Unifying horizontal and vertical interactions in the Bayesian language game

Bas Cornelissen
Willem Zuidema
Institute for Logic, Language and Computation
University of Amsterdam

IN A NUSTELL We propose a Bayesian framework that connects Bayesian iterated learning (il) to naming games (ng), the two main branches of agent-based models of cultural evolution. Surprisingly, the two appear to be closely related: the extremes of continuum. We find that Bayesian il trivializes the effect of cultural evolution, whereas the Bayesian ng yields non-trivial, lineage-specific languages.

FRAMEWORK

1 Bayesian naming game

The speaker picks a language (a distribution over words), accounting for its innate biases towards certain languages, and produces a word. The hearer observes the word and updates the probabilities it assigns to all languages in a Bayesian fashion. On average, this makes the observed word more likely to be produced when the hearer later becomes a speaker. Alignment is thus increased.

Alternative interpretation: a language as a distribution over linguistic features rather than words.

$p(\text{lang} | \text{prod}) \propto \theta(\text{prod} | \text{lang}) \cdot p(\text{lang})$

2 Population model

The life expectancy, in a random walk, interpolates between il ($y = 1$) and ng ($y = \infty$).

$\frac{1}{2} \times \text{chain (il)} + \frac{1}{2} \times \text{hom. mixing (ng)} = \text{random walk}$

3 Strategies: MAP→sample

Sample languages and productions or use the ones with maximum probability (MAP)?

Sample languages and productions with maximum probability (MAP) and use language that is closest to the speaker's language.

Characterising the Bayesian language game

The Bayesian il model seems predictable determined by the biases (even for non-samplers). A higher life expectancy (lower turnover) results in stronger non-trivial cultural effects. The resulting language is shaped by both the bias and the cultural process.

Conclusions

Iterated learning and naming games are naturally connected in the Bayesian language game. One extreme case, the Bayesian ng, reveals new behaviour: lineage-specific languages that reflect innate biases of the learners. In comparison, Bayesian il models seem to trivialize the cultural process. This highlights the importance of horizontal interactions.