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Working memory and language: From phonology to grammar

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Pierce, Genesee, Delcenserie, and Morgan (2017) are right to suggest that working memory is a crucial part of the machinery underlying linguistic development. In this brief commentary, I will move beyond the emergence of phonological representations, on which Pierce et al.'s essay focuses, and consider ways in which working memory shapes the character and acquisition of grammatical phenomena, a topic that has been explored in various ways in the recent literature (e.g., Chater & Christiansen, 2010; Hawkins, 2014; O'Grady, 2005, 2015).

A first illustration of the role of working memory in grammar involves the typology of word order and the question of why verb-initial and verb-medial languages such as English favor prepositions over postpositions, whereas the reverse preference is found in verb-final languages such as Korean.

(1) a. English: **at** school
b. Korean: hakkyo-**eyse** school-at

A promising explanation, developed in detail by Hawkins (2014), is that each language type seeks to reduce the burden on working memory by minimizing the distance between the verb and the pre/postposition with which it is associated.

(2) Maximally economical (and typologically common)
a. Prepositions in a V-initial/medial lg.
stud*y* [***at*** *school*]
V P
b. Postpositions in a V-final lg.
[*school* ***at***] ***study***
P V

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(3) Less economical (and typologically uncommon)

a. Postpositions in a V-initial/medial lg.

study [*school* ***at***]
V P
|_____|

b. Prepositions in a V-final lg.

[**at** *school*] ***study***
P V
|_____|

As Hawkins demonstrates, the same considerations explain the positioning of many other components of sentence structure, including determiners, genitives, complementizers, adjectives, adverbs, and relative clauses.

The interpretation of pronouns offers another example of how working memory shapes grammar. Many languages, including English, have two types of pronominal elements: reflexive pronouns such as *himself/herself* that require a nearby antecedent, and plain pronouns such as *him/her* that are used to refer to more distant antecedents, including those not mentioned in the sentence.

(4) a. Reflexive pronoun (local antecedent):

[S Jill thinks [S Mary doesn't trust ***herself***]].
↑_____|

b. Plain pronoun (distant antecedent):

[S Jill thinks [S Mary doesn't trust ***her***]].
↖_____↑_____|

The development of this contrast in children shows signs of a working memory effect: whereas children sometimes wrongly link simple pronouns to a local antecedent, there is no tendency to associate reflexive pronouns with a more distant antecedent (Conroy, Takahashi, Lidz, & Phillips, 2009; O'Grady, 2015).

(5) a. Possible error: Plain pronoun is associated with a local antecedent:

[S Jill thinks [S Mary doesn't trust ***her***]].
↑_____*_____|

b. Unlikely error: Reflexive pronoun is associated with a distant antecedent:

[S Jill thinks [S Mary doesn't trust ***herself***]].
↑_____*_____|

Moreover, even in languages that allow so-called long-distance reflexives (e.g., Chinese and Korean), children manifest an initial preference for a local antecedent (Joo, Deen, & O'Grady, 2014; Su, 2004).

A third example of a working-memory effect in grammar involves the much discussed constraint on contraction illustrated below.

(6) a. Contraction allowed:

Tell me whether they want to stay at home.
wanna

b. Contraction prohibited:

Tell me who they want to stay at home.
*wanna

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O'Grady (2005) outlines an explanation for this contrast that draws on the need to associate a "fronted" *wh* word such as *who* with the appropriate verb as quickly as possible, for reasons related to working memory (the active filler hypothesis; Clifton & Frazier, 1989). This propensity interacts with an articulatory factor: contraction is most natural when the involved words combine with each other without delay. All goes well in (6a), where the speaker can move seamlessly from *want* to *to*, producing a contracted pronunciation.

(7) Tell me whether they **want to** stay at home.
↓
wanna

However, the situation is very different in (6b), where the need to associate *who* with *want* as soon as the latter is encountered (the active filler hypothesis) disrupts the flow of the sentence at a crucial point: right between *want* and *to*.

(8) Tell me **who** they **want to** stay there.
|_____↑

The resulting delay, often accompanied by prosodic reflexes such as lengthening of *want* (Warren, Speer, & Schafer, 2003), compromises the naturalness of contraction.

Because constraints on working memory are not categorical, they leave room for variation, both across individuals and across languages. Crucially, though, this variation manifests unidirectional asymmetries that confirm the role of working memory. About 3% of the world's verb-final languages have prepositions, but the vast majority employ the more economical postposition option. Not all children learning English have trouble with the interpretation of pronouns, but if there is a problem, it invariably involves plain pronouns rather than the more processing-friendly reflexives. A small number of English speakers permit *want to* contraction without restriction (Pullum, 1997), but anyone who allows *wanna* in the more difficult (8) also permits it in (7), where the transition from *want* to *to* is seamless. In all three of these cases, we see unequivocal attempts to accommodate the demands of working memory: the less taxing option is favored, typologically and developmentally.

These and many comparable phenomena constitute the fabric of what is commonly called a language's "grammar." However, what we think of as a grammar is probably more accurately seen as a system of processing routines, whose precise character reflects the ways in which languages deal with the limitations imposed by working memory, with consequences for typology and development that we are only beginning to understand.

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Commentary on Pierce, Genesee, Delcenserie, and Morgan

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Early linguistic experiences are intimately tied to later language learning outcomes (e.g., Chilosi et al., 2013; Kaushanskaya & Marian, 2009b). The underlying neural and cognitive processes mediating this relationship remain unclear. Pierce, Genesee, Delcenserie, and Morgan (2017) propose that the phonological working memory (PWM) system is the critical component responsible for linking early linguistic experiences to later language development. Their argument arises from research demonstrating that exposure to linguistic input early in life shapes the kinds of phonological representations that are formed about the sounds within one's native language (Kuhl, 2004; Majerus et al., 2005; Mody, Schwartz, Gravel, & Ruben, 1999; Nittrouer & Burton, 2005). These phonological representations, which the authors believe to be created and stored using the PWM system (Gathercole & Baddeley, 1989), are highly predictive of later language outcomes (Bernhardt, Kemp, & Werker, 2007; Kuhl, 2010; Molfese & Molfese, 1985; Tsao, Liu, & Kuhl, 2004). Explaining language development via memory processes has many benefits. For instance, drawing on a large extant literature on memory-related processes allows researchers to make novel predictions about language learning, especially in regard to its connections to other kinds of learning (e.g., Gathercole, 2006). Identifying

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