Linearization of Syntactic Dependency Graphs in terms of Traversal Algorithms

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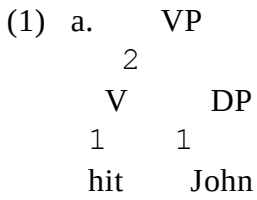
Abstract

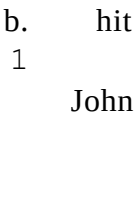
Assuming dependency graphs as syntactic representations instead of phrase structure trees, this study attempts to derive the major word orders, SVO, SOV and VOS, via the set of three tree traversal algorithms common in graph theory and computer science, and to explain their correlations with some of the syntactic differences: (i) clause-internal scrambling in V-peripheral languages and its absence in SVO languages, (ii) obligatory *wh*-movement in SVO languages and its absence in V-peripheral languages; and (iii) pseudo-cleft *wh*-questions in V-initial languages besides in-situ *wh*-phrases. The proposed word order parameter is three-valued in contrast to the more familiar two-valued one, offering finer distinctions between SVO and VSO languages, which are both head-initial.

Keywords: Dependency Graph, Traversal Algorithms, Scrambling, *Wh*-movement, Word Order

1. Dependency Graphs with Bound Morphemes as Independent Nodes

We can identify two kinds of syntactic representations in the current theories of syntax: phrase structure tree adopted in Chomsky (1957) and subsequent work, and dependency tree employed under various frameworks (e.g., Hudson (1984), Mel'čuk (1988), Debusmann & Kuhlmann (2008), and Joshi (1985)). Formally, they are both trees, with a root node dominating all the other nodes and each non-root being immediately dominated by exactly one node (see Diestel 1997). Their PF interpretations, however, are totally different; only the terminal nodes of a phrase structure tree are pronounced, whereas every node is relevant to PF interpretation in a dependency tree. The contrast is illustrated by a pair of subtrees in (1a,b).

(1) a.


b.


(1a) is a phrase structure of the generative tradition. Its non-terminal nodes are not pronounced, whether they are reanalyzed according to the bare phrase structure theory of Chomsky (1995) or not. On the other hand, the two nodes of the dependency tree in (1b) are to be pronounced.

Another related difference is that a phrase structure tree like (1a), if the order of sister nodes is specified by phrase structure rules or a particular value of the head parameter, is mapped into a single word ordering via a very simple algorithm: pronouncing the terminal nodes from left to right. A dependency tree like (1b), in contrast, is not associated with any self-evident ordering algorithm. In fact, drawing on the idea in Gazdar et al. (1985), a dependency tree is decomposed into two parts: immediate domination (ID) and linear precedence (LP) trees. Of course, their correspondence should not be totally free, and a number of formal constraints have been proposed such as projectivity and nestedness.[i]

A tree is a kind of data structure and its properties have been extensively studied in graph theory and computer science, where several algorithms have been formulated and used widely to traverse all the nodes. The left-to-right PF interpretation mentioned above appears to be taken for granted among linguists, but it has almost no resemblance to the common traversal algorithms on trees. Following Yasui (2003, 2004), I will adopt one set of standard graph-theoretic traversal algorithms and apply them to dependency-based syntactic representations.[ii] The key syntactic assumption taken from the generative tradition is that tenses, which are bound morphemes in many languages, constitute independent syntactic nodes. This is not adopted in most dependency-based studies and explicitly denied by Hudson (1984) and Sugiyama & Hudson (2006). I will show that the morphological properties of tenses and other bound morphemes in a dependency structure are crucial in causing displaced phenomena in its PF realization, which include scrambling, *wh*-movement and verb-second.

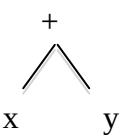
2. A Dependency Graph and its Traversals

An infix arithmetic expression like (2a) has the prefix and postfix variants in

(2b,c).

(2) a. x+y
b. +xy
c. xy+

(2a-c) can be associated with the single hierarchical structure in (3), where the operator + immediately dominates its operands.

(3) 

{<+, x>, <+, y>}

The graphical configuration in (3) can be defined by the set of two edges or ordered pairs on its right; the set-theoretic notation will be adopted below. (2a-c) can be derived from (3) in terms of the well-known recursive algorithms on trees, i.e., by starting a depth-first traversal from the root and pronouncing each node between, before, and after visiting its child nodes, respectively (cf. Knuth (1997:318-320)). They are called inorder, preorder, and postorder traversals. If the right child is traversed before its left child, the three more orderings given in (4a-c) are obtained.

(4) a. y+x
b. +yx
c. yx+

(2a-c) and (4a-c) have the same value if '+' is taken as addition.

It is reasonable to extend this line of analysis to word order variation found in natural languages exemplified in (5a-c).

(5) a. He scolded her.
b. *Kare-ga kanozyo-o sikatta*.
he-NOM she-ACC scolded
'He scolded her.'
c. *Ha-fahan si Maria i bistidu-ña gi tenda.*
3S-buy Maria the dress-3S LOC store
'Maria bought her dress at the sore.' (Chung 1990: 562)

The inorder and postorder traversal algorithms mentioned above derive (5a, b) from the common dependency structure defined in (6), which is given in English for ease of illustration.

(6) {<scolded, he>, <scolded, her>}

(5c) can be derived analogously with irrelevant details set aside. As in (4), the child nodes of the verb are commutative in Japanese and Chamorro but are not in English.

(7) a. *Her scolded he.

b. *Kanozyo-o kare-ga sikatta*.

c. *Ha-fahan i bistidu-ña gi tenda si Maria*. (Chung 1990: 563)

Examples of clause-internal scrambling like (7b) have been extensively studied since Saito (1985), and they are attested in other head-final languages (see Choe (1995) for Korean, Mahajan (1990) for Hindi, and Haider & Rosengren (2003) for German among others).[iii] Steel (1978) reports that about half of the VSO languages in her sample have VOS as an alternative as Chamorro does. As for languages arguably with SVO as their basic word order, S and O cannot be swapped in French, Italian, Spanish, and Icelandic. Though it is hard to make strong typological generalizations especially on V-initial languages, I will assume that the paradigms exemplified in (5a-c) and (7a-c) hold in a substantial number of languages.[iv]

3. Clause-internal Scrambling: Commutability of S and O

I have been assuming a finite verb in a dependency structure to be divided into its bare form and the tense morpheme. So, (6) is to be replaced by (8).

(8) {<[past], he, 2>, (nominative Case checking)
<[past], scold, 1>, (c-selection)
<scold, he, 2>, (θ-marking)[v]
<scold, her, 1>} (θ-marking/accusative Case checking)

The first two elements of each triplet define directed edges that express the local syntactic relations given in parentheses, and the third element is an annotation to distinguish among child nodes, i.e., the relation of the second element (child) to the first element (mother) in contrast to the latter's other child node. The graph defined in (8) is one way to embody the following familiar assumptions: (i) the nominative case is contingent on a tense, while the accusative is on a transitive verb; (ii) the subject (if not expletive) and object are both arguments of the verb but the latter is more closely related to the verb (see Williams (1981), Frampton & Gutmann (2002), Marantz (1984), and Haider & Rosengren (2003)); and (iii) the selection by a finite tense of a verb phrase precedes its agreement with a nominative NP. A more general statement combining (ii) and (iii) under the derivational view of syntactic building is that the local relation of a head with its complement is established prior to that with its non-complement (or specifier).[vi] This distinction is encoded in the third element of each triplet: 1 and 2 mean first and second Merge in the sense of Chomsky (2008), respectively.

The local syntactic relations listed above are directional; (8) defines a directed graph with the matrix tense as its root. It is, however, not a tree since the subject is directly governed by more than one element (i.e., the tense and the verb). The standard traversal algorithms take trees as inputs but also work properly with rooted acyclic directed graphs like (8) if formulated as in (9):

(9) Given a node A in a graph G *and A has not been pronounced*,
   i. traverse A's child 2,
   ii. pronounce A, and
   iii. traverse A's child 1.[vii]

The order of the three components in (9) is inorder; the preorder and postorder traversals are (ii)-(i)-(iii), and (i)-(iii)-(ii), respectively. The italicized proviso prevents a doubly-connected node from being pronounced twice.

The inorder, postorder and preorder traversals of (8) yield (10a-c), where child 2 is traversed before child 1.

(10) Child 2 of [past] and child 2 of *scold* traversed first
   a. INORDER: [past]-he-[past]-scold-(he)-scold-her-scold-[past]
      => he [past] scold her (SVO)
   b. POSTORDER: [past]-he-[past]-scold-(he)-scold-her-scold-[past]
      => he her scold [past] (SOV)
   c. PREORDER: [past]-he-[past]-scold-(he)-scold-her-scold-[past]
      => *[past] he scold her

Each node is to be pronounced where it is underlined in (10a-c); the occurrence of *he* after it has been pronounced is parenthesized. The resultant sequences are given after the arrows. If we make a reasonable assumption that a tense morpheme must be adjacent to the verb it is affixed to in the output of traversal, (10a,b) satisfy it but (10c) does not. The output of (10c) is asterisked in this sense.

If traversals are relaxed so as to let either child be traversed first at the two branching nodes, three more sets of outputs are obtained.

(11) Child 1 of [past] and child 2 of *scold* traversed first
   a. INORDER: [past]-scold-he-scold-her-scold-[past]-(he)-[past]
      => *he scold her [past]
   b. POSTORDER: [past]-scold-he-scold-her-scold-[past]-(he)-[past]
      => he her scold [past] (SOV)
   c. PREORDER: [past]-scold-he-scold-her-scold-[past]-(he)-[past]
      => [past] scold he her (VSO)

(12) Child 1 of [past] and child 1 of *scold* traversed first

a. INORDER: [past]-scold-her-scold-he-scold-[past]-(he)-[past]
=> *her scold he [past]
b. POSTORDER: [past]-scold-her-scold-he-scold-[past]-(he)-[past]
=> her he scold [past] (OSV)
c. PREORDER: [past]-scold-her-scold-he-scold-[past]-(he)-[past]
=> [past] scold her he (VOS)

(13) Child 2 of [past] and child 1 of *scold* traversed first

a. INORDER: [past]-he-[past]-scold-her-scold-(he)-scold-[past]
=> *he [past] her scold
b. POSTORDER: [past]-he-[past]-scold-her-scold-(he)-scold-[past]
=> he her scold [past] (SOV)
c. PREORDER: [past]-he-[past]-scold-her-scold-(he)-scold-[past]
=> *[past] he scold her

The asterisked outputs in (10)-(13) violate the verb-tense adjacency. Note, first, that all the four outputs of postorder traversal satisfy the condition, resulting in SOV and OSV. In postorder traversals, heads are pronounced after all their child nodes regardless of which child is traversed first; so they appear adjacent to each other in clause-final position. As for inorder traversal, of the four outputs, only (10a) is allowed, which yields SVO.[viii] In this way, the present theory predicts the correlation between the possibility of clause-internal scrambling and the position of heads in SOV and SVO languages, which is confirmed by data from Japanese and English

Of the four outputs of preporder traversal, (11c) and (12c) are morphologically well-formed, yielding VSO and VOS. Thus, with respect to the S-O reversal, Chamorro is correctly predicted to behave on a par with postorder languages rather than inorder languages. On closer examination, however, preorder traversals are more restricted than postorder traversals. In particular, while the postorder traversal of (8) can visit either child of the root first, the preorder traversal necessarily chooses the edge between the tense and the verb, skipping the other edge with the subject; otherwise, the verb-tense adjacency would be disrupted. Suppose that a given word order counts as basic or unmarked if derived by a consistent traversal: either child is given priority throughout. Then, the basic order obtained in inorder is SVO, with each node traversed as in (10a), whereas the preorder traversal should proceed as in (12c), in which child 1 is traversed first and VOS results. This accords with the observation that V-initial languages like Malagasy and Palauan, unlike Chamorro, have the rigid VOS order, though the syntactic status of the so-

called ‘subject’ has attracted much controversy (see Chung (2005a) and Pearson (2005) among others). I reserve my conclusion on this issue.

4. Moved and In-Situ *Wh*-phrases

4.1 Overt Wh-movement in Inorder Languages

The S-V-O order in tensed declarative clauses can be generalized into specifier-head-complement, which subsumes *wh*-movement. It is worth examining how much of its parametric differences can be deducible from the theory advocated here.

First, English moves a *wh*-phrase obligatorily into the specifier of CP, whereas Japanese and Chamorro do not. Take (14) as an example, with its dependency graph defined in (15).

(14) What did John buy?

(15) {<[WH], what, 2>, <[WH], [past], 1>, <[past], John, 2>, <[past], buy, 1>, <buy, John, 2>, <buy, what, 1>}

It has been proved that within the subgraph rooted by a tense, the edges marked with 2 (i.e., specifiers) need to be traversed first in English. Let us suppose that on the CP level headed by [WH], edge 2 is traversed first, which results in (16):

(16) [WH]-what-[WH]-[past]-John-[past]-buy-(John)-buy-(what)-buy-[past]-[WH] ==> what [WH] John [past] buy

Traversing edge 1 first on the CP level yields (17).

(17) [WH]-[past]-John-[past]-buy-(John)-buy-what-buy-[past]-[WH]-(what)-[WH] ==> John [past] buy what [WH]

[WH] is adjacent to *what* in both (16) and (17), but in neither is [WH] adjacent to [past]. Of the two outputs, (16) appears to be the more plausible for (14). As a first approximation, suppose that [WH] needs to be adjacent to a tense just like a verb is. Then, this morphological condition can be met in (16) if [past] moves to COMP followed by *Do*-support, which are well-justified processes.[ix] The traversal output in (17), on the other hand, does not seem to be salvaged by any known syntactic operation. Syntactic *wh*-movement is captured in the present theory as obligatory traversal of the edge between the interrogative marker and the *wh*-phrase. I will assume that this line of analysis can be extended to overt *wh*-movement in other SVO languages as well as the so-called verb second property in Germanic languages.

Note that the subject-auxiliary inversion does not apply if the matrix subject is a *wh*-phrase as in (18), with its dependency graph defined in (19a).

(18) Who brought it?

(19) a. {<[WH], who, 2>, <[WH], [past], 1>, <,[past], who, 2>, <[past], buy, 1>, <buy, who, 2>, <buy, it, 1 >}

b. [WH]-who-[WH]-[past]-(who)-[past]-buy-(who)-buy-it-buy-[past]-[WH]
==> who [WH] [past] buy it

Traversing (19a) in inorder with child 2 always first will yield (19b), where [WH], [past] and the verb are not interrupted by the initial *wh*-phrase; hence, the inversion is unnecessary. It remains to explain why the inversion is absent entirely in the embedded context. I will assume that selection of [WH] by a higher interrogative predicate somehow remedies its morphologically dependent status.

4.2 In-situ Wh-phrases in Postorder and Preorder Languages

Second, Japanese and Korean do not obligatorily front a *wh*-phrase. For instance, Japanese allows the two orderings corresponding to (14).

(20) a. *John-ga nani-o kaw-ta ka/no*?
NOM what-ACC buy-PAST Q

b. *Nani-o John-ga kaw-ta ka/no*?
what-ACC NOM buy-PAST Q
'What did John buy?'

Suppose that (20a,b) share the configuration in (15), apart from the phonetic content of each element. It is easy to verify that (20a, b) are obtained in postorder by giving priority to child 1 and child 2 at each branching node, respectively. In either case, the interrogative marker, tense and verb are pronounced clause-finally due to the head-last nature of the postorder traversal. Note that unlike in English, <[WH], what, 2> in (15) can but need not be traversed in Japanese. In this sense, Japanese lacks syntactic *wh*-movement, and (20b) is an instance of clause-internal scrambling discussed in Section 3.

As for V-initial languages, Georgopoulos (1991), Potsdam (2006), and the references cited therein show that quite a few of them allow a *wh*-phrase in situ. Consider the Malagasy example in (21a), which is assumed here to have the configuration defined in (15) apart from irrelevant details.

(21) a. *nividy inona i Bao*?
buy.ACT what Bao

'What did Bao buy?' (Potsdam 2006: 2158 with a slight modification)

b. [WH]-[past]-buy-what-buy-Bao-buy-[past]-(Bao)-[past]-[WH]-(what)-[WH] ==> [WH] [past] buy what Bao

The in-situ ordering is obtained from (15) by consistently giving priority to child 1 as in (21b).

So far, Malagasy apparently behaves on a par with Japanese, which is V-final. If the counterpart of (20b) is considered, some crucial differences arise. If child 2 of the root is traversed first (and the rest is analogous to (21b)), (22) is obtained.

(22) [WH]-what-[WH]-[past]-buy-(what)-buy-Bao-buy-[past]-(Bao)-[WH]
==> [WH] what [past] buy Bao

If (22) were to surface, the *wh*-object *inona* in (21a) would simply be fronted. In fact, the construction with the clause-initial *wh*-object should be (23).

(23) *inona no novidin' i Bao*?
what PRT buy.PASS Bao
'What was bought by Bao?' (Potsdam 2006: 2159)

While the Japanese scrambled *wh*-question in (20b) does not differ from (20a) apart from the word order, (23) differs from (21a) in two respects: the verbal morphology is changed and the particle *no* is required. Setting aside the first point, much evidence has been offered that (23) is a kind of pseudocleft on a par with (24); both involve the particle *no*.

(24) *ny mofo* [no *novidin-dRasoa*]
the bread PRT buy.PASS-Rasoa
'It was the bread that was bought by Rasoa.' (Potsdam 2006: 2169)

The pseudocleft strategy for clause-initial *wh*-phrases and focused phrases is attested in other Austoronesian languages.[x] It differs from scrambling of a *wh*-phrase in V-final languages and overt *wh*-movement in SVO languages.

Before going into the pseudocleft analysis of (23) in more detail, it should be noted that (22) violates the morphological condition on an interrogative marker tentatively proposed for the English *wh*-question in (14): [WH] needs to be adjacent to the tense. Presumably, the clause-initial position is by far the most salient perceptually in languages of any word order, and it should be able to host a semantically special expression like a *wh*-phrase and topic. English meets this need with its child 2-first inorder traversal, while Japanese employs scrambling permissible in its postorder traversal. I will claim that as (22) is unavailable, Malagasy and some

other Austronesian languages resort to the pseudocleft strategy.

4.3 Clause-initial Wh-phrases in Preorder Languages

If (23) is a kind of pseudocleft, the verb is part of the headless relative rather than the matrix element. In other words, (23) lacks a matrix tense and a copula just as predicative constructions like (25a-c).

(25) a. [$_{NP}$ *vorona ratsy feo*] *ny goaika.*
bird bad voice the crow
'The crow is a bird with an ugly voice.'

b. [$_{AP}$ *faly amin' ny zanany*] *Rasoa.*
proud PREP the child.3SG Raso 'Rasoa is proud of her children.'

c. [$_{PP}$ *any an-tsena*] *aho.*
PREP ACC-market 1SG.NOM 'I am at the market.'

(Potsdam 2006: 2157)

Predicative constructions without a finite copula are not uncommon in natural languages. Then, it is necessary to reconsider the morphological conditions on a tense and an interrogative marker assumed for English.

If a clause contains a bound tense morpheme, it must be affixed on some appropriate free morpheme: a verbal in English and an adjective as well in Japanese, for instance. If a language allows a tenseless clause, the adjacency condition is vacuously satisfied.

As for an interrogative marker, Chung's (1991) clausal typing theory crucially depends on the assumption that languages like English lack it; they are forced to front a *wh*-phrase to type a clause as interrogative. In contrast, I have been assuming that an interrogative marker exists in all questions, including a covert one in English. Languages with overt *wh*-movement typically exhibit the verb-second property, which I have claimed to be deducible from the adjacency condition between a phonetically empty interrogative marker and a tense. I thus need to claim that tenseless questions like (23) contain a phonetically empty interrogative marker. Since (23) is well-formed, the abstract interrogative marker should be morphologically innocuous without the presence of tense.

Note that the interrogative marker *ka* in Japanese can follow not only verbs and adjectives but also nouns and prepositions in their predicative usages:

(26) *Kore-wa nani ka/dare-kara ka*?
this-TOP what Q who from Q

'What is this/Who is this from?'

(26) are tenseless clauses with the *wh*-phrases in situ. If Malagasy is strictly head-initial, (23) can be analyzed as containing the abstract interrogative marker initially as the head of the entire sentence, followed by the *wh*-phrase in-situ, which, as Potsdam (2006) and others argue, is the focus predicate of a pseudocleft, with the *no*-marked constituent as the complex subject. This is an instance of the unmarked head-initial order and is the mirror image of the head-final Japanese word order: subject-predicate-*ka*.

If an interrogative bound morpheme in general needs to attach to a predicative constituent rather than a tense, the morphological condition on the English abstract interrogative marker proposed earlier should be revised accordingly; it should be adjacent to a predicate in the matrix context, which is a constituent headed by a finite verbal element including the copula *be*.

In summary, to place a semantically special expression like a *wh*-phrase clause-initially, natural languages employ different strategies depending on their basic word order or traversal mode: overt *wh*-movement as an instance of inorder traversal, clause-internal scrambling inherently available in postorder traversal, and the pseudocleft strategy in preorder languages.

4.4 In-situ Wh-phrases in Chinese and Indonesian

Potential counterexamples to the present theory in favor of Chung's (1991) clausal typing theory are Chinese and Indonesian, which are SVO like English but allow a *wh*-phrase in-situ like Japanese. As is well-known, Chinese is head-final in N projections. If the interrogative marker is under C, as Chung (1991: 26) and others assume, C projections are also head-final at least on the surface level. Some Germanic languages are mixed as to the position of head across categories. Then, it is necessary to specify the mode of traversal for each category in these languages rather than for an entire language once. Any typological study would be burdened with this much of complication. If Chinese is head-final within C projections, its in-situ strategy for *wh*-phrases is not surprising.

As for Indonesian, Chung (1991) analyzes in-situ and fronted *wh*-phrases on a par with those in other V-initial Austronesian languages like Palauan. Moreover, Cole et al. (2005) argue that the clause-initial 'subject' in verbal sentences of Standard Indonesian is like the clause-final 'subject' in other Austronesian languages in disallowing a *wh*-phrase; a pseudocleft construction needs to be adopted instead. If

Indonesian exhibits typical syntactic properties as V-initial languages, one possibility in my theory is to claim that its surface SVO order derives from some V-initial structure. In fact, the Indonesian existential construction with the verb *ada* is V-initial. As for *apa*(*kah*), which marks yes/no questions in Indonesian, it is clearly a free morpheme, and its presence in clause-initial position is not problematic (see Sneddon (1996)). Needless to say, much is to be worked out especially on what is often referred to as subject in Indonesian as well as in V-initial languages.

5. Two-valued and Three-valued Parameters on Word Order

My approach is quite similar to Fukui (1993), Saito & Fukui (1998) and Haider & Rosengren (2003) in that it rests on the correlation between the position of head and word order freedom. They share the idea that scrambling is possible if its output accords with the head parameter value of a language in question; for example, Japanese allows leftward scrambling since it does not disturb its right-headed or head-final structure, while the opposite holds in English. I will concentrate on Fukui (1993) as it mentions V-initial languages while the other two do not. He cites Chamorro data as examples of rightward scrambling in a V-initial language in parallel with leftward scrambling in Japanese, which is V-final. If Palauan and Malagasy are strictly VOS as mentioned in Section 3, however, they do not straightforwardly fit into Fukui's theory. As for leftward movement to the other side of V, V-initial languages are predicted to behave on a par with SVO languages. If the pseudocleft analysis of clause-initial *wh*-phrases in the former is correct, it is totally different from overt *wh*-movement in the latter.

Moreover, Fukui (1993) mentions extraposition and heavy NP shift as instances of rightward scrambling in English.

(27) a. I read a review t_i last week [of John's book]$_i$. (Fukui 1993: 410)

b. They brought t_i into my room [the beautiful pink dress]$_i$.

Constituents to be moved rightward need to be heavy; so (28a, b) are not acceptable.

(28) a.?*I read a review t_i last week [of it]$_i$.

b.?*They brought t_i into my room [that]$_i$.

The heaviness does not govern leftward scrambling in Japanese or rightward scrambling in Chamorro. Fukui and the other two studies mentioned above assume a familiar two-valued head parameter. The differences exemplified in (28) and initial *wh*-phrases would favor the present approach with a three-valued parameter.

[i] According to Debusmann & Kuhlmann (2008) and others, projectivity disallows discontinuous dependency, and nestedness forbids cross-serial dependency. Since discontinuous dependency is amply attested, while cross-serial dependency is rare, projectivity needs to be relaxed but in a restricted manner, by limiting the number of discontinuities in a subtree. The mainstream dependency-based studies focus on mathematical aspects of dependency trees and pay little interest to parametric differences as to word order. Specifically, ID and LP trees are integrated into order-annotated trees to which tree traversal algorithms are applied but for purposes totally different from mine.

[ii] Kural (2005) adopts the same traversal algorithms but apply them to standard tree notations, whereby only terminal nodes are PF-interpreted. Brody (2000) adopts a dependency-like structure to derive the linear order of tense, light verb and main verb but his motivation is quite different from mine.

[iii] It follows from the present theory that long-distance scrambling should be treated differently. This conclusion is supported by data involving A-binding, but I will not go any further here.

[iv] Quite a few researchers claim to derive some instances of V-initial order from SVO, adopting Kayne's (1994) LCA.

[v] Layered structures proposed by Hale and Kayser (1993) and others can be adopted here, but the choice does not affect the overall argument in this paper.

[vi] If each directed edge is expressed as an (annotated) ordered pair, and such pairs are stacked as the structure is built up, the priority of specifier over complement corresponds to the last-in first-out mode in all the three word order types. See Fukui and Takano (1998) for a related but distinct approach.

[vii] Given a set of ordered triplet of the form <*x, y, n*> (i.e., the edge *x*-*y* with the annotation *n* on it), to traverse A's child 2 is to find a node in the second slot of the triplet where x=A and n=2, and go on to another triplet with the obtained node in its first slot.

[viii] English modal auxiliaries are often assumed to be base-generated under T. I assume that the existence of bound tense morpheme as an independent syntactic node limits their traversal choice to be consistently child 2-first.

[ix] Head movement can be defined as an operation on graphs called edge contraction

(Diestel 1997: 16).

[x] Clause-initial *wh*-phrases in Chamorro can be analysed analogously, but see Chung (2005b).

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