A unified approach to questions, quantifiers, and coordination in Japanese

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Abstract

The Japanese language is one of the languages where universal and existential quantification are expressed using *wh*-words with the conjunctive and disjunctive particles, respectively. In this paper, inspired by the syntactic and semantic parallelism found in Japanese between quantification, coordination, and question, we seek to analyze these constructions in a unified fashion. We investigate various phenomena of these constructions and show how these three constructions can be uniformly analyzed as cases where abstracted arguments are questioned or quantified for verbs. We then present an HPSG formalization of the analysis.

1 Introduction

Universal/existential quantifiers can be seen as generalization of logical conjunction/disjunction. The universal (existential) quantification of an open proposition is the conjunction (disjunction) of all its possible instantiations. In other words, conjunction (disjunction) is a special kind of universal (existential) quantification where the domain of the variable is restricted to the set of the conjuncts (disjuncts). The Japanese language seems to reflect this well-known logical relationship. A common way in Japanese to express universal or existential quantification is to use a *wh*-pronoun in combination with *mo* or *ka*, particles otherwise used to denote conjunction or disjunction (Let's call this quantification *wh-mo/ka*).[1] Actually, there is a strong parallelism between these two uses of the particles:

(1) a. Kare-wa ie-de-mo gakkou-de-mo asonda.
he-TOP home-LOC-*mo* school-LOC-*mo* played
'He played at home and at school.'

b. Kare-wa doko-de-mo asonda.
he-TOP where-LOC-*mo* played
'He played everywhere.'

c. Kare-wa ie-ka gakkou-(ka)-de asonda.
he-TOP home-*ka* school-*ka*-LOC played
'He played at home or at school.'

d. Kare-wa doko-ka-de asonda.
he-TOP where-*ka*-LOC played
'He played somewhere.'

Examples (1b) and (1d) are examples of universal and existential quantification, respectively. In (1b), the *wh*-word *doko* 'where' is marked by *mo*, and it means

[1]There are other languages where universal/existential quantification is expressed by a *wh*-word and a conjunctive/disjunctive particle (see, for example, Gill et al. (2004)). This suggests that the use of conjunctive and disjunctive particles in universal and existential quantification in Japanese is not just a coincidence but a typological tendency.

'everywhere'. In (1d), *doko* is marked by *ka*, and it means 'somewhere'. Examples (1a) and (1c) are examples of conjunctive and disjunctive coordination. As you can see, syntactically, (1a) and (1c) are the same as (1b) and (1d), respectively, except that the *mo/ka*-marked argument are repeated several times (2 times in this case) and in each case, the *wh*-word is replaced by a different individual. This syntactic correspondence between (1a, c) and (1b, d) is parallel with the semantic correspondence between these examples because, as the above-mentioned logical relationship between universal/existential quantification and conjunctive/disjunctive coordination suggests, the denotations of (1a) and (1c) are the same as those of (1b) and (1d), respectively, except that the domain of the variable is restricted to the set of conjuncts.

But what are the *wh*-words doing in the quantified sentences (1b, d)? According to Ginzburg and Sag (2001) (henceforth GS)'s semantic ontology, on which they base their HPSG account of English interrogatives, questions are propositional abstracts where *wh*-words correspond to abstracted arguments. If, in (1b, d), the *wh*-words are not *mo/ka*-marked and the verb is in the interrogative form, we have an ordinary *wh*-question:

(2) Kare-wa doko-de asonda-ka?
he-TOP where-LOC played-Q
'Where did he play?'

and its denotation, in GS's view, is

(3) $\lambda\{x\}[\![\text{he played at } x]\!]$

Note here that (3) is the very open proposition which is quantified in (1b, d).

The relationship between the three constructions in question, namely question, quantification, and coordination in Japanese, is informally summarized in Figure 1, which shows the semantic relationship, what syntactic elements each construction consists of, and how these syntactic elements are shared between these constructions.

This relationship leads us to think that the semantics of questions, quantifiers and coordination in Japanese should be consistently accounted for by the semantic contributions of the particles *mo/ka* and of *wh*-words. In the following, we show how such an analysis can be implemented in HPSG.[2]

2 Framework

Before proceeding with the analysis, let us first outline our general framework for representing the semantics of question and quantification and for identifying

[2]Hagstrom (1998) further identified the disjunctive particle *ka* with the question marker *ka* and tried to analyze them uniformly as existential quantification over choice functions. We do not take this view, however, because the disjunctive particle *ka* and the question marker *ka* are a nominal suffix and a suffix to finite verbs, respectively, and thus we consider that they are different lexical entries belonging to different syntactic categories that happen to have the same form.

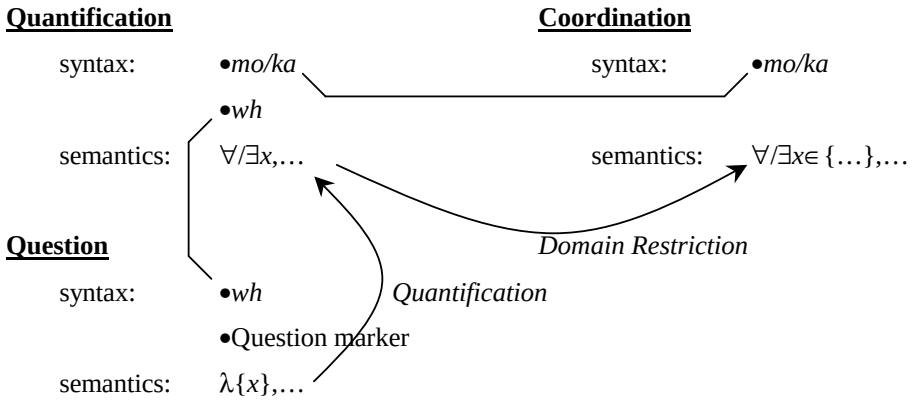


Figure 1: Syntactic/semantic relationship between the three constructions

mo/ka-marked words in HPSG. Our general semantic framework follows that of GS's, but with some modifications. In this section, we first explain our adaptation of GS's framework, and then we introduce a feature to identify *mo/ka*-marked words.

2.1 Ginzburg and Sag (2001)'s semantic framework

GS introduced a separate semantic type, *question*, for the contents of interrogative clauses. The type *question* has the feature PARAMS, "the *wh*-phrase analogue of QUANTS" (Ginzburg and Sag 2001:121), whose value is a set of *params*, "restriction-bearing indices" (Ginzburg and Sag 2001:121), which correspond to the abstracted arguments of the propositional abstract – the *wh*-words in the clause. In their framework, questions are semantically distinguished from other clauses by their contents being of type *question*. Thus, even polar questions, questions with no arguments abstracted, can be distinguished as questions, only with empty PARAMS.

This treatment of polar questions, however, is not without problems. GS define the conjunction of two propositional abstracts as follows (Ginzburg and Sag 2001:110):

> *Given a question* q_1 *(*$= \lambda A.\sigma$*) and a question* q_2 *(*$= \lambda B.\tau$*), where* $A \cap B = \emptyset$*:*
>
> $$\wedge(\lambda A.\sigma, \lambda B.\tau) =_{def} \lambda A \cup B. \wedge \{\sigma, \tau\}$$

($\lambda A.\sigma$ denotes the propositional abstract whose set of abstracted argument is A and whose corresponding proposition is σ) That is, as the conjunction of the corresponding propositions with the set of abstracted arguments being the union of the sets of abstracted arguments of the conjuncts. But in this way, since a polar question is a propositional abstract whose set of abstracted parameters is the empty set and the union of a set with the empty set is the original set itself, if you conjoin

a polar question with another question, the information that the truth value of the corresponding proposition of the polar question is asked is lost. For example, the denotation of (4a) and (4b) will be the same, that is, (4c).

(4) a. whether it is good and whether it is cheap

b. whether it is good and cheap

c. $\lambda\{\}(\text{Good}(i) \wedge \text{Cheap}(i))$

d. $\lambda\{p_1, p_2\}(\text{Good}(i, p_1) \wedge \text{Cheap}(i, p_2))$

e. $\lambda\{p\}(\text{Good}(i, p) \wedge \text{Cheap}(i, p))$

One way to solve this problem is to regard the polarity as an argument and to abstract it in polar questions, instead of identifying polar questions as propositional abstracts with empty PARAMS.[3] For example, if 'Good' and 'Cheap' in (4) have the polarity argument as their second arguments, the denotation of (4a) and (4b) are distinguished as (4d) and (4e), respectively.

To implement this solution, in our framework, the type *rel(ation)* has the feature POL(ARITY), whose value is of type *index*. The POL of a relation indicates whether the relation holds or not. For example, a negative declarative sentence's matrix verb[4] whose CONT|NUCL|POL is i has $negative(i)$ in its BACKGROUND[5] to indicate that the verb's polarity is negative. The POL value is of type *index* so that it can be abstracted. In polar questions, this index is converted to a parameter with the restriction of being a polarity and put in the PARAMS set.

As a byproduct of this solution, we do no longer need a separate semantic type for questions, for questions can now be distinguished simply by their PARAMS being non-empty: in our framework, we do not have the type *question*, and instead PARAMS is made a feature appropriate for *soa*. In this way, PARAMS is more "analogue of QUANTS", as PARAMS and QUANTS are both features of *soa*, and questions and quantified clauses are distinguished from other clauses by their PARAMS and QUANTS being non-empty, respectively.

2.2 *mo/ka*-marked words

In order to be able to identify whether a word is marked by *mo*, *ka*, or neither, we introduce a feature called MOKA. MOKA is a feature appropriate for the type *part-of-speech*, and its value is of type *moka*. The type *moka* has three subtypes: *mo*,

[3]There are other reasons to prefer this solution. First, the PARAMS set can be thought of as the set of inquired information and in a polar question, something is surely asked – the truth-value of the clause. Second, in English, there is a *wh*-word, *whether*, for this argument, as can be seen in (4a, b). Third, and most important for this paper, this polarity argument can be quantified: 'no matter wh...' construction is the English counterpart of Japanese *wh-mo*, and *whether* can be quantified as in 'no matter whether ...'

[4]Throughout this paper, I use the term 'verb' to refer to verbs and adjectives.

[5]We will see the constraint to achieve this in section 4.1.

ka, and -. A word's HEAD|MOKA is *mo* and *ka* when the word is marked (suffixed) by the conjunctive particle *mo* and by the disjunctive particle *ka*, respectively, and otherwise it is -.

Parts of the type hierarchy of our framework are shown in Figure 2

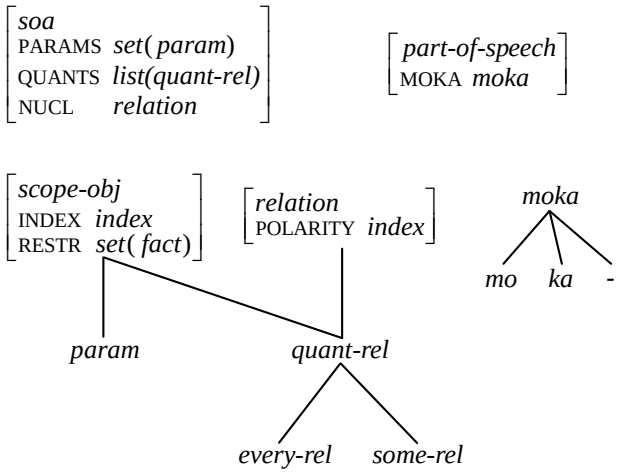


Figure 2: Parts of the type hierarchy

3 Data and Analysis

3.1 Quantification

In *wh-mo/ka*, the particles *mo/ka* do not always mark the *wh*-word directly. Especially, *mo* can mark any verbal dependent[6] containing the *wh*-word.[7] Thus, there are sentences that differ only in the position of *mo* and in such cases, different positions of *mo* can lead to different meanings:

(5) a. Kujyo-ga kare-kara kuru-to komaru.
complaint-NOM he-from come-COND I hate it
'I hate it if he complains.'

b. Kujyo-ga dare-kara-mo kuru-to komaru.
complaint-NOM who-from-*mo* come-COND I hate it
'I hate it if everyone complains.'

[6]By a verbal dependent, I mean a dependent of a verb, and by saying that a dependent is marked by *mo/ka*, I mean that the head word of the dependent is marked (suffixed) by *mo/ka*.

[7] On the other hand, *ka* usually marks *wh*-words directly and there are cases where such *ka*-marked *wh*-words are not verbal dependents. In this paper, however, we restrict ourselves to cases where *ka*-marked *wh*-words make verbal dependents.

c. Kujyo-ga dare-kara kite-mo komaru.
complaint-NOM who-from come-COND-*mo* I hate it
'I hate it if someone complains.'

d. Kujyo-ga dare-ka-kara kuru-to komaru.
complaint-NOM who-*ka*-from come-COND I hate it
'I hate it if someone complains.'

Examples (5b-d) are the same as (5a), except that the argument *kare* is abstracted and quantified by *wh-mo/ka*. Examples (5b) and (5d) differ in whether the *wh*-word is marked by *mo* or by *ka*, and accordingly their meanings differ in whether the antecedent is quantified universally or existentially. Examples (5b) and (5c) differ only in the position of *mo* but their meanings are so different that (5c)'s meaning is the same as (5d)'s.

It has been noted in the literature (e.g., Yatsushiro (2001)) that *mo* marks the scope of the universal quantifier. Considering that *mo* always marks a verbal dependent, we propose the following principle of quantification to explain the semantics of *wh-mo*/*ka*: for each *mo/ka*-marked dependent of a verb, *wh*-words contained in it can be universally/existentially quantified for the verb.[8] It follows from this principle that the quantified clause is the antecedent in (5b, d) and the matrix sentence in (5c). Thus, we get the following denotations for (5b-d):

(6) a. $(\forall x, x$ complains$) \rightarrow$I hate it

b. $\forall x, (x$ complains$\rightarrow$I hate it$)$

c. $(\exists x$ s.t. x complains$) \rightarrow$I hate it

As (6b) and (6c) are logically equivalent, these denotations match the actual interpretations of (5b-d).

3.2 Question

Now consider questions. It has been noted in the literature (e.g., Hagstrom (1998)) that the interrogative scope is marked by the question marker, as can be seen in the following example:

(7) a. Kujyo-ga dare-kara kita-ka tazuneta.
complaint-NOM who-from came-Q I asked
'I asked who complained.'

b. Kujyo-ga dare-kara kita-to omou-ka.
complaint-NOM who-from came-that think-Q
'Who do you think complained?'

[8]By saying that a *wh*-word w is quantified for a verb v, I mean that w is quantified as a variable of the open proposition which the maximal projection of v denotes. In our HPSG framework, it means that the *quant-rel* made from the parameter which w denotes goes into the QUANTS of the *soa* which v denotes.

So the principle of question is as follows: for each verb in the interrogative form (VFORM being *interrogative*), *wh*-words contained in its maximal projection can be questioned for it.[9]

3.3 Interaction of constraints

Note that the principle of quantification does not say that all, or even some, of the *wh*-words in a *mo/ka*-marked dependent of a verb are quantified for the verb. While *ka* usually marks the *wh*-words directly and such *ka*-marked *wh*-words can only be quantified for the word of which the *wh*-word is a dependent, *mo* can mark any verbal dependent, which may contain two or more *wh*-words, and not all *wh*-words there are necessarily quantified for the verb. The following example illustrates this point.

(8) a. Dare-mo nani-mo iwanai.
who-*mo* what-*mo* say-NEG
'Nobody says anything.'

b. Dare-ga nani-o itte-mo kinisi-nai.
who-NOM what-ACC say-COND-*mo* care-NEG
'No matter who says what, I don't care.'

c. Dare-ga nani-o itte-mo kinisi-nai-no?
who-NOM what-ACC say-COND-*mo* care-NEG-Q

d. John-ga nani-o itte-mo kinisi-nai.
John-NOM what-ACC say-COND-*mo* care-NEG
'No matter what John says, I don't care.'

Although both (8a) and (8b) have two *wh*-words universally quantified by *wh-mo*, *mo* appears only once in (8b) and twice in (8a). This is because, while, in (8a), the two *wh*-words are two separate dependents of the verb for which they are quantified, (8b) is an example where the two *wh*-words are contained in one dependent of the verb for which they are quantified.

Example (8c) is the same as (8b) except that the matrix verb is marked by a question marker. Unlike (8b), however, (8c) has an interesting grammatical ambiguity. There are four interpretations of (8c) as each of the two *wh*-words can either be quantified by *wh-mo* or be questioned by the question-marker. Although, out of context and with default prosody, the default interpretation of (8c) would be as a polar question, where the two *wh*-words are both quantified ('Don't you care no matter who says what?'), other interpretations are possible. For example, the interpretation that the first *wh*-word *dare* is questioned and the second *wh*-word *nani*

[9] By saying that a *wh*-word w is quantified for an interrogative verb v, I mean that the interrogative scope is the maximal projection of v. In our HPSG framework, it means that the *param* which w denotes goes into the PARAMS of the *soa* which v denotes.

is quantified ('No matter what WHO says, you don't care?') is natural as a reprise question to (8d) or when the first *wh*-word *dare* is stressed.[10, 11]

Such an ambiguity can be explained as the result of interaction between the principle of quantification and the principle of question. Of course, all *wh*-words must be either quantified or questioned once, and only once, somewhere. But when *mo/ka* and question-markers co-occur, as in (8c), or when a verb phrase is embedded in another, there will be choices as to whether the *wh*-words are questioned or quantified and for which verb. In our HPSG framework, these different choices are represented by whether the parameters go into PARAMS or QUANTS and which *soa*'s PARAMS/QUANTS they go into.[12]

3.4 Coordination

As we noted in the introduction, conjunction (disjunction) is a special kind of quantification, where the domain of the variable is restricted to the set of conjuncts (disjuncts). Marked by *mo*, (1a) and (1b) are both examples of universal quantification that differ only in the domain of the variable. In (1b), the *wh*-word *doko* implies that the domain is the set of places. In (1a), the conjunction implies that the domain is the set of its conjuncts, that is, $\{home, school\}$. So, we analyze a coordinated phrase in the same way as a *mo/ka*-marked *wh*-word, that is, as a parameter, except that the domain is restricted to the set of the conjuncts and that it can only be quantified for the verb of which it is a dependent, not questioned.

In a coordinated phrase, conjuncts (disjuncts) must have compatible syntactic categories whose MOKA values are not -. When they are marked by *ka*, the coordinated phrase must have at least two disjuncts. A *mo*-marked coordinated phrase, on the other hand, may consist of one conjunct (or more).

[10]The correspondence between prosody and scope of *wh*-question has been discussed in previous works (e.g., Deguchi and Kitagawa (2002); Ishihara (2002)).

[11] Out of context and with default prosody, however, interpretations other than as a polar question would be unnatural. We leave it to future work to discuss exactly in what context or with what prosody such interpretations can be natural, that is, what pragmatic/prosodic constraints are to be imposed when not all free *wh*-words in a *mo*-marked verbal dependent are quantified for the verb. Cf. footnote 12.

[12] Previous works such as Shimoyama (to appear) claim the existence of what she calls the island puzzle in Japanese to the effect that all, not some, free *wh*-words in a *mo*-marked verbal dependent are quantified for the verb and all, not some, of the remaining *wh*-words in an interrogative verb's maximal projection are questioned for the verb, thus accepting only the interpretation as a polar question for (8c). Let us call those interpretations that obey the island condition X and those that don't Y. Our attitude is that, although X and Y may impose different pragmatic/prosodic constraints, both are grammatical. Note that, although our implementation in this paper accepts both X and Y, it is easy to distinguish X and Y in our framework. Our implementation can easily be modified to accept only X, and it should also be easy to modify it to impose certain pragmatic/prosodic constrains only for Y, while Shimoyama's analysis can essentially only accept X. Cf. footnote 11.

3.5 Scope ambiguity

When two or more parameters are quantified for a verb, their relative scope must be considered. Basically, any scope order is possible. For example, in (9a), either of *dare* and *nani* can take wide scope over the other.

(9) a. Dare-mo-ga nani-ka-o sitteiru.
who-*mo*-NOM what-*ka*-ACC know
'Everyone knows something.'

b. Dare$_1$-ga nani-o itte-mo dare$_2$-ka-ga sakarau.
who-NOM what-ACC say-COND-*mo* who-*ka*-NOM oppose
'No matter who says what, someone opposes it.'

But for any three parameters p_1, p_2 and p_3 that are quantified for the same verb, if p_1 and p_2 are contained in the same dependent of the verb and p_3 is contained in a different dependent of the verb, p_3 can only either take wide scope over both p_1 and p_2 or take narrow scope under both p_1 and p_2. For example, in (9b), as *dare*$_1$ and *nani* are contained in the same dependent *dare*$_1$*-ga nani-o itte-mo* and *dare*$_2$ is contained in a different dependent *dare*$_2$*-ka-ga*, the scope orders *dare*$_1$ $>$ *dare*$_2$ $>$ *nani* and *nani* $>$ *dare*$_2$ $>$ *dare*$_1$ are not possible.

4 Formalization

In this section, we formalize our analysis in our framework. Here is a rough idea of how our system works: *wh*-words and coordinated phrases contribute as parameters, restriction-bearing indices. Such a parameter can go to the PARAMS of any interrogative verb whose maximal projection contains it (the case of a *wh*-question), or it can go to the QUANTS of any verb in a *mo*- or *ka*-marked dependent of which it is contained (the case of *wh-mo/ka*). When the parameter goes to the QUANTS of a verb, it is converted to an *every-rel* or a *some-rel* depending on whether the dependent is marked by *mo* or by *ka*. If no parameter goes into the PARAMS of an interrogative verb, the polarity of the verb goes into the PARAMS of the verb instead. It is the case of a polar question.

4.1 Parameter Amalgamation

Parameters are propagated via the STORE feature, a head feature whose value is a set of *params*. The STORE of a word designates the parameters in the word's maximal projection that are yet to be quantified/questioned. Parameters originate in the STORE values of *wh*-words[13] and of coordinated phrases[14], and each word amalgamates its arguments' STORE values (we ignore adjuncts in this paper), putting those

[13] *Wh*-words are specified in the lexicon as having *params* in their STORES.

[14] Coordination rule, a grammar rule which licenses coordinated phrases, stipulates that coordinated phrases have *params* in their STORES, as we will see in section 4.2.

parameters that are quantified/questioned for the word into its PARAMS/QUANTS and others into its STORE, which is then inherited up the tree as a head feature. In this way, each parameter is guaranteed to be either quantified or questioned, at most once. To implement this amalgamation, we introduce two new features appropriate for the type *synsem*, namely TO-QUANTIFY and TO-QUESTION, whose values are sets of *params*. The TO-QUANTIFY and TO-QUESTION of a word w_1 are disjoint subsets of w_1's STORE and designate, when w_1 becomes a dependent of another word w_2, what parameters in w_1's STORE will be quantified and questioned for w_2. In the amalgamation, each word uses its arguments' TO-QUANTIFY and TO-QUESTION values to decide its own QUANTS, PARAMS and STORE. The conditions under which parameters are quantified/questioned for verbs are expressed as constraints on these features. The constraints in Figure 3 implement the propagation and retrieval of parameters.

The lexical amalgamation of STORE is stated in constraint (e). The STORE of a word whose content is not of type *soa* is simply the union of its arguments' STORE values. When the content of a word is of type *soa* (that is, when the word is a verb), the parameters in the arguments' TO-QUANTIFY and TO-QUESTION values go to the word's QUANTS and PARAMS, respectively, and the rest of the parameters in the arguments' STORE values go to the word's STORE. Note that the contained difference[15] operation, $s_i \dot{-} q_i \dot{-} p_i$, in constraint (e) constrains each argument's TO-QUANTIFY and TO-QUESTION (q_i and p_i) to be disjoint subsets of the argument's STORE (s_i).

When the parameters in the arguments' TO-QUANTIFY values go to the word's QUANTS, they are converted, by the function f, to sets of *quant-rels* depending on the arguments' MOKA values, and these sets are ordered and then concatenated, by function h, into a list to specify the scope order. In this way, it is ensured that no two parameters from the same dependent have a parameter from another between them in the scope order, as we discussed in section 3.5. Constraint (a) requires that only parameters from *mo/ka*-marked arguments can be quantified.

When the word is not in the interrogative form, constraint (b) restricts the word's PARAMS to be empty, thus restricting, in combination with constraint (e), every argument's TO-QUESTION to be empty. It is the case of a declarative clause. When the word is in the interrogative form and the arguments' TO-QUESTION values are all empty, constraint (b) requires the word's PARAMS to be non-empty and then constraint (e) requires, since the arguments' TO-QUESTION values are all empty, the word's PARAMS to be its parameterized polarity (in this paper, we ignore possible semantic differences between positive and negative polar questions). It is the case of a polar question. Otherwise, as some of the arguments' TO-QUESTION values are non-empty, it follows from constraint (f) that the word's PARAMS is not its parameterized polarity and then constraint (e) requires the word's PARAMS to be the union of the arguments' TO-QUESTION values. It is the case of a *wh*-question.

[15] The contained difference $R \dot{-} S$ is the same as the ordinary set difference $R - S$, but it is defined only for R and S such that $R \subset S$.

(a) $\begin{bmatrix} word \\ \text{MOKA} \ \text{-} \end{bmatrix} \Rightarrow \begin{bmatrix} \text{TO-QUANTIFY} \ \{\} \end{bmatrix}$

(b) $\begin{bmatrix} word \\ \text{VFORM} \ \neg interrogative \end{bmatrix} \Leftrightarrow \begin{bmatrix} \text{PARAMS} \ \{\} \end{bmatrix}$

(c) $root \Rightarrow \begin{bmatrix} \text{STORE} \ \{\} \end{bmatrix}$

(d) $\left(\begin{bmatrix} word \\ \text{MOKA} \ ka \end{bmatrix} \vee \begin{bmatrix} \text{STORE} \ \{ \begin{bmatrix} \text{RESTR} \ \in \end{bmatrix} \} \end{bmatrix} \right) \Rightarrow \begin{bmatrix} \text{STORE} & \boxed{1} \\ \text{TO-QUANTIFY} & \boxed{1} \end{bmatrix}$

(e) $word \Rightarrow / \left(\begin{bmatrix} \text{STORE} & \bigcup_{i=1}^{n} s_i \\ \text{CONT} & \neg soa \\ \text{ARG-ST} & \langle \begin{bmatrix} \text{STORE} \ s_1 \end{bmatrix}, \cdots, \begin{bmatrix} \text{STORE} \ s_n \end{bmatrix} \rangle \end{bmatrix} \vee \right.$

$$\left. \begin{bmatrix} \text{STORE} & \bigcup_{i=1}^{n} (s_i \dot{-} q_i \dot{-} p_i) \\ \text{CONT} & \begin{bmatrix} soa \\ \text{QUANTS} & h(\texttt{order}(\{ f(m_1, q_1), \cdots, f(m_n, q_n) \})) \\ \text{PARAMS} & \left(\bigcup_{i=1}^{n} p_i \right) \vee \{ \begin{bmatrix} param \\ \text{INDEX} & \boxed{1} \\ \text{RESTR} & polarity(\boxed{1}) \end{bmatrix} \} \\ \text{NUCL} & \begin{bmatrix} \text{POLARITY} & \boxed{1} \end{bmatrix} \end{bmatrix} \\ \text{ARG-ST} & \left\langle \begin{bmatrix} \text{STORE} & s_1 \\ \text{TO-QUANTIFY} & q_1 \\ \text{TO-QUESTION} & p_1 \\ \text{MOKA} & m_1 \end{bmatrix}, \cdots, \begin{bmatrix} \text{STORE} & s_n \\ \text{TO-QUANTIFY} & q_n \\ \text{TO-QUESTION} & p_n \\ \text{MOKA} & m_n \end{bmatrix} \right\rangle \end{bmatrix} \right)$$

$$f(\boxed{1}, \{x_1, \cdots, x_n\}) = \{ g(\boxed{1}, x_1), \cdots, g(\boxed{1}, x_n) \},$$

$$g(mo, \begin{bmatrix} param \\ \text{INDEX} & \boxed{1} \\ \text{RESTR} & \boxed{2} \end{bmatrix}) = \begin{bmatrix} every\text{-}rel \\ \text{INDEX} & \boxed{1} \\ \text{RESTR} & \boxed{2} \end{bmatrix}, g(ka, \begin{bmatrix} param \\ \text{INDEX} & \boxed{1} \\ \text{RESTR} & \boxed{2} \end{bmatrix}) = \begin{bmatrix} some\text{-}rel \\ \text{INDEX} & \boxed{1} \\ \text{RESTR} & \boxed{2} \end{bmatrix},$$

$$h(\langle x_1, \cdots, x_n \rangle) = \texttt{order}(x_1) \oplus \cdots \oplus \texttt{order}(x_n)$$

(f) $\begin{bmatrix} word \\ \text{POL} \ i \end{bmatrix} \Rightarrow \left(\begin{bmatrix} \text{PARAMS} & \{[\text{RESTR} \ polarity]\} \\ \text{ARG-STR} & \langle [\text{TO-QUESTION} \ \{\}], \cdots, [\text{TO-QUESTION} \ \{\}] \rangle \end{bmatrix} \right.$

$$\left. \vee \begin{bmatrix} \text{PARAMS} & \neg\{[\text{RESTR} \ polarity]\} \\ \text{VFORM} & negative \\ \text{BCKGRD} & \{negative(i)\} \end{bmatrix} \vee \begin{bmatrix} \text{PARAMS} & \neg\{[\text{RESTR} \ polarity]\} \\ \text{VFORM} & \neg negative \\ \text{BCKGRD} & \{positive(i)\} \end{bmatrix} \right)$$

(The $\dot{-}$ operator denotes contained difference[15], and $\oplus$ denotes list concatenation.)

Figure 3: Constraints for parameter amalgamation

Constraint (f) also requires that, when it is not the case of a polar question, the polarity of the word be specified in its BACKGROUND according to its VFORM.

As we have seen in section 3, coordinated phrases and *ka*-marked parameters can only be quantified immediately. It is stated in (d). Note that, as we will see below in section 4.2, the RESTR value of the parameter that a coordinated phrase represents is a singleton set whose only member is of type $\in$.

Lastly, constraint (c) requires every parameter to be questioned or quantified somewhere.

Figure 4 provides a brief illustration of how (8c)'s interpretation as a reprise question to (8d), the interpretation that *dare* is questioned and *nani* is quantified, can be accepted in our system. First, *dare-ga* and *nani-o* have *params*, $\boxed{1}$ and $\boxed{2}$,

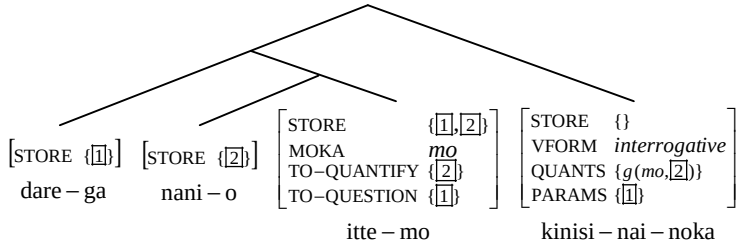


Figure 4: Example

in their STORES, as specified in the lexicon. Then, the verb *itte-mo* amalgamates these *params* into its own STORE. Now, the TO-QUANTIFY and TO-QUESTION values of the verb *itte-mo* can be non-empty, because *itte-mo* is marked by *mo*[16] and because it heads a dependent of an interrogative verb *kinisi-nai-noka*.[17] So, the TO-QUANTIFY and TO-QUESTION of *itte-mo* can be any partition of its STORE.[18] There are four ways of partitioning it into two sets, and one of them is that the TO-QUANTIFY and TO-QUESTION contains $\boxed{2}$ and $\boxed{1}$, respectively. In this case, it follows from constraint (e) that the matrix verb's QUANTS contains $\boxed{2}$, converted to an *every-rel*, and that the matrix verb's PARAMS contains $\boxed{1}$. This is the case shown in Figure 4, and it gives the interpretation that *dare* is questioned and *nani* is universally quantified.

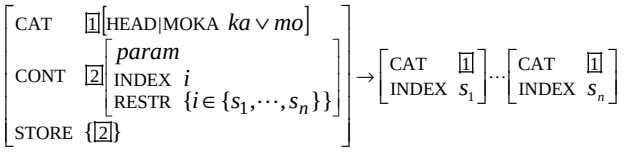
4.2 Coordination rule

Coordinated phrases are licensed by the grammar rule in Figure 5.

[16]Cf. constraint (a).

[17]Cf. constraints (b) and (e).

[18]They must be a partition of the STORE because constraint (c) requires the STORE value of the matrix verb *kinisi-nai-noka* to be empty and thus requires, in combination with constraint (e), the (disjoint) union of the TO-QUANTIFY and TO-QUESTION values of *itte-mo* to be equal to its STORE value.



($n \geq 2$ when MOKA is *ka*, and $n \geq 1$ when MOKA is *mo*.)

Figure 5: Coordination rule

The mother has a parameter in its STORE and the parameter has only one relation, of type $\in$, in its RESTR. The type $\in$ is a relation that takes two arguments, an index and a set of indices, and it specifies that the index is a member of the set of indices. Here, we represent a $\in$ relation briefly as $x \in y$ where x is the index and y is the set of indices.

Figure 6 is an illustration of how (1a)'s coordinated phrase is realized in our system. In this example, the two conjuncts have indices i and j respectively, and

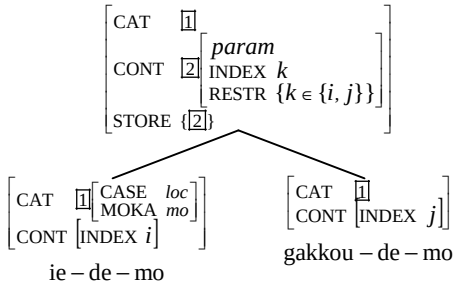


Figure 6: Example

thus the mother's CONT value is a *param* whose domain is the set of i and j.

5 Conclusion

In this paper, we have shown that question, quantification, and coordination in Japanese can be analyzed uniformly as cases where each parameter, denoted either by a *wh*-word or by a coordinated phrase, is quantified or questioned for an appropriate verb. We investigated various phenomena of these constructions to determine the conditions under which a parameter is questioned or quantified for a verb, and we gave an HPSG formalization of the analysis. Our analysis can account for, among other things, the quantifier scope as marked by the position of the conjunctive particle *mo* and the ambiguity of sentences like (8c), which arises from the interaction between the principle of question and the principle of quantification. Note especially that the last-mentioned ambiguity phenomenon is naturally derived in our unified, constraint-based analysis.

We have left two important issues for future work. First, we have ignored the syntactic difference between the conjunctive and disjunctive particles, *mo* and *ka*, and assumed that *ka* behaves the same way as *mo* syntactically. Actually, while *mo* can mark any verbal dependent, *ka* can only mark noun phrases, and, while *mo* can only mark verbal dependents, *ka* can mark any noun phrase regardless of whether or not it makes a verbal dependent.[19] Also, unlike in conjunctive coordination, only the last disjunct is case-marked, and the last disjunct may or may not be marked by *ka*, in disjunctive coordination, as you can see in examples (1a, c). In future work, we will revise the implementation so that *ka* is processed rightly.[20]

Second, the question of exactly what pragmatic/prosodic constraints are to be imposed on certain interpretations has been left unanswered. For example, out of the four interpretations of (8c), only the interpretation as a polar question is natural out of context and with default prosody.[21] Although the implementation given in this paper just accepts all the interpretations as grammatical, it is easy, in our framework, to identify those interpretations that would impose further pragmatic/prosodic constraints, and therefore it should be easy, when the study of the pragmatic/prosodic constraints in question is done, to revise the implementation so that it imposes certain pragmatic/prosodic constraints for certain interpretations.[22]

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[19] Cf. footnote 7.

[20] The syntactic difference between *mo* and *ka* has been discussed in previous works (e.g., Yatsushiro (2001)).

[21] Cf. footnote 11.

[22] Cf. footnote 12.

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