Linguistic Representations and Memory Architectures: The Devil is in the Details

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Commentary on target article by Christiansen & Chater

Abstract
Attempts to explain linguistic phenomena as consequences of memory constraints require detailed specification of linguistic representations and memory architectures alike. We discuss examples of supposed locality biases in language comprehension and production, and their link to memory constraints. Findings do not generally favor Christiansen and Chater's approach. We discuss connections to debates that stretch back to the 19th century.

It is important to understand how language is shaped by cognitive constraints, and limits on memory are natural culprits. In this regard, Christiansen and Chater (C&C) join a tradition in language research that has a long pedigree (Wundt, 1904; Frazier & Fodor, 1978) and that we are sympathetic to. C&C's model aims to integrate an impressive range of phenomena, but they are fast and loose with the details, they mischaracterize a number of phenomena, and key predictions depend on auxiliary assumptions that are independent of their model. An approach that takes the details of linguistic representations and memory architectures more seriously will ultimately be more fruitful. We illustrate using examples from comprehension and production.

C&C propose that comprehenders can maintain only a few low-level percepts at once, and must therefore quickly encode higher order, abstract representations. They argue that this explains the pervasive bias for shorter dependencies. However, memory representations are more than simple strings of words that quickly vanish. Sentences are encoded as richly articulated, connected representations that persist in memory, perhaps without explicit encoding of order, and memory access is similarly articulated (Lewis et al., 2006). As evidence of their model, C&C cite *agreement attraction* in sentences like *The key to the cabinets are on the table*. These errors are common in production and often go unnoticed in comprehension, and it is tempting to describe them in terms of "proximity concord" (Quirk et al., 1972). But this is inaccurate. Agreement attraction is widespread in cases where the distractor is further from the verb than the true subject, as in *The musicians who the reviewer praise so highly will win* (Bock & Miller, 1991). Attraction is asymmetrical, yielding 'illusions of grammaticality' but not 'illusions of ungrammaticality' (Wagers et al., 2009), and depends on whether the distractor is syntactically 'active' (Franck et al., 2010). These facts are surprising if attraction reflects simple recency, but they can be captured in a model that combines articulated linguistic representations with a content-addressable memory architecture (McElree et al., 2003;

Dillon et al., 2013). Hence, agreement attraction fits C&C's broadest objective, deriving attraction from memory constraints, but only if suitably detailed commitments are made.

C&C also endorse the appealing view that locality constraints in syntax ("island effects": Ross, 1967) can be reduced to memory-driven locality biases in the processing of filler-gap dependencies (Kluender & Kutas, 1993). Details matter here, too, and they suggest a different conclusion. When linear and structural locality diverge, as in head-final languages such as Japanese, it becomes clear that the bias for shorter filler-gap dependencies in processing is linear, whereas grammatical locality constraints are structural (Aoshima et al., 2004; Omaki et al., 2014; Chacón et al., submitted).

The moral that we draw from these examples is that each reductionist claim about language must be evaluated on its own merits (Phillips, 2013).

Turning to production, C&C argue that incrementality and locality biases reflect severe memory constraints, suggesting that we speak 'into the void.' This amounts to what is sometimes called *radical incrementality* (Ferreira & Swets, 2002). It implies that sentence production involves word-by-word planning that is tightly synchronized with articulation, i.e., planning is *just-in-time*, leading to a bias for local dependencies between words. However, this view of production does not reflect memory constraints alone and it is empirically unwarranted.

Radical incrementality carries a strong representational assumption whose problems were pointed out in the late 19th century. The philologist Hermann Paul, an opponent of Wilhelm Wundt, argued that a sentence is essentially an associative sum of clearly segmentable concepts, each of which can trigger articulation in isolation. Radical incrementality requires this assumption, as it presupposes the isolability of each word or phrase in a sentence at all levels of representation. Memory constraints alone do not require this assumption, and so there is a gap in C&C's argument that memory constraints entail radical incrementality. Indeed, Wundt was already aware of memory limitations, and yet he adopted the contrasting view that sentence planning involves a successive scanning (*apperception*) of a sentence that is simultaneously present in the background of consciousness during speech (Wundt, 1904). The historical debate illustrates that radical incrementality turns on representational assumptions rather than directly following from memory limitations.

Empirically, radical incrementality has had limited success in accounting for production data. Three bodies of data that C&C cite turn out to not support their view. First, the scope of planning at higher levels (e.g., conceptual) can span a clause (Meyer, 1996; Smith & Wheeldon, 1999). Also, recent evidence suggests that linguistic dependencies can modulate the scope of planning (Momma et al., 2015; under review; Lee et al., 2013). Second, since Wundt's time availability effects on word order have not led researchers to assume radical incrementality (see Levelt, 2012 for an accessible introduction to Wundt's views). Bock (1987) emphasized that availability effects on order result from the tendency for accessible words to be assigned a higher grammatical function (e.g., subject). In languages where word order and the grammatical functional hierarchy

dissociate, availability effects support the grammatical function explanation rather than radical incrementality (Christianson & Ferreira, 2005). Third, contrary to C&C's claim, early observations about speech errors indicated that exchange errors readily cross phrasal and clausal boundaries (Garrett, 1980).

C&C could argue that their view is compatible with many of these data, since memory capacity at higher levels of representation is left as a free parameter. But this is precisely the limitation of their model: specific predictions depend on specific commitments. Radical incrementality is certainly possible in some circumstances, but it is not required, and this is unexpected under C&C's view that speaking reduces to a chain of word productions that are constrained by severe memory limitations.

To conclude, we affirm the need to closely link language processes and cognitive constraints, and we suspect the rest of the field does too. However, the specifics of the memory system and linguistic representations are essential for an empirically informative theory, and they are often validated by the counter-intuitive facts that they explain.

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