Multilevel phylogenetic inference of harmony in Indo-European

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One of the most well-known typological generalizations is that languages tend to order the grammatical head and its dependents in a consistent way (Greenberg, 1963; Dryer, 1992). For example, VO languages are more likely to have prepositions while OV languages are more likely to have postpositions. Over the past decades, new empirical findings and competing theories have been advanced to explain the word order harmony. These theories range from functional explanations focusing on cognitive and learning biases (Hawkins, 1983; Culbertson, Smolensky, & Legendre, 2012; Futrell, Levy, & Gibson, 2020), to alternative views, emphasizing the roles of cultural evolution and historical accidents in language change (Bybee, 1988; Dunn, Greenhill, Levinson, & Gray, 2011; Cristofaro, 2019). So far, there is little evolutionary evidence favoring or against harmony based on cross-linguistic corpus data, and it remains unclear whether the functional explanations can be reflected in the history of languages.

Using 45 dependency-annotated corpora from Universal Dependencies v2.10 (Zeman et al., 2022), we are trying to detect the evolutionary bias of harmony vs. disharmony in the history of Indo-European. To assess the cognitive benefits of consistency in head direction, we measure harmony by counting pairs of word orders (V-O and N-Gen, V-S and N-Adj, etc) that co-occur in the same direction in a sentence. Since word orders are not uniformly distributed, e.g., subjects almost always come before the verb, we need to control for the base distribution of each word order in a language. For this, we introduce two random baselines: one fixes the overall head direction in a language (random 1), and the other keeps unchanged the order of each dependency type in a language (random 2). By comparing the observed against the baselines, we can remove the confound of other possible processes (e.g., word order rigidity) in language change. We go beyond previous phylogenetic approaches that model the correlated evolution separately for each pair of word orders (Dunn et al., 2011; Jäger & Wahle, 2021). Instead, we have developed a multilevel phylogenetic Continuous-time Markov Chain model that can estimate evolutionary rates for harmony and disharmony at both population and group levels (Nalborczyk, Batailler, Lœvenbruck, Vilain, & Bürkner, 2019; Stan Development Team, 2022).

Our results reveal no clear difference in the estimated rate ratio for harmony between observed and random baselines (Figure 1). In particular, the observed rate ratio (mean rate ratio: 1.64, 90% CI = $[0.17, 4.47]$) has substantial overlaps with the second baseline (mean rate ratio: 1.76, 90% CI = $[0.17, 5]$). Our findings challenge the functional motivations for harmony during language comprehension, production, or learning. When the distribution of each individual word order is kept constant in a language, there is not much room left for any additional harmonic constraint between pairs of word orders in real utterances. This further suggests that the attested word order universals in previous work might emerge as a side-effect of word order rigidity in language evolution, and no appeal to cross-category harmony may be needed. In addition, when compared to the first baseline (mean rate ratio: 3.13, 90% CI = $[0.67, 6.23]$), the observed data show a lower rate ratio or a weaker evolutionary bias for harmony. This also contradicts previous theories that predict a general head-initial or head-final preference (Hawkins, 1994; Cancho, 2017). Conversely, word orders seem to be less constrained than commonly assumed, and they tend to evolve towards a more mixed configuration at least in Indo-European. Further research is needed by extending the approach to other families before we can draw firm conclusions.

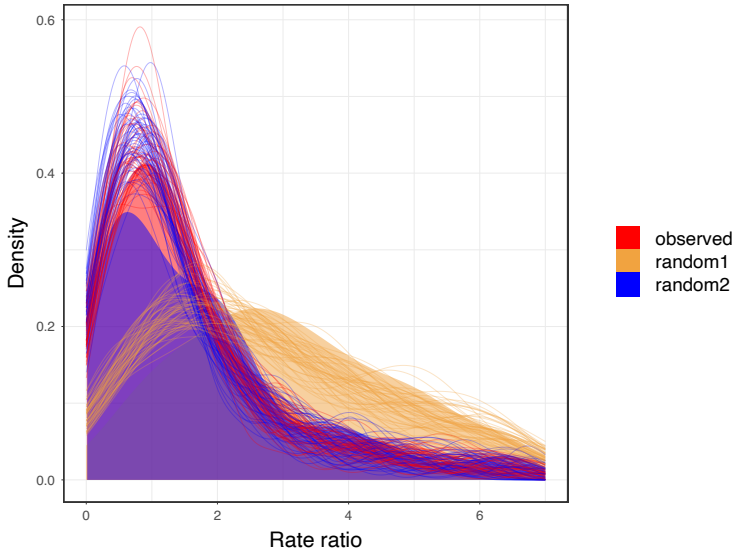

Figure 1. Posterior density of rate ratio of harmony to disharmony from the multilevel phylogenetic model. Higher rate ratios indicate a stronger evolutionary bias towards harmony. The shaded areas under the curve represent the rate ratio at the population level ("fixed effects"), and the thin lines represent the rate ratio at the group level ("random effects").

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