatic slack is allowed. The λ parameter is different from the RSA rationality parameter, which is fixed at 4. In the model, we always set the λ parameters for s_+ and s_- to the same value.

The IL model consists of chains of single agents. The agent in the i^{th} position in the chain, a_i, produces linguistic data D_i consisting of tuples of observations and signals. a_{i+1} performs Bayesian inference on D_i to learn a_i's θ_+ and θ_-. The learner's prior over θ_+ and θ_- is uniform. Since the first agent in the chain has no cultural parent, a_0's θ_+ and θ_- are picked randomly. We simulate chains of 10000 agents for various combinations of λ parameters and numbers of observations.

Fig 1 shows the proportion of extreme thresholds that evolve for each combination of parameters. Uniformly sampled thresholds would (almost surely) not be extreme. However, we observe that, for some combinations of parameters, up to a quarter of the evolved thresholds are extreme. This shows that extreme thresholds have an advantage in cultural evolution, that increases when there are fewer observations and when there is more pragmatic slack.

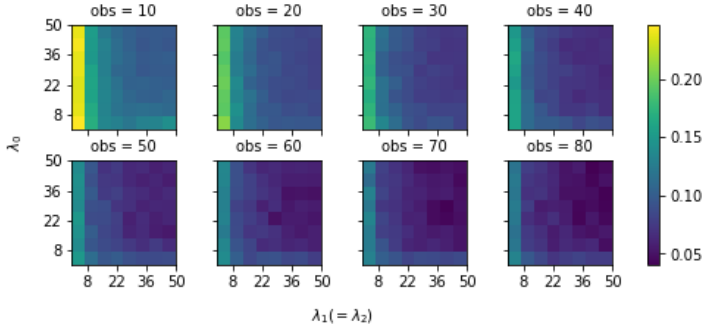

Figure 1. Results of IL for various parameters values. Obs is the number of observations made by learners. λ_σ, λ_+, and λ_- regulate the pragmatic slack of s_σ, s_+, and s_- respectively. Color indicates the proportion of all meanings that are extreme, where extreme means 1. for $\theta_+$and 0. for θ_-.

In sum, we show that extreme thresholds have an advantage in cultural evolution that does not come from a prior preference for extremeness, but rather from the type of data that extreme thresholds produce. Moreover, we show that this advantage is modulated by the amount of data that learners observe and the acceptable level of pragmatic slack.

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