

EFFORT VS. ROBUST INFORMATION TRANSFER IN LANGUAGE EVOLUTION

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In his seminal work, Zipf (1949) popularized the hypothesis that languages are shaped by a trade-off between production effort and robust message transfer. It is hard to overestimate the influence this idea has had in functional linguistics and related approaches (see Piantadosi, 2014 for a comprehensive review). Yet, to this day, there is little direct (rather than correlational) evidence for this trade-off.

Recent large-scale quantitative typological studies have shown that lexicon structure in a variety of languages exhibits properties that are consistent with the hypothesized trade-off (e.g., Ferrer i Cancho et al., 2013; Piantadosi, Tily, & Gibson, 2011). Iterated miniature language learning studies have identified a potential cause for these patterns: biases during learning and communication cause learners to deviate from the input towards languages that conserve effort while still guaranteeing robust communication (Kirby, Tamariz, Cornish, & Smith, 2015).

While this work has identified patterns consistent with the trade-off hypothesis, it has not manipulated effort or the chance of communicative success to directly test the presence of a trade-off. Here we present a crowdsourcing-based miniature language learning experiment that directly assesses whether learners trade off the probability of successful message transmission against the effort associated with producing the message. We ask in particular whether the inverse correlation between word order (WO) flexibility and the presence of a case system in a language is shaped by this trade-off.

In the experiment (administered in 2x45min sessions over 2 consecutive days over Amazon Mechanical Turk), different groups of participants learned miniature artificial languages by watching short videos and hearing their descriptions. All videos depicted human actors performing simple transitive events. Participants first learned the names of the actors and then learned the

grammar through sentence exposure. At the end of each session, participants were shown the entire lexicon of the language at the top of the screen and asked to describe previously unseen scenes by clicking on the corresponding lexical items. All languages had optional case-marking (present on 67% of objects; never on subjects). The languages differed in the amount of WO flexibility: The fixed WO language used SOV 100% of the time, while the flexible WO language used SOV and OSV equally frequently. Thus, the uncertainty about the intended message was low in the fixed and high in the flexible WO language. The critical manipulation was the amount of effort required to produce case. During the production test, participants in the low-effort condition were shown a case-marked and non-case-marked variant of every noun (along with all the verbs). Case production, thus, required the same number of clicks as production of bare nouns. In the high-effort condition, participants saw non-case-marked variants of all nouns along with the two free case-markers. Case production, thus, took 2 additional clicks compared to bare nouns.

While our formalization of effort in terms of additional clicks is an imperfect approximation of production effort in terms of additional syllables, it allows us model the scenarios of case production involving additional effort or not, which would be difficult to tease apart in natural production (there is always additional effort associated with articulating an additional phoneme). If production effort is indeed traded off against robust message transfer, we would expect learners in the high-effort condition to use more case in the language with higher uncertainty about the intended meaning (flexible WO) compared to the language with lower uncertainty (fixed WO). Since there is no difference in effort associated with case use in the low-effort condition, differential case use would not be expected here. The results support our hypothesis. We observed differential case use only in the high-effort condition: Learners tended to maintain case only in the flexible WO language ($p < 0.05$). In contrast, in the low-effort condition, learners of both languages produced the same amount of case, equal to the input proportion ($p > 0.8$). In all conditions, learners matched the input distribution of word order variants.

Our findings suggest that some cross-linguistic patterns are shaped by a trade-off between production effort and robust message transmission. Even though the difference in uncertainty about the message between the flexible and fixed WO languages was equal across the two effort conditions, learners restructured the input language to more closely resemble naturally occurring types only when case production required a substantial effort increase. Our results also highlight the potential of web-based miniature language learning experiments in investigating factors underlying language evolution.

References

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