Generalizing active gap-filling

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Much experimental evidence has shown that human comprehenders adopt an "active gap-filling" (AGF) strategy (Fodor, 1978; Stowe, 1986). AGF is formally analogous to other parsing heuristics such as Late Closure (LC) and Minimal Attachment (Frazier and Clifton, 1996), in the sense that they are all strategies for deciding between two distinct analyses of a sentence prefix. But while LC, for example, can be formulated precisely as a strategy for navigating a context-free parser's search space, no analogous computational formulation of AGF exists. Adopting Minimalist Grammars (MGs) (Stabler, 1997) as the underlying model of filler-gap dependencies, we show that (i) a parser based on left-corner-style structure-building gives rise to a **search space** with choice points where the AGF strategy can be formulated precisely, unlike previous MG parsers, and (ii) this formulation of AGF immediately makes testable **predictions** about intricacies of filler-gap dependency processing that extend beyond the core generalization that AGF describes.

To construe AGF as an ambiguity-resolution strategy analogous to LC, we note first that LC refers to the fact that, upon hearing English sentence (1) up to 'vet', comprehenders choose the partial analysis in (2a) over (2b). Then AGF likewise refers to the fact that, upon hearing (3) up to 'buy', comprehenders choose the partial analysis in (4a), with 'what' linked to a gap in object position, over (4b), with the dependency remaining unresolved. The choice in (2) can be modeled as a context-free parser's choice between two tree-building transitions; in a bottom-up parser, for example, it is the choice between a `shift` step that leads to (2a) and a `reduce` step that leads to (2b) (Shieber, 1983). An analogous concrete model of the choice in (4) requires an explicit theory of the incomplete objects represented informally in (4a) and (4b), and a system of structure-building transitions (richer than `shift` and `reduce`) that assemble those objects incrementally.

These requirements are met by combining the MG formalism's representations with structure-building transitions that adapt ideas from (context-free) left-corner parsing. The structure to be assembled for the interrogative clause 'what Sam buys' is shown in box (c) of Fig.1; this ressembles a (pre-movement) "deep structure", with the wh-movement encoded indirectly via percolation of `-wh` features. The partial structure the parser arrives at given the prefix 'what Sam' is in box (a), from which point there are two paths available. The left path links 'what' to the object position in advance of confirming input, a choice which is confirmed if the full input is 'what Sam buys'; the right path is the "gap as last resort" path, confirmed if the gap is further downstream. AGF therefore boils down to a preference for $\texttt{connect}^{\texttt{up}}_{\texttt{down}}$ transitions (just as LC prefers `shift`). The name refers to the fact that, once 'Sam' triggers the prediction of its sister and mother, the transition to (b) connects this treelet upwards *and* downwards; the transition to (d) connects it only upwards.

The search space of the top-down MG parser of Stabler (2013) (see also e.g. Graf et al. 2017) does not include a choice point that corresponds to these intuitively familiar gap-positing options, because that parser must commit to a gap site before consuming a clause-initial wh-phrase. As well as this improvement, the parser described here maintains the empirically supported memory-load profile for embedding patterns from left-corner parsing of CFGs (Resnik, 1992).

Furthermore, the concrete formulation of AGF as a preference for $\texttt{connect}^{\texttt{up}}_{\texttt{down}}$ transitions immediately makes predictions regarding details that go beyond what follows from intuitive statements of AGF. One consequence is that the choice point in Fig.1 actually comes *before* 'buys' (since the gap is the "corner" that triggers prediction of the verb); this differs from typical conceptions but aligns with the "hyper-active" strategy that Omaki et al. (2015) argue for. Finally, given a grammatical representation that expresses the anaphoric dependency in (5), we predict that there will be no actively-posited matrix subject gap (to be revoked at 'you') because linking the wh-phrase to this position would preclude licensing of the reflexive. These predictions arise from the adoption of a formalism with long-distance dependencies as first-class entities, in contrast to more ad hoc enrichments to context-free parsers such as a "hold cell" (Wanner and Maratsos, 1978).

(1) When Fido scratched the vet removed the muzzle.

(2) a. When [$_S$ Fido scratched the vet] [$_S$ . . .]
b. When [$_S$ Fido scratched] [$_S$ the vet . . .]

(3) What did Sam buy ___ yesterday?

(4) a. What did Sam buy ___ . . .
b. What did Sam buy . . .

(5) [Which story about himself$_1$] do you think John$_1$ likes ___?

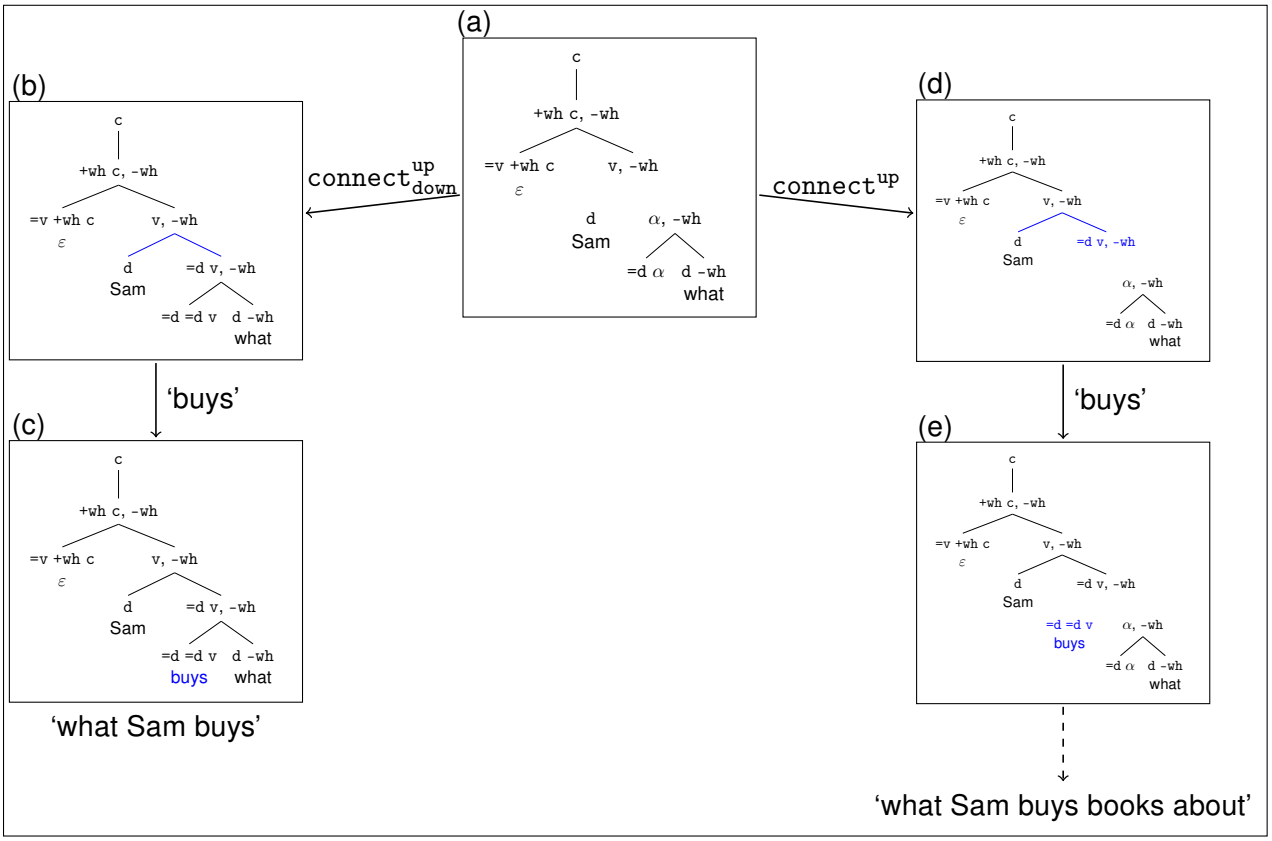

Figure 1: Part of the search space defined by the parser's system of structure-building transitions. (α is a unification variable reflecting as-yet-unknown lexical features.)

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