

MacDonald, M.C. (2016). Memory limitations and chunking are variable and cannot explain language structure. *Behavioral and Brain Sciences*, 39, E84. doi:10.1017/S0140525X15000898 (this document is the copyeditor proofs; see the doi above for the online article)

<Commentary MacDonald on Christiansen & Chater [BBS 38, 2015]>

<CT>**Memory limitations and chunking are variable and cannot explain language structure**

<CA>Maryellen C. MacDonald

<CAA>*Department of Psychology, University of Wisconsin-Madison, Madison, WI 53706.*

mcmacdonald@wisc.edu

<http://lcnl.wisc.edu/people/mcm/>

<C-AB>**Abstract:** Both the Now-or-Never bottleneck and the chunking mechanisms hypothesized to cope with it are more variable than Christiansen & Chater (C&C) suggest. These constructs are, therefore, too weak to support C&C's claims for the nature of language. Key aspects of the hierarchical nature of language instead arise from the nature of sequencing of subgoals during utterance planning in language production.

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Christiansen & Chater (C&C) overstate both the limitations of the Now-or-Never bottleneck and the lossy character of chunking, and they are overly optimistic that memory limitations can explain the nature of language. C&C correctly note that memory limitations during planning for language production promote *incremental planning*

(where planning of the utterance and its execution of action are interleaved), but the memory limitations are not as strict as they suggest. Whereas “radical incrementality” – very minimal advance planning owing to a severe memory bottleneck – once had its proponents in language production, recent studies argue for looser constraints, with more tolerance for higher memory loads and more extensive advance planning (Ferreira & Swets 2002). The extent of advance planning may even be under some degree of implicit strategic control (Ferreira & Swets 2002; Wagner et al. 2010), suggesting that, rather than the memory bottleneck controlling us, we instead can exert some control over our own memory loads during language production. The bottleneck also isn’t always so severe in comprehension, and chunking isn’t as uniformly eager as C&C portray. Downstream linguistic input affects interpretation of earlier material (MacDonald 1994; Warren & Sherman 1974), which shouldn’t occur if chunking greedily passes off the early information to the next level. Variability in the tolerance of memory loads suggests that the Now-or-Never bottleneck is really more of a wide-mouth jar, or perhaps more of an adjustable drawstring closure, and the consequences for the nature of language will therefore need adjustment as well.

Similarly, C&C view the lossy nature of Chunk-and-Pass processing as essential to explaining the nature of language processing, but chunking is neither as lossy nor as bottom-up as they suggest. C&C argue that in speech perception, sounds are rapidly chunked into words, leaving the sounds behind, so that the just-perceived sounds do not interfere with upcoming ones. These claims create several puzzles: First, this very bottom-up characterization of chunking is inconsistent with evidence for top-down

influences in perception. C&C's focus on using context only for predicting the future is misplaced, because top-down processes also allow higher-level information to elaborate earlier percepts. Examples include the word superiority effect (Cattell 1886) and the phoneme restoration effect (Warren 1970), in which word representations affect perception of their parts (letters, phonemes). If chunking is so eager and lossy, it's not clear how higher-level word information could refine the lower-level percepts that should have already been discarded by lossy chunking. Second, if the memory bottleneck is so narrow, how is there room for interference, which by definition depends on several elements being in memory at the same time? There are numerous examples of semantic and sound overlap creating memory interference over fairly long distances during both comprehension (Acheson & MacDonald 2011; Van Dyke & Johns 2012), and production (Hsiao et al. 2013; Smith & Wheeldon 2004), again suggesting that the bottleneck can't be as strict as C&C describe. Third, if lossy chunking is the solution to memory interference, why is it so easy to find interference effects? The existence of memory interference suggests that chunking may not always be so lossy after all. In at least some circumstances, there appears to be real value in non-lossy processing, such as the Levy et al. (2009) example that C&C note as well as use of prosodic information over long distances (Morrill et al. 2014). These and other examples call into question the essence of lossy, greedy, bottom-up chunking as a design feature for language.

C&C note some variability in memory limits and chunking, but they do not discuss the consequences of variability for their account. They illustrate their ideas with an individual identified as SF, who can recall vast strings of meaningless digits by chunking

them into meaningful units such as dates, and using the chunks to guide production. The analogy to language is unfortunate, because SF's chunking strategies are both conscious and idiosyncratic, inviting the inference that language users' chunking units are similarly variable. In sum, if memory limitations and the lossy and eager characteristics of chunking have notable exceptions and are subject to individual differences, then it is difficult to make them the foundation of claims for the nature of human language.

More seriously, no matter how we conceive the memory bottleneck, it can explain neither the existence of a hierarchy in language representations, nor why the hierarchy has certain levels of representation across individuals and not others. Consider a nonlinguistic analogy: the visual processes necessary to recognize a cup. Let's assume that these processes, also constrained by memory bottlenecks, have multiple stages of chunking and passing from low-level visual processing up to object recognition. From these perceptual stages, however, we would not want to conclude that the percept itself, the cup, has a hierarchical structure. Similarly, the memory-constrained chunking and passing for language perception, even if it works exactly as C&C describe, does not give the percept – language – its hierarchical structure.

Rather than trying to wring structure out of memory limitations, I suggest that key aspects of hierarchical structure emerge from how goals are realized in action (MacDonald 2013). Like all actions, language production must unfold over time, meaning that the various subgoals of the action must be planned and ordered in some way (Lashley 1951). For both nonlinguistic and linguistic actions, the nature of the hierarchy

is constrained by the need to make decisions for some subgoals in order to plan others. To reach for a cup, the choice of which hand to use determines and must precede planning the reach. Similarly, a speaker must choose words (*cup* or *mug*?) before programming their articulation, naturally creating a hierarchy of lexical and sublexical plans. Although language and nonlinguistic action are not identical, important aspects of the hierarchical nature of language emerges from the staging of language production planning processes over time. Furthermore, although action plans are held in memory and are affected by the nature of that memory, memory limitations themselves cannot bear the explanatory burden that C&C ascribe to them.

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