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Reply to 'When linguistic dogma rejects a neuroscientific hypothesis'

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Lo, Henke, Matorell and Meyer criticize our recent Perspective (Kazanina, N. & Tavano, A. What neural oscillations can and cannot do for syntactic structure building. *Nat. Rev. Neurosci.* **24**, 113–128 (2023))[1] by challenging the 'dogma' that syntax is hierarchical (Lo, C.-W., Henke, L., Martorell, J. & Meyer, L. When linguistic dogma rejects a neuroscientific hypothesis. *Nat. Rev. Neurosci.* https://doi.org/10.1038/s41583-023-00738-1 (2023))[2]. Their commentary cites construction grammar and dependency grammar as examples of grammars that do not use hierarchy. However, both grammars clearly feature hierarchical representations and relations that are not stateable on the basis of the linear order of elements in the sentence. (Incidentally, this dogma was asserted or assumed in earlier work by some of the commentators, for example, ref. 3, among others.)

In dependency grammar[4,5], within-sentence hierarchy is expressed by separating the horizontal dimension (linear order) from the vertical dimension (hierarchical order). It is the latter that underlies two fundamental dependency grammar concepts: the dependency link or arc (Fig. 1a) and the catena, a basic syntactic unit that is defined as a combination of words that are continuous in the vertical dimension[5]. Dependency grammar should not be confused with universal dependencies, which represent

a dependency grammar-based framework that solves a practical task at the expense of descriptive and explanatory adequacy (as discussed in ref. 6).

Construction grammar[7,8] centres on constructions, which are (usually multi-word) patterns that largely correspond to a phrase or sentence. Construction-internal hierarchical relations are common: for example, the verb (V)–Ving–prepositional phrase (PP) construction as in 'Joe went screaming down the street' is represented as [subject [V Ving PP]] and not [subject V [Ving PP]] to capture that the prepositional phrase 'down the street' refers to 'went' rather than 'screaming'[8]. More fundamentally, a vertical dimension is mandatory to enable nesting constructions within other constructions: for example, the coordinate construction 'John and Mary' enters as the subject into the subject–verb construction in 'John and Mary left'. Reference[9] (cited in the commentary[2]) aims to eliminate construction nesting by viewing such cases as a combination of multiple parallel sequential streams, each of which corresponds to a construction (Fig. 1b). However, is the operation of switching from one stream to another formally distinct from nesting? Until one demonstrates that switching between streams entails no vertical dimension, the approach in ref. 9 cannot serve as an example of a non-hierarchical grammatical account.

It seems contradictory that Lo et al.[2] question syntactic hierarchy while acknowledging 'hard cases' that "would require the build-up of hierarchical structure, such as ambiguities, passives and embeddings." Indeed, these structures sometimes yield an incorrect interpretation. However, taking such errors as evidence for no hierarchy in syntax is akin to taking errors in the Stroop task (identifying the font colour of 'GREEN' written in red font as green) as evidence for absent colour perception. Rather, those errors emerge owing to interaction with limited-resource cognitive systems: working memory, attention and so on. Moreover, crucially, if there were no hierarchy in syntax, how could correct interpretations of such hard cases arise at all?

We further note Lo et al.'s substantial misrepresentation of ref. 10 as "the processing model that corresponds to dependency grammar [that] conceptualizes dependency processing as a set of memory operations that link words and morphemes together and is insensitive to linear order − let alone hierarchy." In fact, ref. 10 is not based on dependency grammar, argues that memory retrieval targets "partial representations of linguistic constituents, not words" (page 448) and upholds hierarchical representations (as shown by the authors' discussion of self-embeddings (pages 452–453).
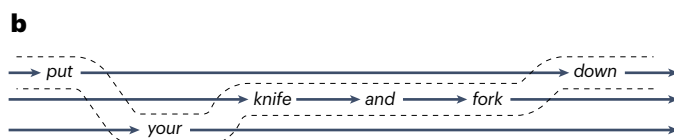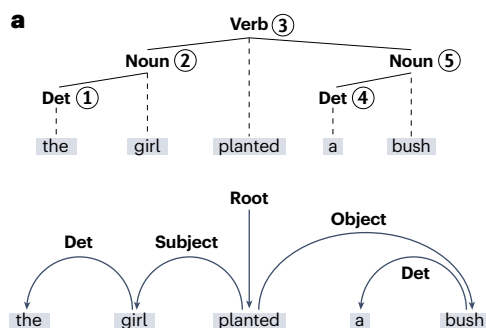
Fig. 1 | **The vertical dimension in dependency grammar and an example of parallel sequential stream representation. a**, Dependency grammar representations of the sentence 'The girl planted a bush' using dependency links (top) or arcs (bottom). Links and arcs may be non-adjacent ('planted' links to 'bush', skipping 'a') and nested within one another – both features going beyond a purely linear organization. A catena – for example, (1)(2), (1)(2)(3), (3)(5) or (2)(3)(5) – is a word combination that is continuous with respect to dominance (that is, in the vertical dimension). Some catenae – for example, (3)(5) or (2)(3)(5) – are linearly discontinuous. **b**, Parallel sequential stream representation, illustrated for the phrase 'put your knife and fork down' and proposed in ref. 9 as a replacement for the vertical dimension in construction grammar. Det, determiner. Part **b** adapted with permission from ref. 9, The Royal Society.

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Finally, Lo et al. claim that oscillations-for-chunking may be useful to produce 'proto-syntactic chunks'. Essentially, this restates our point that chunking may interact with prosody and be useful for reasons of working memory (see pages 120 and 126 of our Perspective[1]). What remains key is that, without an explicit grammatical or parsing theory, such chunks do not explain how syntactic relations among words or phrases within and across chunks are established.

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