Generalizing active gap-filling

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Motivation: Gap-filling as ambiguity resolution

garden-pathing late closure, minimal attachment, etc.		filler-gap dependency processing
↕		↕
classical stack-based parsing		?????
↕		↕
Context-Free Grammars (CFGs) structurally local dependencies		Minimalist Grammars (MGs) structurally non-local dependencies

The treatment of structurally non-local (i.e. movement) dependencies in existing MG parsers (e.g. Stabler 2013, Stanojević and Stabler 2018) does not line up well with ideas in the psycholinguistic literature.

Active gap-filling: Humans pursue (2a) before (2b):

(1) What did John buy books about yesterday?

(2) a. What did John buy ___ …
b. What did John buy …

Late closure: Humans pursue (4a) before (4b):

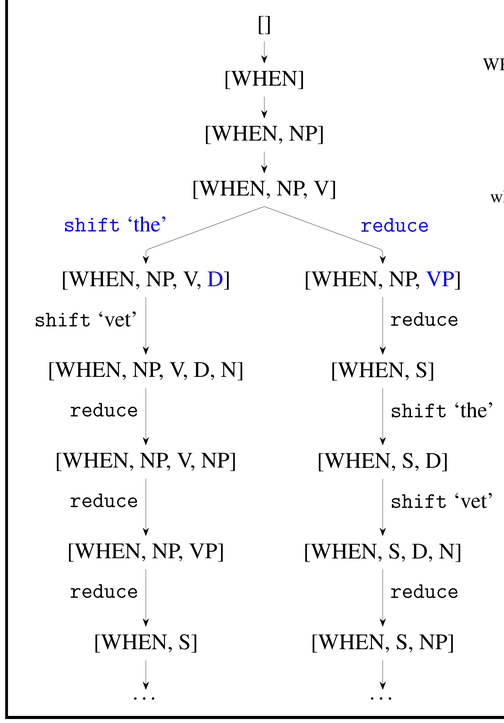
(3) When Fido scratched the vet and his new assistant removed the muzzle.

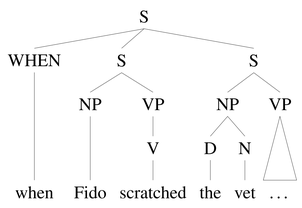
(4) a. When [$_S$ Fido scratched the vet] […]
b. When [$_S$ Fido scratched] [$_S$ the vet …]

We have formal models of parsing for (4), but not for (2).

Late closure in classical stack-based parsing

Late Closure can be cashed out as "try `shift` before `reduce`" (Shieber 1983).





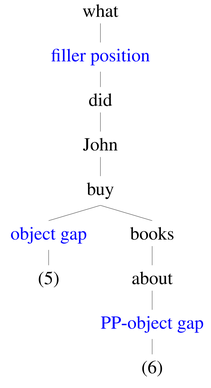
The search space for filler-gap dependencies

What do the relevant parts of the parser's search space for (5) and (6) look like?

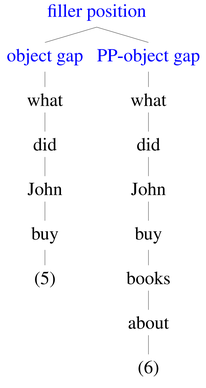
(5) What did John buy ___?

(6) What did John buy books about ___?

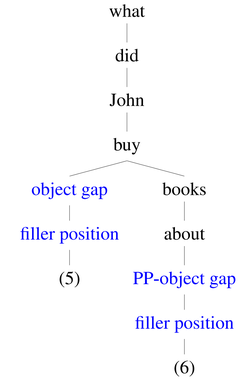
What we want



Stabler (2013)



Stanojević and Stabler (2018)

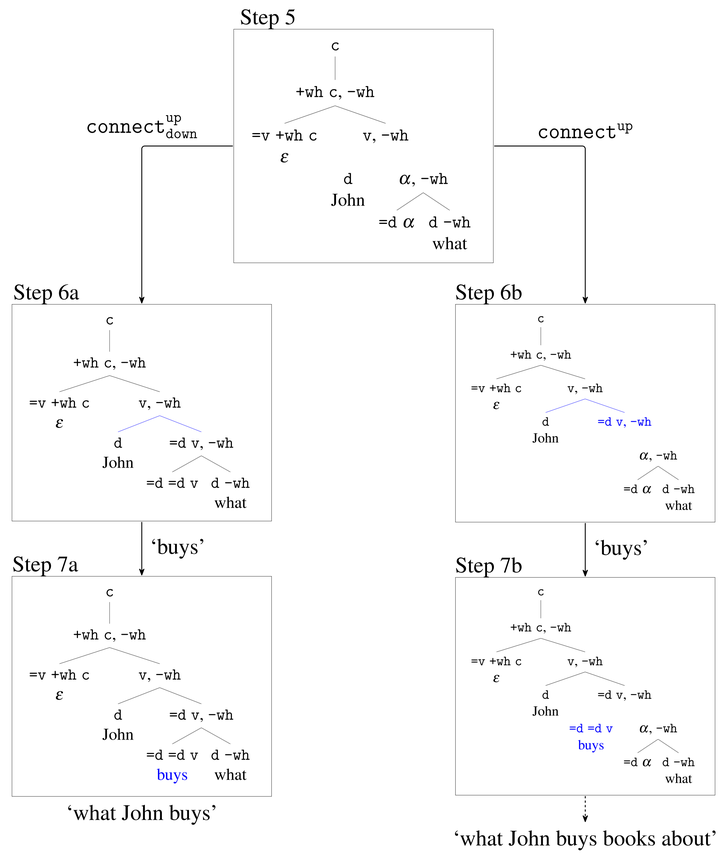


Technical details

0	—	$((0,i) : \texttt{c}) \Rightarrow ((0,i)\,\text{ROOT})$
1	`shift` 'what'	$((0,1) :: \texttt{d -wh})$ $((0,i) : \texttt{c}) \Rightarrow ((0,i)\,\text{ROOT})$
2	`merge`	$((j,k) :\cdot \texttt{=d}\alpha) \Rightarrow ((j,k) : \alpha), ((0,1) : \texttt{-wh})$ $((0,i) : \texttt{c}) \Rightarrow ((0,i)\,\text{ROOT})$
3	`shift` ε	$((1,1) :: \texttt{=v +wh c})$ $((j,k) :\cdot \texttt{=d}\alpha) \Rightarrow ((j,k) : \alpha), ((0,1) : \texttt{-wh})$ $((0,i) : \texttt{c}) \Rightarrow ((0,i)\,\text{ROOT})$
4	$\texttt{connect}^{\texttt{up}}(\texttt{move}(\texttt{merge}))$	$((1,i) : \texttt{v}), ((0,1), \texttt{-wh}) \Rightarrow ((0,i)\,\text{ROOT})$ $((j,k) :\cdot \texttt{=d}\alpha) \Rightarrow ((j,k) : \alpha), ((0,1) : \texttt{-wh})$
5	`shift` 'John'	$((1,2) :: \texttt{d})$ $((1,i) : \texttt{v}), ((0,1), \texttt{-wh}) \Rightarrow ((0,i)\,\text{ROOT})$ $((j,k) :\cdot \texttt{=d}\alpha) \Rightarrow ((j,k) : \alpha), ((0,1) : \texttt{-wh})$
6a	$\texttt{connect}^{\texttt{up}}_{\texttt{down}}(\texttt{merge})$	$((2,i) :\cdot \texttt{=d =d v}) \Rightarrow ((0,i)\,\text{ROOT})$
7a	$\texttt{connect}^{\texttt{up}}(\texttt{shift})$ 'buys'	$((0,3)\,\text{ROOT})$
6b	$\texttt{connect}^{\texttt{up}}(\texttt{merge})$	$((2,n_0) : \texttt{=d v}, ((0,1), \texttt{-wh}) \Rightarrow ((0,n_0)\,\text{ROOT})$ $((n_2,n_3) :\cdot_4 \texttt{=d}\alpha) \Rightarrow ((n_2,n_3) : \alpha), ((0,1) : \texttt{-wh})$
7b	$\texttt{connect}^{\texttt{up}}$ 'buys'	$((2,3) :: \texttt{=d =d v}$ $((2,n_4) : \texttt{=d v}, ((0,1), \texttt{-wh}) \Rightarrow ((0,n_4)\,\text{ROOT})$ $((n_6,n_7) :\cdot_8 \texttt{=d}\alpha) \Rightarrow ((n_6,n_7) : \alpha), ((0,1) : \texttt{-wh})$
8b	$\texttt{connect}^{\texttt{up}}(\texttt{merge})$	$((3,n_0) :\cdot_1 \texttt{d}, ((0,1), \texttt{-wh}) \Rightarrow ((0,n_0)\,\text{ROOT})$ $((n_3,n_4) :\cdot_5 \texttt{=d}\alpha) \Rightarrow ((n_3,n_4) : \alpha), ((0,1) : \texttt{-wh})$
9b	`shift` 'books'	$((3,4) :: \texttt{=p d}$ $((3,n_2) :\cdot_3 \texttt{d}, ((0,1), \texttt{-wh}) \Rightarrow ((0,n_2)\,\text{ROOT})$ $((n_5,n_6) :\cdot_7 \texttt{=d}\alpha) \Rightarrow ((n_3,n_4) : \alpha), ((0,1) : \texttt{-wh})$
10b	$\texttt{connect}^{\texttt{up}}(\texttt{merge})$	$((4,n_0) :\cdot_1 \texttt{=d p}\alpha) \Rightarrow ((0,n_0)\,\text{ROOT})$
11b	$\texttt{connect}^{\texttt{up}}(\texttt{shift})$ 'about'	$((0,5)\,\text{ROOT})$

Active gap-filling in our MG parser

Active Gap-Filling can be cashed out as "try $\texttt{connect}^{\texttt{up}}_{\texttt{down}}$ before other options".



Predictions

We maintain some desirable "old" predictions from previous related work:

- This parser maintains the empirically supported memory-load profile for left-, right- and center-embedding structures from left-corner CFG parsing (Resnik 1992, Liu 2024).
- Via a metric that counts the number of "loose ends" being maintained, this parser can account for the SRC/ORC asymmetry just as well as the more widely-studied top-down MG parser Stabler (2013), Graf et al. (2017).

But the hypothesized preference for $\texttt{connect}^{\texttt{up}}_{\texttt{down}}$ transitions also makes new predictions about details that go beyond what follows from intuitive statements of active gap-filling:

- The critical choice point actually comes before the verb — perhaps not the typical way to think of active gap-filling, but in line with what Omaki et al. (2015) call "hyper-active gap-filling".
- Given a grammatical representation that expresses the anaphoric dependency in (7), 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.

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

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Omaki, A., Lau, E. F., White, I. D., Dakan, M. L., Apple, A., and Phillips, C. (2015). Hyper-active gap filling. *Frontiers in Psychology*, 6(384).

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