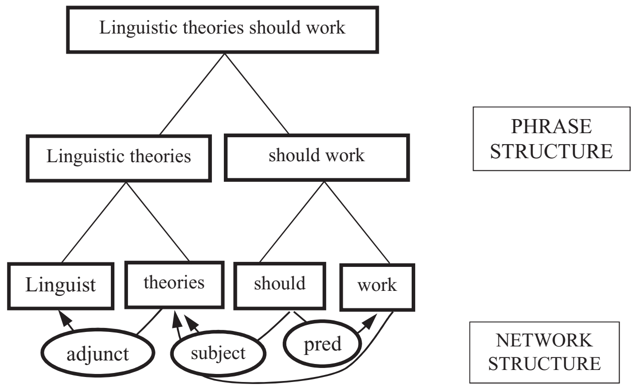

Figure 1 (Hudson). Phrase structure compared with network structure.

underpinnings of priming are not well understood," but the standard explanation for priming (Reisberg 2007, pp. 257–80) sees it as the effect of activation in a neural network spilling over from the intended target to network neighbours, thereby making the latter more accessible. In lexical priming, for example, reading *nurse* primes this word's network neighbours so that *doctor* becomes easier to retrieve than it would be otherwise. This explanation, however, makes sense only if knowledge is stored as a network of interconnected nodes; so the relevant units must be connected in a network, and if the units concerned are grammatical categories such as active and passive, these, too, must be part of a network.

This argument is familiar from the literature on connectionist models of processing and learning (Dell et al. 1999; Elman et al. 1996), but linguistic theories are pitched at a higher level of abstraction than the neurons that carry activation, so the two streams of research have hardly met. For B&P, as for most linguists, language consists of abstract units such as words, phrases, categories, and relations; so, if these are part of a network, this must be a symbolic network. On the other hand, the activation responsible for priming in this network is a property of neural networks, so it is reasonable to assume that language is a symbolic network supported by a neural network. In other words, language belongs to the mind, while activation belongs to the brain.

The network view of language is widely accepted in modern theories of the lexicon (Allan 2006), with its multiple types of relation (meaning, realization, spelling, word class, and so on) and its many-to-many mappings. Structural priming shows that networks are just as relevant to syntax: A sentence's structure combines a network of patterns such as voice, tense, transitivity, and so on, each of which is sufficiently active to prime other examples of the same pattern. These patterns are the constraints of any constraint-based theory of syntax, including B&P's preferred linguistic model, Parallel Architecture. In short, a sentence's grammatical structure must be a rich network of interacting and active nodes.

Where does this leave phrase structure, however, which is taken for granted in virtually every modern theory of syntax (and, disappointingly, by B&P themselves)? Phrase structure is an extremely impoverished theory of the human mind that recognises only one possible mental relation: the part-whole relation between smaller and larger units. According to phrase structure, direct relations between individual words are not possible. For example, in the sentence *Linguistic theories should work*, the only possible relations are those shown in a tree such as the one above the words in Figure 1. For example, the word *linguistic* can be related to the phrase *linguistic theories*, but not to *theories*. Moreover, if phrase structure is right, phrases cannot intersect; so, if *linguistic theories* is part of the phrase *linguistic theories should work*, it cannot also be part of *linguistic theories work*. As we all know, however, both of these assumptions are really problematic: Words do relate directly to one another (e.g., for agreement and government), and complex relations such as raising (from *work to should*) do exist.

Suppose, however, that syntactic theory is actually a network, not a tree. In that case, words can relate directly to one another, and multiple links are also possible. One such analysis is shown by the labeled arrows below the words in the figure for *Linguistic theories should work*. The labelled dependencies from *theories* to *linguistic* and from *should* to *theories* are typical of the very ancient tradition of dependency analysis (Percival 1990) and of more recent work in theoretical and descriptive linguistics (Tesnière 1959; 2015; Sgall et al. 1986; Mel'čuk 2009) as well as computational linguistics (Kübler et al. 2009) and psycholinguistics (Futrell et al. 2015; Gildea & Temperley 2010; Jiang & Liu 2015; Ninio 2006). All this work builds on the simple idea that our minds are free to recognise relations between words – an idea espoused some time ago by one of B&P (Pickering & Barry 1991).

The network notion, however, takes us further than this, to the idea that such relations need not be formally equivalent to a tree. In the example, *theories* is the subject not only of *should*, but also of *work* – a pattern that goes well beyond the formal limits of trees. This example illustrates the enriched dependency structure of one particular modern theory of grammar, Word Grammar (Duran-Eppler 2011; Gisborne 2010; Hudson 2007; 2010). In this theory, syntactic structure is so rich that it can even recognise mutual dependency in cases such as *Who came?*, in which *who* depends (as subject) on *came* and *came* depends (as complement) on *who*. Mutual dependency is absolutely impossible in any tree-based theory, but of course, it is commonplace in ordinary cognition (e.g., in social structures).

In conclusion, structural priming shows not only that a grammar is a network, but also that enriched dependency structure is more plausible than phrase structure as a model of mental syntax.

Action sequences instead of representational levels

doi:10.1017/S0140525X17000449, e296

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Abstract: Despite enthusiastic agreement that experimental data are directly relevant for determining grammar architecture, we present one main objection to the conclusions that the authors draw from their results: The data are perfectly compatible – in fact, much more in line – with an alternative that does not rely on syntactic representations. Instead, it is processing actions whose activation for comprehension/production explains intra-/inter-speaker priming.

The target article is part of a welcome recent trend to take psycholinguistic results as able to adjudicate among competing theoretical proposals, rather than being treated as simply presupposing linguists' constructs. We wholeheartedly agree with this stance; in fact, we endorse it to a much greater extent than the authors advocate: From our point of view, the paper presents a rather conservative interpretation of the cited results in that it persists with the preoccupation of abstracting over behavioural/neuronal data to underlying abstract knowledge representations presumed to underlie their explanatory mechanisms (Gregoromichelaki & Kempson, forthcoming; cf. Ferreira et al. 2008).

We support the claim that methods of structural priming comparisons can be informative about mechanisms underlying linguistic processing. However, the authors argue that structural priming results are explainable only by assuming separate linguistic *representations* encoding semantic/syntactic/phonological information. Here, perhaps surprisingly, the authors seem to adopt the standard linguistic stance that theoretical frameworks/explanations need to presuppose an abstract, static view of linguistic knowledge, separating models of *competence* from accounts of *performance*.

In contrast, we propose an alternative formal architecture based on *Dynamic Syntax* (DS) as the syntactic engine (Cann et al. 2005; Kempson et al. 2001; 2017) enhanced with incremental construction of Type-Theory-with-Records (TTR; Cooper 2012) conceptual representations (DS-TTR; Gregoromichelaki et al. 2013; Hough 2015; Kempson et al. 2016; Purver et al. 2010). While eschewing a level of syntactic representation and any competence/performance distinction, such a framework is able to account directly for the priming data as well as standard linguistic generalisations.

Concentrating on syntax, the main focus of the paper, the data presented provide no evidence for theoretical or implementational perspectives on syntactic knowledge that would necessarily assume string-level hierarchical representations or accessing of stored well-formedness constraints in some kind of context-free-grammar format. Instead, a formal grammar adopting a DS-TTR-style architecture consisting of routinised sequences of processing actions with no syntactic representations is much more compatible with the overall data. From this perspective, the appearance of abstract structural pattern-matching is epiphenomenal on the incrementality/predictivity of the processing of time-linearly unfolding stimuli. In contrast, the methodology that involves abstracting a level of syntactic representation over the actions impedes straightforward analyses of patterns of interlocutor coordination in dialogue (Gregoromichelaki et al. 2011).

Instead of syntactic hierarchical structure, according to DS-TTR, a small set of elementary domain-general processing actions underpins both parsing and generation: Cross-linguistically available sequences of such actions cluster into higher-order sequential patterns (macros) that can be learned online, activated long-/short-term, and stored as chunks triggered by specific word forms (Eshghi et al. 2013). It is the reuse, and potential for adjustment, of such sequences that accounts for the authors' findings of "syntactic-pattern" repetitions appearing as distinct and/or independent from semantic interpretations. These results can be explained more explicitly in DS-TTR because the framework addresses the pervasive local ambiguity problem of incremental parsing/generation by predictive activation of various potential probabilistically weighted processing paths (sequences of actions). These processing paths are taken to constitute part of the context and some of them lead to identical TTR conceptual structures (Hough 2015; Hough & Purver 2017; Sato 2011). For example, PO/DO or active/passive alternations in DS-TTR reflect the invocation of distinct sequences of actions to construct or linearise equivalent conceptual event frames (with distinguishing information-structure aspects reflected in the processing order). The parser/generator initially pursues the highest-ranked option, with the rest maintained in the context for conversational-repair purposes (Eshghi et al. 2015; Hough 2015). Success of one such path in achieving the intended conceptualisation will enhance the probability of perception/execution of the same action sequence subsequently if the word forms accessed make it available, while inhibiting the pursuance of alternatives.

Cumulative priming effects are predicted with additional repetition of the triggering word forms (the *lexical boost* effect), because phonological forms are stored in context for conversational purposes like clarification. Facilitation of retrieval is predicted even when repetition of the same word forms in conjunction with the same word order leads to distinct conceptual frames (Bock & Loebell 1990), a mechanism independently needed for ellipsis resolution, or in priming across languages (given that code-switching in DS-TTR does not involve shift of processing environment [Gregoromichelaki 2017]).

The TTR conceptual frames invoked in processing explain the observation that speakers may show behaviour indicating that they represent semantic elements they do not hear/utter. However, with sequences of actions modelling incremental conceptual integration of stimuli, there is no need for postulating movement or empty categories while it is also predicted that long-distance dependencies of the standard kind should trigger parallel sequential patterns subsequently even in the absence of semantic parallelism. Finally, given that the DS-TTR modelling of the grammar itself is driven by the generation of predictions of upcoming sequences of actions, any already pursued action paths will always be prioritised (Myslín & Levy 2016), tuning processing accordingly and thus explaining why comprehension is cross-primed by production and vice versa within and between speakers.

From this perspective, syntactic knowledge is not autonomous but derivative upon other forms of procedural knowledge, namely sequential action planning and comprehension with gradual elaboration of conceptual representations expressing stimuli categorisation as it occurs across cognition (Gregoromichelaki 2013). Consequently, such knowledge needs to be modelled in an architecture that integrates simultaneous qualitatively related constraints from various sources, rather than separate modular components expressed in distinct vocabularies, as the authors advocate. For this reason, we believe the consequences of structural priming, while transparently operative when isolated in carefully controlled experimental designs, seem to disappear in investigations of corpora that reflect multiple other sources of constraints such as frequency, creativity, affective, and social effects (Healey et al. 2014).

In conclusion, an explanation of the structural-priming results from a DS-TTR perspective dispenses with the heterogeneous multilevel representational nature of the grammar proposed by the authors. Yet, this more radical move we propose turns out to be much more supportive of the general conclusion the authors draw, namely, the relevance of psycholinguistic explorations in determining the nature of linguistic theories. It is also more compatible with recent neuro-physiological evidence (e.g., Covington & Duff 2016). In fact, from our perspective, priming experiments provide valuable tools for guiding the formalisation/implementation of grammar models – for example, by providing measures estimating the temporal course of pattern memory decay, investigating the competition among alternatives resulting in inhibitory effects, and determining variable probability distributions of available sequences, all currently being theoretical and observation-based assumptions in need of further substantiation.

Moving beyond the priming of single-language sentences: A proposal for a comprehensive model to account for linguistic representation in bilinguals

doi:10.1017/S0140525X17000450, e297

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