# snippets

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# A novel algorithm for minimal search

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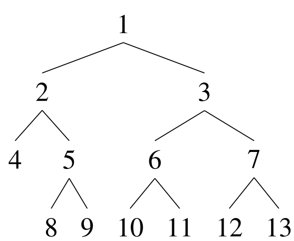
Much work in contemporary syntactic theory since Chomsky 2004 refers to an operation of "minimal search" as underlying syntactic dependency formation, without a concrete description of this procedure. Preminger (2019) proposes that any candidate algorithm should at least satisfy the properties in (1), thereby deriving well-known constraints on attracting the "closest" goal: those based on c-command (Chomsky 1995; Kitahara 1997; Rizzi 1990), and the A-over-A condition (Ross 1967; Chomsky 1964).

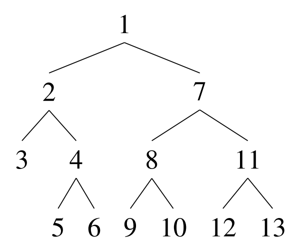
(1) a. If *y* asymmetrically c-commands *x* (Reinhart 1976), then the algorithm encounters *y* before *x*.
  b. If *y* asymmetrically dominates *x*, then the algorithm encounters *y* before *x*.

Ke (2019), Atlamaz (2019), and Branan and Erlewine (forthcoming) discuss two well-studied algorithms for tree traversal in computer science, Breadth-First Search (BFS) and Depth-First Search (DFS), as candidates for minimal search. The example trees in (2) illustrate the order in which nodes are considered by the algorithms.

(2) a. Breadth-First Search




b. Depth-First Search




In brief, BFS (2a) considers all nodes at a given depth level before considering nodes at a subsequent depth level. DFS (2b) considers the left daughter at each step, searching deeper into the tree until a terminal node is reached. It then minimally backtracks to a node with daughters not yet visited. These algorithms require the non-standard assumption that linearisation occurs before probing to impose an ordering between sisters which may later be reordered by probing and subsequent operations, and that search privileges left over right sisters. (See Ke and Atlamaz for detailed descriptions of these algorithms.)

Ke (2019) proposes to adopt BFS for minimal search because DFS may violate Closest c-command (1a) by considering a c-commandee before its c-commander (e.g. node 5 before node 7 in (2b)). In contrast, BFS satisfies both Closest c-command and A-over-A.

However, Branan and Erlewine (forthcoming) argue that adopting BFS over DFS may be premature, as there are cases where DFS is preferred in derivations involving "smuggling" (Collins

2005; Belletti and Collins 2020). In smuggling derivations (3), a goal is contained within a phrase moving across other potential goals, and the containing specifier is not made inaccessible to probing. As all attested instances of smuggling involve extraction from a left specifier, it is crucial that elements within the left specifier are searched before those in its sister, thus avoiding a non-target goal.

(3) [PROBE: F] [ [$_{\text{container}}$ ... F ... ] [ ... F ... t ] ]

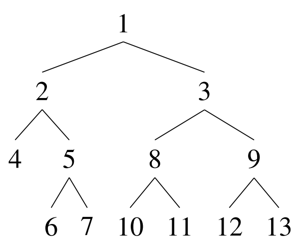
I propose a novel search algorithm in (4) which (i) fulfils both of Preminger's desiderata, thus deriving Closest c-command and A-over-A (like BFS), and (ii) is compatible with derivations involving smuggling (like DFS). Here, "consider" means to check whether a node matches the probe's feature specification.

(4) Proposed algorithm

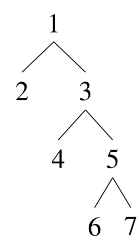
a. Consider the root node, N.
b. Consider N's left daughter, followed by N's right daughter, and mark N as visited.
c. Continue the search with the left daughter as node N in step (b).
d. Upon reaching a terminal node, minimally backtrack (in the order nodes were visited) to a visited node with an unvisited daughter node, and continue the search with that daughter as node N in step (b).

(5) Examples involving proposed algorithm

a.




b.




Before searching deeper into nodes within the left daughter, the left daughter's sister is first considered (but not yet "visited"). The algorithm thus satisfies Closest c-command, since the immediate daughters of any node are considered before nodes they asymmetrically c-command, and A-over-A, since parent nodes are always considered before their descendants.

Suppose (5a) represents a smuggling configuration where the subtree rooted at 2 is a movement-derived specifier containing the desired goal. The algorithm ensures search into the complex left specifier before its sister's contents, deriving the desired result for smuggling. For strictly right-branching trees (5b), the algorithm produces the same order as BFS and DFS.

The proposed algorithm, like DFS, searches left before right daughters regardless of their moved/non-moved status or structural status (as specifiers, adjuncts, or complements), as long as the constituent is not made inaccessible to probing. One prediction of the algorithm, thus, is that in languages which allow extraction from leftward adjuncts, extraction of a goal within a leftward adjunct is preferred over a competing goal within the non-adjunct sister. Conversely, in a similar configuration involving a rightward adjunct, extraction of a goal in its non-adjunct sister is favoured instead. As the validity of this prediction regarding adjuncts is currently unclear, I leave this open to further empirical investigation.

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