A Multimodal Type Logical Grammar Analysis of Japanese: Word Order and Quantifier Scope⋆

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Abstract. This paper presents an analysis of the interaction of scrambling and quantifier scope in Japanese, based on multimodal type logical grammar [5,6]. In developing the grammar of the language, we will make use of several modes. In particular, we will exploit the continuation mode as used in [2,7]. The concept deals with computational side effects and the evaluation order. After establishing the analysis of simple quantifier cases, we also discuss some morphologically related phenomena such as focus and split-QP construction [8,9], and show how they can be dealt with in our system.

1 Introduction

It is a well-known fact that a sentence like (1a) has two readings: the linear scope reading (1b) and the inverse scope reading (1c), although there is a preference for the former over the latter.

(1) a. Someone praised everyone.
 b. $\exists x[\text{human}(x) \wedge \forall y[\text{human}(y) \rightarrow \text{praise}(x, y)]]$
 c. $\forall y[\text{human}(y) \rightarrow \exists x[\text{human}(x) \wedge \text{praise}(x, y)]]$

In Japanese, however, such ambiguity does not arise from the word-to-word translation of sentence (1a). The only reading available for (2) is the linear scope reading (1b).

(2) Dareka-ga daremo-o hometa
 someone-NOM everyone-ACC praised
 'lit. Someone praised everyone.'

The reading (1c) can be obtained by preposing or scrambling the object noun phrase as in (3). It is also reported that the reading in (1b), *inverse* scope reading (with respect to this new surface word order) is also available (cf. [3]).

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(3) Daremo-o dareka-ga hometa
everyone-ACC someone-NOM praised
'lit. Everyone, someone praised.'

These observations suggest that the two languages differ in the strategy to realize the non-canonical scope interpretation. This paper attempts to formalize this idea in terms of multimodal type logical grammar. In particular, we will exploit the notion of continuation as used in [2,7] for the analysis of English, and specify how Japanese grammar is different from English grammar.

The rest of the paper is organized as follows. Section 2 describes scrambling phenomena in Japanese and provides an account within the framework of multimodal type logical grammar. In section 3 we introduce continuation mode into our grammar drawing on the work by Barker and Shan [2], and Shan [7] on English. We present the analysis of the interaction of word order and quantifier scope in Japanese. In section 4, we extend the analysis of the previous sections to the related phenomena, namely focus particle and split-QP construction. Finally, section 5 concludes.

2 Word Order in Japanese

This section aims at the multimodal analysis of scrambling phenomena in Japanese. After the brief introduction of the framework, we will look at some simple data and analyze them by introducing several unary modes. First, case features are encoded by the modal decorations of the form $\boxminus\Diamond$. This captures the optionality of the explicit case marking via the derivability relation $A \vdash \boxminus\Diamond A$. And then scrambling phenomena will be analyzed in terms of unary modes θ and s, which introduce a restricted form of commutativity into our grammar.

2.1 Multimodal Type Logical Grammar

In type logical grammar, all the grammatical/semantic information is encoded in the lexicon.[1] And just by applying logical rules and structural rules to the lexical items, we can derive the proof of (the acceptability of) any given utterance, which can directly be used to specify how to compute the meaning of that utterance (in the given context), due to Curry-Howard correspondence.

The virtue of a multimodal system is that while the base logic **NL** has the rigid notion of constituent structure (both hierarchically and horizontally, because of non-associativity and non-commutativity, respectively), we can fine-tune the structural properties of the grammar by the appropriate set of the modes and the structural rules that regulate the interaction between different modes.

[1] In the framework adopted here, one would argue that some grammatical information is encoded by structural rules. Also, the presence or absence of the Unquote rule as argued in section 3 can be seen as a kind of grammatical information. However, the application of a structural rule is licensed by its associated mode, which is specified by the lexicon (either directly or indirectly, through another structural rule). So there is a sense in which the lexicon is responsible for all the grammatical information.

Figure 1 summarizes the logical rules. Subscripts i and j are metavariables for the indices of binary and unary modes, respectively. Semantically, \E and /E (slash elimination) rules correspond to functional application, and \I and /I (slash introduction) rules correspond to λ-abstraction. The unary connectives $\Diamond$ and $\boxminus$ are used to regulate the structural behavior of the expression marked by them, and they have no significance on the part of semantics.

$$\frac{}{A \vdash A}\,\text{Id} \qquad \frac{\Gamma \vdash A/_iB \quad \Delta \vdash B}{(\Gamma,_i \Delta) \vdash A}\,/_i\text{E} \qquad \frac{(\Gamma,_i B) \vdash A}{\Gamma \vdash A/_iB}\,/_i\text{I}$$

$$\frac{\Delta \vdash B \quad \Gamma \vdash B\backslash_i A}{(\Delta,_i \Gamma) \vdash A}\,\backslash_i\text{E} \qquad \frac{(B,_i \Gamma) \vdash A}{\Gamma \vdash B\backslash_i A}\,\backslash_i\text{I}$$

$$\frac{\Gamma \vdash \boxminus_j A}{\langle\Gamma\rangle^j \vdash A}\,\boxminus_j\text{E} \qquad \frac{\langle\Gamma\rangle^j \vdash A}{\Gamma \vdash \boxminus_j A}\,\boxminus_j\text{I}$$

$$\frac{\Delta \vdash \Diamond_j B \quad \Gamma[\langle B\rangle^j] \vdash A}{\Gamma[\Delta] \vdash A}\,\Diamond_j\text{E} \qquad \frac{\Gamma \vdash A}{\langle\Gamma\rangle^j \vdash \Diamond_j A}\,\Diamond_j\text{I}$$

Fig. 1. Logical Rules

2.2 Case Marking and Scrambling in Japanese

In Japanese, word order is relatively free except that the main predicates (verbs or adjectives) of a clause are strictly fixed to the final position.[2] In particular, noun phrases can appear in any order as long as they are suffixed by a case particle, as illustrated in (4).[3] In such cases, permuting order does not lead to any ambiguity, since the thematic role of a noun phrase with respect to the predicate can be read off from the case marking.

(4) a. Taroo-ga Hanako-o hometa.
Taro-NOM Hanako-ACC praised

b. Hanako-o Taroo-ga hometa.
Hanako-ACC Taro-NOM praised
'Taro praised Hanako.'

[2] There is an exception to this generalization. See (i), an example of Right Dislocation:

(i) Taroo-ga hometa yo, Hanako-o.
Taro-NOM praised ASSERT Hanako-ACC
'Taro praised Hanako.'

This kind of irregularity seems to be confined to the main clause. They are not included in the fragment presented here.

[3] We assume that the meanings of these sentences are identical. Of course, scrambled word order may well have discourse related meaning. However, since we are focusing on the sentential meaning, the above assumption suffices for the current purposes.

Often in colloquial speech, nominal arguments occur without a case particle, in which case its thematic role is determined solely on the basis of the position relative to the predicate. The utterance (5) expresses the same meaning as (4), and cannot mean ‘Hanako praised Taro’.[4]

(5) Taroo Hanako hometa (yo).
Taro Hanako praised ASSERT

In view of these observations, a transitive verb like hometa is given the lexical assignment shown in (6):

(6) $\mathsf{hometa} \vdash \lambda x \lambda y.\mathrm{praise}(y, x) : \boxminus_a \Diamond_a n \backslash (\boxminus_n \Diamond_n n \backslash s)$

Note that the syntactic type of the (transitive) verb is *curried*, and that the case of the arguments are encoded by the decorations $\boxminus_j \Diamond_j$ where j is either n (for nominative) or a (accusative). In isolation, the case of a bare noun phrase is unspecified. But within a sentence, it must be specified via successive applications of $\Diamond$I and $\boxminus$I rules. Put another way, the optionality of case marking is captured by the theorem $A \vdash \boxminus \Diamond A$. The non-case marked sentence in (5) is derived thus:[5]

$$\dfrac{\dfrac{\dfrac{\mathsf{Taroo} \vdash n}{\langle \mathsf{Taroo} \rangle^n \vdash \Diamond_n n}\,\Diamond_n \mathrm{I}}{\mathsf{Taroo} \vdash \boxminus_n \Diamond_n n}\,\boxminus_n \mathrm{I} \qquad \dfrac{\dfrac{\dfrac{\mathsf{Hanako} \vdash n}{\langle \mathsf{Hanako} \rangle^a \vdash \Diamond_a n}\,\Diamond_a \mathrm{I}}{\mathsf{Hanako} \vdash \boxminus_a \Diamond_a n}\,\boxminus_a \mathrm{I} \quad \mathsf{hometa} \vdash \boxminus_a \Diamond_a n \backslash (\boxminus_n \Diamond_n n \backslash s)}{\mathsf{Hanako\ hometa} \vdash \boxminus_n \Diamond_n n \backslash s}\,\backslash \mathrm{E}}{\mathsf{Taroo\ (Hanako\ hometa)} \vdash s}\,\backslash \mathrm{E}$$

To reduce clutter, we will henceforth abbreviate $\boxminus_n \Diamond_n n$ and $\boxminus_a \Diamond_a n$ to n_n and n_a, respectively.

2.3 Scrambling Mode

Given the discussion in 2.2, the function of the case particles is twofold. First, they case mark the attached noun, naturally. The other function is to give the *potential* for the displacement to the resulting noun phrase. To capture this latter function, we introduce two unary modes θ (for θ-position) and s (for scrambling) to our grammar. The structural postulates for these modes are shown in (7).

(7) $$\dfrac{\Gamma[\langle \Delta \rangle^\theta] \vdash C}{\Gamma[\langle \Delta \rangle^s] \vdash C}\,\mathrm{Incl} \qquad \dfrac{\Gamma[\Sigma(\langle \Delta \rangle^s\ \Pi)] \vdash C}{\Gamma[\langle \Delta \rangle^s(\Sigma\ \Pi)] \vdash C}\,\mathrm{Scramble} \qquad \dfrac{\Gamma[\langle \Delta \rangle^s] \vdash C}{\Gamma[\Delta] \vdash C}\,\mathrm{T}_s$$

Intuitively, θ-mode is licensed by a case particle and used to record the position that the noun phrase would have occupied if it had not been case marked. Incl rule turns θ-mode into s-mode, which can be seen as the potential for the

[4] In the example the sentence final particle yo is added since otherwise the sentence may sound awkward.

[5] The binary structural operator $\cdot,\cdot$ of the default mode will be omitted throughout for the readability. Outermost parentheses are also left out.

movement. Scramble rule says that s-marked noun phrases may move towards the front.[6]

In this system, case-marking indirectly licenses scrambling in that θ-mode originating from a case particle must be converted to s-mode before movement. See footnote 9 for the reason why this roundabout is necessary. T_s rule just discards the s-mode. T_s and Incl rules jointly capture the optionality of the scrambling. Case particles ga and o are accordingly given the lexical assignments in (8). In terms of semantics, they are just the identity function on nouns.

(8) a. $\mathsf{ga} \vdash \lambda x.x : n \backslash \boxminus_\theta n_n$
b. $\mathsf{o} \vdash \lambda x.x : n \backslash \boxminus_\theta n_a$

Given these setup, the scrambling word order is derived thus:

$$\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{\text{Taroo ga} \vdash \boxminus_\theta n_n}{\langle\text{Taroo ga}\rangle^\theta \vdash n_n}\boxminus_\theta \mathrm{E}}{\text{Taroo ga} \vdash n_n} \quad \dfrac{\dfrac{\text{Hanako o} \vdash \boxminus_\theta n_a}{\langle\text{Hanako o}\rangle^\theta \vdash n_a}\boxminus_\theta \mathrm{E} \quad \text{hometa} \vdash n_a\backslash(n_n\backslash s)}{\langle\text{Hanako o}\rangle^\theta\ \text{hometa} \vdash n_n\backslash s}\backslash \mathrm{E}}{(\text{Taroo ga})(\langle\text{Hanako o}\rangle^\theta\ \text{hometa}) \vdash s}\backslash \mathrm{E}}{(\text{Taroo ga})(\langle\text{Hanako o}\rangle^s\ \text{hometa}) \vdash s}\mathrm{Incl}}{\langle\text{Hanako o}\rangle^s((\text{Taroo ga})\ \text{hometa}) \vdash s}\mathrm{Scramble}}{(\text{Hanako o})((\text{Taroo ga})\ \text{hometa}) \vdash s}\mathrm{T}_s$$

The derivation for the canonical order is trivial. It is obtained if we simply drop the s-mode by T_s rule at the antepenultimate line, instead of applying Scramble.

To sum up, the Scramble rule gives rise to a limited form of commutativity. An argument can be moved toward the front insofar as it is marked by s-mode which is indirectly qualified by the case particle. Yet the scrambling of a non-case marked noun phrase is disallowed.

3 Continuation Analysis of the Quantifier Scope

In this section, we will first show that quantifier scoping is closely related to the word order, then present an analysis based on the continuation mode [2,7].

3.1 Quantifier Scope in Japanese

Consider the data in (9), repeated from (2) and (3):

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[6] If utterances like (i), where only one of the arguments is case marked, should also be accepted, then lowering of a case marked noun phrase will be necessary and Scrambling rule must be restated so as to apply in both directions.

(i) Hanako Taroo-ga hometa
Hanako Taro-NOM praised
'Hanako, Taro praised.'

But the status of such sentences is subtle, so we will not pursue this possibility here.

(9) a. Dareka-ga daremo-o hometa
someone-NOM everyone-ACC praised
'lit. Someone praised everyone.'

b. Daremo-o dareka-ga hometa
everyone-ACC someone-NOM praised
'lit. Everyone, someone praised.'

As we saw in the introduction, the non-scrambled sentence (9a) is unambiguously interpreted as the subject taking wide scope, while the scrambled sentence (9b) can have both wide and narrow readings for the object (cf. [3]). In both sentences, at least on one reading, the leftmost quantifier takes the widest scope. Put simply, the two sentences have linear scope reading. Setting aside for a moment the presence of the inverse scope reading for (9b) (which we will discuss in 3.3), it could be argued that the above fact derives from the general tendency to the left-to-right evaluation order. The notion of evaluation order can be neatly modelled by incorporating the continuation mode in a multimodal type logical grammar as demonstrated in [2,7], the details of which we will turn to below.

3.2 Continuation Mode

Basically, the continuation for an element is the *context* in which it occurs. So for example, in the sentence (4a), repeated as (10a), the continuation for Hanako can be depicted informally as in (10b).

(10) a. Taroo-ga Hanako-o hometa.
Taro-NOM Hanako-ACC praised

b. ((Taroo ga)(([ ] o) hometa))

c. $\lambda x.\text{praise}(\text{taro}, x)$

The context (10b) can be seen as the function from the expression of type n (like Hanako) to the expression of type s. Accordingly, the semantic interpretation of (10b) can be given in (10c). Now consider (11), where a quantifier daremo appears in the same context as (10b).

(11) Taroo-ga daremo-o hometa.
Taro-NOM everyone-ACC praised
'Taro praised everyone'.

It is obvious that the meaning in (10c) cannot apply to the interpretation of daremo. Conversely, the latter takes its continuation as its argument as follows (ignoring the restriction for simplicity):

$$\underbrace{(\lambda k \forall x.k(x))}_{\text{daremo}}\ \underbrace{(\lambda x.\text{praise}(\text{taro}, x))}_{(10\text{b})} \rightsquigarrow \underbrace{\forall x.\text{praise}(\text{taro}, x)}_{(11)}$$

It is easy to see that, if we can manipulate the continuation like (10b) as a syntactic unit, then we will have a very simple account of the nonlocal behavior of quantifiers. For this purpose, we introduce a new binary mode, *continuation* mode, following [2,7]. For readability, the symbols $\circledcirc$, $/\!\!/$ and $\backslash\!\!\backslash$ (read *at*, *outside* and *inside*, respectively) are used instead of the structural punctuation $,_c$ and the type constructors $/_c$ and $\backslash_c$. Figure 2 indicates the structural rules that license the legitimate continuation. Figure 3 shows the same rules as well as two other necessary structural rules T and K′ in the Natural Deduction format.

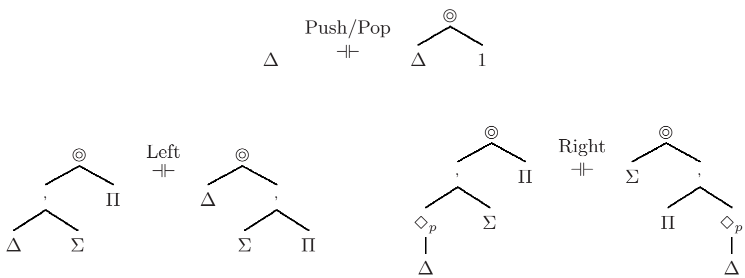


Fig. 2. Structural postulates for continuation mode, represented in tree form

$$\frac{\Gamma[\Delta] \vdash C}{\Gamma[\Delta \circledcirc 1] \vdash C}\,\text{Push} \qquad \frac{\Gamma[\Delta \circledcirc 1] \vdash C}{\Gamma[\Delta] \vdash C}\,\text{Pop} \qquad \frac{\Gamma[\langle \Delta\ \Sigma \rangle^p] \vdash C}{\Gamma[(\langle \Delta \rangle^p \langle \Sigma \rangle^p)] \vdash C}\,\text{K}'$$

$$\frac{\Gamma[\Delta \circledcirc (\Sigma\ \Pi)] \vdash C}{\overline{\Gamma[(\Delta\ \Sigma) \circledcirc \Pi] \vdash C}}\,\text{Left} \qquad \frac{\Gamma[(\langle \Delta \rangle^p\ \Sigma) \circledcirc \Pi)] \vdash C}{\overline{\Gamma[\Sigma \circledcirc (\Pi\ \langle \Delta \rangle^p)] \vdash C}}\,\text{Right} \qquad \frac{\Gamma[\langle \Delta \rangle^p] \vdash C}{\Gamma[\Delta] \vdash C}\,\text{T}$$

Fig. 3. Structural postulates for continuation mode, in Natural Deduction format

The connective $\circledcirc$ combines two things, by plugging what appears to its left hand side into what appears to its right hand side. The Push/Pop rules concern with the most trivial continuation, the null context. It is expressed by the atomic type 1, which is the right identity for the continuation mode.

Left and Right rules at first sight may give an impression that they are drastically destructing the structural configuration. But they have a very natural interpretation and in fact they do not affect the surface constituent structure. In order to see this, you can think of these trees as representing graphs where the vertical directionality has no significance but only the (counter-clockwise) rotating order count.[7] Then in each of these rules, when you start from the node Π, which stands for the context containing the 1 node (which in turn corresponds to the root of the constituent tree), tracing the same path while skipping the $\circledcirc$ node, you arrive at the same node in both sides.

The Left and Right rules can be seen as allowing the $\circledcirc$ node recursively going down (or going up) the original constituent tree (of which the root node is temporarily labelled by 1) to establish the legal configuration for a continuation.

[7] We adopt here Shan's version [7] rather than Barker and Shan's [2].

Note that in the Right rule, the ◎ node can go down to (or up from) the *right* (with respect to the original surface syntactic tree) branch, only if the *left* branch is enclosed by the unary structural operator $\langle\cdot\rangle^p$. This new mode p (for *pure* value) indicates that the constituent so marked has already been evaluated. Thus the Right rule enforces the left-to-right evaluation order for the continuation-sensitive elements such as quantifiers. This is the most attractive feature of the continuation mode, since it provides the tool to talk and reason about the evaluation order in the object language of the type logical grammar. Now we redefine the type of sentences as $\Diamond_p s$ rather than just s. Note that this change will not affect the derivability of the examples we considered so far, since in the presence of T rule we have $s \vdash \Diamond_p s$. The rules T and K′ regulate the p mode: T rule says that any expression can be turned into a pure value, and K′ rule says that two pure terms can be concatenated. The lexical entries for quantifiers can now be specified as in (12).

(12) a. dareka $\vdash \lambda k \exists x.\text{human}(x) \wedge k(x) : \Diamond_p s /\!\!/ (n \backslash\!\!\backslash \Diamond_p s)$
b. daremo $\vdash \lambda k \forall x.\text{human}(x) \rightarrow k(x) : \Diamond_p s /\!\!/ (n \backslash\!\!\backslash \Diamond_p s)$

The argument type of the quantifier $(n \backslash\!\!\backslash \Diamond_p s)$ is a type of the continuation that expects an element of type n within it to produce the expression of type $\Diamond_p s$. And the type of quantifier itself expresses the idea that if it is plugged into the continuation of type $(n \backslash\!\!\backslash \Diamond_p s)$, it produces the expression of type $\Diamond_p s$. Figure 4 illustrates the linear scope reading for (9a).[8]

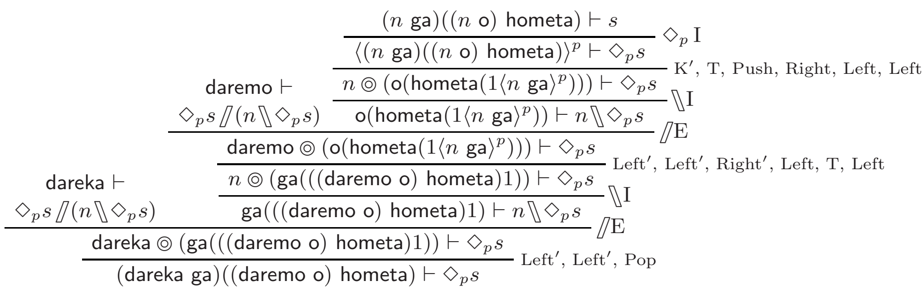


Fig. 4. Linear scope reading for SOV canonical order (9a)

Generally speaking, in the derivations like Figure 4, the element being applied at a lower step (that is, evaluated earlier) is the one that takes precedence over the other element at a higher step (that is, evaluated later). To get the linear scope reading for the scrambled word order (9b), we first derive the scrambled word order and then apply the same sequence of rules as in Figure 4, with the points at which dareka and daremo are introduced exchanged.

[8] Sequence of structural rules are compressed to save space. The labels Left′ and Right′ indicates the bottom-to-top application of the Left and Right rules respectively.

We can explain the impossibility of the inverse scope for (9a) as follows. In order for the object quantifier daremo to take wide scope, we have to plug the expression into the continuation of the form ((dareka ga)(([ ] o) hometa)). However, this configuration cannot be licensed, since we have (dareka ga) which is not a pure value to the left of the gap [ ].

Of course, it is possible to mark (dareka ga) as pure via T rule, but in the absence of the converse of T rule, $\langle\cdot\rangle^p$ punctuation cannot be discharged.

In fact, the presence or absence of the (partial) converse of T is the key to derive the difference of quantifier scoping between Japanese and English discussed in the introduction. Recall that in English, although left-to-right preference for scope interpretation is present, the inverse scope reading is also available. In order to derive this reading, [2,7] introduce Unquote rule, which implements the idea of multistage programming (for the discussion of this see the cited work). This is shown in (13). The modality u is introduced and s is redefined as $\Diamond_u s'$.

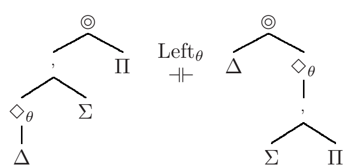
(13) $$\frac{\Gamma[\langle\Delta\rangle^u] \vdash C}{\Gamma[\langle\langle\Delta\rangle^u\rangle^p] \vdash C}\ \text{Unquote}$$

Unquote rule optionally allows that the evaluation of some element with computational side effect to be delayed, through the derivability relation $\Diamond_p s \vdash s$. Although inclusion of such a rule is certainly needed to account for the English data, we cannot follow the same strategy to account for the Japanese data, since Unquote rule would allow the inverse scope reading as a global option. In contrast, the current proposal predicts the fact that Japanese does not allow inverse scope in non-scrambled sentences like (9a), by *not* including the Unquote rule.

3.3 Inverse Scope Reading for Scrambled Sentence

The inverse reading of the scrambled sentence (9b) can be generated if the $\circledcirc$ node can *skip* the θ-modality. This is achieved by the Left_θ rule shown in (14).[9] Figure 5 illustrates the derivation. It amounts to computing the scope relation with respect to the word order *before* the scrambling of the object quantifier noun phrase takes place.

(14) $$\frac{\Gamma[\langle\Delta\rangle^\theta\ \Sigma] \circledcirc \Pi \vdash C}{\Gamma[\Delta \circledcirc \langle\Sigma\ \Pi\rangle^\theta] \vdash C}\ \text{Left}_\theta$$



[9] If we had allowed the communication between $\circledcirc$-mode and s-mode, the inverse scope reading for the SOV order would be derivable, since it is possible to have

$$(\langle\text{Obj}\rangle^p(\langle\text{Subj}\rangle^s\ \text{Verb})) \vdash \Diamond_p s$$

by first fronting the object, and we would be able to compute the *linear* reading with respect to this structure, and then move the subject at the front. So the distinction between θ-mode and s-mode is necessary.

$$\dfrac{(n\ \mathsf{ga})(\langle n\ \mathsf{o}\rangle^{\theta}\ \mathsf{hometa}) \vdash s}{\langle(n\ \mathsf{ga})(\langle n\ \mathsf{o}\rangle^{\theta}\ \mathsf{hometa})\rangle^{p} \vdash \Diamond_p s}\ \Diamond_p\mathrm{I}$$

$$\dfrac{\langle(n\ \mathsf{ga})(\langle n\ \mathsf{o}\rangle^{\theta}\ \mathsf{hometa})\rangle^{p} \vdash \Diamond_p s}{(\langle n\ \mathsf{ga}\rangle^{p}(\langle n\ \mathsf{o}\rangle^{\theta}\ \mathsf{hometa})) \vdash \Diamond_p s}\ \mathrm{K}', \mathrm{T}$$

$$\dfrac{(\langle n\ \mathsf{ga}\rangle^{p}(\langle n\ \mathsf{o}\rangle^{\theta}\ \mathsf{hometa})) \vdash \Diamond_p s}{n \circledcirc (\mathsf{o}\langle(\mathsf{hometa}\ (1\langle n\ \mathsf{ga}\rangle^{p}))\rangle^{\theta})) \vdash \Diamond_p s}\ \mathrm{Push, Right, Left}_{\theta}, \mathrm{Left}$$

$$\dfrac{n \circledcirc (\mathsf{o}\langle(\mathsf{hometa}\ (1\langle n\ \mathsf{ga}\rangle^{p}))\rangle^{\theta})) \vdash \Diamond_p s}{\mathsf{o}\langle(\mathsf{hometa}\ (1\langle n\ \mathsf{ga}\rangle^{p}))^{\theta}\rangle \vdash n \backslash\!\!\backslash \Diamond_p s}\ \backslash\!\!\backslash\mathrm{I}$$

$$\dfrac{\mathsf{daremo} \vdash \Diamond_p s /\!\!/ (n \backslash\!\!\backslash \Diamond_p s) \qquad \mathsf{o}\langle(\mathsf{hometa}\ (1\langle n\ \mathsf{ga}\rangle^{p}))^{\theta}\rangle \vdash n \backslash\!\!\backslash \Diamond_p s}{\mathsf{daremo} \circledcirc (\mathsf{o}\langle(\mathsf{hometa}\ (1\langle n\ \mathsf{ga}\rangle^{p}))\rangle^{\theta})) \vdash \Diamond_p s}\ /\!\!/\mathrm{E}$$

$$\dfrac{\mathsf{daremo} \circledcirc (\mathsf{o}\langle(\mathsf{hometa}\ (1\langle n\ \mathsf{ga}\rangle^{p}))\rangle^{\theta})) \vdash \Diamond_p s}{n \circledcirc (\mathsf{ga}((\langle \mathsf{daremo}\ \mathsf{o}\rangle^{\theta}\ \mathsf{hometa})1)) \vdash \Diamond_p s}\ \mathrm{Left}', \mathrm{Left}'_{\theta}, \mathrm{Right, T, Left}$$

$$\dfrac{n \circledcirc (\mathsf{ga}((\langle \mathsf{daremo}\ \mathsf{o}\rangle^{\theta}\ \mathsf{hometa})1)) \vdash \Diamond_p s}{(\mathsf{ga}((\langle \mathsf{daremo}\ \mathsf{o}\rangle^{\theta}\ \mathsf{hometa})1)) \vdash n \backslash\!\!\backslash \Diamond_p s}\ \backslash\!\!\backslash\mathrm{I}$$

$$\dfrac{\mathsf{dareka} \vdash \Diamond_p s /\!\!/ (n \backslash\!\!\backslash \Diamond_p s) \qquad (\mathsf{ga}((\langle \mathsf{daremo}\ \mathsf{o}\rangle^{\theta}\ \mathsf{hometa})1)) \vdash n \backslash\!\!\backslash \Diamond_p s}{\mathsf{dareka} \circledcirc (\mathsf{ga}((\langle \mathsf{daremo}\ \mathsf{o}\rangle^{\theta}\ \mathsf{hometa})1)) \vdash \Diamond_p s}\ /\!\!/\mathrm{E}$$

$$\dfrac{\mathsf{dareka} \circledcirc (\mathsf{ga}((\langle \mathsf{daremo}\ \mathsf{o}\rangle^{\theta}\ \mathsf{hometa})1)) \vdash \Diamond_p s}{(\mathsf{dareka}\ \mathsf{ga})(\langle \mathsf{daremo}\ \mathsf{o}\rangle^{\theta}\ \mathsf{hometa}) \vdash \Diamond_p s}\ \mathrm{Left}', \mathrm{Pop}$$

$$\dfrac{(\mathsf{dareka}\ \mathsf{ga})(\langle \mathsf{daremo}\ \mathsf{o}\rangle^{\theta}\ \mathsf{hometa}) \vdash \Diamond_p s}{(\mathsf{daremo}\ \mathsf{o})((\mathsf{dareka}\ \mathsf{ga})\ \mathsf{hometa}) \vdash \Diamond_p s}\ \mathrm{Incl, Scramble, T}_s$$

Fig. 5. Inverse scope reading for OSV scrambling word order (9b)

In this section, we have explained the different scope taking possibilities between English and Japanese in terms of the different set of structural rules (and the modes associated with them). With regard to the availability of the Unquote rule in English and its absence in Japanese, it might be speculated that given the strict word order, in deriving inverting scope reading the grammar of English has to take recourse to the Unquote rule, which does not change the word order, but changes the evaluation order. By contrast, the grammar of Japanese, already having a strategy to invert scope, namely Scramble rule, the need for delaying the evaluation simply does not arise. To put it another way, the different degree of flexibility in word order is reflected by the different strategies to the availability of scope reading *reversed* with respect to the thematic roles, assuming that Agent taking scope over Patient is the default case.

4 Some Related Phenomena

In this section, we will look at some related phenomena, namely focus and split-QP construction, that are also properly understood in terms of continuation.

4.1 Focus

Up to now, we have treated the quantifiers like daremo 'everyone' and dareka 'someone' as if they are unanalyzable units. Morphologically speaking, however, they can be decomposed into two parts: daremo can be decomposed into dare 'person' and mo 'every'. Likewise, dareka can be decomposed into dare 'person' and ka 'some'. Here, mo and ka are the elements that are responsible for the quantificational force of these items. On the other hand, dare belongs to the class called *indeterminates* [4], which also have a function similar to *wh*-words in English.

Now, let us investigate the morpheme mo in more detail. When the complement of mo does not contain indeterminates, its meaning will be equivalent to *also*. Consider (15):

(15) a. Taroo-mo Hanako-o hometa.
Taro-also Hanako-ACC praised
'*Taro* also praised Hanako.'
b. Taroo-ga Hanako-mo hometa.
Taro-NOM Hanako-also praised
'Taro also praised *Hanako*.'
c. Taroo-ga Hanako-o home-mo sita.
Taro-NOM Hanako-ACC praise-also did
'Taro also *praised* Hanako.'

As the translation suggests, the complement of mo is construed as a focused element. Continuation semantics is clearly related to the focus denotation [1]. We can specify the lexical assignment of mo as in (16):

(16) $\mathsf{mo}_{\text{also}} \vdash \lambda x \lambda k.k(x) \wedge \exists y.y \neq x \wedge k(y) : \Diamond_i X \backslash (\Diamond_p s /\!\!/ (X \backslash\!\!\backslash \Diamond_p s))$

We show the derivation of (15b), but now in the informal notation:

$$\dfrac{\dfrac{\langle \mathsf{Hanako} \rangle^i \vdash \Diamond_i n \quad \mathsf{mo} \vdash \Diamond_i n \backslash (\Diamond_p s /\!\!/ (n \backslash\!\!\backslash \Diamond_p s))}{\langle \mathsf{Hanako} \rangle^i \ \mathsf{mo} \vdash \Diamond_p s /\!\!/ (n \backslash\!\!\backslash \Diamond_p s)} \backslash \mathrm{E} \quad (\mathsf{Taroo\ ga})([\ ]\ \mathsf{hometa}) \vdash \Diamond_i n \backslash\!\!\backslash \Diamond_p s}{(\mathsf{Taroo\ ga})((\langle \mathsf{Hanako} \rangle^i\ \mathsf{mo})\ \mathsf{hometa}) \vdash \Diamond_p s} /\!\!/ \mathrm{E}$$

The derivation above gives us the interpretation (see also (10)):

$$((\lambda x \lambda k.k(x) \wedge \exists y[y \neq x \wedge k(y)])(\text{hanako}))(\lambda x.\text{praise}(\text{taro}, x)) \rightsquigarrow$$
$$(\lambda k.k(\text{hanako}) \wedge \exists y[y \neq \text{hanako} \wedge k(y)])(\lambda x.\text{praise}(\text{taro}, x)) \rightsquigarrow$$
$$\text{praise}(\text{taro}, \text{hanako}) \wedge \exists y[y \neq \text{hanako} \wedge \text{praise}(\text{taro}, y)]$$

In words, this sentence asserts that Taro praised Hanako, and presupposes that there is another person whom Taro praised. For the presuppositional part of the meaning, we blatantly used logical conjunction. But in this way, we also notice the similarity to the meaning of mo in the universal quantifier reading. Recall that (11) Taroo-ga daremo-o hometa has the interpretation:

$$\forall x.\text{praise}(\text{taro}, x)$$

which can be thought of as the conjunction of the form:

$$\text{praise}(\text{taro}, \text{hanako}) \wedge \text{praise}(\text{taro}, \text{jiro}) \wedge \text{praise}(\text{taro}, \text{saburo}) \wedge ...$$

where x in the body of the universal quantifier substituted for constants in the domain of individuals.

4.2 Split-QP and *wh*-Island

There exists a construction where the indeterminate and the quantifier appear separated from each other, but semantically interact. Consider (17).

(17) [Dare-ga kaita hon] mo omosiroi
person.INDET-NOM wrote book every is:interesting
'lit. Every book that a person wrote is interesting.'

Following [9], we will refer to such construction as *Split-QP* (see also [3,4,8], among others). For the lack of space, we will only sketch the analysis in terms of continuation, leaving out the fuller treatment for future study.

We regard mo-phrase in split-QP as forming the complex quantifier phrase. Semantically speaking, the entire mo-phrase is a function that takes its continuation as its argument (or scope):

$$\underbrace{(\lambda k \forall x.k(\iota y.\text{book}(y) \wedge \text{wrote}(x,y)))}_{\textsf{dare ga kaita hon mo}}\ \underbrace{(\lambda x.\text{interesting}(x))}_{([\ ]\textsf{omosiroi})} \rightsquigarrow$$

$$\underbrace{\forall x.\text{interesting}(\iota y.\text{book}(y) \wedge \text{wrote}(x,y))}_{(17)}$$

By reasoning backwards, dare ga kaita hon mo should have the same syntactic type as daremo, i.e., $\Diamond_p s \sslash (n \bbslash \Diamond_p s)$. And the lexical assignments of dare and mo can be specified as in (18).

(18) a. $\textsf{mo}_\forall \vdash \lambda p \lambda k \forall x.k(px) : \Diamond_i (n \backslash_? n) \backslash (\Diamond_p s \sslash (n \bbslash \Diamond_p s))$
b. $\textsf{dare} \vdash \lambda k \lambda x.k(x) : (n \backslash_? X) \sslash (n \bbslash X)$

The following proof shows that dare ga kaita hon mo has the same type as the quantifier daremo:[10]

$$\dfrac{\dfrac{\dfrac{\textsf{dare} \vdash (n \backslash_? n) \sslash (n \bbslash n) \quad ((([\ ]\ \textsf{ga})\ \textsf{kaita})\ \textsf{hon} \vdash n \bbslash n}{((\textsf{dare ga})\ \textsf{kaita})\ \textsf{hon} \vdash n \backslash_? n}\bbslash E}{\langle ((\textsf{dare ga})\ \textsf{kaita})\ \textsf{hon}\rangle^i \vdash \Diamond_i (n \backslash_? n)}\Diamond_i I \quad \begin{array}{c}\textsf{mo} \vdash \\ \Diamond_i (n \backslash_? n) \backslash (\Diamond_p s \sslash (n \bbslash \Diamond_p s))\end{array}}{\langle ((\textsf{dare ga})\ \textsf{kaita})\ \textsf{hon}\rangle^i\ \textsf{mo} \vdash \Diamond_p s \sslash (n \bbslash \Diamond_p s)}\bbslash E$$

Note that by the lexical assignments in (16) and (18a), we require that the complement of mo be marked by the unary mode i. This is needed for the account of *wh*-island effect: indeterminates like dare cannot be associated with mo or ka, across intervening mo or ka. This is illustrated in (19):

(19) a. [[Dare-ga kaita hon] mo omosiroi to omou gakusei]
person.INDET-NOM wrote book MO interesting COMP think student
mo kita.
MO came

[10] We have made implicit the derivation of the relative clause. We simply assume the head noun is assigned the type $(\Diamond_s \boxminus_s n \backslash \Diamond_p s) \backslash n$ in the lexicon, where $\Diamond_s \boxminus_s n$ corresponds to the *gap* in the relative clause (an alternative way to get the same thing would be to posit a phonologically empty relative pronoun).

b. The student who thinks that for every x, x a person, the book x wrote is interesting came, too.
c. *For every x, x a person, a student who thinks that the book x wrote is also interesting, came.

In (19a), there are two occurrences of mo. Given the presence of the indeterminate dare, one of them has to be construed as the universal quantifier (18a) and the other as the focus particle (16). So in principle there is two possible interpretations as shown in (19b–c).

But in the presence of i mode, and the *lack* of the structural rule that communicates i mode and continuation mode (or the variant of T rule that discards i mode), indeterminate dare can only take the context:

$$[[\ ]\mathsf{ga\ kaita\ hon}]$$

as its argument, but not the larger context:

$$[[[\ ]\mathsf{ga\ kaita\ hon}]\mathsf{mo\ omosiroi\ to\ omou\ gakusei}]$$

so that *wh*-island effect ensues.[11]

Finally, we show how the lexical assignments in (18a–b) relate to the non-split form daremo. Actually, the lexical entry for daremo can be derived from (18a–b), if we posit the phonologically empty element ϵ:

$$\epsilon \vdash \lambda x.x : n \mathbin{\backslash\!\!\backslash} n$$

We can derive the string daremo with type $\Diamond_p s \mathbin{/\!\!/} (n \mathbin{\backslash\!\!\backslash} \Diamond_p s)$:

$$\dfrac{\dfrac{\dfrac{\mathsf{dare} \vdash (n\backslash_? n) \mathbin{/\!\!/} (n \mathbin{\backslash\!\!\backslash} n) \quad \epsilon \vdash n \mathbin{\backslash\!\!\backslash} n}{\mathsf{dare}\ \epsilon \vdash n\backslash_? n} \mathbin{/\!\!/}\mathrm{E}}{\langle \mathsf{dare}\ \epsilon\rangle^i \vdash \Diamond_i(n\backslash_? n)} \Diamond_i\,\mathrm{I} \quad \mathsf{mo} \vdash \Diamond_i(n\backslash_? n)\backslash(\Diamond_p s \mathbin{/\!\!/} (n \mathbin{\backslash\!\!\backslash} \Diamond_p s))}{\langle \mathsf{dare}\ \epsilon\rangle^i\ \mathsf{mo} \vdash \Diamond_p s \mathbin{/\!\!/} (n \mathbin{\backslash\!\!\backslash} \Diamond_p s)} \backslash\mathrm{E}$$

However, the derivation above is presented just for explaining the relatedness between the split and non-split quantifiers, and we may have to retain the separate lexical entry for daremo. This is because of the fact that daremo seems to require a case particle, while mo in split-QP does not, the difference remains unexplained in this paper.[12,13]

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[11] The unary bracket $\langle\cdot\rangle^i$ can be seen as simulating the *delimited continuation*.

[12] If daremo is used without case particle, it is most likely to be construed as negative polarity item 'nobody', the case not treated in this paper.

[13] This requirement can be encoded in the grammar by introducing another unary mode k and setting the lexical entries for daremo and case particle as in (i).

(i) a. $\mathsf{daremo} \vdash \Diamond_p s \mathbin{/\!\!/} (\boxminus_k \Diamond_k n \mathbin{\backslash\!\!\backslash} \Diamond_p s)$
b. $\mathsf{ga} \vdash \boxminus_k \Diamond_k n \backslash \boxminus_\theta\, n_a$

5 Conclusion

In the multimodal type logical grammar formalism, an analysis of scrambling word order and the limitation on quantifier scope readings in Japanese was presented. We also discussed the difference of scope taking possibilities between English and Japanese as reflecting the different strategy to give a noncanonical scope reading, namely a global optional delaying device (Unquote) and the word order flexibility (Scramble). We also made some comments on the related phenomena in Japanese, namely focus and split-QP construction, however the discussion there was too far from being conclusive, and thus awaits further study.

References

1. Barker, C.: Continuations in Natural Language. In: Thielecke, H. (ed.) CW'04: Proceedings of the 4th ACM SIGPLAN continuations workshop, Tech. Rep. CSR-04-1, School of Computer Science, University of Birmingham, pp. 1–11 (2004)
2. Barker, C., Shan, C.-c.: Types as Graphs: Continuations in Type Logical Grammar. Journal of Logic, Language and Information 15, 331–370 (2006)
3. Hoji, H.: Logical Form Constraints and Configurational Structures in Japanese. Ph.D. dissertation, University of Washington (1985)
4. Kuroda, S.-Y.: Generative Grammatical Studies in the Japanese Language. Ph.D. dissertation, MIT (1965)
5. Moortgat, M.: Categorial Type Logics. In: van Benthem, J.F.A.K., ter Meulen, A.G.B. (eds.) Handbook of Logic and Language, ch. 2, Elsevier Science, Amsterdam (1997)
6. Morrill, G.V.: Type Logical Grammar: Categorial Logic of Signs. Kluwer, Dordrecht (1994)
7. Shan, C.-c.: Linguistic Side Effects. Ph.D. dissertation, Harvard University (2005)
8. Shimoyama, J.: Indeterminate Phrase Quantification in Japanese. Natural Language Semantics 14, 139–173 (2006)
9. Takahashi, D.: Determiner Raising and Scope Shift. Linguistic Inquiry 33, 575–615 (2002)