An Order-Free Representation of Syntactic Structure and the Head-Parameter

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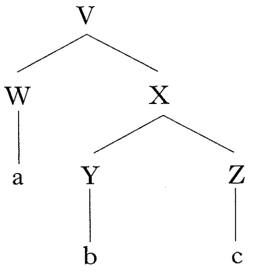
1. Trees as abstract data structures

A given piece of data can be represented in a number of ways, and the choice depends on what task should be performed on that data. It is well-known in computer science that if an appropriate data structure is chosen, the algorithms to be used to carry out the task often become relatively obvious.

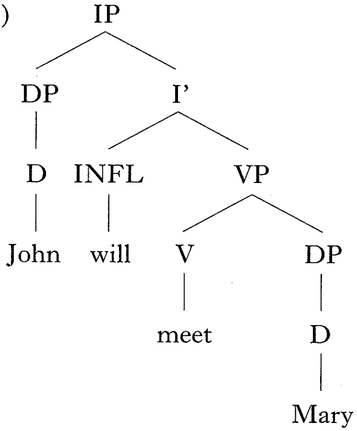
In the field of generative syntax, syntactic structure has been represented by the abstract data structure called tree. A tree such as (1) consists of a finite set of nodes and a finite set of edges connecting them with the following two properties: (i) there is one node, called the root, that dominates all the other nodes and (ii) every node other than the root has exactly one node that immediately dominates it.

(1)



Since some ordering is almost inevitably imposed on the subtrees of each node, computer science adopts trees that have one more property: (iii) the nodes each node immediately dominates are ordered linearly. The kind of tree adopted widely in generative research of natural languages has property (iii). Moreover, it crucially distinguishes terminal and non-terminal nodes; only the former are subject to PF-interpretation. Because of property (iii), the task of PF-interpretation is trivial. Take (2) for example.

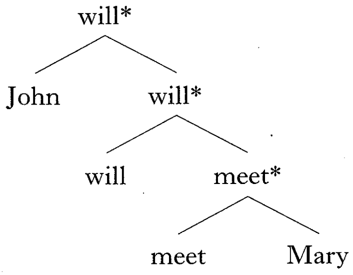
(2)



Reading the terminal nodes of (2) from left to right yields its PF-interpretation. The non-terminal nodes are ignored under this task but have functions such as defining constituents and important syntactic relations holding among them such as binding.

The theory of bare phrase structure proposed by Chomsky (1994) and pursued in Chomsky (1995, 1999, 2000, 2001) and others is innovative in simplifying the node labeling system by eliminating non-branching intermediate nodes and using input lexical items as projection labels. In particular, the bare phrase structure representation of (2) is (3), where lexical items as projection labels are asterisked.

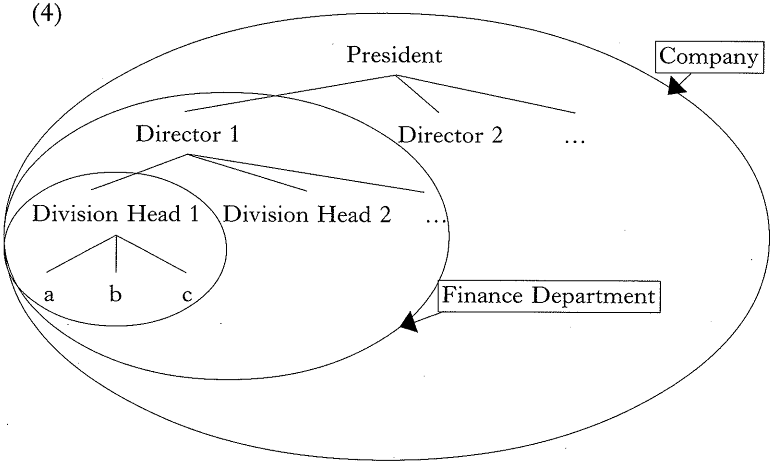
(3)



Still, (3) is no different from (2) in retaining the traditional distinction between terminal nodes, which have PF value, and non-terminal nodes, which do not. Thus, the trivial algorithm for deducing word order mentioned above is available. Chomsky, however, does not adopt it, abstractly assuming a tree representation without property (iii). Along this line, Kayne (1994), Takano (1996), and Fukui and Takano (1998) propose ingenious theories of word order, rejecting the algorithm inherent to a tree representation. These attempts appear to be against the afore-mentioned insight in computer science; choosing an ordered tree makes its PF-interpretation extremely easy, but this naturally given algorithm is turned down. If word order plays no substantial role in the core syntactic computation, we should adopt a truly order-free representation.

In fact, linearization of terminal nodes has no significant meaning in more typical usages of tree as data structure. For example, all the workers of a company can be naturally represented as a tree: the president is the root node, and those who are next in the administrative hierarchy are directly dominated by the president and so on. In this case, the terminal nodes are clerks without any subordinates and lining them up is not particularly meaningful. More important are the subtrees rooted by each of the non-terminal nodes, which correspond to the departments and subdepartments of the company, as described below:

(4)



The whole tree is the company, and the subtree rooted by Director 1 is one of its departments, say, Finance Department, which in turn has several divisions. In this way, each non-terminal node in (4) has the double function of representing a department/section of the company and its chief. Going back to (2), the two terminal nodes *meet* and *Mary* form the constituent that is headed by *meet*, which is represented by the projection node VP. By analogy to (4), we can say that *Mary* belongs to the group headed by the verb *meet*. Then, constituency represented by projection nodes in (2) should be expressible by subtrees without them. (3) might be closer to (4) in that a lexical head is used as the label of the constituent it heads in addition to that of itself, but its multiple appearance is superfluous.

The nodes of (4) are persons working for the company, and there are a number of ways to list them up. For instance, we can start from the president, list up all the department directors, followed by the section heads and so on. Another systematic way is to line up all the members of one of the smallest sections of some department, followed by those of another section of the same department, and so on. Other orderings of the workers are conceivable. (4) is thus not inherently associated with a fixed ordering of its nodes unlike (2) and (3), although all of them are trees. If the configurational property of a sentence is expressed on a par with (4) rather than (2) and (3), it can be regarded as an order-free representation. In this paper, I will propose a theory of order-free syntactic representation along this line.

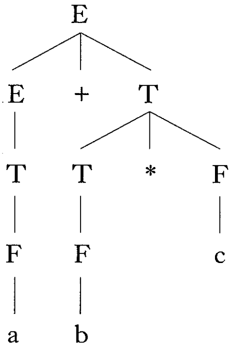
The rest of this paper is organized as follows: I will discuss in Section 2 how arithmetic expressions can be represented in an order-free manner and mapped into multiple orderings by the simple tree traversal algorithms commonly used in computer science. In Section 3, I will extend the order-free notation that dispenses with projection labels to Japanese and English sentences without losing an explanatory basis for constituency and core syntactic relations, which have been defined in terms of PF-vacuous projection labels in standard tree representations. Section 4 will be concerned with the limited application of the order-free notation in Brody (2000) and its weaknesses. In Section 5, I will argue that the left/right distinction of each node's children, which is crucial for the traversal algorithms to work, can be properly made according to the derivational history of structure building. I will further claim that two of the major parametric differences between Japanese and English are attributed to the distinct modes of traversal: word order variation in Japanese and its absence in English, and overt movement properties in English and their absence in Japanese. Section 6 will be devoted to an elaboration of the traversal algorithms in terms of the abstract data structure called stack. Remaining issues will be briefly discussed in the last section.

2. Order-free representations of arithmetic expressions

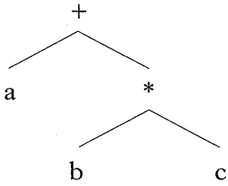
Arithmetic expressions familiar to most of us such as (5) can be represented by the two kinds of trees in (6a,b).

(5) a+b*c

(6) a.



b.



(6a) is on a par with trees assumed in generative syntax; the non-terminal nodes of (3a) have no PF values and (5) is derived straightforwardly by lining up its terminal nodes from left to right. (6b), on the other hand, does not so simply define the order in (5); + immediately dominates *a* and * but it neither precedes nor follows them.

There is a well-established algorithm that derives (5) from (6b) (cf. Knuth (1997) among others). The nature of a tree is recursive in that any of its subtrees has a tree structure with the properties (i) - (iii), which offers the following recursive algorithm for ordering the nodes in (6b):

(7) If there is a node p, then
  i. traverse p's left child,
  ii. pronounce p, and
  iii. traverse p's right child.

If (7) is applied to the root of (6b), (7) is called again and applied to its left child, namely, *a*. Since *a* has no child nodes, (7i, iii) are skipped and only (7ii) is executed, which results in the pronunciation of *a*. At this stage, (7i) of the first application of (7) to the root has been carried out, so that (7ii) is executed, which results in the pronunciation of the root +. Then, (7iii) of the initial application of (7) is carried out, which eventually leads to the pronunciation of the remaining nodes in the order *b* * *c*. (7) is referred to as inorder traversal algorithm in computer science, and (5) is the PF-interpretation of (6b) obtained through it. Applying (7ii) before and after (7i, iii) yield (8a, b), respectively.

(8) a. +a*bc

b. abc*+

The two algorithms at stake are called preorder and postorder traversals, respectively. (5) and (8a,b) have the same interpretation if multiplication (*) is given priority to addition (+) in (5) as is usually assumed.

According to (7) and their preorder and postorder counterparts, the nodes are traversed exactly in the same order but they are pronounced at different times, as illustrated below:

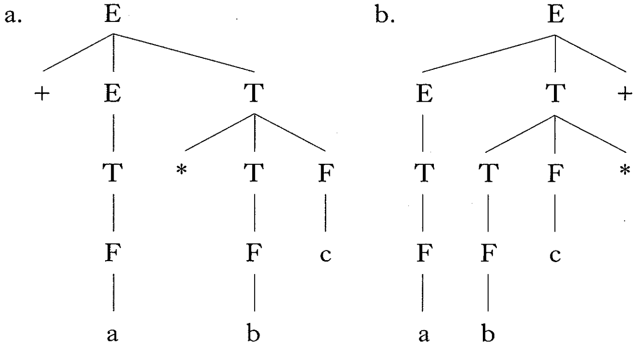
(9) a. preorder: $\underline{+}\ \underline{a} + \underline{*}\ \underline{b} * \underline{c} * +$ (= (8a))

b. inorder: $+ \underline{a}\ \underline{+} * \underline{b}\ \underline{*}\ \underline{c} * +$ (= (5))

c. postorder: $+ \underline{a} + * \underline{b} * \underline{c}\ \underline{*}\ \underline{+}$ (= (8b))

Each symbol is pronounced in the underlined position. In this way, (6b), which itself does not define any word order, can be rendered into (5) and (8a,b) by the independently defined algorithm given in (7) and its variants. In contrast, (6a) is associated only with the expression in (5); (8a,b) require distinct trees in (10a,b).

(10)



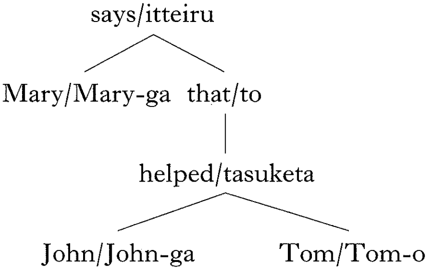
It can be said that (6b) is an order-free or purely configurational representation shared by the three arithmetic expressions in (5) and (8a,b).

3. An initial extension of order-free representations to natural languages

Addition and multiplication are two-argument functions like transitive verbs in natural languages. The arithmetic expressions in (5) and (8b), therefore, can be regarded on a par with sentences of head-initial and head-final languages, respectively. In particular, the English and Japanese sentences in (11a,b) can be associated with the bilingual tree in (12) if the predicate-internal subject hypothesis is not taken and other details are set aside:

(11) a. Mary says that John helped Tom.
b. Mary-ga John-ga Tom-o tasuke-ta to ittei-ru
Nom Nom Acc help past Comp say-pres

(12)

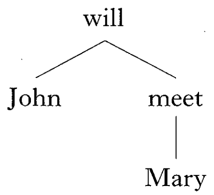


(12) has almost the same configuration as that of (6b); thus, (11a, b) are expected to be derivable by pronouncing the nodes in (12) in the inorder and postorder manners stated in Section 2, respectively. One proviso is that the traversal algorithms work properly only if each node's left and right child are distinguished. I will argue in Section 5 that the distinction is made based on the derivational history of sentence formation.[1)]

While Kayne (1994) argues that Japanese shares the universal SVO or SHC order with English, I will stand on a more conservative position: they are hierarchically the same but linearly different. What is innovative in the present theory is that an order-free representation such as (12) is adopted to capture the configurational properties of a sentence and it is mapped into more than one ordering. The two kinds of traversals mentioned above constitute the parameter for deducing word order differences. The spirit is quite close to Kayne's idea of mapping asymmetric c-command into linear ordering in that the whole configurational representation of a sentence determines its word ordering but the claim is quite the contrary.[2)]

Let us examine how constituency can be defined in the order-free notation. (2) and its equivalent under the bare phrase structure theory in (3) can be simplified as in (13):

(13)

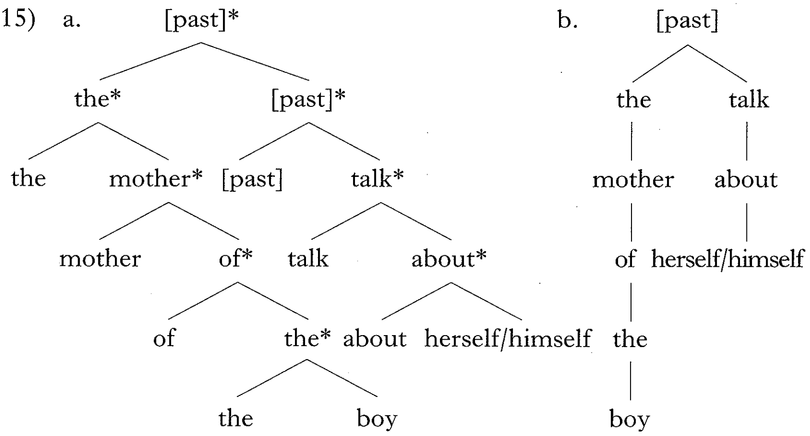


(13) will be elaborated in Section 5 by incorporating the light verb and the predicate-internal subject hypothesis. (13) has two non-trivial (sub) trees: the whole tree rooted by *will* and the one rooted by *meet*. The two (sub) trees are the constituents expressed by the upper *will** and *meet** in (3). (13) has no subtree that corresponds to the lower *will** in (3) or the intermediate projection I' in (2). This is a welcome result if an intermediate projection is syntactically and semantically invisible as Chomsky (1994: 10) claims.

C-command can also be defined without recourse to projection labels. (14) shows a typical contrast in reflexive binding, and its bare phrase structure and order-free representations are (15a, b), respectively.

(14) The mother of the boy talked about herself/*himself.

(15)



In (15a), the upper *the** is immediately dominated by the root, which dominates the reflexive, but the lower *the** is immediately dominated by of*, which does not dominate the reflexive: the latter does not c-command and hence does not bind the reflexive. Applying the same definition of c-command to (15b) can account for the contrast; the upper *the* c-commands the reflexive but the lower *the* does not. Note that in the subject of (15a), the upper *the* c-commands *of*, the lower *the*, and *boy*, while it is not the case in (15b). Long-distance binding, which hold between phrases, is attested in many languages, but heads are not known to be related non-locally. This supports (15b) over (15a); a head fails to c-command distant heads within its complement.

It can be said that constituency and core syntactic relations such as binding can be defined in the order-free notation, without recourse to PF-vacuous projection nodes that have been standardly assumed in syntactic representations.

4. Brody (1998)'s Mirror Theory and Kayne (1994)'s Universal Order Hypothesis

In an order-free representation like (15b), a head immediately dominates its spec and complement just as an arithmetic operator directly connects to its operands in (3b) and a department director of a company directly dominates his or her subordinate in (4). (3b) and (4) presumably look natural but (15b) might not to most linguists in the long tradition of generative grammar. Brody (1998) is an exception, adopting the order-free notation in a limited part of syntactic representation, but his usage of the notation is motivated to express the head-complement order directly under Kayne's universal order hypothesis, contrary to the position here.

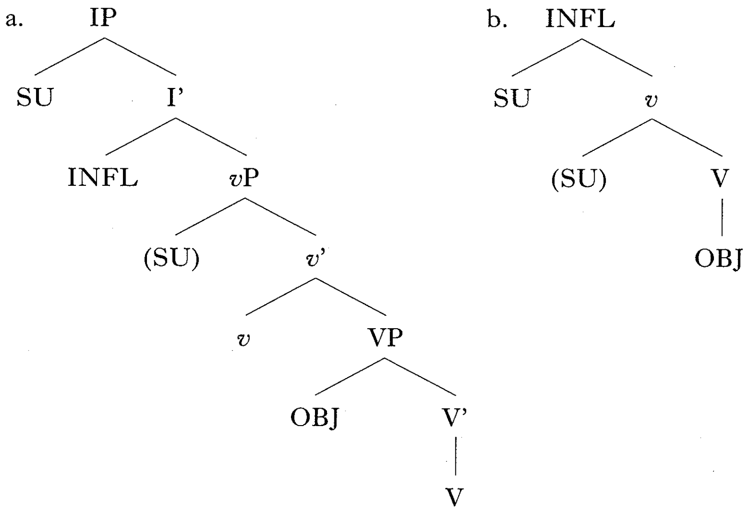
The most important in Brody's theory is the mirror principle in (16).

(16) X is the complement of Y in syntactic structure only if Y-X form a morphological unit.

(16) is intended to account for the symmetry observed between syntactic structures of head-initial languages like English and their morphological

structures. In particular, the order of a verb and its associated functional heads in English is the mirror image of their morphological realizations. Consider the schematic clausal structure in (17a).

(17)



In (17a), INFL selects a projection of the light verb *v*, which selects a projection of V; the three elements appear linearly in the order INFL-*v*-V. They form a morphological unit V-*v*-INFL. To express this inverse relation directly, Brody reduces (17a) to (17b), where the three morphemes in question are directly connected without projection nodes in the reverse order of the morphological unit they form. The order-free notation is adopted here to express the head-complement relations established by INFL, *v* and V.

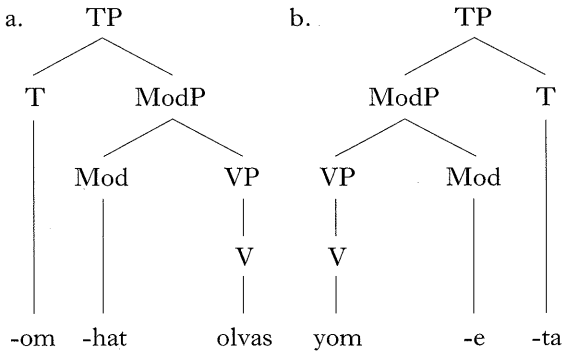
If a representation without projection nodes is suitable to express head-complement relations such as those holding between INFL, *v* and V in English, it is not unreasonable to extend it to other types of head-complement relations as well as spec-head relations. What (16) says, however, is that Y is the complement of X only if Y is a suffix that is to be attached to the right of X; if Y is a free morpheme, it is not the complement of X but a spec of X or the spec of some element of X. In particular, the overt complementizer *that* and a modal like *should* do not form a morphological unit; neither does *should* form a morphological unit with the following main verb. Brody is forced to conclude that the main verb should be analyzed as a spec of *should*, which in turn should be analyzed as a spec of the complementizer. Moreover, when a [WH] COMP selects a clause headed by the modal *should*, a *wh*-phrase it attracts and *should* have to be analyzed as specs of it (and some functional head related to it).

Instead of adopting Brody's radical definition of head-complement relation, I will maintain that all constituents that have long been regarded as complements are in fact complements, and represent them without projection nodes as in (15b). It is partly because the mirror principle in (16) has some unwanted arbitrariness, which comes from the question of why the constituents of a morphological unit must appear in reverse syntactically; they might as well appear in the same order. Actually, in Japanese and many other head-final languages, a verb and its associated bound morphemes like tense and aspect appear in the same order in syntax and morphology. Brody cites the Hungarian example in (18b) to support his mirror theory, and (18b) is a similar example from Japanese.

(18) a. olvas-hat-om
read-permissive-1sg/pres
b. yom-er-ta
read-can-past

The order of the three morphemes in (18a) is mirrored in (19a).

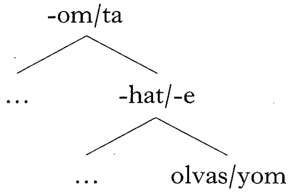
(19)



For (18b), I assume a conservative analysis in (19b) without adopting

Kayne's universal SHC order hypothesis. The order of the morphemes in (18b) coincides with that in (19b). Applying the order-free notation to (19a,b) yields the bilingual representation in (20).

(20)



On the other hand, Brody reduces only (19a) into (20), providing (19b) with a head-initial representation involving abstract functional heads and movement triggered by them. It is well-known that a morphological unit is universally right-headed (c.f., Williams (1984)); however, syntactic structure is left-headed in English, Hungarian and others while right-headed in languages like Japanese and Korean at least on the superficial level. In theory, syntactic head-complement structure and morphological structure can be (i) in a mirror-image relation or (ii) a normal-image relation, and the universal word order can be (iii) head-initial as in (19a) or (iv) head-final as in (19b). Brody adopts the combination of (i) and (iii) based on the fact exemplified by (18a), but what (18b) straightforwardly suggests is that (ii) and (iv) are correct.[3] The morphemes in (18a, b) appear to be equally strongly bound with each other, disallowing any material to intervene among them. If (i) and (iii) are assumed, the straightforward account of the morphological unity of (18a) based on the order-free notation in (20) is not applicable to that of (18b), and the opposite is true if (ii) and (iv) are assumed.

The above dilemma can be circumvented if the universal word order hypothesis, whether it is (iii) or (iv), is given up. If syntactic structure can be left-headed or right-headed but morphological structure is universally right-headed for some reason that does not concern us here, a free morpheme appears according to the head-parameter value but the right-headed principle in morphology overrides it if the element in question is a suffix. Aoyagi (1998) pursues this line of analysis for Japanese under

Kayne's hypothesis. The reasoning can be applied in the opposite way; in head-final languages like Japanese, the head-parameter value is respected in morphology but it is overridden in head-initial languages if suffixes are involved as in (17a) and (18a).

Brody's mirror theory is an attempt to capture the strict locality observed on the sequence of INFL, *v* and V in English and others in terms of representations without projection nodes, and to deduce the syntactic head-complement relation from morphology. I have argued in this section that the head-complement relation should not be so narrowly limited and that the order-free notation should be adopted extensively to express any local syntactic relations regardless of whether they correspond to morphological local relations or not.

5. The spec/complement distinction based on the derivational history

Analyses of the word order variation or scrambling phenomena in Japanese fall into two major types: configurational and non-configurational. The configurational approach is represented by Saito (1985), according to which the basic word order of Japanese is SOV, or more generally SCH, and the spec is positioned hierarchically higher than the complement just as in English. A so-called scrambled sentence is assumed to be derived by a syntactic operation. The non-configurational approach is proposed by Hale (1980, 1981) and Farmer (1984), where a Japanese sentence is assumed to be 'flat' with no hierarchical distinction among arguments. The essence of this approach is that scrambled sentences are base-generated without recourse to a syntactic operation. Recent versions of essentially the same idea are proposed by Bošković and Takahashi (1998), and Ikawa (2003). The theory advocated here is configurational in that Japanese and English are assumed to have the same hierarchical structure, but differs from Saito's position in 'base'-generating sentences with basic and scrambled word orders, deriving them from the shared order-free representation.

The configurational approach generally assumes (21a, b).

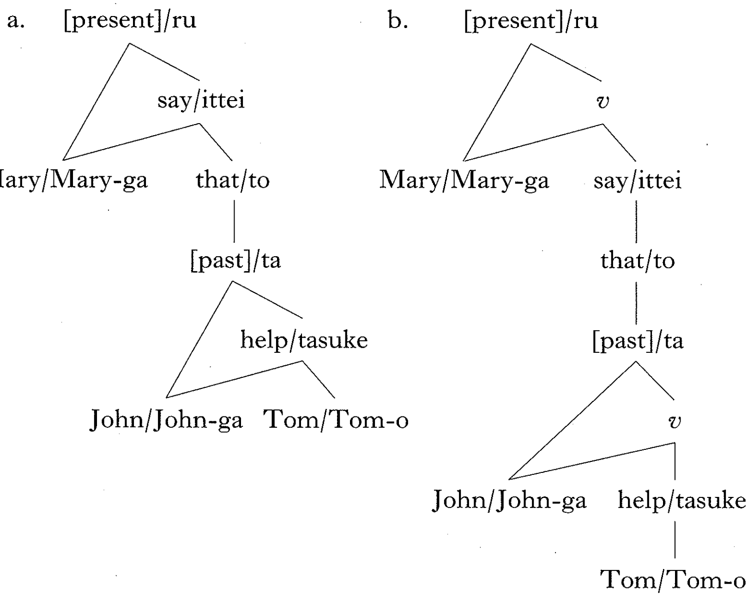
(21) a. The selectional requirement of an internal argument of a lexical head is satisfied before that of its external argument.
b. The selectional requirement of a functional head is satisfied before its agreement (or feature-checking) requirement.

(21b) is uncontroversial in resent minimalist research. (21a) is based on the external/internal distinction among arguments proposed by Marantz (1984), Williams (1984) and others. I will assume that just like ordinary trees, order-free representations are built bottom up according to (21a, b). Merging two objects here means adding one ordered pair or directed edge to the graph already formed. Then, (22a, b) hold.

(22) Given a lexical item as a node p in the graph formed,
a. If p has two downward edges, the one connecting to its complement or internal argument is added before that connecting to its spec/external argument.
b. If p has just one downward edge, it connects to its complement/internal argument.

p's left child is the spec/external argument, and p's right child, the complement/internal argument. In this way, the left/right distinction of each node's child nodes can be properly made based on the derivational history of sentence formation, and the traversal algorithms given in Section 2 can properly derive the SHC and SCH order from an order-free representation like (12). This point will be elaborated in the next section.

Going back to (12), if the predicate-internal subject hypothesis is taken, it should be replaced by (23a) or (23b):

(23)


(23a) involves two verbs and they immediately dominate the heads of their external and internal arguments. (22a, b) ensure that their left and right child nodes can be distinguished on the basis of the derivational information on (23a). In (23b), the light verb is posited, which helps distinguish the external and internal arguments hierarchically. Since the light verb and a lexical verb it selects are subsequently combined by head-movement, (23b) will become indistinguishable from (23a) at the point where it is subject to PF-interpretation. Thus, I will assume the analysis without the light verb here for ease of exposition.

(23a) by definition is not a tree, but it has the property (i) and all of its subtrees do the same. The subjects are doubly pronounced if (7) applies to (23a): immediately before the tenses as well as the verbs. This can be avoided simply by modifying the first part of (7) as follows:

(24) If there is a node p and p has not been pronounced, then

(24) guarantees that those nodes that have been pronounced are never traversed. The inorder and postorder traversals of the English and Japanese versions of (23a) with the modification in (24) are given in (25a, b),

respectively:

(25) a. [present] → Mary → [present] → say → that → [past] → John → [past] → help → Tom → help → [past] → that → say → [present]
(cf., (11a) Mary says that John helped Tom)
b. ru → Mary-ga → ru → ittei → to → ta → John-ga → ta → tasuke → Tom-o → tasuke → ta → to → ittei → ru
(cf., (11b) Mary-ga John-ga Tom-o tasuke-ta to ittei-ru)

In (25a), *Mary* is pronounced due to the edge coming from the matrix tense, so that it is skipped in the traversal stating from the verb *say*. The same is true of *John* in (25a) as well as *Mary-ga* and *John-ga* in (25b).

It has been shown that two orderings have been derived from the single order-free representation in (23a). Actually, the Japanese sentence in (11b), which has the so-called basic word order, has other variants given in (26b-d):

(26) a. [Mary-ga [John-ga Tom-o tasuke-ta] to ittei-ru] (= (11b))
Nom Nom Acc help-past Comp say-pres
b. [Mary-ga [Tom-o John-ga tasuke-ta] to ittei-ru]
c. [[John-ga Tom-o tasuke-ta] to Mary-ga ittei-ru]
d. [[Tom-o John-ga tasuke-ta] to Mary-ga ittei-ru]

A single application of clause-internal scrambling to the embedded and matrix clauses, respectively, produces (26b, c), and its double application yields (26d). How can (26b-d) be obtained from (23a)?

Note that the postorder traversal in (25b) that generates the basic word order in (26a) is not economical in that most of the nodes are pronounced at later stages, which are indicated by underlines. The inorder traversal in (25a) takes ten steps to pronounce all the nodes of (23a), and the last five steps have no PF effects. On the other hand, the postorder traversal in (25b) requires all the steps to pronounce the nodes of (23a). This is because a postorder traversal starts from the root but the root is pronounced at the very end by definition. A postorder traversal is more economical if it starts from a leaf node, which by definition is pronounced immediately. (23a) has three leaf nodes and starting from each of them in the postoder and depth-priority manner yields (27a-c):

(27) a. Mary-ga → ittei → to → ta → John-ga → ta → tasuke → Tom-o
→ tasuke → ta → to → ittei → ru (= (26a))
b. John-ga → tasuke → Tom-o → tasuke → ta → to → ittei →
Mary-ga → ittei → ru (= (26c))
c. Tom-o → tasuke → John-ga → tasuke → ta → to → ittei →
Mary-ga → ittei → ru (= (26d))

(26b) can be derived as a variant of (27a) by traversing the right child of *tasuke* before its left child. (27a), which yields the same PF output as (25b) does, requires thirteen steps before all the nodes are pronounced, while (27b, c) take only ten just like the inorder traversal given in (25a). (25a) and (27b, c) can be said to be more economical than (25b), (27a) and its variant producing (26b). Note that the complement clause in (26a, b) is center-embedded, while that of (26c, d) is positioned on the left edge and that of the English sentence in (11a) is on the right edge. Hawkins (1994) argues that center-embedding causes parsing difficulties. In fact, (26a, b) require a pause before the beginning of the complement clause in pronouncing and understanding them.

It has been argued that a given order-free representation can be traversed in inorder or postorder, which constitutes the parameter. The root is assumed to be the only starting point in the standard traversal algorithms. The root is special in that it dominates all the other nodes. A leaf node is special in the opposite sense: it dominates no nodes. It is natural to include leaf nodes as possible starting points in addition to the root. I will claim that parsing decides or imposes a preference on the starting node of each traversal: an inorder traversal starts from the root, while a leaf node distant from the root is a preferred starting point in a postorder traversal.4) Since an order-free representation has only one root node but usually has more than one leaf node, head-final languages like Japanese, which are subject to the postorder traversal algorithm, show word order variation, whereas English and other SHC languages do not.

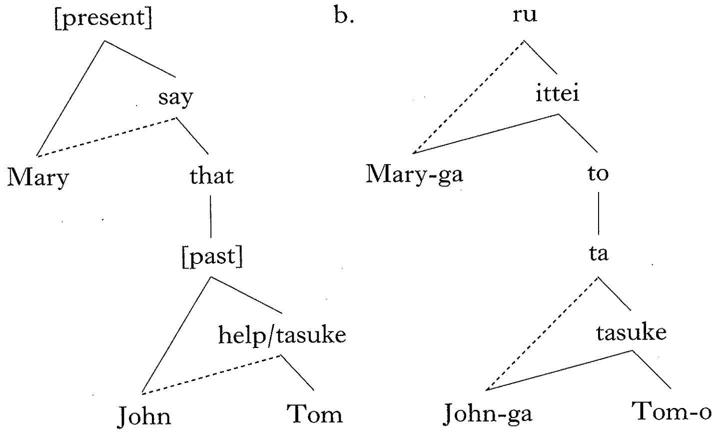
In this connection, a case of long-distance scrambling such as (28) cannot be derived by a systematic traversal of (23a), which is a welcome result.

(28) [Tom-o$_i$ [Mar-ga [John-ga t_i tasuke-ta] to ittei-ru]
Acc Nom Nom help-past that say-pres
"Tom, Mary says that John helped."

To derive (28) from (23a), it is necessary to start from the embedded object, skip the embedded subject, pronounce the matrix subject, go down to the embedded verb and finally go up to the root. This traversal is unsystematic and extremely inefficient. The scrambled constituent is stressed and focused unlike the left-peripheral phrases in (26c, d), and it should be analyzed as deriving from a distinct configuration. I will conclude that the kind of variation arising from the multiplicity of postorder traversal is limited to cases of clause-internal scrambling.

In addition to the difference in word order freedom, another major contrast between Japanese and English can be naturally accounted for under the present theory: English has overt leftward movement while Japanese does not. This point can be illustrated with the traversals in (29a,b), which result in (11a) and (26c), respectively

(29) a. b.



Since the inroder traversal in (29a) starts from the root, the matrix subject is pronounced due to the edge coming from the root rather than the one from the verb *say*; for the same reason, the embedded subject is traversed after the embedded tense but not after the verb, which is hierarchically lower than the tense. The edges that have not be traversed are indicated by broken lines. In contrast, the postorder traversal (26c) depicted in (29b) begins at the embedded subject and processes the rest of the representation in a depth-priority manner. The two subjects are doubly-connected and the edges coming form the lower node are traversed. According to the theory here, overt movement or displacement amounts to the pronunciation of a doubly-connected node by traversing the edge coming from a node nearer to the root and bypassing the one from the lower node. (29a) involves overt movements in this sense, whereas (29b) does not.

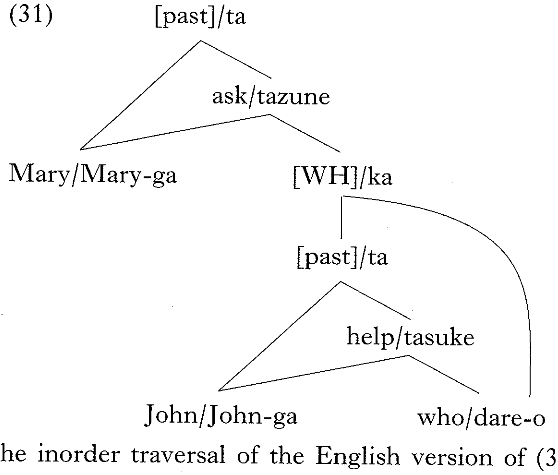
Since each of the subjects in (29a, b) is dominated by the two nodes that are directly connected to each other, displacement properties are not obvious. The contrast shows up more clearly in case of *wh*-movement. (30a, b) are to be analyzed as sharing the representation in (31).

(30) a. [Mary asked [who John helped]]

b. [[John-ga	dare-o	tasuke ta ka]	Mary-ga	tazune-ta]
Nom	who-Acc	help-past Q	Nom	ask-past

Lit. "John helped who, Mary asked."

(31)



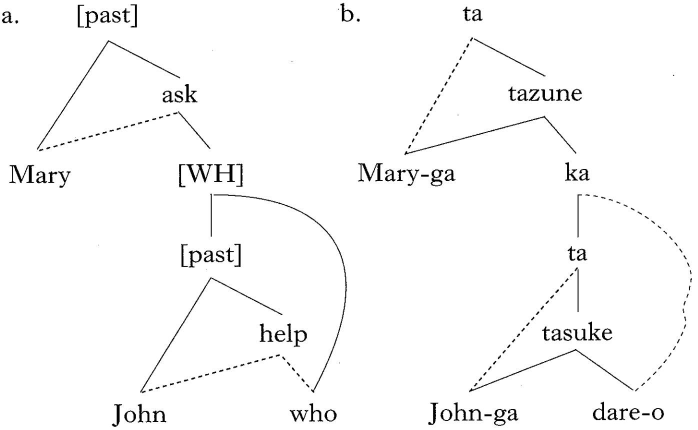
The inorder traversal of the English version of (31) that starts from the root is given in (32a), and the postorder traversal of the Japanese version that starts from the embedded subject is described in (32b).

(32) a. [past] - Mary - [past] - ask - [WH] - who - [WH] - [past] - John - [past] - help

b. John-ga - tasuke - dare-o - tasuke - ta - ka - tazune - Mary-ga - tazune - ta

The edges traversed in each case are as follows:

(33) a. b.



At the point where the inorder traversal that has started from the matrix tense reaches [WH], there are two ways to go: towards the embedded tense or *wh*-phrase. Since the sentence is constructed according to (21a, b), the edge or ordered pair with the *wh*-phrase has been added later than the one with the embedded tense; the *wh*-phrase is the spec or left child of [WH], and the embedded tense its complement or right child, though they are depicted in the opposite way in (33a). It follows that the *wh*-phrase is traversed and pronounced before the embedded tense, and accordingly, its edge coming from the embedded verb *help* is not traversed. On the other hand, the postorder traversal in (33b) starts from the embedded subject *John-ga*, goes up to the branching root, *tasuke* (help), and makes the *wh*-phrase pronounced It should be noted that since it is postorder, the traversal goes back to the branching root instead of climbing the other edge connecting to *ka* (Q). In this way, *wh*-movement in the two languages can be analyzed uniformly as involving a *wh*-phrase connected to a [WH]

COMP attracting it as well as to a lexical category selecting it. The difference is that the *wh*-phrase is pronounced near the [WH] COMP in English, while it is pronounced near the verb selecting it, which is due to the distinct modes of traversal.[5)]

6. Stack as a Representation of Derivational History

As mentioned in the previous section, merging a head X and a non-head Y (spec or complement) to built up an order-free representation is to add an ordered pair ⟨X, Y⟩ to the set E of the ordered pairs already introduced. It has been argued that an ordered pair is created according to (21a, b), from which (22a, b) follow. Let us assume that ordered pairs are indexed incrementally as they are added to E. Then, (22a, b) can be restated as (34a, b), respectively.

(34) Given a lexical item as a node p in the graph already formed,

a. If p appears as the first member of two ordered pairs ⟨X, Y⟩ with index i and ⟨X', Y'⟩ with index j ($i > j$), Y is p's spec/external argument (left child) and Y' is its complement/internal argument (right child).

b. If p appears as the first member of one ordered pair ⟨X, Y⟩, Y is p's complement/internal argument (right child).

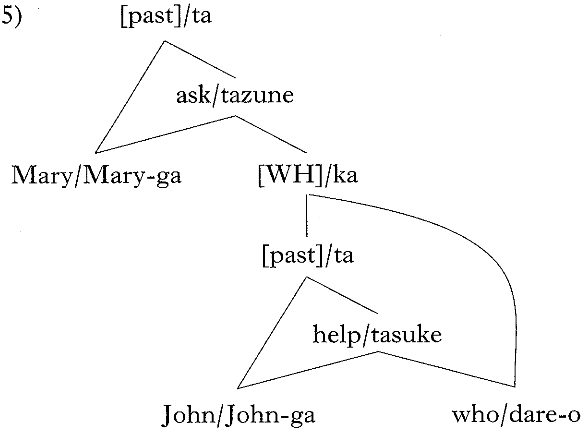
c. If p does not appear as the first member of any ordered pair, it is a leaf node.

d. If p appears as the second member of two ordered pairs ⟨X, Y⟩ with index i and ⟨X', Y'⟩ with index j ($i > j$), X is the functional head that has attracted p, and X' is the lexical category selecting p.

(34c, d) are added, which characterize a leaf and a doubly-connected node, respectively.

(34a-d) can be illustrated with the formation of the English version of (31) repeated below as (35). The ordered pairs constituting (35) are added as in (36).

(35)



(36)

index	0	1	2	3	4
E	⟨help, who⟩	⟨help, John⟩	⟨[past], help⟩	⟨[past], John⟩	⟨[WH], [past]⟩
index	5	6	7	8	9
E	⟨[WH], who⟩	⟨ask, [WH]⟩	⟨ask, Mary⟩	⟨[past], ask⟩	⟨[past], Mary⟩

The verb *help* appears as the first memeber in pairs 0 and 1; the second member of pair 1 is its external argument and that of pair 0 is its internal argument. *Who* appears as the second member in pairs 0 and 5; the first member of pair 5 is the [WH] COMP that has attracted *who*, and that of pair 0 is the verb selecting it. Note that the root of the whole graph is the first member of the last ordered pair. Intuitively speaking, traversing (36) in inorder is to process ordered pairs according to the descending order of their indices: the second member of the pair with index 9 is pronounced first, its first member, which is identical to the first member of the pair with index 8, is pronounced next, the second member of the pair with index 8 is pronounced next, and so on. Since a node that has been pronounced is not traversed again, a doubly-connected node such as *who* in (36) is pronounced based on a pair with the larger index, namely pair 5. The ordering obtained is (30a) discussed in Section 5.

This kind of data structure is called stack or last-in, first-out (LIFO) list: a piece of data added last is to be popped up and processed first. Fukui and Takano (1998) suggest that structure-building and its linear realization could be based on a stack, though they do not implement them along that line and they assume the head-final order to be derived universally, contrary to the position here.[6)]

Since the SHC order of English can be derived on a LIFO basis, the head-final order of Japanese is expected to be obtainable in a first-in, first-out (FIFO) manner. This is in fact basically correct. Consider the Japanese counterpart of (36) given in (37).

(37)

index	0	1	2	3	4
E	⟨tasuke, dare-o⟩	⟨tasuke, John-ga⟩	⟨ta, tasuke⟩	⟨ta, John-ga⟩	⟨ka, ta⟩
index	5	6	7	8	9
E	⟨ka, dare-o⟩	⟨tazune, ka⟩	⟨tazune Mary-ga⟩	⟨ta, tazune⟩	⟨ta, Mary-ga⟩

As argued in the previous section, an economical postorder traversal should start from a leaf node. (35) contains three leaf nodes, which appear as the second members of pairs 0, 1, 3, 5, 7 and 9. If we start with the pair with the smallest index in them, namely pair 0, its second member is pronounced first. The first member of pair 1 is identical to that of pair 0; the second member of pair 1 is its external argument and thus pronounced next, followed by the pronunciation of its first member. The remaining pairs will be processed similarly according to the ascending order of their indices. The PF output of this traversal is (38a).

(38) a. [[dare-o John-ga tasuke-ta ka] Mary-ga tazune-ta]
b. [[John-ga dare-o tasuke-ta ka] Mary-ga tazune-ta] (= (30b))
c. [Mary-ga [John-ga dare-o tasuke-ta ka] tazune-ta]

The starting leaf node to derive (38b) is *John-ga*, which appears in pairs 1 and 3; the former has the smaller index. Since the traversal algorithms advocated here are essentially of the depth-priority nature just like the standard algorithm given in (7), given p as the current node, those pairs that are related to p with smaller indices (or "deeper" pairs) are to be processed before those with larger ones.[7] Processing of pairs 1 and 0 results in the embedded clause of (38b). The remaining pairs will be processed in a FIFO manner. (38c) can be obtained by starting with pair 7, processing pairs 6 to 0 and finishing up with the last two pairs.

The above algorithms based on a set of ordered pairs allow a traversal to proceed from non-head to head as well as from head to non-head; only the latter is possible in the standard traversal algorithm in (7). Formalization of the bi-directional algorithms is more complicated than (7), but they yield a wider range of orderings that are empirically attested in Japanese and English.[8]

7. Remaining Issues

This paper has been an attempt to formalize a theory of order-free syntactic representations and to deduce from it some of the major parametric differences in word order between Japanese and English. One important operation that greatly affects word order but cannot be discussed here is head-movement. Another issue, which has not been explored here or solved in other syntactic studies, is a treatment of adjuncts. It is not clear whether they are introduced by external MERGE or some comparable operation at the edge of the graph already formed, or they are inserted into the graph post-cyclically. Moreover, locality of overt movement has not been discussed so far. According to the theory here, a *wh*-phrase is connected to a lexical category selecting it as well as to a [WH] COMP, which is true both in Japanese and English. It has been argued that the edge coming from the former is processed for PF-interpretation in Japanese, while the one coming from the latter is in English. It might be the case that an edge cannot be introduced if the two nodes to be connected by it are separated by barriers, which are to be formalized somehow in the present theory. I leave these problems for future research.

Notes

1) The theory to be proposed below is an extension of Yasui (2002, 2003a, 2003b, 2004).

2) Whitman (2001) presents several pieces of evidence to support the head-initial underlying structure for Japanese. One of them is the contrast observed in Saito and Murasugi (1990: 291–292). Second, Whitman, following Kayne's idea, assumes that the nominative case-marker takes a clause on its right and a noun phrase moves out of the clause to its spec position. If this is correct, the nominative case-marker and the preceding noun phrase do not form a constituent. Whitman argues that this conclusion is supported by the fact that a nominative phrase resists scrambling, as exemplified below:

(i) *[sono hon -ga [Taroo -ga [*t* ii to] omottei-ru]] (koto)
that book -Nom Nom good Comp thinking-pres fact
"(that) that book, Taroo thinks is good"

Scrambling of a nominative phrase is possible if it is semantically easy to associate with its original position as in (ii).

(ii) [Inoue Koosei koso-ga [daremo-ga [*t* mottomo tuyoi juudo-ka da]
exactly-Nom everyone-Nom most strong judo man is
to omottei-ru]] (koto)
Comp thinking-pres fact
"(that) Kosei Inoue, everyone thinks is the strongest judo man"

Then, the ungrammaticality of (i) does not show the non-constituency of the scrambled phrase but a difficulty in its reconstruction.

3) Kayne (1994: 38–41) notices this problem, illustrating it with the compound *overturn*.

4) Alphonce and Davis (1997) present a performance-based account of the presence of leftward overt *wh*-movement and the absence of comparable rightward movement.

5) An adjunct has no place in the present system, but adjunct *wh*-phrases can be analyzed essentially along the same line. The distinction between the two languages can be generalized as follows: obligatory leftward movement is attested only in languages of inorder traversal, namely, SHC languages, and there is no rightward obligatory movement. This accords with the observations by Greenberg (1970), Bach (1970) and Bresnan (1976). My account of the correlation between word order and leftward movements is close to Fukui's (1993) "parameter value preservation measure," but it also covers the total absence of obligatory rightward movement on the same basis.

6) Their linealization system is the opposite of bottom-up structure-building: it decomposes a given sentence structure in a top-down manner by detaching a

maximal projection before the head that has merged with it and pronounces the resultant sequence of maximal projections in that order.

7) Since the starting node in an inorder traversal is the root, which appears in the pair with the largest index, and only those pairs related to the root can be processed subsequently, pair 0, for instance, cannot be processed immediately after pair 8.

8) The scripts in C are available at http://www2.dokkyo.ac.jp/~esemi003/publications/index.html.

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