

PROCESSING PREFERENCES SHAPE LANGUAGE CHANGE

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Why do languages share structural commonalities? One long-standing tradition has argued that linguistic universals reflect pressures on language use: languages have evolved to better suit the needs of human information processing and communication (Bates & MacWhinney, 1982). By what means these pressures come to shape language evolution, however, remains unknown. In a series of experiments, we explore the possibility that processing pressures operate during language acquisition, biasing learners to deviate from the input they receive, thus changing the input to the subsequent generation of learners and ultimately causing a shift towards a linguistic system that explicitly expresses these biases.

We modeled the situation of language change in the laboratory using a miniature language learning paradigm (Hudson Kam & Newport, 2005; Kirby et al., 2008). In all experiments, we exposed participants (adult monolingual native speakers of English) to miniature languages with several competing forms that expressed the same meaning. In training (administered over 3x1h-sessions on consecutive days), participants heard utterances in a novel language paired with videos depicting simple transitive actions performed by male actors. Participants first learned novel nouns, and then heard sentences using these nouns along with novel verbs. At the end of each session, learners described novel videos in the new language. We studied the deviations from the input in learners' productions.

Psycholinguistic research has linked dependency length minimization to the ease of processing (Grodner & Gibson, 2005) and cross-linguistic investigations have found evidence for this preference at the level of language structure (Futrell, Mahowald, & Gibson, 2015) suggesting a correlation between processing performance and grammar. Prior work, however, has not directly tested the *causality* underlying this correlation. In **Experiment 1**, we directly probe the causal link between processing biases in individual language learners and the preference for shorter dependencies observed cross-linguistically.

Different groups of learners were exposed to two miniature languages that were either head-initial (VSO/VOS word order) or head-final (SOV/OSV word order). All utterances were disambiguated through obligatory case-marking on objects (never subjects). In exposure sentences, subjects and objects were either both long (i.e., modified by a prepositional phrase in the head-initial language or by a postpositional phrase in head-final language, as cross-linguistically common) or both short (no modification). Balanced word order (SO/OS 50/50%) was maintained in all sentence types. During the production test, learners described novel videos, in which only one of the constituents (subject or object) was long (i.e., modified by an adpositional phrase) or both constituents were short. We find that despite receiving only unbiased (short-short, long-long) input, learners of the head-initial language followed the short-before-long ordering ($p < 0.05$), but learners of the head-final language showed the inverse long-before-short preference ($p < 0.001$). These length-based orderings minimize the average length of linguistic dependencies in the two languages. Our results thus suggest that learners are indeed biased towards shorter linguistic dependencies.

Experiment 2 tested the link between biases during learning and another cross-linguistic property linked to constraints on incremental processing – a preference to provide informative cues early. We explored whether learners are biased to provide informative cues early as it permits faster parsing decisions. The two miniature languages in Experiment 2 had SOV/OSV word order variation (50/50%) and optional case-marking (present 67%), but differed in its locus. In the subject-marking language, *subjects* but not objects were optionally case-marked independently of word order. In the object-marking language, *objects* were case-marked independently of word order (never subjects). Thus, the languages differed in the word order that allowed earliest disambiguation in case-marked sentences (SOV in the subject-marking and OSV in the object-marking language). We found that only learners of the object-marking language preferentially used case-marking at the earliest point of disambiguation in OSV sentences ($p < 0.001$). Learners of the subject-marking language marked both SOV and OSV orders equally often ($p > 0.7$) and significantly more frequently than the input on the final day of training ($p < 0.05$). We argue that this behavior is indicative of two preferences influencing language production – a bias to provide informative cues early and a bias to case-mark the less expected (i.e., non-English object-before-subject order) since the two pressures work in the same direction for the object-marking language and in opposite directions for the subject-marking language.

Our results suggest that biases in acquisition are reflected in typologically frequent patterns and can account for cross-linguistic structural similarities in natural languages. At least some of these biases stem from pressures of incremental processing: Even though our languages allowed several alternatives, learners consistently preferred structures that increased processing efficiency.

References

- Bates, E., & MacWhinney, B. (1982). Functionalist approaches to grammar. In E. Wanner & L. Gleitman (Eds.), *Language Acquisition: the State of the Art* (pp. 173-218). Cambridge: Cambridge University Press.
- Futrell, R., Mahowald, K., & Gibson, E. (2015). Large-scale evidence of dependency length minimization in 37 languages. *Proc Natl Acad Sci USA*, 112(33), 10336-10341.
- Grodner, D., & Gibson, E. (2005). Consequences of the serial nature of linguistic input. *Cognitive Science*, 29(2), 261–290.
- Hawkins, J. A. (2014). *Cross-linguistic variation and efficiency*. Oxford: Oxford University Press.
- Hudson Kam, C., & Newport, E. (2005). Regularizing unpredictable variation: The roles of adult and child learners in language formation and change. *Lang Learn Dev*, 1(2), 151-195. doi: 10.1080/15475441.2005.9684215
- Kirby, S., Cornish, H., & Smith, K. (2008). Cumulative cultural evolution in the laboratory: An experimental approach to the origins of structure in human language. *Proc Natl Acad Sci USA*, 105(31), 10681.