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Reconsidering Merge and the labeling algorithm (LA) from a biolinguistic perspective within the framework of I-language: its theoretical and empirical consequences*

Koji Hoshi

Abstract

In this article, I critically examine Merge and the labeling algorithm (LA) standardly assumed in the mainstream minimalist program from a biolinguistic perspective within the framework of I-language, proposing function-based alternatives along the lines of Hoshi (2023, 2024a) with some substantive modifications.[1] Theoretically, I argue that the so-called {XP, YP} problem regarding determination of labels is non-existent. Empirically, I demonstrate that the phenomena of scrambling, scope ambiguity, and (overt/covert) *wh*-movement discussed by Saito (2016, 2017) and

* An earlier version of a portion of this work was presented at the 96th General Meeting of the English Literary Society of Japan on May 4, 2024 (Tohoku University). I would like to express my gratitude to the audience, in particular, Satoshi Oku and Masashi Totsuka, for their valuable questions and comments. Additionally, I am deeply thankful to Nobuhiro Miyoshi, Satoru Kanno, and Hirokazu Tsutsumi for their valuable feedback during the preparation for the conference presentation. The current version includes new materials and substantial modifications of the earlier version. Needless to say, the usual disclaimers apply.

1 Throughout this piece, I will use the conventional term "Merge" rather than the capitalized "MERGE" (see, e.g., Chomsky 2021) for the following reason. MERGE is defined as taking a workspace (WS) as input, shifting it to another workspace (WS'), while combining two elements, X and Y, in the WS. Although I acknowledge that a syntactic operation like Merge must operate within a cognitively restricted workspace, the term "merge" implies just taking two (or more) entities to combine them into one in English. Therefore, it sounds somewhat odd to use it, even in a capitalized form, to refer to an operation with the form MERGE (X, Y, WS) = WS'. Consequently, I will continue to use the term Merge rather than MERGE. Nevertheless, I basically agree with Chomsky's view that Merge is binary, being subject to Minimal Search, Preservation, Restricting Resources, and Minimal Yield (see, e.g., Chomsky 2021).

Oku (2018, 2021) can be reinterpreted under this theoretical stance, without invoking the {XP, YP} problem, while discussing some consequences for externalization of the upper copy of an IMed element.

1. Introduction

In the quest of the Strong Minimalist Thesis (SMT) as a guiding principle for genuine explanation of human language as part of natural science (Chomsky 2000 et seq.), the generative enterprise has been successful in demonstrating that the core generative procedure of syntactic combinatorics has the simplest form possible as Merge, while leaving the assignment of syntactic labels to constructed syntactic objects (SOs) to an independent labeling algorithm (LA) in the mappings to the interface systems in the faculty of language (FL) (Chomsky 2013).

Acknowledging the validity of this general research direction, this article aims to critically reconsider the conventional assumptions of Merge and LA in the mainstream minimalist program and explore the possibility of alternative reformulations of Merge and LA that are more closely aligned with a rigorous I-language perspective in biolinguistics. More specifically, I will claim that both Merge and LA should be reformulated on the basis of intensional concepts of functions in connection with the minimal search (MS) as an instance of the third factor principle imposed on the interfaces (Hoshi 2023, 2024a), mulling over the theoretical and empirical consequences of the proposed reformulations of Merge and LA.[2] Theoretically, I will contend that the so-called {XP, YP} problem related to labels is non-existent. Empirically, I will investigate how this new framework can reinterpret phenomena such as scrambling, QR, and (overt/covert) *wh*-movement, as discussed in Saito (2016, 2017) and Oku (2018, 2021).

The following sections are organized as follows. Section 2 discusses possible theoretical inadequacies of the conventional formulations of Merge and LA. Section 3 puts forth alternative reformulations of Merge and LA that fit more strictly to the view of I-language in biolinguistics. Section 4 examines some consequences of the proposed new systems of Merge and LA for IM and externalization in natural language. Section 5 concludes this article.

2 Hoshi (2023) also discusses the neurobiological reason why Merge should be reformulated in terms of recursive composition of functions from the perspective of brain oscillatory nature of language. Due to space limitations, I cannot address this point in this article. See Hoshi (2023) and references cited therein for details.

2. Theoretical desiderata?

2.1. Merge

Although the original formulation of Merge in Chomsky (1995) contained labels in set-theoretic SOs, at least ever since Chomsky (2000), a more parsimonious version of Merge has been sought, reaching the simplest form of Merge by eliminating labeling from the definition of Merge per se as follows (see Collins 2002 for the first attempt. See also Epstein et al. 2022 for the historical review of Merge and Chomsky et al. 2023 for the recent development of Merge):

(1) Merge (X, Y) = {X, Y} (where X, Y = a lexical item (LI) or an SO selected in the workspace (WS))

I believe that the shift in generative grammar from geometrical tree diagram-like syntactic representations in the pre-minimalist program to set-theoretic syntactic representations in the minimalist program is a significant theoretical step toward understanding syntactic computation in the mind/brain. However, strictly speaking, such set-theoretic representations of SOs go against the fundamental tenet of generative grammar: language as I-language, where I- stands for internal, individual, and intensional (Chomsky 1986), given that the very notion of set itself is "extensional" rather than "intensional" (Hoshi 2023).

In fact, referring to I-language, Chomsky (1995, p. 15) clearly states, "… I-language, where I is to suggest 'internal', 'individual', and 'intensional'. … It is intensional in the technical sense that the I-language is a function specified in intension, not extension: its extension is the set of SDs (what we call the structure of the I-language)."

Note also that, since Merge is applied recursively, extensional sets are involved not only in the output of Merge but in the input to Merge as well. Thus, it is more desirable to conceive Merge as a purely higher-order intensional operation involving only intensional entities such as functions (Hoshi 2023).

Furthermore, to the extent that Merge is defined as involving a set-theoretic notation, a question arises as to why there is no case of intersection of two sets in syntactic derivation. Note that both external Merge (EM) and internal Merge (IM) in syntactic derivation correspond to joining of two sets to form a larger inclusive set in extensional terms.

In light of the strict interpretation of I-language and cognitive operations/computations in I-language, I will propose an intensional function-based reformulations of Merge (and LA) in section 3, departing from the extensional set-theoretic formulation of Merge.

2.2. Labeling algorithm (LA)

Chomsky (2013) argues that identifying the status of an SO created by Merge should be carried out by LA, which exemplifies the third factor minimal computation of minimal search (MS) being applied in the mappings to the interfaces (see also Chomsky 2015). He outlines three patterns of LA as shown below:

(2) a. {H, XP} (= head-complement structure)
b. {<XP>, YP} (= XP-YP structure with XP undergoing IM)
c. {XP, YP} (= XP-YP structure with agreement between X and Y)

The pattern in (2a) indicates the head-complement structure, where the head element H is designated by MS to provide the label for the entire structure {H, XP}. On the other hand, (2b) and (2c) illustrate two scenarios of the XP-YP structure. In (2b), XP undergoes internal Merge (IM), leaving a copy indicated by <XP>. According to Chomsky (2013), this residual copy <XP> is not considered for labeling because it is part of the discontinuous chain of XP under IM. Consequently, the head of YP is selected by MS to label the entire structure {<XP>, YP}. In (2c), the heads of XP and YP enter into agreement regarding features such as φ-features and Q-feature. Chomsky (2013) suggests that this agreement leads to labels like <φ, φ> or <Q, Q> for the entire structure {XP, YP}, depending on the nature of the agreement. This labeling pattern occurs when MS recognizes the shared relevant formal features in the two heads, X and Y.

There are a couple of potential theoretical problems with Chomsky's (2013) LA. First, the three label determination patterns in (2) are all different in nature, and at least between (2a-b) and (2c), there is no commonality in the nature of labels. From the perspective of optimal design and minimal computation for the faculty of language (FL), such a miscellaneous state is not theoretically desirable in minimalism, which aims to pursue as simple a theory as possible. As is often the case, such a miscellaneousness highly likely indicates overlooking of some more fundamental underlying common mechanism.

Furthermore, there are theoretical consistency issues with Chomsky's (2013) assumptions for labeling. According to the assumptions, in the case of (2b), the lower copy represented as <XP> becomes invisible for labeling purposes because it is part of a discontinuous element associated with IM. However, if we consider the upper copy in terms of MS, it should also be part of a discontinuous element in the syntactic structure, and thus, the upper copy should likewise be invisible for labeling purposes. If this were to be the case, when XP is merged to YP via IM to form the configuration {XP, YP} as in (2c), XP would become invisible for labeling, making YP as the label. Consequently, labeling through agreement feature-sharing as in (2c) would become unnecessary in the first place.

Moreover, labeling provides crucial information for the semantic interpretation of SOs at the conceptual-intentional (CI) interface (and partially for phonological interpretation at the sensorimotor (SM) interface). If <XP> associated with IM is invisible for labeling, but it must remain visible for operations such as theta-marking, it unnecessarily complicates the mechanism for the semantic interpretation of SOs. This added complexity is undesirable from the perspective of SMT.

With regard to the agreement-related labeling of <ϕ, ϕ>, Shim (2018) contends that the labeling associated with agreement, denoted as <ϕ, ϕ>, under ϕ-feature agreement presents theoretical challenges (see Shim 2018 for detailed empirical issues with Chomsky's (2013) LA). He notes that it is not clear how the non-categorial label <ϕ, ϕ> contributes to the interpretive process at the C-I interface when it serves as the label for the syntactic object {NP, TP}. He also points out that within such an agreement-related {XP, YP} structure, the LA must perform a "comparison search" between X and Y in {XP, YP} in addition to the MS in order to establish the agreement-related label <ϕ, ϕ>, thereby complicating the LA, which is suboptimal from a minimal computation standpoint. Although Shim's (2018) proposal is not identical to mine, the assertion that syntactic labeling should be limited to categorial labeling aligns with the alternative analysis I will be advancing in section 3 (see also Murphy and Shim 2020 for a broader discussion, expanding on Shim 2018).

As for the agreement-related labeling of <Q, Q>, Hoshi (2024b) claims that it is unclear whether the non-categorial label such as <Q, Q> is required as the label for interrogative interpretation of the SO {Wh, CP} at the C-I system, independently of the Q-specification of C for interrogatives. If the analysis presented in this section is on the right track, neither <ϕ, ϕ> nor <Q, Q> need not exist as valid labels for any SO in narrow syntax (NS). In my opinion, labels such as <ϕ, ϕ> and <Q, Q>

should be excluded from NS and the mapping from NS to the C-I interface along the line of Shim's (2018) view (see also his footnote 2). In fact, the proposition that agreement phenomena, encompassing both ϕ-feature and Q-feature agreement, are morpho-phonological rather than part of NS is plausible if we extend the idea that case/Case is purely a morpho(-phono)logical phenomenon proposed by Marantz (1991) and McFadden (2004) to ϕ-feature and potentially Q-feature agreement, as argued in Hoshi (2024b) (see also Frampton & Gutmann 2006 and Chomsky 2021 for the view that Case does not belong to NS but is related to the morphological domain).

On the other hand, considering the fact that an agreement inherently has some impact on the PF side, it seems quite reasonable to regard the patterns of agreement-related labeling such as <ϕ, ϕ> and <Q, Q> as being involved in computations on the PF side, even if such labeling does not pertain to NS and the CI interface. I will discuss some possible implementation of this idea in section 4.

3. Alternative reformulations of Merge and LA

In reformulating Merge in intensional terms, Chomsky's (2000, p. 133) following remark is very suggestive:

"… Set-Merge typically has an inherent asymmetry. When α and β merge, it is to satisfy (selectional) requirements of one (the selector) but not both. Fairly generally, furthermore, the selector is uniquely determined for a pair (α, β), …."

Here, (set-)Merge is regarded as inherently possessing asymmetry, where one of the elements, X or Y, always acts as the selector, providing the label for the SO created by Merge. This remark is embedded in part of Chomsky's discussion to think of a possibility to separate labeling from Merge, and now the current minimalist program views Merge as applying freely, independent of the properties of X and Y. However, Chomsky's intuition in the above quote can be reinterpreted as follows: while X and Y are freely combined by the simplest Merge in NS, when interpreting the Merge-constructed SO at the interface(s), an asymmetric selector-selectee relationship between X and Y can be read off.

Returning to Chomsky's intuition above and capturing the intensional concept of I-language more rigorously, I propose the following reformulation of Merge.[3]

3 Chomsky (2023) mentions the principle T alongside of the principle S in pursuing SMT:

(3) Function-based Merge:

Merge (X, Y) = Merge (f*, g) => f*(g) (linear order irrelevant)

(= adapted from Hoshi 2023, p. 3, with some modifications)[4]

In the case of set-Merge under this reformulation, the statuses of the merged two characteristic functions are not equal/symmetrical in their workings. One of them, indicated by f* with an asterisk, is taken to serve as a function that selects for the other function g as an element that virtually plays the role of an 'argument' for the former function. Let us call the function f* *a selector function* and the other g *an argument function* for expository purposes. Accordingly, under this function-based reformulation of Merge, Merge is a higher-order recursive function that takes in a selector function indicated by f* and an argument function indicated by g and yields a composite function indicated by f*(g) as its output as a result of functional application in a workspace (WS).[5]

[S] The computational structure of language should adhere as closely as possible to SMT.

[T] All relations and structure-building operations (SBO) are thought-related, with semantic properties interpreted at CI.

The function-based Merge and the function-based LA proposed in this article are indeed thought-related in that both of them contribute to the semantic interpretation at CI, in conformity to this fundamental tenet of the minimalist program.

4 In Hoshi (2023), I proposed the following reformulation for the function-based Merge:

(i) Function-based Merge:

Merge (X, Y) = Merge (f_x*, g_y) = [f_x*(g_y)]$_z$ (= w_z)

Note that characteristic functions in (i) contain subscripted variables such as x, y, and z, which are assumed to have specific phonological representations as their values, corresponding to lexical items/SOs indicated by the characteristic functions. I will depart from Hoshi (2023) by getting rid of these variables and instead assume that each characteristic function (whether it is simplex or complex) takes such a specific phonological representation as its argument in the process of categorization (see, e.g., Benítez-Burraco et al. 2023, Hoshi 2023, 2024b for some discussion on categorization).

5 A minor caveat is in order here. The concept of "function" assumed here is different from the concept of function traditionally used in model-theoretic formal semantics (see, e.g., Dowty et al. 1981, Heim & Kratzer 1998). All lexical items (LIs) and syntactic objects (SOs) are treated here as characteristic functions (to be served as labels for categorization), corresponding to conceptual atoms and conceptual complexes, with no model-theoretic objects as their arguments. See Hoshi (2023) for details.

Although I have been focusing on a sub-type of Merge called "set-Merge" in this article, let me briefly touch on another sub-type of Merge referred to as "pair-Merge" in the literature. Adjuncts are standardly taken care of by pair-Merge as follows (see Chomsky 2000: 133):

(4) Pair-Merge (X, Y) = <X, Y> (with the label being, say, X, as a result of adjunction of Y to X)

Dealing with the reformulation of pair-Merge in my current framework would go beyond the scope of this article, so let me just mention one possible reformulation of this mode of operation of Merge under the function-based version of Merge as follows:

(5) Pair-Merge (X, Y) = Merge (f*, g) = f*∧g

Given that adjuncts generally do not provide distinct labels for the whole SO in which an adjunct is attached to its host and that the host maintains its original label after adjunction, it is reasonable to assume that the host remains as a selector function which will take its argument function later in the derivation, while the *adjunct* function indicated by g without * will be added by conjunction ∧ rather than functional application (see, e.g., Takahashi 1994 for the treatment of adjuncts as involving conjunction. See also Parsons 1990 for the neo-Davidsonian event semantic treatment of adjuncts as conjuncts). This system will capture the fact that the adjunct function g does not serve as the argument function to the selector function f*.

Next, let us turn to the function-based reformulation of LA (for the counterpart of the conventional set-Merge). Now that Merge is reformulated as a higher-order recursive function that creates a composite function on the basis of a selector function and its argument function, a corresponding reformulation of LA is expected to be function-based as well in conjunction with the MS procedure. I propose the following as a function-based LA at the CI interface:[6]

6 One might wonder about the label for the SM interface. On the organizational relationship between the SM system and the CI system in FL, I will assume that the SM interface has access to the CI interface (and its mapping) and reads off and utilizes the information there relevant for the SM system, including information regarding labels (see Dobashi 2020 for a similar perspective on the architecture of FL). This perspective aligns naturally with

(6) Function-based LA:
The label of SOs of the form f*(g) is identified as the selector function f* by MS.

Since the selector function f* asymmetrically "embeds" the argument function g, the former is more prominent and is primarily accessed by MS, determining the label of the entire SO. For instance, in an H-XP structure, where H is the selector function f* and XP is its argument function g, if f* includes semantic features characterizing a noun or a verb, the overall label determined by the MS would be nominal or verbal in the whole syntactic configuration.[7]

In the {XP, YP} structure, in principle, ambiguity arises regarding label detection by MS. Traditionally, this theoretical issue led to the stipulations in (2b, c) to avoid the {XP, YP} problem.

I would like to claim that this kind of ambiguity is in fact effectively utilized in natural language.[8] For example, in the subject-predicate structure, if the predicate part is interpreted as the selector function (providing the label), the subject part serves as the argument function, being engaged in theta-marking. Conversely, if the subject part is construed as the selector function (providing the label), the predicate part plays the role of the argument function, aligning with the Generalized Quantifier structure interpretation (Barwise & Cooper 1981) or the Montagovian semantic treatment of the subject-predicate construction (Dowty et al. 1981), which contributes to quantification, independent of theta-marking, in natural language.

Now, let us observe how some representative SOs will be constructed by the function-based Merge and how their labels will be determined by the function-based LA proposed in this section, on the assumption that all the lexical items (LIs) and SOs correspond to characteristic functions to be employed for labels of the cognitive

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Chomsky's (2013: 4) reversed Aristotelian view of language, which posits that language is fundamentally meaning with sound or other modalities for externalization.

7 Note, in passing, that the conjunction structure f* ∧ g for adjunction (= pair-Merge) in (5) predicts that the MS for labeling for that structure will search and detect both f* and g, providing each label, e.g., verbal and adverbial, independently, unlike in the functional application structure for "set-Merge" in (3), which involves "embedding."

8 I would like to thank Nobuhiro Miyoshi for asking a question about the case of Generalized Quantifier interpretation, which led to my realization of the use of ambiguity of the {XP, YP} structure in natural language.

process of categorization in the CI system (Hoshi 2023, 2024a, b). In the following illustration, syntactic categorizers in the sense of Marantz (1997) are posited for lexical categories. However, if we consider Chomsky's assertion that I-language fundamentally serves as a mechanism for the generation of thought, then, ultimately, all LIs, including categorizers and root elements, might be thought-related constructs derived from more primitive epistemological concepts such as object/entity, event, and property. The ultimate nature of syntactic categories might even stem from the relative positional/configurational relationships within the whole syntactic structures (see Lenneberg 1967). I will leave the full considerations on this point to another occasion, though.

(7) a. v-√R*(DP) => Here, the composite function v-√R* (defined as an event predicate), which I provisionally assume to be created by Merge, serves as the selector function, taking DP as an argument function, resulting in an incomplete eventuality.[9] Due to the fact that the composite function v-√R* plays the role of a selector function, its label, that is, verbal, will be the label of the whole SO v-√R*(DP).

b. vP*(DP) => Next, vP* and DP are merged. This corresponds to the subject-predicate construction, where vP*(defined as an incomplete eventuality) is the projection of the composite function v-√R* and serves as the selector function, with the subject DP as the argument function, yielding a complete eventuality. Given that vP* is the selector function, the whole SO is labeled as verbal again, capturing the fact that the subject DP is theta-marked by the verbal element vP*. Note that the relative linear order between vP* and DP is irrelevant on a par with the set-theoretic standard notation {DP, vP}. I am assuming that both v-√R* and vP* operate as selector functions, comparable to λ-expressions in standard formal semantics (see, e.g., Dowty et al. 1981, Heim & Kratzer 1998).

Notice, however, that in the case of the subject-predicate construction, it is also possible to analyze the subject DP as a Generalized Quantifier (Barwise and Cooper 1981), which implies that the DP (specifically the D) could provide the label. In this scenario, the subject DP would function as the selector function, and the predicate vP

9 I will leave open the exact procedure of creating the composite function v-√R*. Given that head-movement is abandoned in the current minimalist program (Chomsky 2015), one possibility is to assume that it is directly constructed by Merge in NS.

as the argument function, suggesting a "reanalysis" of the whole SO as DP* (vP) (see in what follows for more discussion on this point). This means that the ambiguity in the XP-YP structure is effectively utilized in the semantic interpretation of natural language, where vP provides the theta-structure-related label, and the subject DP provides the Generalized Quantifier structure-related label.

c. T*(vP) => Here, T (tense) functions as the selector function, taking vP, which represents an eventuality, as the argument function, and producing a tensed eventuality, i.e., a situation.

d. C*(TP) => In this case, C (force) serves as the selector function, with TP as the argument function, resulting in a tensed eventuality with force, i.e., a proposition (see Ramchand and Svenonius 2014).

e. TP*(DP) => This configuration encompasses subject-raising, scrambling, and Quantifier Raising (QR) as a result of IM. In this context, TP functions as the selector function virtually acting as something like a λ-expression in formal semantics, with DP serving as its argument function (see Hirayama 2018 for scrambling; Heim & Kratzer 1998 for QR).

f. CP*(DP) => This configuration pertains to phenomena such as *wh*-movement. Here, CP functions as the selector function comparable to a λ-expression in formal semantics, with DP serving as its argument function (see Karttunen 1977; Hamblin 1973; Shimoyama 2006 for *wh*-interrogatives).

In cases of QR and *wh*-movement, however, where DP acts as a quantifier or an operator, "reprojection" (Hornstein & Uriagereka 2002) or "relabeling" (Oku 2018, 2021) occurs at Logical Form (LF)/the CI interface. This process results in the formation of a head-complement structure, where the quantifier or the operator functions as the head, and the nuclear scope, including the restricted variable, serves as the complement, with the DP essentially providing the label in such a reprojected/relabeled structure. Note that such "reprojection/relabeling" has to be theoretically possible under the MS procedure for labeling on a par with the case of the subject-predicate construction discussed above.

For theoretically implementing such reprojection/relabeling in the current

framework, I would like to adopt as a null hypothesis the idea that, in principle, the MS procedure at the CI interface can freely analyze the XP-YP structure created by EM or IM as either of the following ways, not simultaneously, though, of course, but one at a time derivationally: either XP = a selector function f* with YP = its argument function g or YP = a selector function f* with XP = its argument function.[10] Notice, however, that the emergence of such ambiguity is "in principle" but not necessarily always the case, given that whether an element can serve as a selector function f* or an argument function g depends on the CI-related semantic properties of the element in question, such as those related to individual, eventuality, quantification, etc. detected by MS at the CI interface.

4. Some consequences for IM and externalization

If the {XP, YP} problem does not exist in the first place, IM can freely apply, leaving behind copies of an IMed element, while causing no labeling problems at all in the course of derivation. There are, however, theoretical analyses in the literature based on Chomsky's (2013) LA and MS proposed for syntactic phenomena such as scrambling, quantifier raising (QR), and overt/covert *wh*-movement. As representative and important works that deal with IM and the {XP, YP} problem, I would like to take up Saito (2016) and Oku (2018) for scrambling, Oku (2018) for QR, and Saito (2017) for overt/covert *wh*-movement (see also Oku 2021) in this section.

4.1. Scrambling and QR effects

First, consider the following scrambling example in (8):

Scrambling:

(8) a. Minna-ga [$_{CP}$ Hanako-ga dono hon-o eran-da ka] sir-ita-gat-te i-ru.
all-Nom H.-Nom which book-Acc choose-Past Q want.to.know-Pres.
'Everyone wants to know which book Hanako chose.'
b. Dono hon-o$_i$ minna-ga [$_{CP}$ Hanako-ga t_i eran-da ka] sir-ita-gat-te i-ru.
(= adapted from Saito 2016, (24))

Based on Chomsky's (2013) assumption that the {XP, YP} structure created by Merge will lead to labeling failure, Saito (2016) argues that the {XP, YP} configuration is

10 I would like to thank Satoshi Oku for clarification on this point.

permitted for scrambling in Japanese, as illustrated in (8), due to the language-specific condition that suffixal elements such as suffixal particles in the language serve as "anti-labeling devices." Thus, in (8), the scrambled object *dono hon-o* 'which book-Acc' merged to the matrix clause by scrambling does not cause any labeling problem, thanks to the attached suffixal case-particle *-o*. It is well-known that English, in contrast, does not allow for scrambling, as illustrated in (9), which can be explained because of the fact that the language does not possess the relevant suffixal particles unlike in Japanese:

(9) a. John handed the book to Mary.
b.*To Mary$_j$, the book$_i$, John handed t_i t_j. (= Oku 2018, (9))

Under my current framework, this phenomenon can be quite naturally reinterpreted by considering that elements with suffixal particles in Japanese generally play the role of argument functions, while their host constituents serving as selector functions that provide the label for the entire SO.

Next, observe the following well-known contrast in QR effects between English and Japanese discussed in Oku (2018), as illustrated in (10)-(11):

QR effects:

(10) A girl recommended every boy.
a. There is x, x a girl such that for every y, y a boy, x recommended y
b. For every y, y a boy, there is x, x a girl such that x recommended y
(= adapted from Oku 2018: (1), (2))

(11) Onnanoko-ga hitori dono otokonoko-mo suisensita.
girl one every boy-mo recommended
'A girl recommended every boy'
a. There is x, x a girl such that for every y, y a boy, x recommended y
b. *For every y, y a boy, there is x, x a girl such that x recommended y
(= adapted from Oku 2018: (3), (4))

(10) shows that quantifier phrases (QPs) in subject and object can take either scope pattern, displaying scope ambiguity in English (May 1985). On the other hand, (11) demonstrates that it is not the case in Japanese, which allows for only the "surface" scope pattern (Kuroda 1970). Oku (2018) attempts to capture this contrast between

English and Japanese by relating it to another contrast on scrambling between the two languages as an instance of Szabolcsi's (1997) generalization on inverse correlation as follows:[11]

(12) English: lack of scrambling, presence of scope ambiguity
Japanese: presence of scrambling, lack of scope ambiguity

Oku (2018) postulates that as a result of IM, the {XP, YP} problem (i.e., the inability to determine a label) arises on the PF side in English, leading to a computation that prevents the externalization of the upper copy, say, XP, producing QR as covert IM but yielding no scrambling as overt IM. Conversely, in Japanese, Saito's (2016) anti-labeling devices could avoid this problem, allowing the upper copy, XP, to be externalized, producing scrambling as overt IM but yielding no QR as covert IM.

If the {XP, YP} problem does not exist, surely, an alternative explanation is to be required to account for the relevant patterns of externalizing upper versus lower copies, as observed for the presence/absence of QR effects and scrambling in English and Japanese. Whether the upper or lower copy is externalized pertains to linear order, which is fundamentally a PF side issue. Now the question that I would like to address in this connection is whether we could generalize and theorize the relationship between the externalization of the upper copy on the PF side and the presence or absence of agreement patterns in English and Japanese in comparative syntax, which will be addressed in section 4.3.

4.2. Overt/covert *Wh*-movement

It is well-known in the literature of Japanese linguistics that *wh*-island effects are observed in *wh*-interrogatives in spite of the fact that *wh*-elements are not obligatorily moved overtly to the sentence-initial position unlike in English (see Nishigauchi 1990, Watanabe 1992 inter alia.), as illustrated in (13) (= adapted from Saito 2017, (3c)):

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11 Szabolcsi's (1997) inverse correlation:
a. languages with free word order: rigid scope
b. languages with strict possibilities of word order: tolerance for scope ambiguity
(= adapted from Oku 2018, (5))

(13) Hanako-ga sono toki [[**dare**-ga kuru] **ka**] tazuneta] **ka**] osiete kudasai.
'Hanako-NOM that time who-NOM come Q asked Q teach please'
A: 'Please tell me if Hanako asked then who was coming.'
B: ??'Please tell me who Hanako asked then if she/he is coming'
(Saito 2017, (3c))

The fact that the locality effect is observed in (13) suggests that *wh*-movement is involved in Japanese in a "covert" fashion. Saito (2017) puts forth an analysis of (13) by proposing that *wh*-phrases such as *dare-ga* 'who-NOM' are operators without specified quantificational force that undergo covert movement to Spec-CP to probe for quantificational particles such as *ka* 'Q' to value their quantificational features.[12]

While maintaining Saito's (2017) idea of analyzing *wh*-phrases in Japanese as operators, I would like to extend Oku's (2018, 2021) analysis of covert movement in QR in English as overt movement with the upper copy of IM failing to be externalized due to some PF reasons, with crucial theoretical modifications to covert *wh*-movement in Japanese. Nevertheless, given that I cannot appeal to the {XP, YP} problem in accounting for covert *wh*-movement in Japanese as well as QR in English, I will propose an alternative mechanism that operates in externalization in what follows.

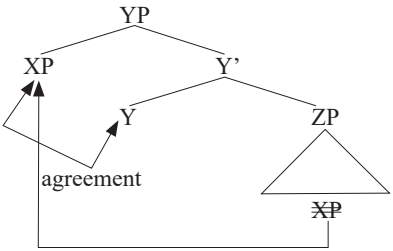
4.3. Externalization of the upper copy: MS on the PF side at the SM interface[13]

First, look at the following conventional Spec-head agreement for overt movement:

12 Contra Nishigauchi's (1990) analysis of *wh*-in situ elements in Japanese as unselectively bound variables (see also Kuroda 1965), Saito (2017) argues that *wh*-phrases in the language are operators rather than unselectively bound variables on the basis of different behaviors from those of typical unselectively bound variables in other languages (see Saito 2017 for details).

13 Chomsky (2023) restricts the number of application of IM to only one, eliminating successive-cyclic movement in NS with the realization of the other "copies" of an IMed element being left to externalization processes by accessing down to the IMed element from a phase head. I will leave the issue of how to implement my hypothesis in this new system to future research.

(14) Spec-head agreement for overt movement:



Within the framework of X-bar schema, this kind of Spec-head agreement for overt movement can be readily formulable, as standardly practiced in the pre-minimalist program era in generative grammar (see, e.g., Chomsky 1995). On the other hand, the very notion of Spec-head agreement for overt movement is not technically formulable in the same fashion under set-theoretic syntactic structures in the current mainstream minimalist program and my own proposal in this article.

Given the fundamental intuition that agreement is to be reflected on the PF side rather than the LF side, one plausible approach to the reformulation of Spec-head agreement for overt movement is to appeal to the third factor principle of minimal computation: minimal search (MS) at the SM interface. To be more specific, I would like to propose that MS is at work for externalization of the upper copy of an IMed element, reformulating the conventional Spec-head agreement for overt movement under MS in the mapping to the SM system. In externalization of SOs in the mapping to the SM system, the upper copy of an IMed element will be externalized based on the matching status of the two elements in the configuration where the argument function g (= XP) has been IMed to the selector function f* (= YP), contingent upon whether they share the presence or absence of relevant agreement features, which may be subject to parametric variation. This would cover not only agreement feature-related overt movement like *wh*-movement but also agreement feature-free overt movement like scrambling. Note that IM per se applies freely regardless of the presence or absence of agreement features in NS, though.

Even if the externalization of the upper copy is accounted for by this mechanism, on top of that, the following conditions should apply to the entire copy chain as well: (i) due to the conditions of minimal computation/efficient computation, not all copies will be externalized (Chomsky 1995 et seq.); (ii) due to the condition of recoverability, at least one copy must always be externalized.

Unlike the MS on the LF side, which applies to the asymmetric relation for "set-Merge" in the functional application structure between a selector function and its argument function for the semantic interpretation at CI, when the MS for agreement patterns on the PF side will search and detect the presence or absence of PF-related agreement features on the two functions f* and g, corresponding to XP and YP in the conventional set-theoretic notation {XP, YP}, there should be no asymmetry between the two functions, since apparently it does not make any sense to claim that such a functional application structure has to be visible for the purpose of PF-related agreement. Hence, both the two functions f* and g should be equally searched and detected by the MS for agreement patterns on the PF side. If the MS for searching and detecting agreement patterns on the PF side were to take place during the process of externalization of SOs in the mapping from NS to the SM system and if externalization were to require "flattening" of SOs for their linearization, it seems reasonable to assume that SOs as involving the functional application structures f*(g) will be converted into corresponding "concatenated" flat structures as follows before the ultimate liner ordering will be fixed for externalization in the SM system:

(15) SO conversion on the PF side:
f*(g) => [f*]^[g] (linear ordering between [f*] and [g] not determined at this stage)

[f*] and [g] indicate the selector function and its argument function accompanied with their phonological features relevant at PF and the upper small conjunction ^ represents the fact that [f*] and [g] are "concatenated" in the flat structure.

I propose that the MS for agreement patterns on the PF side will be conducted with the flat structure as its target, as defined in (15). Thanks to the flat structure, the MS for agreement patterns on the PF side will be able to equally search and access the contents in [f*] and [g], i.e., X(P) and Y(P) in the conventional terms. With this theoretical mechanism in mind, I would like to put forth the following externalization procedure for the upper copy of an IMed element:[14]

14 However, as discussed by Oku (2018, 2021), in multiple *wh*-fronting languages such as Romanian, the lower copy can sometimes be externalized instead. This suggests that externalization patterns are influenced not only by MS but also by additional PF conditions, thereby shaping the ultimate externalization pattern. Moreover, the issue of how partial *wh*-movement, as observed in languages like German (cf. McDaniel 1989), can be accounted for remains an open question.

(16) (Non-)externalization of the upper copy of an IMed element:

The upper copy of an IMed element [g] will be externalized only when the relevant agreement-related properties of [f*] and [g] are identical under MS at the SM interface.

Theoretically, the following <X, Y> patterns, where X on the left corresponds to an IMed element, would be expected to emerge concerning ϕ-features and Q-feature:

(17) ϕ-feature agreement pattern:
<ϕ, ϕ> => subject (and object) overt movement with agreement in English
<0, 0> => scrambling in Japanese (see Fukui 1986 et seq., Kobayashi 2022 for the lack of ϕ-features in Japanese)
<ϕ, 0> => Quantifier Raising (QR) in English
*<0, ϕ> => theoretically nonexistent, because if the IMed element has no ϕ-features, the value of the righthand element cannot be determined.

(18) Q-feature agreement pattern:
<Q, Q> => overt *wh*-movement in English
<0, Q> => covert *wh*-movement in Japanese
*<Q, 0> => theoretically nonexistent
*<0, 0> => theoretically nonexistent

Note that the pattern <0, 0> in (17) does not fall under the conventional ϕ-feature agreement. However, on the assumption that the MS for "agreement" looks for and detect similarities on ϕ-features, including the sharing of non-presence of ϕ-features, this pattern could be counted as a possibility in this new framework.

Although Kuroda (1988) does not explicitly address the relationship between the presence of φ-feature agreement and forced versus non-forced agreement (Fukui 2023), considering the free application of IM, it is reasonable to assume that the presence of φ-features in T/I is a necessary condition for a language to exhibit forced agreement. Hence, the following pattern of subject placement in NS will arise for English and Japanese, respectively:

(19) a. In English, IM of the subject to TP/IP is forced.
(φ-feature agreement present)
b. In Japanese, IM of the subject to TP/IP is free but not forced.
(φ-feature agreement absent)

Parametric variation of ϕ-features is quite natural, since they generally pertain exclusively to the PF side and vary in their realization cross-linguistically. Even if they are related to the universally shared LF side across languages, such a relationship is secondary and can be assumed to be mediated indirectly through associated semantic features.

Unlike the ϕ-features, the Q-feature as semantically motivated interrogative feature should not be subject to parametrization in syntax. Thus, I would like to make the case that the externalization of the upper copy of an IMed *wh*-element (as in *wh*-movement) is not subject to parametrization unlike in the case of ϕ-feature agreement and, instead, it is universally determined by whether MS identifies a shared Q-feature or not. This is because the Q-feature of the complementizer (C) is fundamentally related to the universally shared LF side across languages, and it is highly likely only indirectly associated with the PF side through corresponding phonological features related to prosody.

5. Concluding Remarks

In this article, I critically reconsidered the conventional set-theoretic formulation of Merge (Chomsky 2000 et seq.) and Chomsky's (2013) formulation of labeling algorithm (LA) under MS, pointing out some theoretical inadequacies from the perspective of a strict interpretation of the view of I-language in biolinguistics. Then, I proposed a function-based Merge operation in NS and a function-based LA in the mapping from NS to the CI interface as alternatives along the lines of Hoshi (2023) and Hoshi (2024a, b) with some consequential modifications. The theoretical implication is that there exists no {XP, YP} problem. While addressing empirical data on scrambling, QR, (overt/covert) *wh*-movement discussed by Saito (2016, 2017) and Oku (2018, 2021) on the premise that the {XP, YP} problem exists, I claimed that the ambiguity for labeling in the XP-YP structure is in fact effectively used in natural language, and also offered a novel mechanism of externalization of the upper copy of an IMed element on the basis of "feature-matching" under MS at the SM interface.

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