1. Morten H. Christiansen and Nick Chater
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3. References: 606
4. Entire Text: 1693

03. Linguistic structure emerges through the interaction of memory constraints and communicative pressures
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10.
If memory constraints were the only limitation on language processing, the best possible language would be one with only one word. But to explain the rich structure of language, we need to posit a second constraint: the pressure to communicate informatively. Many aspects of linguistic structure can be accounted for by appealing to equilibria that result from these two pressures.

11.
Christiansen and Chater claim that memory limitations force the cognitive system to process the transient linguistic signal by compressing it. They suggest that this processing pressure influences the ultimate structure of language over the course of language evolution. Taken at face value, this proposal would lead to a degenerate linguistic structure, however. If memory constraints were the only pressure on language, languages would evolve to compress meaning into the simplest possible form – a single word (Horn, 1984). But, as the authors point out, natural languages are not of this sort; they are richly structured into lexical and phrasal units of varying length. To account for this variability, we highlight the need to consider the communicative function of language. Communication serves as an important counter-pressure against compression in language processing, not just as a caveat.

Interlocutors use language with the goal of communicating information, but they also aim to minimize energetic cost (Zipf, 1949). For the speaker, this goal implies minimizing production cost and for the listener it implies minimizing comprehension cost. Importantly, these processing constraints have opposing cost functions (Horn, 1984; Zipf, 1949). For a producer, processing is minimized when a form is easy to say, and thus highly compressible. For the comprehender, however, processing is minimized when a form is minimally ambiguous and thus verbose. Compressing information is a useful strategy for a speaker who faces memory constraints, but it is only useful to the extent that the listener can still recover the intended meaning. This view of language use as rational action – minimizing costs while maximizing information transfer – is supported by a rich body of theoretical and empirical work (Grice, 1975; Clark, 1996; Frank & Goodman, 2012; Goodman & Stuhlmüller, 2013).

While Christiansen and Chater argue that compression is the key factor in the emergence of structure, evidence at both the acquisition and evolution timescales suggests language is the product of the interaction between both compression and informativity. At the timescale of acquisition, experimental work suggests the resolution of reference in word learning is the product of communicative inferences (e.g., Baldwin, 1991; 1993; Frank, Goodman, & Tenenbaum, 2009; Frank & Goodman, 2014). And at the timescale of language evolution, a growing body of work suggests that the forms of words are also equilibria between these two pressures (Zipf, 1936; Piantadosi, Tily, & Gibson, 2011; Mahowald, Fedorenko, Piantadosi & Gibson, 2012; Lewis & Frank, 2014). For example, Piantadosi, Tily, and Gibson (2011) find that words that are less predictable in their linguistic context are longer, suggesting that speakers may lengthen words that are surprising in order to increase time for the listener to process.

In addition to linguistic form, these pressures influence the mapping between form and meaning. An equilibrium in the structure of form-meaning mappings is one in which the listener is able to recover the intended meaning, but the speaker does not exert additional effort over-describing. A range of semantic domains reflect this equilibrium (Regier, Kay, & Khetarpal, 2007; Baddeley & Attewell, 2009; Kemp & Regier, 2012) and ambiguity, more generally, has been argued to reflect this communicative tradeoff (Piantadosi, Tily, & Gibson, 2012). Ambiguity is an equilibrium in cases where the listener can recover the intended meaning from the communicative context. One example is the word "some," which has a literal meaning of "at least one and possibly all" but can be strengthened pragmatically to mean "at least one but not all" (Horn, 1972). Because its meaning is determined via communicative context, its literal semantics can overlap those of its competitor, "all."

The key challenge associated with this broader proposal – that processing pressures influence linguistic structure – is providing direct evidence for a causal link between these two timescales. This problem is difficult to study in the laboratory because the proposed mechanism takes places over a long timescale and over multiple individual speakers. Furthermore, the presence of a causal link does not entail that phenomena in processing are directly reflected in linguistic structure – rather, entirely new properties may emerge at higher levels of abstraction from the interactions of more fundamental phenomena (Anderson, 1972). It may therefore not be possible to directly extrapolate from brief communicative interactions observed in the laboratory to properties of linguistic structure.

Several recent pieces of experimental data begin to address this challenge, however. In one study, Fedzechkina, Jaeger, and Newport (2012) asked speakers to learn an artificial language that arbitrarily distinguished nouns through case-marking. Over learning sessions, speakers developed a system for marking in contexts where meanings were least predictable – a pattern reflected in the case marking systems of natural language. Other work has used a similar paradigm to reveal the emergence of typologically prevalent patterns in the domains of word order (Culbertson, Smolensky, & Legendre, 2012; Culbertson & Newport, 2015) and phonology (Wilson, 2008).

A particularly promising approach for exploring this causal link is through transmission chains (Kirby, Cornish, & Smith, 2008; Reali & Griffiths, 2009). In a transmission chain, a participant learns and recalls a language, and then the recalled language becomes the learning input for a new learner. By iterating over learners, we can observe how languages change across transmission of learners over the course of language evolution. Kirby, Tamariz, Cornish, and Smith (2015) compare the emergence of linguistic structure in a regime that iterates over different partners of learners versus a regime where the same two partners repeatedly interact with each other. They find that linguistic structure emerges only by iterating over different partners, demonstrating the unique contribution of cross-generational learning to the emergence of structure. Others have begun to use this paradigm to link the interaction of processing pressures to the emergence of communicative regularities in semantic structure (Lewis & Frank, in press; Carstensen, Xu, Smith, & Regier, in press).

In sum, the consequences of memory constraints are likely a critical factor in shaping language structure. But an additional important constraint is the pressure to communicate informatively, and this constraint should not be overlooked in accounting for linguistic structure.

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