Why natural language models must be partial and shifting: a Dynamic Syntax with Vector Space Semantics perspective

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This paper brings together Dynamic Syntax and Vector Space semantics with current work in cognitive neuroscience and evolution to argue that natural language (NL) models need to be defined in partial and shifting terms. Dynamic Syntax (DS; Kempson et al., 2001; Kempson, 2016) is a grammar architecture which replaces conventional syntax assumptions in their entirety. The core notion is that of contextually dependent word-by-word incremental interpretation of word-sequences (comprehension/perception) or linearisation of contents (production/action). The syntactic engine is underpinned by a specialised version of Propositional Dynamic Logic, able to express probabilistically licensed transition events among the states of a dynamic system (Sato, 2011), construed as transitions across partial decorated trees. To reflect this growth process, DS actions, both general and lexical, are articulated in terms of conditional and goal-driven actions whose accomplishment either gives rise to expectations of further actions (*requirements*), tests the environment for further contextual input, or leads to abandonment of the current strategy. Words, morphology, and syntax, all defined to develop partial binary branching trees, are "affordances", indicators of opportunities for (inter-)action. Such actions incrementally open a range of options for the interlocutors, modelled as a directed acyclic graph (DAG) representing possible transition alternatives. With parsing and generation defined in the same tree-growth terms, the fluency of partner interaction in dialogue is immediately ensured: each agent can contribute directly to the emergent and continually evolving DAG, by request for clarification, by development, or, by correction, cutting off putative lines of development. The DAG may maintain multiple possible parsing paths, such as that afforded by transitive and intranstive verbs being initially maintained before one is used (see Fig 1).

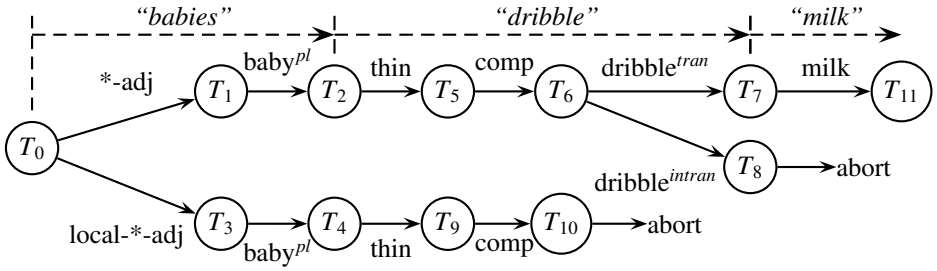

Figure 1: DS parsing as a DAG: actions (edges) are transitions between partial trees (nodes).

This architecture has many parallels with the Predictive Processing perspective (PP) (Clark, 2016; Friston and Frith, 2015), being fundamentally action-oriented with predictive moment by moment processing involving continuous intermingling of production, thought, encyclopedic and immediate context, with an error correction measure filtering out improbable alternatives. Perception and action make use of the same basic computational strategy so no higher-order inference, "efference-copy" replication, or "mutual knowledge" constraint is required. DS thus has a niche in the PP perspective as a model of language as an unencapsulated set of potential actions determining interactive behaviour in real time.

While the DAG gives us a handle on traditional syntactic ambiguity as it occurs in real time, a challenge for DS has been how to characterize the content of tree nodes to allow content provided by words to be non-deterministic. The representation should under-determine any putative denotational content to capture the sys-

temic ambiguity in conversational interaction in real time, and therefore make a language acquisition model possible. The goal then to be achieved is defining a semantic system able to project the necessary nondeterminism of meaning, and its variability across distinct uses, contexts and users, a task for which vector space semantics (VSS) is extremely well suited (Kartsaklis and Sadrzadeh, 2013; Kartsaklis, 2013). On the combined DS/VSS approach, language constitutes a mechanism for interaction in which contents established by either partner in an exchange do not have to match content by content: overlap in the vector space severally established from the words in combination merely has to be sufficient to allow inconsistencies to go undetected, yet licensing clarification and corrective interjections to probe closeness of the match achieved should any mismatch become interactionally relevant.

Exploring this avenue opens up new horizons for acquisition research and by analogy evolution, given the Tomasello (2019) demonstration of human adaptivity to group interaction with children's development of pro-social skills alongside language development, in phases of development not shared with apes. Tomasello takes this as showing that humans are adaptively predisposed to pro-social behaviour involving altruistic capabilities and collective intentionality. But this conclusion can be transformed in the light of work on evolution following the multi-level selection hypothesis (MLS; Wilson, 2019) in which groups as well as individuals can be taken to constitute adaptive units, imposing as necessary for successful group-level adaptivity the condition that group- and individual-level pressures be statistically balanced so that group level pressures predominate, e.g. through sufficient altruistic in-group behaviour.

Current studies of NL evolution have largely retained conservative assumptions about the gulf between formal and empirical study of language use (cf Christiansen and Chater, 2016), and without the backing of MLS methodology, all face a ceiling imposed by the joint assumptions that linguistic knowledge is a static, denotationally grounded capacity and that all explanations of evolution have to be reducible to individual level considerations. This means they do not address problems such as the systemic ambiguity inherent in NL or the challenge of explaining human group-level adaptivity. However, bringing together DS, PP, VSS and MLS assumptions, language is modelled as procedures for interaction, with NL semantics defined in VSS terms, predicting flexibility with respect to all uses, users and contexts, within whatever limits through iterated routinised uses the language normatively imposes. Languages and hence language behaviour can then be seen to be group-level adaptive at all language-internal levels, phonological, morphological, structural and semantic, ensuring an interactivity in language use sufficient for the predominance of group-level benefits without having to assume any a priori altruistic disposition at individual levels. By combining process-oriented language perspectives (DS) and open-endedness of meaning perspectives (VSS), the possibility of developing an integrated account of language behaviour and how it might have emerged thus becomes, tantalisingly, a more nearly realisable goal.

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