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Victor Junnan Pan* and Yuqiao Du

A multi-dimensional derivation model under the free-MERGE system: labor division between syntax and the C-I interface

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Abstract: This paper proposes a general multi-dimensional derivation model under a free-MERGE system. MERGE indicates the derivational dimensions that participate the computation. Set-MERGE is considered as an operation that keeps the two merge-mates in the same dimension, and Pair-MERGE sends the two merge-mates to two different dimensions. Each dimension has its own Labeling Algorithm (LA); the LA inside one dimension ignores syntactic objects merged from other dimensions. The resulting multi-dimensional structure will then be transferred to the Conceptual-Intentional (C-I) interface. A syntactic object resulted from Pair-MERGE will be interpreted in terms of coordination relation or modification relation. Different possible labelings in a multi-dimensional structure gives rise to different modification possibilities at C-I. C-I can see the competition of different labels, and will exhaust every possibility to decide which labeling gives rise to an appropriate interpretation.

Keywords: Pair-MERGE; Set-MERGE; labeling; dimension; Conceptual-Intentional system; interface

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***Corresponding author: Victor Junnan Pan**, The Chinese University of Hong Kong, Hong Kong S.A.R., E-mail: victorjunnanpan@cuhk.edu.hk
Yuqiao Du, The Chinese University of Hong Kong, Hong Kong S.A.R., E-mail: yqdumalin@link.cuhk.edu.hk

1 Introduction

While the Labeling Algorithm (LA) is gaining increasing attention under the Minimalist Program, it remains a mystery as to how adjunction structures get their labels, as Chomsky (2013, 2015, 2020b) points out. On the one hand, adjuncts are never problematic intuitively for labeling because they are never the label of the resulting structure. On the other hand, however, LA is incapable of labeling an adjunction structure because neither of the two approaches to label $\{_{??}$ XP, YP$\}$ proposed by Chomsky (2013, 2015) necessarily applies to adjunction. Movement, as the first approach, is not an option here because the positions of adverbs are relatively stable (see Cinque 1999; Pollock 1989). Semantically, this is in accordance with the idea that modification relation must be local (see Ernst 2001: 111; Sportiche 2006).[1] The second approach, feature sharing, does not help here either. A structure labeled by a shared critical feature is based on a pre-established probe-goal relation under Agree, such as the $\langle \phi, \phi \rangle$ label obtained under the ϕ-feature Agree between T and EA. It is hard to identify a critical feature shared between a modifier (i.e., an adjunct) and its host (see Adger and Harbour 2008; Polinsky 2016; Winchester 2019). It is not plausible to postulate an Agree relation between a head and its adjunct.[2] We are then pointed to the conclusion that current Chomskyian LA does not cover the labeling for adjunction.

This paper proposes a solution to the labeling of adjunction based on several recently established hypotheses put forward by Chomsky (2019; 2020a; 2020b; 2021). One core hypothesis is about the dimensions in languages. Dimension is proposed as a natural property of language, and language is assumed to contain multi-dimensions. Another core hypothesis is that MERGE is free. Under the free MERGE operation, the computational system could generate deviant structures that are grammatical yet unintelligible. The deviant structures of this type will be transferred to the C-I system and then C-I will decide whether to assign them any specific interpretation.

The paper is organized as follows. Section 2 outlines the main assumptions and proposals of the paper. Derivational dimension is to be proposed as an independent factor which works differently from workspace and phase. The relation between

1 Also see Morzycki (2016, sec. 2.5) for discussion on a type of “non-local reading” of adjectives, which could be derived by head-movement.

2 Existing studies on adjectives have identified the possible morphological agreement between adjectives and their modification targets as concord rather than agree (see Carstens 2000). However, relevant discussions on the relation between adverbs and V is scarce given the lack of overt morphological evidence. We assume that adverbs and V do not feed probe-goal since adjectives, as adjuncts, do not feed probe-goal either. Also see Baker (2008) for an alternative theory on this issue.

MERGE, Labeling Algorithm and the Conceptual-Intentional system will also be discussed. Section 3 illustrates the derivation of prototypical cases involving Pair-MERGE. Structures contain a single adjunct, such as manner adverbs and gapless relative clauses, will be discussed. For structures containing multiple adjuncts, we will focus on how the so-called Markovian and the non-Markovian readings are derived. Section 4 discusses how C-I assigns interpretations to different possible ways of labeling a structure resulted from Pair-MERGE. Section 5 discusses Internal Set-MERGE and derivational dimensions. Movement inside one single dimension, movement across multi-dimensions, and adjunct island will be examined. Section 6 discusses how our analysis contributes to the unification analysis of coordination and adjunction. Section 7 discusses Pair-MERGE and head-raising. Section 8 concludes the paper.

2 Main assumptions and proposals

2.1 Derivational dimensions

The original notion of Pair-Merge is defined as an alternate Merge that produces an ordered pair ⟨α, β⟩ instead of an unordered set {α, β} (see Chomsky 2000, 2004, 2008). This operation is specially proposed for adjuncts. The core idea of Pair-Merge is the introduction of a "separate plane", which is subsumed under a syntactic object in the main panel of derivation, such as the AdjP *young* under the NP *man* in the NP *young man*, formally represented as $\langle_{\mathrm{NP}}$ $\{_{\mathrm{AdjP}}$ *young*}, $\{_{\mathrm{NP}}$ *man*}⟩. The idea of separate planes reflects the assumption that there exists more than one derivational dimension in human language (see Chomsky 2020b). This assumption is based on the fact that stacked modifiers could each link to the same modifiee independently, such as in *happy young man*; we will refer to this parallel interpretation of multiple modifiers as the Markovian reading (see Irurtzun and Gallego 2007).

We now turn to the ontology of dimensions. The assumption that multi-dimension is an inherent property of human language will be a fundamental assumption for our analysis. Obviously, "dimension" here does not refer to the physical notion, because the physical parameters such as length or height do not concern syntax. Derivational dimensions are actually abstract panels for syntactic computation. In this article we treat the derivational dimension as a domain-specific property of human language, an inherent aspect in any syntactic derivation.

A note is due regarding the relation between derivational dimension and MERGE as a set-theoretical operation. It is important to distinguish between the abstraction of language and language itself. MERGE as a set-theoretical operation is a powerful abstract representation of the mechanisms in the faculty of language, which is expected, because the set-forming binary operation, being the logically simplest operation, should properly describe MERGE's function at a certain level. However, this abstraction does not cover everything. The real items in the language activities are more complex than their abstractions, and these complications would have effects on the language activities. Dimension is such an example. The existence of Markovian reading already constitutes the argument in support of derivational dimension as a valid property of items in language. MERGE as defined in set theory does not cover dimension, and dimension does not hinder the abstraction using set theory either. We will not modify the definition of MERGE, because the issue of dimension is not a prominent matter unless relevant problems in coordination and adjunction are involved.

The question then falls on the relations between dimension, workspace, and phase, which all mark the boundaries of the derivation course in some sense. First, derivational dimension is not workspace. Under Chomsky's (2019, 2020b) model, workspace hosts the two merged syntactic objects. The number of workspaces resulted from each MERGE can only be one. MERGE works on workspace and keeps the workspace from expanding: External MERGE always reduces the workspace by one, and Internal MERGE keeps the workspace the same. By contrast, there is no limits on the number of derivational dimensions. In fact, derivational dimension and workspace are two independent components of human language, although they do interact one with the other. A given workspace may contain more than one dimension, and the syntactic objects in each dimension can be merged from multiple workspaces.[3] Second, derivational dimension is not phase. Different from phase, which is linked to the limited working memory of human brain, derivational dimension is not limited in such a way. Quite on the contrary, derivational dimension is capable of tracing multiple syntactic derivations, and therefore, it does not reflect the limitation of working memory.[4] Concrete case studies will be presented in Sections 3 and 4.

2.2 Set-MERGE and Pair-MERGE under the multi-dimensional approach

With the notion of derivational dimension established as an entity independent of workspace and phase, the division between Pair-MERGE and Set-MEREGE is only

3 For instance, modifiers (i.e., adjuncts) and subjects must be constructed in workspaces independent from the one in which, the direct object, V, *v* and T are merged.

4 Having said that, we wish to point out that derivation dimensions are expected to be subject to 3rd factor principles, because the language faculty is generally constrained by such principles. We will leave the discussion on what these principles are to future research. We thank the reviewer for raising this issue.

a natural result. In our model, there is only one type of MERGE, and MERGE can either keep the two merge-mates in the same dimension, or, send them into two different dimensions, as this is taken as an inherent property of MERGE. The former case corresponds to Set-MERGE, and the latter Pair-MERGE. Very importantly, Set-MERGE and Pair-MERGE are not two different operations under our model. Operation-wise, Pair-MERGE does not do more than Set-MERGE given that they only differ in one aspect: the two merge-mates are in the same dimension or in different dimensions. In this sense, Pair-MERGE is just as primitive as Set-MERGE.[5]

On the other hand, Labeling Algorithm (LA) is assumed to be limited to one dimension, and each dimension has its own LA. The LA inside one dimension ignores syntactic objects merged from other dimensions. This assumption naturally solves the labeling problem for adjuncts. When XP and YP are merged, instead of Set-MERGE, XP can be pair-merged to YP from a different dimension. Each dimension has its own labeling, so inside the dimension where YP (but not XP) is located, LA will ignore XP and label the structure as YP, producing $\langle_{\mathrm{YP}}$ XP, YP$\rangle$. Likewise, the LA inside XP's dimension will produce $\langle_{\mathrm{XP}}$ XP, YP$\rangle$. Different labeling possibilities will give rise to different interpretation possibilities at the C-I interface. When the resulting multi-dimensional structure is transferred to C-I, C-I will judge the competition of different labels, ruling in the label that cues an appropriate interpretation and ruling out the label that cues gibberish. For instance, if C-I can only interpret XP as the modifier of YP but not the opposite, then the structure with the labeling $\langle_{\mathrm{XP}}$ XP, YP$\rangle$ will be filtered, the same way as C-I filters uninterpretable deviant structures (see Figure 1).[6]

Take the Pair-MERGE of *young* and *man*, $\langle\{_{\mathrm{AdjP}}$ *young*$\}$, $\{_{\mathrm{NP}}$ *man*$\}\rangle$, as an example. From the point of view of C-I, when it sees that *young* and *man* are located in different dimensions, it will try to interpret their relation with modification relation. Then, C-I sees that two possible labels are assigned to the resulting structure $\langle\{_{\mathrm{AdjP}}$ *young*$\}$,

5 One remaining issue concerns the "ordering" in the produced structure in the sense of "ordered pairs" of Chomsky (2000, 2004, 2008). If the adjunct and the "stem" syntactic object form a pair with a syntactically fixed order, as what Chomsky has defined for Pair-Merge, then Pair-MERGE is more complex than Set-MERGE. However, we will argue later that the "ordering" effect is a consequence of the filtering at the C-I system, rather than the result of an additional operation by Pair-MERGE, and therefore, Pair-MERGE has no more complexity than Set-MERGE. An important consequence from this conclusion is that Pair-MERGE and Set-MERGE apply in equal chance: MERGE is free.

6 One interesting question is raised by the reviewer regarding Minimal Search (MS). According to Chomsky (2021), MERGE also involves MS in its selection of the merge-mates, so that weak islands like ECP violations could be explained. The question then is why Labeling Algorithm (LA) cannot operate across dimensions while MERGE can, given that they are both MS-based. The difference comes from the fact that LA and MERGE are two distinct operations. Both MERGE and LA search through one dimension after another, so they do abide by the same MS. However, after the search, MERGE updates the structure, while LA does not. This gives rise to the reviewer's impression.

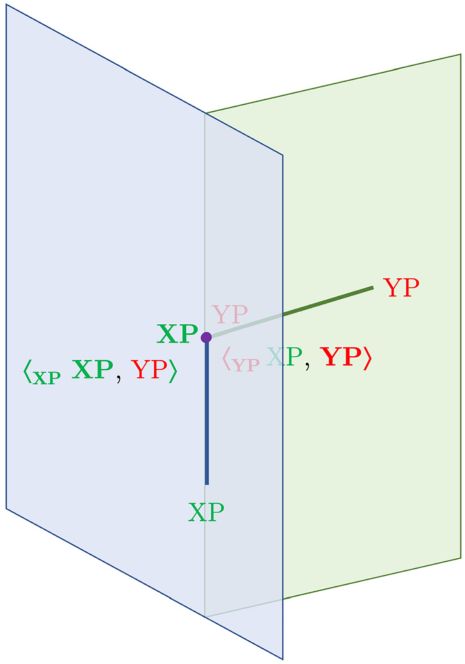

Figure 1: Labeling and multi-dimension.

{$_{\text{NP}}$ *man*}⟩: NP and AdjP. When the structure is labeled as ⟨$_{\text{NP}}$ {$_{\text{AdjP}}$ *young*}, {$_{\text{NP}}$ *man*}⟩ inside the dimension where *man* is located, it is *young* that modifies *man*, whereas when the structure is labeled as ⟨$_{\text{Adjp}}$ {$_{\text{Adjp}}$ *young*}, {$_{\text{NP}}$ *man*}⟩ inside the dimension where *young* is located, it is *man* that modifies *young*. C-I will see that only the former way of modification gives rise to a correct interpretation. As a result, the latter labeling ⟨$_{\text{Adjp}}$ {$_{\text{AdjP}}$ young}, {$_{\text{NP}}$ *man*}⟩ is then filtered. Set-MERGE works in a similar way. Take the Set-MERGE of {$_{\text{VP}}$ *eat*, {$_{\text{DP}}$ *an apple*}} as an example. When C-I sees that *eat* and *an apple* are located inside the same dimension, and that the label of the resulting structure is VP, it will interpret the structure as (partial) argumental relation: *an apple* being the patient of *eat*.[7]

Note that the existence of Pair-MERGE is not dictated by the need of resolving labeling problems, so Pair-MERGE is NOT a last-resort to the labeling problem. Contrary to the common assumption that Pair-MERGE exists to solve the labeling problem of adjunction, in our analysis, Pair-MERGE and Set-MERGE are both primitive. Pair-MERGE feeds labeling only by contingency ('nature's grace'),

7 As a reviewer points out, we can also assume that C-selection exists in syntax to cue the proper label. This way, the burden of C-I can be reduced as the structures with wrong labels will be filtered at syntax. But in order to fully pursue the idea of free MERGE, we will not adopt this alternative here.

because dimensionality exists independently of labeling. Relatedly, there is no absolute "stem" or "main" dimension during the syntactic derivation, because at syntax each dimension is independent and equal. The assignment of 'stem dimension' is not done until C-I.

2.3 Labor division between syntax and the C-I interface

Although MERGE is free, there are filters on the output of the operation. Same as what has been proposed for Set-MERGE, there are at least two conditions that the output of Pair-MERGE must satisfy. The first one is the Full Interpretation Condition. The output that feeds the interface system can only contain interpretable features, but not any uninterpretable features. The second filter is the Legibility Condition. The C-I system filters out the outputs that are incomprehensible.

This paper also proposes a strict mapping from syntax to semantics, at a rather fundamental level. A necessary assumption here is that the type of MERGE indicates how C-I interprets the structure. Syntactic objects (SO) resulted from Pair-MERGE will be interpreted in terms of modification relation or coordination relation. Concretely, when the pair-merged SO are of different categories, modification relation is assigned; by contrast, when the pair-merged SO are of the same category, coordination relation is assigned. We will further argue that coordination is an unstable relation assigned by C-I, and that under certain circumstances, it can be discarded in favor of other possible relations, such as modification, as will be demonstrated in detail in Section 6.

It is not hard to see that Set-MERGE only accepts certain types of interpretation relations as well: a set-merged structure is either interpreted as an argument structure or as conveying discourse functions, which introduces scopal relations, but a set-merged syntactic object is never interpreted as modification relation.[8] For a quick demonstration, the external argument (EA) DP-*the student*, when merged with the *v*P-*bought a book*, could resort to Pair-MERGE, which is a sound syntactic possibility, as shown in (1).

(1) # $\langle_{v\mathrm{P}}$ $\{_{\mathrm{DP}}$ the student}, $\{_{v\mathrm{P}}$ bought a book}$\rangle$

8 On a bigger picture, this implies that the establishment of modification and non-modification (with potentially few subtypes) as primitive modes of thinking is an attribute specific to human mind, and is closely related to human language. A deeper discussion goes way beyond the scope of the current paper. For now, we only take the correspondence between modification/non-modification and Pair-MERGE/Set-MERGE as a contingent fact, and relate it to the only difference between Set-MERGE and Pair-MERGE, which is, the number of derivational dimensions involved in a given type of MERGE.

However, this derivational option is problematic at C-I, because C-I cannot interpret the EA *the student* as the modifier of the *v*P-*bought a book*. C-I will thus reject the possibility to pair-merge the EA. In this regard, a tight connection exists between LA and MERGE. The connection is the C-I system. Both MERGE and LA contributes to the interpretation at the C-I interface, which is in accordance with the Strong Minimalist Thesis, and satisfies the Legibility Condition. However, Pair-MERGE and LA make different contributions to C-I. Pair-MERGE indicates to C-I that the type of relation between the two merged syntactic objects, located in different dimensions, is modification. Labeling indicates to C-I which one of two merged syntactic objects is interpreted as the modifier, and which one is interpreted as the modifiee. Finally, it is up to C-I to decide which labeling gives rise to a correct interpretation.

3 Derivation of prototypical cases involving Pair-MERGE

This section discusses how the current model works by demonstrating the derivation of several structural prototypes involving Pair-MERGE.

3.1 Simple adjunction

Start with the simplest scenario, where a “stem” syntactic object is modified by one adjunct. Two cases will be discussed: manner adverbs and gapless relative clauses.

3.1.1 Manner adverbs

Sentences in (2a, b) illustrate three possible positions where a manner adverbial adjunct can appear. These sentences are adopted from Chomsky (2021) examples.

(2) a. The mechanic who fixed the car carefully packed his tools.
b. ?? *Carefully*, the mechanic who fixed the car packed his tools.

Sentence (2a) is ambiguous. The mechanic could have packed his tools carefully, or could have fixed the car carefully. The former reading has the modification on the matrix verb level, the latter on the embedded verb level. (2b) on the other hand has the modification unambiguously on the matrix verb level. We now examine the derivation of these three cases.

– Embedded verb level:

The modifier *carefully* is pair-merged with the embedded VP from a different dimension, and as a result, Labeling Algorithm in VP's dimension will ignore *carefully*, and the resulting structure α will still be labeled as VP. Given that *carefully* is pair-merged with the VP, C-I will interpret it as the modifier of the verb. If α is labeled as VP, (2a) will be interpreted successfully as modification on the embedded VP. This option is illustrated in (3a, b). In (3b), the two derivational dimensions are separated by the dotted line, and the dimension where an adjunct is located is indicated in gray.

(3) a. $\langle_{\alpha=\mathrm{VP}}$ {$_{\mathrm{AdvP}}$ carefully}, {$_{\mathrm{VP}}$ fixed, {$_{\mathrm{DP}}$ the, {$_{\mathrm{NP}}$ car}}}$\rangle$

b. $\langle$ {$_{\mathrm{AdvP}}$ carefully},
- -
$_{\alpha=\mathrm{VP}}$ {$_{\mathrm{VP}}$ fixed, {$_{\mathrm{DP}}$ the, {$_{\mathrm{NP}}$ car}}} $\rangle$

Given our assumption that Labeling Algorithm is limited to one derivational dimension, labeling across different dimensions is impossible. Each derivational dimension has its own labeling. Accordingly, the LA in the dimension where *carefully* is located will label α as AdvP, as illustrated in (4a, b). This labeling will result in a structure that will be filtered by C-I, given the Legibility Condition, because C-I will have no way to interpret the VP as a modifier of the AdvP. This resulting structure is then uninterpretable.

(4) a. * $\langle_{\alpha=\mathrm{AdvP}}$ {$_{\mathrm{AdvP}}$ carefully}, {$_{\mathrm{VP}}$ fixed, {$_{\mathrm{DP}}$ the, {$_{\mathrm{NP}}$ car}}}$\rangle$

b. * $\langle^{\alpha=\mathrm{AdvP}}$ {$_{\mathrm{AdvP}}$ carefully},
- -
{$_{\mathrm{VP}}$ fixed, {$_{\mathrm{DP}}$ the, {$_{\mathrm{NP}}$ car}}} $\rangle$

– Matrix clause level:

Carefully is pair-merged with the matrix VP from a different dimension, and the resulting structure β will be directly labeled as VP, because the modifier dimension is ignored for LA. This option will give rise to the reading where the modification is on the matrix VP.

(5) a. $\langle_{\beta=\mathrm{VP}}$ {$_{\mathrm{AdvP}}$ carefully}, {$_{\mathrm{VP}}$ packed, {$_{\mathrm{DP}}$ his, {$_{\mathrm{NP}}$ tools}}} $\rangle$

b. $\langle$ {$_{\mathrm{AdvP}}$ carefully}
- -
$_{\beta=\mathrm{VP}}$ {$_{\mathrm{VP}}$ packed his tools} $\rangle$

– Left-Peripheral level:

To derive (2b), *carefully* must be pair-merged with the TP (i.e., ⟨ϕ, ϕ⟩) from another dimension. The resulting structure is not perfectly acceptable. C-I cannot interpret a manner adverb, such as *carefully*, as a modifier of an entire TP. For the speakers who accept it, *carefully* is still read as a modifier of the matrix verb *observed*. Note that at the surface level, the apparent position that *carefully* occupies can be analyzed as a topic position; however, a manner adverb cannot be interpreted as a topic by C-I either.

(6) ?? $\left\langle_{\gamma=\langle\phi,\ \phi\rangle} \begin{array}{c} \{_{\text{AdvP}}\ \text{carefully}\}, \\ \hdashline \{_{\langle\phi,\ \phi\rangle}\ \text{the mechanic who fixed ...}\}, \end{array} \right\rangle$

Different from *carefully*, the adverb *slowly* can be either a VP-level manner adverb, as in (7a) or a sentential adverb meaning "gradually", as in (7b). Importantly, modification must be local, which is reflected in syntax. Given that modification relation is local, C-I will interpret *slowly* in (7a) as a modifier of the verb *write*. *Slowly* in (7b) is traditionally analyzed as an adjunct of the entire TP, which gives rise to a syntactically possible derivation. This means that (7b) involves no topicalization structures.

(7) a. Mary learnt how to ⟨$_{\text{VP}}$ {$_{\text{AdvP}}$ slowly} {$_{\text{VP}}$ write}⟩ with her left hand.
b. ⟨$_{\gamma=\langle\phi,\ \phi\rangle}$ {$_{\text{AdvP}}$ Slowly}, {$_{\beta=\langle\phi,\ \phi\rangle}$ Mary learnt how to write with her left hand }⟩.

3.1.2 Nouns with complex modifiers

Nouns with complex modifiers including clausal modifiers are very productive in languages such as Japanese, Korean and Chinese (see Keenan and Comrie 1977; Kuno 1973; Matsumoto 1997; Matthews and Yip 2017; Zhang 2008). (8) Shows two examples from Japanese and Chinese.

(8) a. ⟨$_{\alpha=\text{NP}}$ {$_{\text{TP}}$ sakana-ga yakeru}, {$_{\text{NP}}$ nioi}⟩
fish-NOM burn smell
'the smell of fish burning'

b. ⟨$_{\alpha=\text{NP}}$ {$_{\text{CP}}$ {$_{\text{TP}}$ Zhāngsān tán gāngqín}, {$_{\text{C}}$ de}}, {$_{\text{NP}}$ shēngyīn}⟩
Zhangsan play piano C sound
'the sound of Zhangsan's playing piano'

The modifier clause, TP in Japanese, and CP (headed by *de*) in Chinese, will be pair-merged to the NP from another dimension, and the resulting structure will be labeled as NP by the Labeling Algorithm inside the dimension where this NP is located. The relevant structure is also referred to as gapless relative clause in Chinese as there is no gap which corresponds to the antecedent NP. At the C-I interface, the CP will be interpreted as the modifier of the NP. Note that gapless relative clauses should be crucially differentiated from complement clauses of noun, as in (9).

(9)	{NP {CP {TP Xiǎolì	yào	chū	guó	niàn	shū},	{C de}},	{N shir}}
	Xiaoli	will	go.out	country	study	book	C	claim

‘the claim that Xiaoli will go abroad for study’

In (9), the clause CP is the complement of the head noun, which is derived by set-merging the CP with the N head. Given that N is the head, the resulting structure is labeled as NP. Note that both CP and N are located in the same dimension. C-I will thus interpret the relation between the CP and the N as complementation rather than modification.[9]

3.2 Multiple adjuncts

This section examines more complex cases involving multiple modifiers.

3.2.1 Deriving the Markovian reading

The so-called Markovian reading refers to cases where the multiple modifiers are interpreted in parallel (see Irurtzun and Gallego 2007). In (10), each modifier is located in a separate dimension.

9 A reviewer raises the question as to why such structures are not attested in languages like English. A tentative answer is that the gapless relative clauses do not involve operators, and instead uses only induction based on the general world knowledge. This renders the gapless relative clauses less capable than the true relative clauses, and perhaps less efficient when the semantic context gets more complex due to the lack of syntactic cues like traces/variables. Some languages may have chosen to discard the gapless relative clauses. Another possibility is related to the strength of the concerned heads in different languages as proposed in Saito (2018): weak heads cannot label.

(10) a. John is a happy young man.

b. John is {$_{DP}$ a, ⟨$_{NP}$ {$_{AdjP}$ happy}, ⟨$_{NP}$ {$_{AdjP}$ young}, {$_{NP}$ man}⟩⟩}.

c. $$\left\langle_{NP} \begin{array}{c} \{_{AdjP}\,\text{happy}\}, \\ \hdashline \left\langle_{NP} \begin{array}{c} \{_{AdjP}\,\text{young}\}, \\ \hdashline \{_{NP}\,\text{man}\} \end{array} \right\rangle \end{array} \right\rangle$$

The AdjP-*young* cannot be set-merged with the NP-*man* because the resulting structure, {$_{??}$ {$_{AdjP}$ *young*}, {$_{NP}$ *man*}}, in unlabelable. Instead, *young* will be pair-merged with the NP-*man* from another dimension and the resulting structure, {$_{NP}$ {$_{AdjP}$ *young*}, {$_{NP}$ *man*}}, is labeled as NP given that the Labeling Algorithm in the dimension where the NP *man* is located will ignore *young*. Equally, the LA in the dimension where *young* is located will ignore *man* by labeling the resulting structure, {$_{AdjP}$ {$_{AdjP}$ *young*}, {$_{NP}$ *man*}}, as AdjP. However, C-I can only interpret *young* as a modifier of *man* but not the other way around, and as a result, only {$_{NP}$ {$_{AdjP}$ *young*}, {$_{NP}$ *man*}} gives rise to the correct interpretation. Next, in a similar way, the AdjP-*happy* will be pair-merged with the NP-(*young*) *man* resulting in a structure labeled as NP. Note that *happy* and *young* are located in different dimensions, and both of them are invisible to the LA in the dimension where *man* is located. Importantly, *happy* and *young* are in different dimensions as well, and there is no relation between these two dimensions, as can be seen in (10c) and Figure 2. As a result, there are three dimensions involved in final output. This derivation gives rise to the Markovian reading, where the two modifiers are parallel.

3.2.2 Deriving the non-Markovian reading

Examine the derivation of the non-Markovian reading in (11), where the adverb *extremely* modifies the adverb *fast*.

(11) a. He runs extremely fast.
b. He ⟨$_{VP}$ {$_{VP}$ runs}, ⟨$_{AdvP\text{-}fast}$ {$_{AdvP}$ extremely}, {$_{AdvP}$ fast}⟩⟩

c. $$\left\langle_{VP} \begin{array}{c} \left\langle_{AdvP-fast} \begin{array}{c} \{_{AdvP}\,\text{extremeley}\}, \\ \hdashline \{_{AdvP}\,\text{fast}\} \end{array} \right\rangle, \\ \hdashline \{_{VP}\,\text{runs}\} \end{array} \right\rangle$$

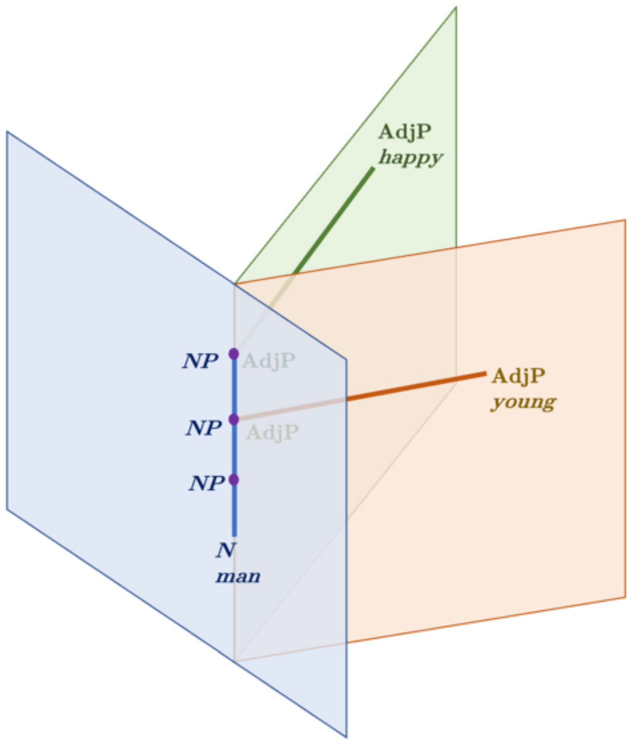

Figure 2: Markovian reading.

In (11), the AdvP-*extremely* seeks to set-merge with the AdvP-*fast*, and the resulting structure is unlabelable given the {XP, YP} pattern. Alternatively, these two are pair-merged. In the dimension where *extremely* is located, the Labeling Algorithm will label the structure as AdvP-degree-*extremely* by ignoring *fast*. However, this labeling will be filtered by C-I as *fast* cannot be a modifier of *extremely*. By contrast, in the dimension where *fast* is located, the LA will label the structure as AdvP-*fast* by ignoring the degree adverb *extremely*, and C-I will interpret the latter as the modifier of the former. Next, the resulting structure will be pair-merged with the VP-*runs*. The LA in the dimension where *runs* is located will label the structure as VP by ignoring the AdvP-(*extremely*) *fast*, and C-I will interpret *extremely fast* as the modifier of *runs*. Similarly, the LA in the dimension where the AdvP-(*extremely*) *fast* is located will label the structure as AdvP; however, this labeling will be filtered by C-I as the VP-*runs* cannot be the modifier of the AdvP-(*extremely*) *fast*. See also Figure 3.

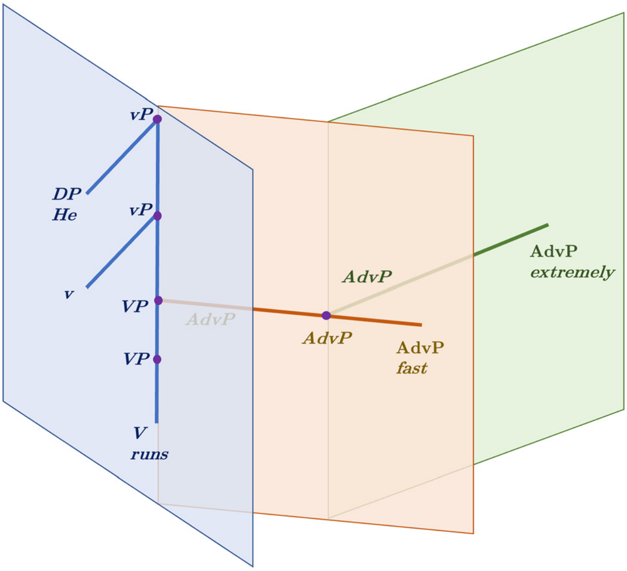

Figure 3: Non-Markovian reading.

4 Labeling and the C-I interface

Recall that in Chomsky's (2000, 2004, 2008) original proposal, Pair-Merge results in an ordered pair and the order between the adjunct and the "stem" is prescribed. In other words, syntax assumes an inherent asymmetry between the adjunct and the stem; however, this would require that syntax can automatically identify which one is the adjunct and which one is the stem. The implication of this requirement is either that syntax can foresee the result of labeling even before the Pair-Merge takes place, or, that syntax assumes specific templates exactly as what X′-theory does. Neither of the two possibilities is feasible with a free-MERGE system.

Different from Chomsky's (2000, 2004, 2008) original idea of ordered pair, we assume no such an inherent order between the two syntactic objects that undergo Pair-MERGE, because there is no prior "stem" status of either dimension that hosts each of them. In other words, syntax does not know which dimension is the "correct" dimension to continue the development of the stem workspace. Given our earlier assumption that Labeling Algorithm does not apply cross-dimensionally, the LA in one dimension will treat this dimension as "stem", and sees no other dimension. For instance, the structure resulted from the Pair-MERGE of XP and YP can be either labeled as XP (i.e., $\langle_{XP}$ YP, XP$\rangle$) in the dimension of XP, or, labeled as YP (i.e., ⟨$_{YP}$ XP, YP⟩) in the dimension of YP. Both labelings will be produced by syntax, and will be transferred to the C-I interface. Then, C-I will exhaust every possibility and decide whether to assign any interpretation to the multi-dimensional outcome of syntax, same as the idea that C-I filters the deviant structures.[10] This gives rise to three possibilities at the C-I interface: (i) both labelings are interpretable at C-I; (ii) only one of the two labelings is interpretable at C-I; (iii) neither labeling is interpretable at C-I. This section will discuss these three scenarios with concrete examples.

4.1 Case (I): both labelings are interpretable at the C-I interface

This case can be easily evidenced by Chinese compound words (see Chao 1968; Li and Thompson 1981). In (12), the NP-*xuě* 'snow' and the AdjP-*bái* 'white' cannot be set-merged, but can only be pair-merged. In the dimension where *bái* 'white' is located, the NP-*xuě* 'snow' is pair-merged to *bái* 'white', and the resulting structure is labeled as AdjP meaning "white as snow", as illustrated in (12a). By contrast, in the dimension where *xuě* 'snow' is located, the AdjP-*bái* 'white' is pair-merged to the NP-*xuě* 'snow', and the resulting structure is labeled as NP meaning "white snow", as shown in (12b). Both labelings are interpretable at C-I.

(12) a. ⟨$_{AdjP}$ {$_{NP}$ xuě}, {$_{AdjP}$ bái}⟩
snow white
'white as snow'

b. ⟨$_{NP}$ {$_{AdjP}$ bái}, {$_{NP}$ xuě}⟩
white snow
'white snow'

Similar effects are also observed with the serial verb constructions (see Li and Thompson 1981) for the description of this type of structures). The sentence in (13) contains two VPs, *yòng kuàizi* 'use chopsticks' and *chī fàn* 'eat food'.

(13) Zhāngsān {$_{VP1}$ yòng kuàizi} {$_{VP2}$ chī fàn}.
Zhangsan use chopsticks eat food
(Lit.) 'Zhangsan uses chopsticks to eat.' = 'Zhangsan eats with chopsticks.'

The two VPs are externally set-merged, and the resulting structure α is unlabelable given the {XP, YP} pattern.

10 Under the free MERGE operation, the computational system will generate deviant structures, which no longer contain any uninterpretable features. The deviant structures of this type will be transferred to the C-I interface, and then C-I will decide whether to assign them any specific interpretation (see Chomsky 2008, 2019).

(14) $\{_{\alpha=??}$ $\{_{VP1}$ use chopsticks$\}$, $\{_{VP2}$ eat food$\}\}$

VP1-*use chopsticks* is pair-merged to VP2-*eat food* from another dimension, and is thus invisible to the LA in the dimension where VP2 is located. Consequently, the resulting structure α is labeled as VP2. C-I will interpret VP1-*use chopsticks* as a modifier of VP2-*eat food*, which gives rise to the meaning "eat with chopsticks".

(15) $\langle_{\alpha=VP2}$ $\{_{VP1}$ use chopsticks$\}$, $\{_{VP2}$ eat food$\}\rangle$

Turn to another possibility, as shown in (16).

(16) Zhāngsān {VP2 chī fàn} {VP1 yòng kuàizi}.
Zhangsan eat food use chopsticks
(Lit.) 'Zhangsan uses chopsticks while eating.'

VP2-*eat food* is pair-merged to VP1-*use chopsticks* from another dimension, and is thus invisible to the Labeling Algorithm in the dimension where VP1 is located. Consequently, the resulting structure is labeled as VP1. C-I will interpret VP2-*eat food* as a modifier (i.e., adverbial) of VP1-*use chopsticks*, which gives rise to the meaning "use chopsticks while eating".

(17) a. $\langle_{\alpha=VP1}$ $\{_{VP2}$ eat food$\}$, $\{_{VP1}$ use chopsticks$\}\}\rangle$

As we have observed in this section, a structure resulted from Pair-MERGE can be labeled in different ways, which give rise to different modification possibilities. As long as these possibilities make sense to C-I in a given language, C-I will assign appropriate interpretations to them. We will examine in the following sections cases where C-I fails to assign interpretations to all the possible labelings.

4.2 Case (II): only one of the two labelings is interpretable at the C-I interface

Recall (2a), where the AdvP-*carefully* and the VP-*conducted the experiment* are merged. Only the labeling by VP, i.e., with *carefully* modifying VP, feeds the correct interpretation, as shown in (18a), but not the other way around, as shown in (18b).

(18) a. ⟨$_{\alpha=\mathrm{VP}}$ {$_{\mathrm{AdvP}}$ carefully}, {$_{\mathrm{VP}}$ conducted, {$_{\mathrm{DP}}$ her, {$_{\mathrm{NP}}$ experiment}}}⟩
b.* ⟨$_{\alpha=\mathrm{AdvP}}$ {$_{\mathrm{AdvP}}$ carefully}, {$_{\mathrm{VP}}$ conducted, {$_{\mathrm{DP}}$ her, {$_{\mathrm{NP}}$ experiment}}}⟩

Examine a more complicated case. The Mandarin case in (19) can have two readings: the AdvP-*very quickly* either modifies VP1-*take the knife* or modifies VP2-*cut the vegetables*. In both readings, VP1 is analyzed as an adjunct to VP2.

(19) Māma ⟨$_{\mathrm{AdvP}}$ hěn kuài-de⟩ {$_{\mathrm{VP1}}$ ná dāo} {$_{\mathrm{VP2}}$ qiē cài}.
Mum very quickly take knife cut vegetables
(i) (Lit.) ‘Mum [quickly cut the vegetables] (after) taking the knife.’
= ‘Mum took the knife to [quickly cut the vegetables].’
(ii) (Lit.) ‘Mum cut the vegetables [(after) quickly taking the knife].’
= ‘Mum [quickly took the knife] to cut the vegetables.’

The analysis of the first reading is illustrated in (20), where *very quickly* directly modifies VP2 *cut vegetables*, which gives rise to the Markovian reading.

(20) a. Māma ⟨$_{\beta=\mathrm{VP2}}$ ⟨$_{\mathrm{AdvP}}$ hěn kuài-de⟩, ⟨$_{\alpha=\mathrm{VP2}}$ {$_{\mathrm{VP1}}$ ná dāo}, {$_{\mathrm{VP2}}$ qiē cài}⟩⟩.
Mum very quickly take knife cut vegetables
(Lit.) ‘Mum [quickly cut the vegetables] (after) taking the knife.’
= ‘Mum took the knife to [quickly cut the vegetables].’

b. $$\left\langle \frac{\left\langle \frac{\{_{\mathrm{AdvP}}\ \text{very}\},}{\{_{\mathrm{AdvP}}\ \text{quickly}\}} \right\rangle_{\mathrm{AdvP}-quickly},}{\left\langle \frac{\{_{\mathrm{VP1}}\ \text{take the knife}\},}{\{_{\mathrm{VP2}}\ \text{cut vegetables}\}} \right\rangle_{\alpha=\mathrm{VP2}}} \right\rangle_{\beta=\mathrm{VP2}}$$

First, VP1-*take the knife* will be pair-merged with VP2-*cut vegetables* from a different dimension, and the resulting structure α will be labeled as VP2 by the Labeling Algorithm inside the dimension where VP2 is located. Next, the AdvP-*very quickly* will be pair-merged with α (i.e., VP2), and the resulting structure β will also be labeled as VP2 as the LA in the dimension where VP2 is located will ignore the AdvP-*very quickly*. In this derivation, the two modifiers, VP1-*take the knife* and AdvP-*very quickly*, are located in different dimensions, and there is no connection between them. Also note that the AdvP-*hěn kuài-de* ‘very quickly’ results from a Pair-MERGE of the degree AdvP-*hěn* ‘very’ with the AdvP-*kuài-de* ‘quickly’, and the resulting structure is labeled by *quickly*. As a result, *very* and *quickly* are located in separated dimensions, as illustrated in (20b).

The second reading, which is non-Markovian, is illustrated in (21), where *very quickly* modifies VP1-*take the knife*.

(21) a. Māma $\langle_{\beta=\text{VP2}}$ $\langle_{\alpha=\text{VP1}}$ $\langle_{\text{AdvP}}$ hěn kuài-de$\rangle$, {$_{\text{VP1}}$ ná dāo}$\rangle$, {$_{\text{VP2}}$ qiē cài}$\rangle$.
Mum very quickly take knife cut vegetables
(Lit.) 'Mum cut the vegetables [(after) quickly taking the knife].'
= 'Mum [q uickly took the knife] to cut the vegetables.'

b. $\left\langle_{\beta=\text{VP2}} \left\langle_{\alpha=\text{VP1}} \left\langle_{\text{AdvP}} \frac{\{_{\text{AdvP-degree}}\ \text{very}\},}{\{_{\text{AdvP}}\ \text{quickly}\}} \right\rangle, \over \{_{\text{VP1}}\ \text{take the knife}\} \right\rangle, \over \{_{\text{VP2}}\ \text{cut vegetables}\} \right\rangle$

First, the AdvP-*very quickly* will be pair-merged with VP1-*take the knife* from a different dimension, and the resulting structure α will be labeled as VP1 inside the dimension where VP1 is located. Next, α (i.e., VP1) will be pair-merged with VP2-*cut vegetables* from a different dimension, and the resulting structure β will be labeled as VP2 inside the dimension where VP2 is located.

4.3 Case (III): neither labeling is interpretable at the C-I interface

In (22a), the AdjP-*small* set-merges with the VP-*eat an apple*, resulting in an unlabelable structure α. Alternatively, *small* will pair-merge with the VP from another dimension. Inside the dimension where the VP is located, α is labeled as VP (cf. 22b), which is uninterpretable for C-I. Inside the dimension where *small* is located, α is labeled as AdjP (cf. 22c), which is also uninterpretable for C-I. Therefore, both labelings give rise to uninterpretable structures.

(22) a. *{$_{\alpha=??}$ {$_{\text{AdjP}}$ small}, {$_{\text{VP}}$ eat an apple}}
b. *$\langle_{\alpha=\text{VP}}$ {$_{\text{AdjP}}$ small }, {$_{\text{VP}}$ eat an apple}$\rangle$
c. *$\langle_{\alpha=\text{AdjP}}$ {$_{\text{AdjP}}$ small }, {$_{\text{VP}}$ eat an apple}$\rangle$

5 Internal MERGE and derivational dimensions

An important issue is whether the relevant mechanisms in the Minimalist Program can apply to the dimension-based definition of Pair-MERGE, given that historically these mechanisms are investigated and established with Set-MERGE. The answer varies with the specific mechanism in question. In this section, we focus on whether derivational dimensions block Internal MERGE.

5.1 Internal Pair-MERGE is filtered by C-I

One important question is whether Internal Pair-MERGE is possible during the derivation. Examine the example in (23).

(23) a. *John *carefully* observed that Mary ~~*carefully*~~ conducted her experiment.

↑__________✘__________|

b. *John ⟨$_{\mathrm{VP}}$ *carefully* {$_{\mathrm{VP}}$ observed that Mary …{$_{v\mathrm{P}}$ *v*-conducted ⟨$_{\alpha=\mathrm{VP}}$ ~~*carefully*~~ {$_{\mathrm{VP}}$ ~~conducted~~ her experiment}⟩}⟩.

As shown in (23), *carefully* is firstly pair-merged with the embedded VP-*conducted her experiment*, and then is internally pair-merged with the matrix VP-*observed that […]*. Even if such a movement is allowed at syntax, the resulting structure will still be filtered by the C-I interface. *Carefully* is associated with two different verbs, and the C-I interface has no way to interpret such a dual modification relation. In other words, under this analysis the sentence fails at C-I, but not at syntax.

One might wonder whether a syntactic analysis is possible, e.g., assuming that cross-dimensional MERGE is generally banned. This assumption implies the question of whether a dimension constitutes an island for any movement. As will be discussed immediately below, the answer is no, given that cross-dimensional Internal Set-MERGE is possible. Consequently, the impossibility of Internal Pair-MERGE is not driven by syntax.

For now, examine more complex cases in (24).

(24) * How$_3$ did [$_{\mathrm{TP}}$ you ~~how~~$_2$ know [$_{\mathrm{CP}}$ that [$_{\mathrm{TP}}$ John ~~how~~$_1$ laughed]]]?

↑__________✘__________|

In (24), *how*$_1$ is firstly pair-merged with the embedded VP-*laughed*. As Internal Pair-MERGE is not an option, the chain [*how*$_2$ …*how*$_1$] cannot be derived. The chain [*how*$_3$… *how*$_2$…*how*$_1$] thus cannot be formed either. As a result, a legitimate chain is either [*how*$_3$ …*how*$_1$] or [*how*$_3$ …*how*$_2$], both formed by Set-MERGE. This is further evidenced by the fact that there is no answer to the question in (24), because a potential answer would simultaneously cover the two questions, "how you know?", and "how John laughed?".

In (25a), *this month* is firstly set-merged with *forgetting* as its complement, and then is pair-merged with *prefers* as its modifier. However, *this month* cannot be interpreted as an argument and a modifier at the same time (also see Figure 4). The failure is at C-I, but not at syntax.

(25) a. * John [prefers [forgetting ~~this month~~] this month].

b. * John ⟨$_{VP}$ {$_{VP}$ prefers, {$_{VP}$ forgetting, {$_{NP}$ ~~this month~~}}}, {$_{DP}$ this month}⟩.

5.2 Derivational dimensions do not block Internal Set-MERGE

5.2.1 A′-movement: cross-dimensional Internal Set-MERGE

The equivalent of derivational dimension has been assumed to spell the total inaccessibility for the elements inside to participate in certain syntactic operations

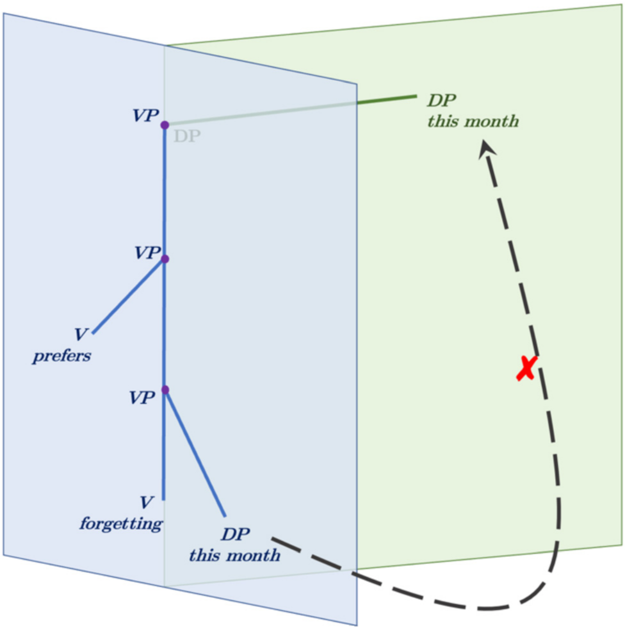

Figure 4: Illicit movement from complement to adjunct.

that involve another dimension (see Chomsky 2020b). For instance, the impossibility to move either *man* or *young* from ⟨*young*, *man*⟩ serves as evidence in favor of this hypothesis.

(26) a. *{$_{\text{AdjP}}$ young}, … ⟨$_{\text{NP}}$ ~~{$_{\text{AdjP}}$ young}~~, {$_{\text{NP}}$ man}⟩
b. *{$_{\text{NP}}$ man}, … ⟨$_{\text{NP}}$ {$_{\text{AdjP}}$ young}, ~~{$_{\text{NP}}$ man}~~⟩

However, this claim is not entirely convincing if we simply consider the verbal domains with adverbs. For instance, for a pair-merged VP such as ⟨$_{\text{VP}}$ *fast*, *run*⟩, there is no problem extracting or questioning the adverb or its modifiee, as shown in (27).

(27) a. - How did she run?
- She ran FAST.
b. - What can you do fast?
- I can RUN fast.

Clearly, a pair-merged structure is not a barrier for movement, and Internal Set-MERGE could apply freely across derivational dimensions in principle. As for the contrast between nominal and verbal domains, several possibilities suggest themselves. For the impossible *wh*-movement of *young* out of ⟨*young*, *man*⟩, the most direct explanation is that attributive adjectives simply resist open interrogations. Languages like English lack *wh*-words that target only attributive adjectives; to inquire the missing information on the attributives, these languages resort to questions on the nominal, as in "what kind of dog do you like". For other types of A′-movements like topicalization, the movement is out because both attributive adjectives and manner adverbs do not qualify as topics given that they are not nominals bearing features such as GIVENNESS or ABOUTNESS.

5.2.2 Adjunct island

As discussed above, a dimension is not inherently an island, which can be evidenced by cross-dimensional internal Set-MERGE, as shown in (28a). Then, a mysterious question is why adjunct still constitutes an island for movement. (28b, c) illustrate a classical adjunct island case: *who* cannot be extracted from the CP *because*-clause.

(28) a. Why do you want to ⟨ ~~{$_{\text{AdvP}}$ why}~~, - - - - - - - - - $_{\alpha=\text{VP}}$ {$_{\text{VP}}$ go to Japan} ⟩?
b. * Who do you want to go to Japan [because ~~who~~ had a great plan]?
c. * Who do you want to ⟨ {$_{\text{CP}}$ because ~~who~~ had a great plan}, - - - - - - - - - - - - - - - - - - - $_{\alpha=\text{VP}}$ {$_{\text{VP}}$ go to Japan} ⟩?

It seems that movement is not blocked if the entire adjunct is cross-dimensionally moved; by contrast, the movement of a subpart of an adjunct is blocked. We can assume that adjunct is constructed in an independent workspace, which is in accordance with the view on workspace in Chomsky (2019). Then, *why* in (28a) and the CP *because*-clause in (28b, c) are independently merged in a separate workspace before being pair-merged with the VP (i.e., α). Consequently, a contrast is established: the maximum item in a workspace can be moved freely as a lexical item across dimensions, but smaller syntactic objects inside the adjunct workspace cannot, which is why *who* inside the adjunct CP cannot be moved alone (see Figure 5).

Based on this contrast, we propose a new understanding of adjunct island:

(29) An adjunct island is the biggest syntactic object located in a different dimension.

Along this line, an adjunct island is constructed under two conditions: 1) an adjunct is the biggest SO located in an independent workspace, and 2) this workspace hosting the adjunct is located in a dimension different from the dimension hosting the stem.

Concretely, the causal clause CP in (28b, c) is the biggest SO located in a dimension different from the one where the VP-*go to Japan* is located. Although

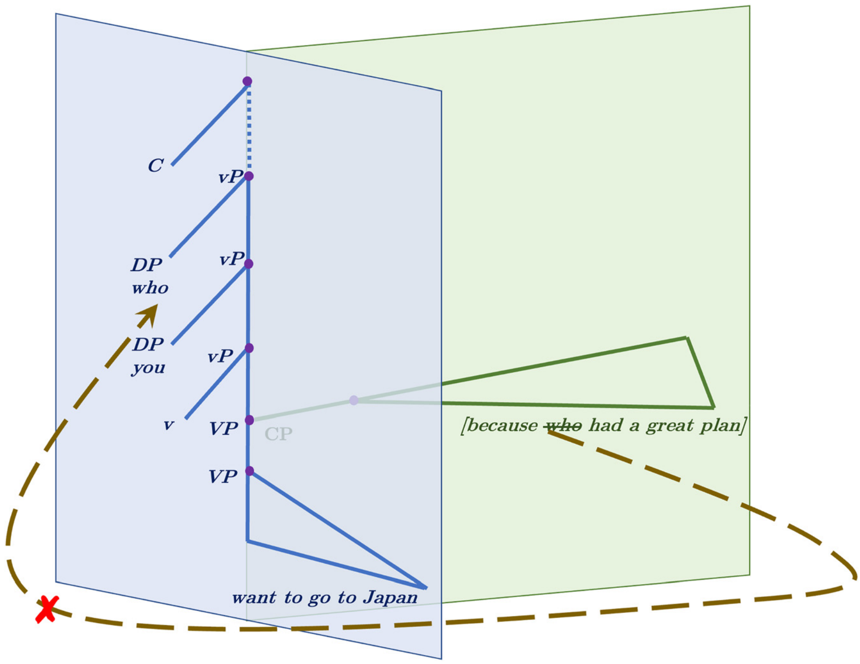

Figure 5: Adjunct island.

neither the workspace containing the adjunct SO nor the dimension containing this workspace works alone as an island, somehow when they work together, they constitute an island. Thus, adjunct island is accounted for in terms of a general ban on the cross-dimensional internal MERGE of a non-biggest SO in the workspace.[11] This account is schematically illustrated in (30–31), where *a* and *b* are set-merged in a separate workspace, noted as [{a, b}], before being pair-merged with X. As an entire workspace, [{a, b}] can undergo cross-dimensional internal Set-MERGE, as shown in (30). By contrast, neither *a* nor *b* alone can be cross-dimensionally internally pair-merged with X, as shown in (31).

(30) {[{a, b}], ⟨X, ~~[{a, b}]~~⟩}

(31) *{b, ⟨X, [{a, ~~b~~}]⟩}

5.3 Multiple interpretative possibilities at C-I resulted from Internal Set-MERGE

The labor division between syntax and C-I assumed in the current model presupposes a strict mapping from syntax to semantics.[12] Set-MERGE and Pair-MERGE feed interpretation relations that are in complementary distributions. Table 1 summarizes combinations of different types of interpretation relations. Note that these are not combinations of derived syntactic positions that usually host the relevant interpretations.

11 What we provide here is a generalization based on observed facts. Though we do not give a specific account of the island, we would attribute it to the general constraints posed by limited computation resources, meaning the 3rd-factor. This restriction on multi-dimensional items may be homogeneous with the Phase Impenetrability Condition. We thank the reviewer for raising this issue. Also note that under our approach, subject island and adjunct island cannot have a unified account because sub-extraction from a subject is never cross-dimensional.

12 These mappings are essentially observational facts. A principled explanation goes beyond this paper, because it would mean explaining the mapping from syntax to semantics thoroughly. However, dimensionality does offer a new perspective into this issue. It would be reasonable to assume that two items in two dimensions are not assigned as “close” a relation as they would be when in the same dimension. This way, a structure of multi-dimensions will be mapped to “looser” interpretations such as coordination and modification, otherwise closer interpretations like argumentation and scope relations can be assigned. “Close relation” can roughly be understood as obligatory relations required either by argument structure such as complementation or by A′-dependency such as operator-variable binding, while “loose relation” corresponds to optional relation such as “adjunction” in terms of X′-theory. This conforms with our idea that coordination is the default interpretation that is the loosest, which can be overwritten by other interpretations, discussed in Section 6. We thank an anonymous reviewer for raising this issue.

Table 1: Combinations of interpretation relations at C-I.

Original relation	Added relation		
	Argumental relation	**Scopal relation**	**Modification relation**
Argumental relation	✗ (32)	✓ (35)	✗ (38)
Scopal relation	✗ (33)	✓ (36)	✗ (39)
Modification relation	✗ (34)	✓ (37)	✗ (40)

Let us briefly summarize these possibilities one after another.

(i) Adding a new argumental relation to an argumental relation is filtered under the considerations related to theta criterion. In (32), *John* receives two theta roles when moving from the complement position of *likes* to the subject position.

(32) * John likes ~~John~~.

(ii) Adding a new argumental relation to a scopal relation is filtered by C-I, as in (33).

(33) a. * Who wonders ~~who~~ John will meet ~~who~~?
b. * … C {$_{TP}$ who$_1$ wonders {$_{\langle Q,\ Q\rangle}$ ~~who~~$_2$ {$_{CP}$ C [+Q] {$_{TP}$ John will meet ~~who~~$_3$}}}}

The verb *wonder* selects an interrogative clause as its complement, and therefore, the intermediate C has an interrogative force which is represented by the Q-feature. When *who*$_2$ is internally set-merged with the CP, the resulting structure is labeled by the shared Q-feature between *who*$_2$ and the intermediate C. Note that *who*$_2$ is assigned an interpretation at the specifier of the intermediate CP, which is a criterial position in the sense of Rizzi (2007, 2015). Moving *who*$_2$ to a higher Spec of TP will have problems related to theta relations. Chomsky (2013) also notes that if *who*$_2$ moves away, then the remaining Q feature on the embedded C will make the CP a *yes-no* question, which is gibberish at C-I.

(iii) Adding a new argumental relation to a modification relation yields an uninterpretable structure at C-I. In (34), *yesterday* is firstly merged as an adjunct, and then it is moved to the subject position.

(34) a. * Yesterday seems John to leave ~~yesterday~~.
b. * {$_{TP}$ Yesterday seems {$_{TP}$ John to ⟨$_{VP}$ leave ~~yesterday~~⟩}}.

(iv) Adding a new scopal relation to an argumental relation is perfectly interpretable. This is standard A′-movement, as shown in (35).

(35) Who do you like ~~who~~?

(v) Adding a new scopal relation to a scopal relation is generally possible only if the original scope position is not a criterial position. This corresponds to an ordinary cyclic A′-movement, from a lower (non-criterial) position to a higher (criterial) position. Note that C-I will have a full record of each copy of the *wh*-phrase so that it can assign them an interpretation.

(36) Mary wonders [which pictures of each other$_{i/j/k}$]$_4$ you$_i$ think [$_{CP}$ t_3 that [$_{CP}$ they$_j$ said [$_{CP}$ t_2 that [$_{CP}$ we$_k$ liked t_1]]]]. (Sportiche 2006)

The sentence in (36), cited from Sportiche (2006), is ambiguous in three ways. The reciprocal *each other* could refer to *you*, *they*, or *we*. Since a reciprocal requires a local binding relation, this three-way ambiguity suggests that the *wh*-element has an interpretation at each intermediate Spec of CP. Thus, the successive cyclic movement is an instance of the addition of a scopal relation to another scopal relation.

(vi) Adding a new scopal relation to a modification relation is possible. This corresponds to *wh*-adjunct movement, as in (37).

(37) How did you run ~~how~~?

(vii) Adding a new modification relation to an argumental relation is filtered by C-I, as in (38). Also see Section 5.1 for the relevant discussion.

(38) * John ⟨$_{VP}$ {$_{VP}$ prefers, {$_{VP}$ forgetting, {$_{DP}$ ~~this month~~}}}, {$_{DP}$ this month}⟩.

(viii) Adding a new modification relation to a scopal relation is filtered by C-I, as in (39).

(39) a. * I wonder ~~why$_2$~~ John will leave ~~why$_1$~~ why$_3$.
b. * I ⟨$_{VP}$ {$_{VP}$ wonder, {$_{CP}$ ~~why$_2$~~, {$_{TP}$ John will ⟨$_{VP}$ leave, ~~why$_1$~~⟩}}}, why$_3$⟩.

In (39), *why*$_1$ is the adjunct of the verb *leave*, and then it is moved to the Spec of CP (i.e., *why*$_2$), before moving to the adjunct position of the matrix verb *wonder* (i.e., *why*$_3$). Such a movement gives rise to an uninterpretable structure at C-I.

(ix) Adding a new modification relation to a modification relation is ruled out by C-I, as in (40). Also see Section 5.1 for the relevant discussion.

(40) * I slowly learnt to drive ~~slowly~~.

Patterns of different combinations are clear. If the interpretation acquired after the movement features an argumental or modification relation, then this addition of interpretation will not be available. On the other hand, scopal (operator-variable) relation is freely available for all interpretation relations to acquire as an additional interpretation. The explanation is likely to draw on the distinction between the left periphery and the non-peripheral positions.[13]

6 Pair-MERGE and coordination

Bošković (2020a, 2020b) points out several reasons to propose a unified mechanism for coordination and adjunction.[14] Our hypothesis provides a derivational model which accommodates Bošković's unified analysis. Under our hypothesis, coordination and adjunction are defined as syntactically homogeneous, yet interpretation-wise distinguished by the C-I system. The origin of this difference in interpretation is labeling. If the two syntactic objects that participate in Pair-MERGE have the same label, C-I will interpret the resulting structure as coordination. When the labels are different, C-I will interpret the structure as modification. In other words, we are revising the contingent relations between C-I and Pair-MERGE. The revised model is presented in Table 2.

Table 2: Types of Pair-MERGE and their interpretations at C-I.

Syntax	**Pair-MERGE**	
	⟨XP, XP⟩	⟨XP, YP⟩
C-I	Coordination $\{XP\} \cup \{YP\}$	Modification $\{XP\} \cap \{YP\}$

13 We thank a reviewer to draw our attention to an interesting implication of this mapping regarding the analysis of topicalization and scrambling. Classic literature debated over whether adjunction better captures topicalization (Authier 1992; Saito 1985, a.o.) and scrambling (Bošković and Takahashi 1998; Miyagawa 1997, a.o.), an issue which later grew trivial as the distinction between spec and adjunct was not as sharp in Minimalist Program. However, such a distinction is re-introduced by our model, because spec means Set-MERGE while adjunct means Pair-MERGE. The current model would predict that neither topicalization nor scrambling involves Pair-MERGE since Internal Pair-MERGE of phrases are principally impossible for C-I to interpret. This position aligns with recent theories such as Cartography (Pan 2019; Rizzi 2015) and Labeling Blocker (Saito 2018). A full investigation, however, is out of the scope of this paper.

14 Bošković's analysis is based on the identical patterns that coordination and adjunction show in extraction of the conjunct/adjunct. We will instead focus on the derivation of conjunction with Pair-MERGE in this section.

Under our current hypothesis, the previously discussed case ⟨VP, VP⟩ in Chinese serial verb constructions should be reanalyzed as coordination. In fact, the coordination reading is possible for native speakers, and is equally good as the modification reading, as shown in (41).

(41) Zhāngsān ⟨$_{\text{VP2}}$ {$_{\text{VP1}}$ yòng kuàizi} {$_{\text{VP2}}$ chī fàn}⟩.
Zhangsan use chopsticks eat food
(Lit.) 'Zhangsan uses chopsticks and eats.' (coordination reading)
'Zhangsan eats with chopsticks.' (modification reading)

Coordination marks union in the sense of set theory, and forms a natural pair with modification, which marks intersection, contrasting with argumental relation or operator-variable relation established by Set-MERGE. According to our assumption, when the pair-merged syntactic objects are of the same category, coordination reading is expected. Then, the modification reading in (41) is unexpected given that both conjuncts are VPs.

We propose that this unexpected modification reading is actually a second reading preferred over the original coordination reading. Along this line, the modification reading in (41) is not the primary reading that C-I originally assigns to the structure, but a secondary reading which is implied by the co-speaker. This secondary reading can further be strengthened, intuitively, by the world knowledge of the relation between "using chopsticks" and "eating", because "using chopsticks" is more likely to be interpreted as a supplement of an instrumental detail for the "eating" event, rather than some unrelated information to be coordinated with the "eating" event. Note that this secondary reading is not stable, and always depends on the semantic relation between the two conjuncts. For instance, although both coordination reading and modification reading are available in (42), the easiest reading obtained by our informants is the coordination reading. By contrast, the modification reading is mostly obtained on a second thought or with a certain prosodic pattern. Under our analysis, the prosodic intervention forces the asymmetry between the two conjuncts, which could elicit asymmetrical interpretations, for instance, modification.

(42) Xiǎolì xǐhuān [$_{\text{VP}}$ tīng yīnyuè] [$_{\text{VP}}$ chī píngguǒ].
Xiaoli like listen music eat apple
(i) 'Xiaoli likes listening to music and eating apples.' (coordination)
(ii) 'Xiaoli likes eating apples while listening to music.' (modification)

Importantly, this pragmatic preference will disappear if the two VPs denote the events that are empirically independent. In other words, when a modification relation is empirically hard to find between the two events, the interfering effect of pragmatic preference will be impossible. For example, the only available reading in (43) is the coordination reading. The secondary reading is unavailable due to the impossible modification relation between the two events: lunch cooking and having dinner.

(43) ⟨{$_{\mathrm{VP1}}$ zuò wǔfàn} {$_{\mathrm{VP2}}$ chī wǎnfàn}⟩
cook lunch eat dinner
'cook for lunch and have dinner'

A fundamental question is why coordination allows such preference-induced violations, whereas other interpretations do not. We propose that the simplex function of coordination lends it vulnerable to such phenomena, because coordination, in a sense, underlies other interpretation relations. This intuition is reflected in (Neo-)Davidsonian semantics, as suggested by Higginbotham (1985), where arguments, predicates and adjuncts are connected in the form of conjunction, such as in (44) (also see Hunter 2009, 2011).

(44) a. Brutus stabbed Caesar yesterday.
b. $\exists e.$[STAB(e) $\wedge$ Agent (b) (e) $\wedge$ Patient (c) (e) $\wedge$ Time (yesterday) (e)]

The essence of event semantics is the (speaker's) assignment of semantic functions to all the elements coordinated in the event. In other words, C-I will seek to interpret the primitive relation (represented by the conjunction operator $\wedge$) between the coordinated elements by allocating an appropriate semantic interpretation to it. One important syntactic indicator which the C-I system relies on is the parameter of dimensions, i.e., the type of MERGE. If two syntactic objects undergo Set-MERGE, C-I will interpret their relation either as argumental or as scopal; if two syntactic objects undergo Pair-MERGE, C-I will interpret their relation as modification if they are not the same category, or, as coordination if they have the same label. The maintenance of the coordination interpretation, however, marks the maintenance of a "primitive" interpretation, which C-I always instinctively tries to replace with concrete semantic relations, such as modification. It is then not surprising why coordination shows vulnerability to preference by secondary readings, while other interpretation relations do not. Earlier, we observed preference over conjunction relation by modification relation in the case of ⟨VP, VP⟩, and now take ⟨NP, NP⟩ as another example. For pair-merged NPs, such as ⟨$_{\mathrm{NP}}$ {$_{\mathrm{NP}}$ philosophy}, {$_{\mathrm{NP}}$ student}⟩ or ⟨$_{\mathrm{NP}}$ {$_{\mathrm{NP}}$ river}, {$_{\mathrm{NP}}$ pollution}⟩, an argumental relation is assigned as a secondary reading by C-I. It is also possible to have the modification relation assigned as the secondary reading. In (45), *cherry* and *tomato* are both nominals, and they form a ⟨NP, NP⟩ construction. By default, they form a coordination structure meaning 'cherry and tomato', so there are two types of fruits, as shown in (45a). However, it is also possible to interpret it as 'mini tomato', where there is only one type of fruit and *cherry* is the re-interpreted as the modifier to *tomato*, as shown in (45b).

(45) a. ⟨$_{\alpha=\text{NP1-NP2}}$ {$_{\text{NP1}}$ yīngtáo}, { $_{\text{NP2}}$ fānqié}⟩ wǒ dōu hěn ài chī.
cherry tomato I all much love eat
'I love both cherry and tomato.'

b. ⟨$_{\alpha=\text{ NP2}}$ {$_{\text{NP1}}$ yīngtáo}, { $_{\text{NP2}}$ fānqié}⟩ wǒ dōu hěn ài chī.
cherry tomato I all much love eat
'I love all (kinds of) mini tomatoes.'

Note that the "primitive" coordination relation as assumed in event semantics does not imply that Pair-MERGE underlies Set-MERGE, because the correspondence between the types of MERGE and the interpretation relations is only established at the "post-primitive" stage at the C-I interface, i.e., between the types of MERGE and the re-assigned semantic relations.

In the above discussed cases, pair-merged syntactic objects of the same category are automatically assigned a coordination relation by C-I without the presence of any overt coordination marker. As explained, given that this coordination reading is a less pragmatically-robust reading, it can therefore be dis-preferred. However, a coordination relation can also be syntactically marked by overt conjunction heads like *and*. Although coordination reading does not require the presence of these conjunction heads, their presence is a means to enhance the coordination interpretation, i.e., to prevent C-I from re-assigning it a secondary reading. In other words, under our model, coordination relation is a consequence of Pair-MERGE, and does not depend on an overt conjunction head. Mongolian data offer supports on this point. As shown in (46), coordination is preferably without any overt conjunction head in Mongolian.

(46) a. bi [evdej (bolon) khool iddeg].
I break and food eat
'I broke (and) ate the bread.'

b. bi [aav (bolon) [eej dee]] ulsen.
I father and mother ACC see
'I saw my father and mother.'

7 Pair-MERGE and head-movement

One of the possible ways to analyze head raising is internal Pair-MERGE, as proposed by Epstein et al. (2012, 2016).[15] Take T-to-C movement as an example. In (47), T is internally pair-merged to C, and then the complex C-T head is merged with the TP.

(47) {⟨C, T⟩, {$_{\text{TP}}$ T, *v*P}}

15 In Epstein et al. (2016), they propose that External PM can also be involved in the alleged phasal cancellation.

This analysis can easily be accommodated under our proposal. There are two possible scenarios, as illustrated in (48–49).

(48) a. $\{_{\alpha=CP} \langle_{C}\ \mathbf{C}, T\rangle, \{_{TP}\ T, \nu P\}\}$ b. $\{_{\alpha=CP} \left\langle \begin{array}{ll} ^{T} & T, \\ & -\,- \\ _{C} & C \end{array} \right\rangle, \{_{TP}\ T, \nu P\}\}$

(48) illustrates the first possibility, where C is set-merged with the TP, which means that C and the TP stay in the same dimension. When T is internally pair-merged with C from another dimension, in the dimension where C and the TP are located, $\langle_{C}$ C, T$\rangle$ is labeled as C. Then, C can probe a *wh*-phrase inside the TP to derive a normal *wh*-question. The final outcome will be interpreted as a *wh*-question at C-I. By contrast, in the dimension where the pair-merged T is located, $\langle_{T}$ C, T$\rangle$ is labeled as T, and the final outcome will be uninterpretable at C-I.

(49) a. $*\{_{\alpha=TP} \langle_{T}\ C, \mathbf{T}\rangle, \{_{TP}\ T, \nu P\}\}$ b. $*\{_{\alpha=TP} \left\langle \begin{array}{ll} ^{C} & C, \\ & -\,- \\ _{T} & T \end{array} \right\rangle, \{_{TP}\ T, \nu P\}$

(49) illustrates an alternative scenario, where T undergoes a vacuous movement but it still stays in the same dimension, and C is externally pair-merged with T from another dimension. In the dimension where T is located, $\langle_{T}$ C, T$\rangle$ is labeled as T, and this new complex head $\langle_{T}$ C, T$\rangle$ is to set-merge with the TP $\{_{TP}$ T, *v*P$\}$. However, this derivation will also give rise to an uninterpretable structure at C-I.

8 Conclusions

This paper proposes a general multi-dimensional derivation model under a free-MERGE system. Pair-MERGE and Set-MERGE are both primitive operations. MERGE indicates the derivational dimensions that participate the computation. Set-MERGE is considered as an operation that keeps the two merge-mates in the same dimension, and Pair-MERGE sends the two merge-mates to two different dimensions. A syntactic object resulted from Set-MERGE will be interpreted in terms of argumental relation or scopal relation; a syntactic object resulted from Pair-MERGE will be interpreted in terms of modification relation or coordination relation. Therefore, the type of MERGE is necessary because C-I maps different types of interpretation relations to the syntactic output based on the inspection of derivational dimensions. If C-I does not have any information concerning dimensions, it will not be able to decide the type of interpretation relations, such as argumentation versus modification. This is because, lexical semantics like theta grid is not enough to ensure a complete semantic interpretation of an entire syntactic output. For instance, without information concerning the derivational dimensions, C-I cannot filter a sentence like "**John decides* [*to forget yesterday*] *yesterday*." Therefore, Pair-MERGE is necessary in the system. The multi-dimensional syntactic output resulted from Pair-MERGE will then be transferred to C-I.

Both MERGE and Labeling Algorithm contribute to the interpretation at the C-I interface, which is in accordance with the Strong Minimalist Thesis, and satisfies the Legibility Condition. Given that MERGE alone does not ensure a complete semantic interpretation, LA is also necessary for the interpretation at C-I. The decision on the type of interpretation relations is based on the information concerning the number of dimensions involved in the structure. Each derivational dimension has its own independent status, and has its own LA. The LA inside one dimension ignores syntactic objects merged from other dimensions. Different possible labelings will give rise to different modification possibilities at the C-I interface. LA provides C-I with necessary information to realize the interpretation relations. For instance, when C-I sees that the two merged syntactic objects are located in two different dimensions, it will interpret their relation as modification or coordination. Based on the labels of the two merged syntactic objects, C-I then makes a decision between the two interpretation possibilities. If the two syntactic objects are of the same category, coordination relation will be assigned; conversely, if they are of different categories, modification relation will be assigned.

Cross-dimensional internal MERGE is generally possible. Adjunct island is accounted for in terms of a general ban on the cross-dimensional internal MERGE of a non-biggest syntactic object inside a workspace. Our analysis also generally accommodates the Pair-MERGE analysis of head-raising.

Some research issues still remain unaccounted for under the current derivation model. For instance, it is not clear whether an agree-based probe-goal relation can be established cross-dimensionally. Second, other properties related to adjunction as discussed extensively by Hornstein and Nunes (2008) should also be systematically examined under the current model. Third, it is not clear how to derive Across-The-Board movement, Parasitic Gap constructions, sideward movement with the current model, given that "parallel merge" is not an option (see Williams 1990; Nunes 2004; Citko 2005; Citko and Gracanin-Yuksek 2021, for the discussion on properties of these structures). We leave these questions to future study.

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