Cultural evolution renders strong innateness implausible

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Natural languages do not differ arbitrarily, but are constrained so that certain properties recur across languages. These constraints presumably arise, at least in part, from the nature of the human brain, but the nature of the brain-language mapping is unclear. One theory argues that strong language-specific constraints are built into learners (Chomsky, 1965). Evolutionary considerations appear to support this hypothesis, since co-ordinated constraints on learning may facilitate communication and therefore be adaptive (Pinker & Bloom, 1990). An alternative suggestion (Christiansen & Chater, 2008) is that strong constraints on linguistic variation could arise given only weak and/or domain-general biases in learners, as a consequence of cultural transmission in populations. We set out a very general agent-based model of the interactions between the biological evolution of the language faculty and the cultural transmission of languages which shows that such weak or domain-general constraints are more plausible on evolutionary grounds: cultural transmission renders the biological evolution of strong domain-specific innate constraints on language learning unlikely.

We use a Bayesian model of language learning, assuming the minimal case where there are simply two classes of language: this allows us to specify varying degrees of (innate) prior bias for one language type. Language is culturally transmitted: learners select a language based on its posterior probability given some linguistic data, where that data is produced by another individual in the simulated population. We model biological evolution by specifying genes that encode the prior bias of a learner: the prior of a language type is simply the proportion of the learner's genes that have the allele that promotes that type. Genes are inherited by new learners, subject to mutation, and we assume that reproduction is determined by communicative success. We initialize simulated populations with equal proportions of both language types and genes which specify a perfectly neutral prior, which does not favour either language type.

Previous work has shown that cultural transmission by iterated learning can lead to the amplification of weak biases (Kirby, Dowman & Griffiths, 2007). Our coevolutionary model shows that, as tiny perturbations in initial gene frequencies move the population away from perfectly neutral priors, this amplification associated with cultural transmission *unmasks* these weak biases in individuals, yielding large effects in the population's language: one language type begins to dominate the population. Natural selection then favours biases encoding the emerging majority language. However, iterated learning also *masks* relative strength of bias (Smith & Kirby, 2008): because the effects of weak priors are amplified by cultural transmission, both weak and strong priors give rise to strong linguistic universals. Consequently, in a population where weak biases have become established, there is little selection for stronger biases, since these yield equivalent effects to weak biases. This combination of *unmasking* and *masking* leads to a balance of evolutionary forces: mutation pressure induces drift towards neutrality, but natural selection keeps biases away from perfect neutrality. The population therefore settles on the weakest possible biases that nevertheless lead to clear linguistic universals (Figure 1). Our co-evolutionary model also shows that strong constraints on learning *can* evolve, under some parameters. However, this requires an extended period of benign genetic drift: given that such benign drift is unlikely, this renders the evolution of strong domain-specific constraints on language learning problematic.

The model therefore suggests we should expect constraints on language learning to be weak if domain-specific (i.e if selected for their linguistic consequences), and only strong if domain-general (i.e. if selected for their non-linguistic consequences).

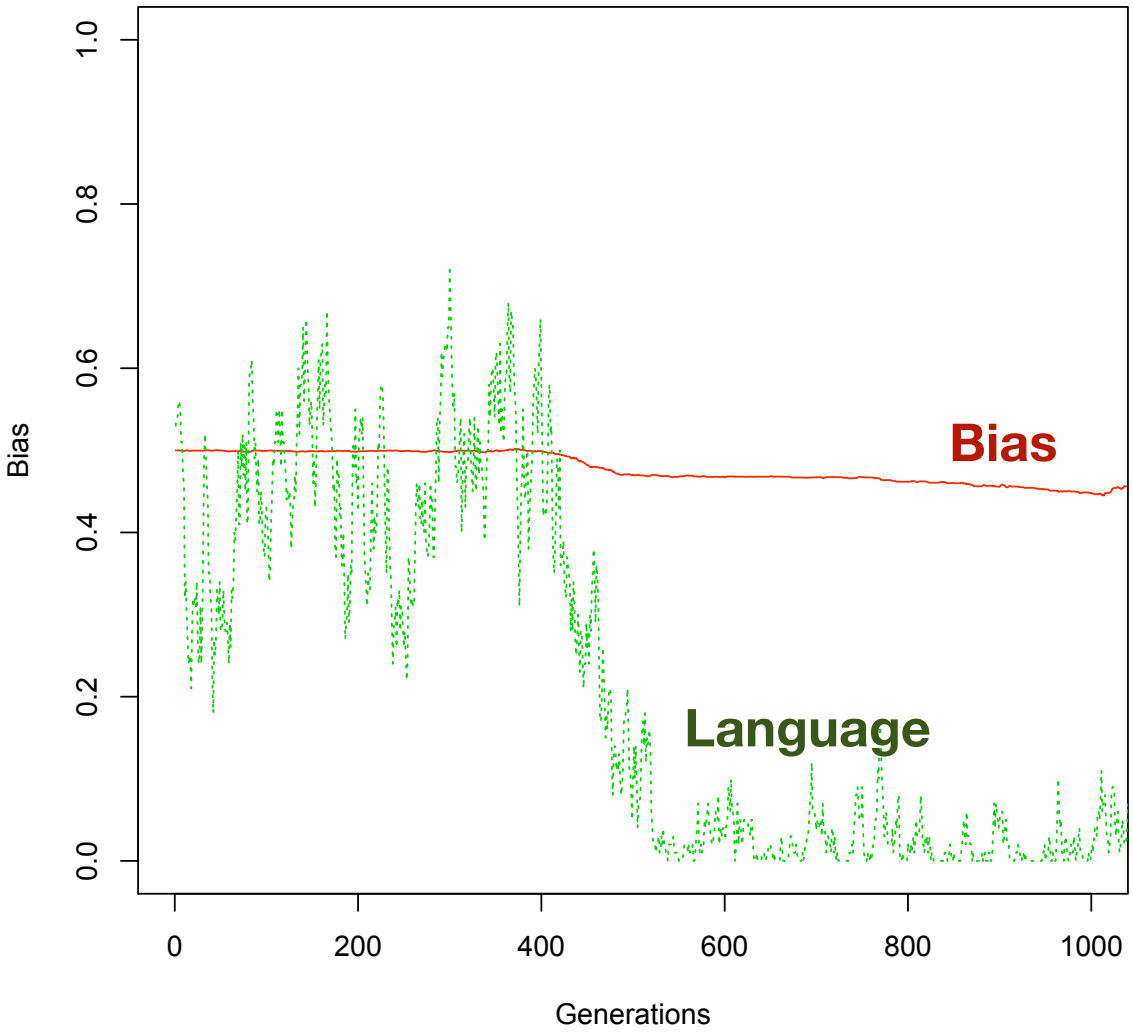

Figure 1: A representative run illustrating the evolution of weak biases which lead to a strong language universal, in this case the near-universality of the language type associated with biases below 0.5.

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