

## **Balancing regularization and variation: The roles of priming and motivatedness**

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Languages exhibit both variation and regularities across different domains (Dryer & Haspelmath, 2013). A key question in language evolution research is how conventions that exist today arose from early stages of language with motivated variation. Priming, a tendency to repeat forms that you have seen before, is a potential mechanism driving regularization (Fehér, Wonnacott, & Smith, 2016; Pickering & Garrod, 2017; Schouwstra, Smith, & Kirby, 2020). On the other hand, research has shown that the use of motivated forms allows variation to persist (Mudd, Vos, & De Boer, 2022). In this work, we use an agent-based model to show when priming is able to cause regularization in a population, and when a level of variation is maintained. Maintenance of variation, even when there are dominant patterns, has been demonstrated in existing languages on lexical as well as structural levels (Napoli & Sutton-Spence, 2014; Flaherty, Schouwstra, & Goldin-Meadow, 2018; Napoli, Spence, & Quadros, 2017; Lutzenberger, Mudd, Stamp, Schembri, & Schembri, 2023).

In our models we focus on word order, in particular in connection with the balance between motivatedness and regularity. Traditionally, the regular nature of the ordering of Subject, Object and Verb in existing languages has been emphasised (Dryer, 2013). At the same time, improvised silent gesture experiments show that semantically motivated orders are preferred when there are no linguistic conventions yet: SOV when communicating about extensional events (the direct object is specific and concrete: e.g. boy kicks ball) and SVO when communicating about intensional events (the direct object is more abstract, and possibly dependent on the verb: e.g. boy thinks of ball) (Schouwstra & Swart, 2014; Motamedi, Wolters, Naegeli, Kirby, & Schouwstra, 2022). While existing languages do not generally exhibit the same level of variation as silent gesture, it was recently recognized that many languages exhibit some variation in word order, which therefore might best be analyzed as a gradient phenomenon (Levshina et al., 2023).

Here we model how syntactic priming affects the emergence of word order

regularity in a population, when it exists in direct competition with motivatedness. Our simulations consists of  $N$  agents, who engage in communication for  $M$  steps. Every step, each agent produces a word order (which will be observed by another randomly chosen agent) according to a linear weighted combination of word orders that were observed before (priming) and word order preferences that are driven by the intensionality or extensionality of the event (motivatedness). In all simulations, production is fully based on motivatedness when there are no observations yet. As a consequence, there is more semantically motivated variation at the start of a simulation, which makes way for more regularity as agents align.

We executed simulations (all with 50 agents and 300 time steps) with different constant relative influences of motivatedness and priming and measure the proportion of the majority word order at each step. Results are presented in figure 1. Larger values of  $P(\text{majority order})$  correspond to more regularity.

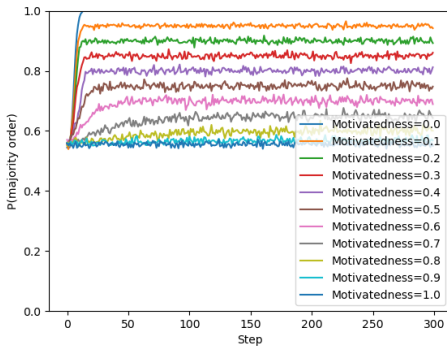


Figure 1.: Mean (over 50 runs)  $P(\text{majority order})$  over time in simulations with different relative influences of motivatedness and priming

Figure 1 shows a direct relationship between the relative influence of priming and motivatedness on word order regularization. We see stronger reductions in variation when motivatedness has less influence than priming, but a small motivatedness bias will prevent the system from regularizing fully. This brief phase of stronger regularization, followed by a relatively stable situation with residual variation, is consistent with experimental data (Motamedi et al., 2022; Schouwstra, Naegeli, & Kirby, 2022) and with data from existing sign languages

(Napoli & Sutton-Spence, 2014; Flaherty et al., 2018; Napoli et al., 2017). This reinforces the view that word order is a gradient phenomenon (Levshina et al., 2023). Our model shows that motivatedness and priming can jointly balance variation in the domain of word order, and provides a framework for other domains.

We extended these simulations to investigate the dynamics between priming and motivatedness under various social network structures (Lupyan & Dale, 2010; Richie, Yang, & Coppola, 2014; Lou-Magnuson & Onnis, 2018; Raviv, Meyer, & Lev-Ari, 2020). The average shortest path distance of a network influenced the extent of regularisation: regular networks retained the most variation, fully connected networks retained the least variation and others are in between. Importantly, in all network structures that were not fully connected, even a very small influence of motivatedness prevented full regularization of the system.

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