The Syntax and Semantics of
The Japanese Language Engine

Megumi Kameyama

SRI International AI Center
333 Ravenswood Ave., Menlo Park, CA 94025
megumi@ai.sri.com
and
The Center for the Study of Language and Information
Stanford University
megumi@csli.stanford.edu

May 1992

Contents

1 Introduction .......................... 1

2 The Japanese Language Engine .... 3
   2.1 Current Application .............. 3
   2.2 JLE Modules ..................... 4

3 JLE Syntax ................................ 5
   3.1 Basic Categories ................ 5
   3.2 Basic Rules ...................... 8
   3.3 Robust Syntax .................... 9

4 JLE Semantics .......................... 10
   4.1 Basics ................................ 10
   4.2 Aterms and Qterms .............. 10
   4.3 “Underspecified” Relations .... 11
   4.4 “Syntactic” Information in the Logical Form ........ 11

5 Context-independent Rules in Japanese Grammar 12
   5.1 Argument Omissibility .......... 13
   5.2 Flexible Order .................. 14
   5.3 Relativization ................... 16
   5.4 Topicalization ................... 18
   5.5 Quantifier Floating ............ 19

6 Resolution Prospects ............... 22

7 Conclusion .......................... 23

8 Acknowledgments .................... 23
Abstract

The paper describes the basic syntactic rules in the Japanese Language Engine (JLE), a unification-based Japanese grammar used as part of a spoken Japanese interpretation system. The underlying assumption in this grammar is the Nondefeasibility Thesis — the rules of grammar are nondefeasible, and all defeasible rules belong to pragmatics. In an overall understanding of an utterance in discourse, such a grammar module can have a meaningful functionality by giving each utterance a set of context-independent underspecified interpretations under the assumption that the module of pragmatic inferences is responsible for further elaborations of the interpretations. The JLE grammar developed with this perspective is robust and exception-free. The major syntactic phenomena of Japanese discussed include: argument omissibility, flexible word order, relativization, topicalization, and quantifier floating.

1 Introduction

A major goal of computational linguistics is to develop formally sound and computationally tractable theories of human linguistic use that can be implemented in natural language processing systems to be used for database interface, information retrieval, machine translation, and other real-world applications.

In this paper, I will describe the basic syntactic rules in the Japanese Language Engine (JLE) currently under development at SRI International, and discuss their role in an overall Japanese understanding system.

The essential task of a natural language understanding system is to assign each utterance in discourse (written or spoken) a set of interpretations that are both grammatically possible and contextually appropriate.¹

We can conceptually distinguish three top-level modules in an overall understanding system: speech, grammar, and pragmatic inferences (see Figure 1). The speech module contains the system of mapping between the sounds of an utterance and its surface form in terms of a string of characters. The grammar, together with the lexicon, models the grammatical competence. The module for pragmatic inferences contains a system of inference rules that apply to the database of information about the context, world, and domain of discourse. This database is potentially open-ended, and the special problem here is how to control and optimize the inferences.

It seems reasonable to assume certain independence of each module, but there should be interactions, or even interdependencies among them. I will make a simplifying assumption, however, that the rules of grammar are nondefeasible, that is, the results of other inferences cannot override them. As a consequence, I will also

¹I will henceforth focus the discussion on understanding rather than generation.
assume that if a certain apparently grammatical rule can be overridden by pragmatic inferences, this rule should be part of the pragmatic inference rather than the grammar. Let me state this assumption explicitly:

**Nondefeasibility Thesis:** The rules of grammar are nondefeasible. All defeasible rules belong to pragmatics.

This assumption is in fact so basic in modern linguistics (the "generative enterprise" to be more precise) that people often do not state it explicitly. The reason I take this view in developing JLE is that it leads to a clear division of rule types into those that enumerate possibilities and those that enumerate preferences, which would correspond to monotonic and nonmonotonic systems of logic, respectively. This is an engineering motivation, which may or may not be supported by cognitive evidence such as processing data. It would indeed be of theoretical interest if such an engineering motivation coincides with people's processing principles and strategies.

In this paper, I will discuss Japanese grammar from this perspective. The grammar I am assuming models grammatical competence, and consists of rules for analyzing the meaning of a sentence independent from the context. The rules of pragmatic inferences are needed in addition to the grammar for fleshing out the interpretation adequate in a particular discourse context. The latter models the pragmatic competence. A consequence of this division of labor, though not a necessary one, is that the result of grammatical analysis can be an underspecified interpretation in the sense that the references and relations whose interpretations need contextual resolutions are left unresolved. What the grammar has to do, then, is to map the surface forms of sentences to such underspecified semantic interpretations, which are then specified as the result of pragmatic inferences.²

²This contrasts quite sharply with the view that the result of grammatical analysis must enumerate all possible references and specific relations, most of which are to be "filtered out" by pragmatic constraints.
2 The Japanese Language Engine

The rules discussed here are implemented in the Japanese Language Engine (JLE). JLE is a descendant of the Core Language Engine (CLE) (Alshawi, Moore, and Moran, 1987), a unification-based parser-interpretter implemented in Prolog. Throughout the system, whether it is the morphological, syntactic, or semantic level of analysis, feature structures of the form

\[ \text{category: [feature1=value1, \ldots, featureN=valueN]} \]

are used to pass information around and impose constraints. JLE grammar is thus completely declarative, and can be the basis for generation as well as for understanding.

2.1 Current Application

JLE's current application is a speech understanding system for conference room scheduling. For each spoken utterance as input, the speech recognizer outputs a set of best-scored hypotheses, each of which is a string of Roman letters with spaces between "words". JLE analyzes these hypotheses one by one. If a string is a well-formed Japanese sentence, JLE outputs a set of possible interpretations. If it is not a well-formed sentence, JLE rejects it.

Since a hypothesis is completely dropped once rejected, it is important that JLE assign some interpretation to all natural utterances in spoken Japanese. On the other hand, since the output of the speech recognizer typically contains a number of wrong hypotheses, it is also important that JLE correctly reject them. That is, we do not want JLE to overreject nor overaccept. We need to attain the right balance between these two demands on the grammar.

The following illustrate well-formed sentences in the conference-scheduling domain that JLE must parse and interpret:

- \text{konsyuu dai roku kaigisitu wo yoyaku dekiru hi wa arimasu ka.}
  (Are/Is there day[s] this week [when] [one] can reserve [the] 6th conference room?)

- \text{dai iki kaigisitu no hirosa wa donogurai desu ka.}
  (About how much is [the] size of [the] 1st conference room?)

- \text{nunzi made dai go kaigisitu no kaigi wa yatte imasu ka.}
  (Until what time are [they] doing [the] conference in [the] 5th conference room?)
- ono san no konsyuu no yoyaku wo hyouzi site kudasai.
  (Please display Mr. Ono's this week's reservation[s].)

- nisio san no yoyaku wa asu sono kaigisitu ni arimasu ka.
  (Mr. Nisio's reservation[s], are [they]/is [it] on that conference room tomorrow?)

- hutuka kara kokonoka no dai ni kaigisitu no yoyaku wo dasite kudasai.
  (Please show [me] [the] reservation[s] on [the] 2nd conference room from [the] 2nd day [through] [the] 9th day [of the month].)

- maisyu nanyou ni dai san haado no utiawase wa arimasu ka.
  (What day[s] of every week are/is there meeting[s] of [the] 3rd hardware department?)

- nisio no yoyaku wo asita no hati z ni henkou site kudasai.
  (Please change Nisio's reservation[s] to tomorrow's 8 o'clock.)

- gogo ni wa dai go kaigisitu ka dai roku kaigisitu wa akimasu ka.
  (In [the] afternoon, will either [the] 5th conference room or [the] 6th conference room be available?)

- ni zi kara no yoyaku wo san zi kara ni kaete kudasai.
  (Please change [the] reservation[s] [starting] from 2 o'clock into [starting] from 3 o'clock.)

- dai nana kaigisitu wa nanzi made siyou dekimasu ka.
  ([The] 7th conference room, until what time can [one] use [it]?)

- dai ni haado no tantou no utiawase wo torikesite kudasai.
  (Please cancel [the] meeting[s] [that] [the] 2nd hardware department is in charge of.)

- konsyuu no yoyaku no kyanseru wo onegai simasu.
  ([I] would like to ask for [a] cancellation[s] of this week's reservation[s].)

2.2 JLE Modules

The grammatical core of JLE is the lexicon and rules. The lexicon is compiled from the source lexicon together with the inflection rules (called morph rules) that specify the inflectional variants of some lexical categories. The source lexicon also makes reference to a set of lexical templates, predefined feature-structure bundles shared by groups of lexical items.

Syntactic rules are context-free rules augmented with feature structure constraints. Each syntactic rule is associated with one or more semantic interpretation
rules, which assign compositional semantics to the string-combination operation of syntax. A rule application succeeds only when all the syntactic and semantic features unify.

The output of semantic interpretation is the **quasi logical form** (QLF) (Alshawi, 1990), the underspecified meaning representation without the effect of the context. Intuitively, QLF represents the information content of a sentence that can be known by the sentence alone. It contains unresolved anaphoric expressions (called aterms), unscoped quantifiers (called qterms), and underspecified relations (e.g., nnRelation, noRelation, aboutRelation). These will be discussed later. JLE also has a mechanism for eliminating implausible interpretations at the QLF level using sortal constraints based on a sort hierarchy (e.g., animate, inanimate, human, time, room).3

**Scoping rules**, which will not be discussed in this paper, give preferred scoping possibilities for each sentence. In the final logical form (LF) expressions to be used in application, references have been resolved, underspecified relations have been specified, scoping possibilities have been ordered by preference, and implausible interpretations in the given discourse context have been eliminated.4 To achieve this, we will need a set of resolution rules, a context-dependent system of inferences. I will briefly discuss the prospects for this at the end.5 The overall system under development is shown in Figure 2.

This paper concerns the basic syntactic and semantic rules that lead up to the level of quasi logical forms.

## 3 JLE Syntax

A design objective for the JLE syntax is to minimize the number of categories and rules and to make the system robust, leaving much of the interpretation work to semantics and pragmatics.

### 3.1 Basic Categories

The major syntactic categories of JLE are: Ptl, N, NP, V, S. Basic nouns and names are of category N, which can be modified with genitive phrases (N no), relative

---

3This mechanism is nondefeasible, that is, implausibility is in fact judged to be impossibility. It makes the system efficient for domain-specific applications, but clearly too restrictive for more general applications.

4Although the logical forms are central to the representation of the information communicated by the utterances, the resolution and application components can also access the parse trees with all the syntactic and semantic features if necessary.

5Alshawi and van Eijck (1989) and Alshawi (1990) discuss the resolution rules in an English system implemented with CLE.
INPUT sentence (character string) \[\rightarrow\] Syntactic Rules + Lexicon

Parse Trees

\[\rightarrow\] Semantic Rules + Sortal Constraints

Underspecified Logical Form Expressions

QUASI LOGICAL FORMS

Scoping Rules

Context + Resolution Rules

Logical Form Expressions

Application

Figure 2: The JLE Overview
clauses (S), or a demonstrative (Det) to form layers of N. When N changes to NP, it must be semantically "determined" and its role as a complement or an adjunct of a verbal phrase must be fixed. Particles are combined with N in the process of becoming an NP (thus our NP is often more like a PP).

Particles (Ptl) fall into a number of classes corresponding to different syntactic and semantic constraints: Case Particles (Nominative, Accusative, Dative, and Genitive), Discourse Particles (wa, mo, etc.), Semantic Particles (de, kara, made, etc.), Focus Particles (sae, deke, koso, etc.), Sentential Complement Particles (to, ka, etc.), Sentential Adjunct Particles (node, noni, nara, etc.), Conjunction/Disjunction Particles (to, ya, ka, etc.), and Sentence-final Particles (ka, ya, ne, etc.). Particles can string together to form a cluster, and the order and co-occurrence constraints on them are complex. Only an initial treatment is given in current JLE. When category N combines with a Case Particle or a Discourse Particle, it forms the category NP. When category N combines with a Semantic Particle or a Focus Particle, it forms either another category N or the category NP. This allows, for instance, a sequence of Semantic and Case particles such as kara ga ('from' Nominative).

Some Ns are inherently determined semantically — for instance, names (e.g., nisshi san (Mr. Nisio)), (demonstrative) pronouns (e.g., koko (here)), numerals (e.g., san nin (three person-units)), and WH-quantifiers (e.g., doko (where)). Common nouns such as heya (room) are not, and an NP with such a head noun must have a "determiner" with a certain quantificational scope. This semantic "determination" of NPs draws on demonstratives (e.g., kono (this)), genitives (e.g., watashi no (my)), numerals (e.g., mitpu no (three)), and perhaps some other factors yet to be discovered. When there is no explicit indication — that is when the nominal is "bare" — we regard the determiner to be INDETERMINATE.

An inflected verb is of category V. Any number of arguments and adjuncts can be combined with V in any order to form layers of V. When V changes to S, the illocutionary force of the sentence (i.e., declarative, interrogative, or imperative) is identified, and any arguments that have not yet been found are interpreted to be ZERO PRONOUNS.

The structure of both nominals and verbs is thus analyzed to be arbitrarily complex layers of the basic category, N and V, that reach the semantically fleshed-out level, NP and S, at a higher level. At the level of NP and S, all the semantically obligatory elements have been filled even if they have no corresponding linguistic items on the surface. For NP, bare nominals are interpreted to have the semantic "determiner" called INDET (for "indeterminate"). For S, omitted arguments are interpreted to be zero pronouns whose references must be resolved.

The following is an example of this syntactic analysis:

nisio no yoyaku wo asita no hati zi ni
Nisio GEN reservation ACC tomorrow GEN 8 o'clock GOAL

henkou site kudasai.
change doing please_give_me

(Please change Nisio's reservation[s] to tomorrow's 8 o'clock.)
nisio no yoyaku wo asita no bati zi ni henkou site kudasai.

\[
\begin{array}{cccccc}
N & no & N & Ptl & N & no & N & Class & Ptl & N & V & V \\
\\
N & N & V \\
\\
NP & N & V \\
\\
NP & V \\
\\
S
\end{array}
\]

3.2 Basic Rules

The major syntactic rules of JLE are:

- \( S \rightarrow V \) (zero pronouns found and illocutionary force set)
- \( V \rightarrow NP \ V \) (argument/oblique/adjunct nominal incorporated)
- \( NP \rightarrow N \ Ptl \) (argument/adjunct formed)
- \( NP \rightarrow S \ Ptl \) (sentential argument/adjunct formed)
- \( NP \rightarrow N \) (particle-less adjunct formed)
- \( N \rightarrow N \ Ptl \) (semantic/focus particle attached)
- \( N \rightarrow \text{Det} \ N \) (demonstratives attached)
- \( N \rightarrow N \ N \) (NN compounding)
- \( N \rightarrow N \ no \) ('no' pronominal head)
- \( N \rightarrow N \ no \ N \) (genitive 'no' modification)
- \( N \rightarrow N \ N\text{conj} \ N \) (NN conjunction)
- \( N \rightarrow S \ N \) (relative clause and head combined)

Category V formed by morphological rules.

Category V is formed by combining various other lexical categories: V1 (verbs of inflection type simo ni dan and kami ni dan), V5 (verbs of inflection type go dan),
ADJ (adjectival verbs), NADJ (nominal adjectives or keiyou dousi), and COPULA (plain and polite copulas - da, desu). Inflections are handled as morph rules that apply on the source lexicon. Derivational morphology is treated either as "inflections" generating derived forms in the lexicon - for instance, Negation (e.g., toranai (does/do not take)), or as (morpho)syntactic rules - for instance, N → N CLASS (numeral and classifier combined) (e.g., go nin (five-persons)). There are in fact many more morphological rules (below N and V) than syntactic rules (above N and V) in JLE.

This initial set of rules already has a substantial coverage of the syntactic patterns of Japanese sentences. For instance, it gives a set of parses to about 85% of our Conference Room Reservation (CRR) corpus consisting of 840 sentences with the average length of 11.56 words. The vocabulary size of the corpus is about 150 (inflected) words.

3.3 Robust Syntax

The syntactic rules of JLE constitute an example of robust and rule-parsimonious approaches to grammar-writing in the line of Categorial Grammar (CG) (Oehrle, Bach, and Wheeler, 1988), Japanese Phrase Structure Grammar (JPSG) (Gunji, 1987), and Head-driven Phrase Structure Grammar (HPSG) (Pollard and Sag, 1988). In fact, most of the JLE rules can be straightforwardly rewritten into rules in these frameworks.

The context-free grammar of JLE can be translated into an equivalent categorial grammar since context-free rules and categorial calculus are equivalent in their generative power. This would involve changing most of the morpho-syntactic categories into directed functor categories using the basic categories N, NP, V and S. Semantic rules would be translated into undirected type calculus. The CG perspective would help clean up the logical basis of the grammar by identifying those rules that perform nonstandard compositional semantics. For instance, the rule S → V in JLE is associated with semantic interpretation rules that "find" zero to three zero pronominal arguments in one step. What kind of compositional semantics could it be?

The notion of "head" as in JPSG and HPSG may add a higher-level unity to JLE syntax. The binary rule V → NP V, for instance, can be seen as Argument+Head and Adjunct+Head combination rules with respective semantics that pass up information to the parent node. However, in many cases we cannot decide what the head should be in a particular rule. For instance, in the rule that combines an action noun with a "light" verb to form a verb (e.g., kakunin + suru (confirm)), the basic

---

6Moore (1989) addresses this issue of how to stay within the bounds of compositional semantics using unification-based, as opposed to lambda-calculus-based, semantics.
semantic content of the resulting verb comes from the noun, but the inflectional information comes from the light verb. Which should be regarded the “head” in this case? In this and other cases, the utility of the notion becomes questionable.

4 JLE Semantics

JLE’s QLF expressions represent that part of the meaning of the sentence that can be determined without taking into account the effect of the context.

4.1 Basics

The model in JLE semantics consists of:

- Individual and group objects (i.e., object entities)
- Individual and group events (i.e., event entities)
- Properties
- Relations

Each verbal is associated with a Davidsonian event variable. Each event has a property and an ordered list of “event modifiers” (MODS) consisting of arguments and adjuncts associated with the event.

4.2 Aterms and Qterms

The QLF expression contains unresolved anaphoric expressions called ATERMS and unscoped quantifiers called QTERMS. Their forms are:

\[
\text{aterm}(\text{Type, Variable, Restrictions}) \\
\text{qterm}(\text{Type, Variable, Restrictions})
\]

JLE’s aterm types include: zero pronouns (ZPRO), overt pronouns (PRO), reflexive pronouns (SELF), and demonstrative pronouns and nominals (DEMO). JLE’s qterm types include: interrogative words (WHAT, WHICH, HOWMANY), universal and existential quantifiers (ALL, SOME), and unexpressed “indeterminate” determiners (INDET). The JLE scoping rules assign preferences to the relative scopings generated by these qterms. After scopings are fixed, qterms are replaced by scoped quantifiers (QUANT) in the logical form.
4.3 "Underspecified" Relations

QLF expressions also contain a number of "UNDERSPECIFIED" RELATIONS. What exactly should be best characterized as these relations is an empirical question. One criterion that I have used is as follows:

**criterion:** An underspecified relation in QLF is posited when there is an open-ended set of possible specific relations associated with a construction type, and the interpretation is typically affected by the discourse context.

For instance, JLE has relations called **NN.RELATION** and **NO.RELATION** for NN compounds and genitive modification, respectively. Neither of these relations is enumerable and their interpretation heavily depends on the discourse context. In addition, I have posited **ABOUT.RELATION** for relative clause dependencies and **UNIT.MEASURE** for the "adjunct" role of floating quantifiers. The motivation for these is discussed below.

Positing these relations keeps the grammar "exception-free" as intended by the nondefeasibility thesis above, and allows the grammar writer to try out various heuristics in the pragmatics module.

4.4 "Syntactic" Information in the Logical Form

The JLE logical form preserves the following information about the utterance that may be normally considered "syntactic":

1. The hierarchical structure among clauses and phrases
2. Linear ordering of nominals
3. Thematic roles of nominals

The hierarchical structure, or relative subordination relations among clauses and phrases, is the most basic syntactic information, and this is directly preserved in the nesting relations within the logical form. This information is not only truth-conditionally important but also useful for controlling the resolution of intrasentential anaphoric dependencies.

---

7These are similar to the NN compounds and 'of' relations in English. Hobbs, Stickel, Appelt, and Martin (1990) give their treatments as underspecified relations in an abduction-based natural language understanding system TACITUS.
Linear order variation does not make truth-conditional differences, but is a rich source of information about (a) the relative givenness/newness of the objects mentioned in discourse, (b) anaphoric dependencies, and (c) scoping possibilities. In JLG, the linear ordering of nominals associated with each verbal is retained in an ordered list of labeled arguments in the logical form. More specifically, an ordered list of event modifiers (MODS) is created for each event associated with a verbal. When the rules of the form $V \rightarrow NP \, V$ apply, the QLF for the NP is appended to the tail of the mods list together with its thematic role. This way, both the relative linear position and role of each nominal is represented in the logical form. See the following examples:

\[\text{yoyaku \ wo kyou torikesita.}\]
\text{reservation ACC today canceled}
\text{([zpro] canceled reservation today)}

\[\text{[decl, [past, exists(A, [and,}
\text{torikesu,A]},
\text{[at.time, A, today]},
\text{[theme, A, qterm(indet, B, [and, [yoyaku, B]])] ],}
\text{[agent, A, a_term(zpro, C, [subj, C])]])]]}\

\[\text{kyou yoyaku \ wo torikesita.}\]
\text{today reservation ACC canceled}
\text{(today [zpro] canceled reservation)}

\[\text{[decl, [past, exists(A, [and,}
\text{torikesu,A]},
\text{[theme, A, qterm(indet, B, [and, [yoyaku, B]])] ],}
\text{[at.time, A, today]},
\text{[agent, A, a_term(zpro, C, [subj, C])]])]]}\

The two sentences above differ only in the relative ordering of the theme argument (\textit{yoyaku wo}) and the time adjunct \textit{(kyou)}. This difference is retained in the order in which the corresponding nominals appear in the logical form. The nominals that are closer to the verbal appear earlier in the list. The subject zero pronoun is at the tail of the list in both logical forms.

5 Context-independent Rules in Japanese Grammar

The outstanding feature of Japanese syntax is its flexible surface structure that reflects subtle differences in the discourse context. The first task in implementing
a Japanese understanding system is then to enable this surface flexibility to cover all possible discourse contexts without making it overly permissive. What follows are the JLE approaches to five major syntactic features of Japanese: argument omissibility, flexible order, topicalization, relativization, and quantifier floating. I will also briefly discuss what kind of a processing model each treatment represents.

5.1 Argument Omissibility

Verbs, adjectives, and nominal adjectives "subcategorize" for certain arguments, but these arguments are obligatory only semantically, and can be missing from the surface string altogether.

In JLE, each verbal has a cluster of information about its obligatory arguments. Each argument has four fields:

1. **Found/NotFound** – whether this argument has been found or not found syntactically
2. **Particle Form** – what particle it should be marked with (ga, wo, ni, etc.)
3. **Grammatical Function** – subject, object, object2, etc.
4. **Thematic Role** – agent, theme, experiencer, goal, source, etc.

Whenever a V is adjacent to an NP whose particle matches the particle form of one of the obligatory arguments, this argument has been "found". When there are no more NPs to process, V becomes S, and any arguments "not found" at this point are interpreted to be "found" as zero pronouns. Each zero pronoun is an anaphoric term with its grammatical function information. This information is useful for the subsequent reference resolution. This is the only place where the surface grammatical function of a nominal shows up in the JLE logical form. The following example contains two zero pronouns, as subject and object:

\[
\text{torikeshimasu. ([zpro] cancel [zpro])}
\]

\[
\text{[decl,[present,exists(A,[and,[torikeshu,A],
[agent,A,a_term(zpro,B,[subj,B])],
[theme,A,a_term(zpro,C,[obj,C])]]])]
}\]

The processing implication of this treatment of zero pronouns is that the exact number of zero pronouns in each sentence is known only after the sentence has been processed all the way. Only after all the verbs in the sentence have been processed, can the hearer "in retrospect" assign the overt arguments to the verbs and identify zero pronouns for those arguments that were not overt. I think this is a general fact of Japanese sentences rather than a particular consequence of the JLE treatment of zero pronouns.
5.2 Flexible Order

Although the canonical order of arguments is Nominative - Dative - Accusative, arguments, obliques, and adjuncts can occur in any order as long as the verb is at the end.⁸ This is achieved by the set of binary rules by which V incorporates NPs one by one. The following are the syntactic rules for combining the 1st, 2nd, and 3rd argument NP, an oblique object NP, and an adjunct NP with V. Variables start with uppercase letters following the Prolog convention.

% V -> NP V

syn(v_arg1_v, j),
   [v:[vform=Vform, subcat=Subcat, auxtype=Aux, obl_obj=0bl,
      args=args(arg_features(found, Ptl, Gf, Role),Arg2, Arg3)],
   np:[nptype=compl,lexform=Ptl],
   v:[vform=Vform, subcat=Subcat, auxtype=Aux, obl_obj=0bl,
      args=args(arg_features(notfound, Ptl, Gf, Role),Arg2, Arg3)])].

syn(v_arg2_v, j),
   [v:[vform=Vform, subcat=Subcat, auxtype=Aux, obl_obj=0bl,
      args=args(Arg1, arg_features(found, Ptl, Gf, Role), Arg3)],
   np:[nptype=compl,lexform=Ptl],
   v:[vform=Vform, subcat=Subcat, auxtype=Aux, obl_obj=0bl,
      args=args(Arg1, arg_features(notfound, Ptl, Gf, Role), Arg3)])].

syn(v_arg3_v, j),
   [v:[vform=Vform, subcat=Subcat, auxtype=Aux, obl_obj=0bl,
      args=args(Arg1, Arg2, arg_features(found, Ptl, Gf, Role))],
   np:[nptype=compl,lexform=Ptl],
   v:[vform=Vform, subcat=Subcat, auxtype=Aux, obl_obj=0bl,
      args=args(Arg1, Arg2, arg_features(notfound, Ptl, Gf, Role))]).

syn(v_oblique_v, j),
   [v:[vform=Vform, subcat=Subcat, auxtype=Aux, obl_obj=obl(Ptl,Role),
      args=Args],
   np:[nptype=adjunct,lexform=Ptl],
   v:[vform=Vform, subcat=Subcat, auxtype=Aux, obl_obj=obl(Ptl,Role),
      args=Args])].

syn(v_adjunct_v, j),

⁸An extension of the grammar would also handle right-dislocations (i.e., those utterances where nominals occur after the verb). We will do this as a need arises.
The first three rules incorporate the 1st, 2nd, and 3rd obligatory argument into V, respectively. For each NP of type compl (complement), the rule “finds” the argument whose particle form matches the particle form of the NP. The fourth rule incorporates an oblique argument of the verbal. An oblique argument is part of the verbal semantics, but its surface absence in an utterance does not result in a zero pronominal. When an NP of type adjunct has the particle form that matches the particle form of the verbal’s oblique object, this NP is added to the event modifier list with the oblique role. This does not change the argument-finding status of the given verbal. The rule also allows multiple occurrences of obliques with the same role (e.g., *getyou ni asa hati zi ni soko wo totte kudasai* (Please take that place for Monday 8 o’clock a.m.)). The last rule incorporates an adjunct nominal with an adjunct role. It applies to all the adjunct type NPs. An oblique NP is always ambiguous with an adjunct NP in the current grammar.

There is one order constraint in a matrix clause. When the subject and object are marked with the same particle, the order must be Subject · Object. For instance, with a Double Nominative verbal *suki* (like), *X ga Y ga suki da* means “X likes Y” but not “Y likes X.” This seems to be an instance of a nondefeasible rule that the commonsense world knowledge does not override. Consider *Koohii ga Mariko ga suki da* (coffee NOM Mariko NOM likes). This sentence is at best marginal precisely because the interpretation is “Coffee likes Mariko.” The following rule ensures that the object NP, if found, must be found before the subject NP (that is, the GA-marked object must be closer to the verb than the GA-marked subject).9

9This order constraint is less compelling in subordinate clauses, however, as pointed out by Yasunari Harada. For example, *eigo ga Tarou ga yoku hanaseru koto* [English NOM Tarou NOM well can speak that] (that Tarou can speak English well) is better than *eigo ga Tarou ga yoku hanaseru* (Tarou can speak English well).
The processing implication of this treatment of flexible order is significant. Since JLE posits no special underlying order from which scrambled orders are generated, it implies that no order is more "complex" than others, contrary to the view that scrambling increases the cognitive complexity.

5.3 Relativization

A relative clause is directly followed by the head noun without a relative pronoun in Japanese. Here are some examples:

- torikesita hito ([the] person [who] canceled [it])
- tukatta OHP ([the] OHP [that] [we] used)
- yoyaku sita zikan ([the] time [for which] [he] reserved [it])
- kono heya wo konomu riyuu ([the] reason [we] prefer this room)
- sukuriin wo tenzyou kara turuseru heya ([the] room [where] [one] can hang [a] screen from [its] ceiling)
- huzisan ga soko kara mieru heya ([the] room [such that] [one] can see Mt. Fuji from there)

Correct interpretation requires determining what role the head noun should fill inside the relative clause. One simplifying way to look at it is that there is a "bindee" inside the relative clause that is bound to the head noun. Finding this bindee, however, is not at all easy because:

1. There are no grammatical indicators for the role or grammatical function of the bindee.

2. The bindee's "role" can be one of the arguments or adjuncts, or none at all. It can be something indirectly associated with the total event described by the relative clause.

3. The bindee may be either totally omitted from the surface in terms of an omitted argument or an implicit adjunct, or appear as an overt anaphoric item such as a reflexive pronoun, an overt pronoun, and a demonstrative pronoun. Even when there are omitted arguments in the relative clause, they may simply be zero pronomininals having nothing to do with the bindee.

For the second point, witness:
sakana wo yaku nioi
fish ACC grill-PRES smell
([the] smell [that arises when] [one] grills fish)

hitoranai keeki
get-fat-NUT-PRES cake
([the] cake [despite eating which] [one] does not get fat)

Hanako ga iede-sita Tarou
Hanako NOM ran_away_from_home Taro
(Taro [who is affected by the fact that] Hanako ran away from home)

CLE uses a gap-threading mechanism (see Moore (1989)) to analyze long-distance dependencies in English, but the fact stated in 3 above calls for some other method in Japanese.

Interpreting relative clause dependencies requires a full-scale contextual reasoning that takes into account certain grammatical preferences. Grammatically possible interpretations would typically be too numerous to be practical. This fact naturally renders itself to a treatment of relative clause dependencies as one of the cases of underspecified relations. This is the motivation for the ABOUT_RELATION, a two-place relation between the event described by the relative clause and the entity referred to by the head noun.

asita aku heya
tomorrow open-PRES room
([the] room [that] [will be] available tomorrow)

$qterm(indet,C,[and,
[heya,C],
[about\_relation,
C,
[present\_exists(D,[and,
[aku,D],
[at\_time,D,tomorrow],
[theme,
D,
a\_term(zpro,E,[subj,E])]))]))$

Syntactic preferences can be used as the control information during the resolution of about_relations. For instance, missing matrix arguments in the relative clause are most likely bindees, with the subject being more likely than nonsubjects. The above example is one such case of matrix-subject bindee. The resolution rules must
propose the subject zero pronominal as the most likely bindee, and this interpretation should be pragmatically acceptable since rooms are among the objects that can "open" or "become available". This general syntactic preference is, however, easily overridden by the sortal restrictions on the arguments — for example, rooms do not DO the reserving in interpreting the phrase *yoyaku suru heyā* ([the] room [that] [one] reserves). The discourse context may also prefer to interpret the missing arguments as zero pronominals with extra-sentential references. The resolution of about-relateds will have to take advantage of information from multiple sources — lexical, syntactic, semantic, discourse, and the world knowledge.

The processing implication of this treatment of relativization is that argument binders and adjunct binders have the same complexity. What adds to the complexity is how deeply the bindee is buried inside the relative clause. The deeper it is, the more complex, due to the default heuristics of preferring binders in higher clauses. Another kind of complex binders are those that are not directly the arguments or adjuncts but are "related" to them in some way.

### 5.4 Topicalization

Discourse particles such as *wa* (topic) and *mo* (also) may "bind" an argument, adjunct, or something completely outside the event described by the rest of the sentence. For instance,

- *sono heyā WA aite imasu* (That room, [it] is available) [topicalized subject]
- *mokuyou kara WA aite imasu* (From Thursday, [it] is available) [topicalized adjunct]
- *sakana WA tai ga ii* (Speaking of fish, snappers are good) [topic outside the event]

Interpreting where a topicalized entity should belong also requires pragmatic inferences, though on a smaller scale than relative clauses because role-marking particles remain on topicalized adjuncts. When there is no role-marking particle on a topicalized nominal, JLE assigns an underspecified binary relation *IS_TOPIC_OF* between the topic and the rest of the sentence. The topic bindee in this case is one of the unexpressed arguments or its implicit possessor, and the higher in the clause the more likely. The search space for the topic bindee is thus highly controllable with syntactic information. The following is the QLF for a sentence with a topicalized argument:

```
howaitoboodo wa tukatte imasu.
([the] white board, [zprc] is using [it])
```

18
[decl, [present,
    [is_topic_of,
      qterm(indet, A, [and, [howtoboodo, A]]),
      [in_progress,
        exists(B, [and, 
          [tukau, B],
          [agent, B, a_term(zpro, C, [subj, C])],
          [theme, B, a_term(zpro, D, [obj, D])]]))])])]]

In contrast, there is no "bindee" to be found for a topicalized adjunct or oblique object since its role is clearly marked on the postposition that obligatorily clusters with the topic particle (e.g., san zi kara wa (3 o'clock from TOPIC)). JLE recognizes both the binary relation \texttt{ADJUNCT\_TOPIC\_OF} and the topic’s specific adjunct role in the event described. The following is the QLF for a sentence with a topicalized adjunct:

\texttt{san zi kara wa aite iimasu.}
(From 3 o'clock. [it] is open)

[decl, 
[present, 
 [adjunct_topic_of, 
   qterm(exists, A, [from, A, a_term(number_of(3), B, [and, [hour0OfDay, B]])]),
   [in_progress, exists(C, [and, [aku, C]],
     [at_time, C, A],
     [theme, C, a_term(zpro, D, [subj, D])]]))]]

The processing implication of this treatment of topicalization is that argument topicalization is more complex than adjunct topicalization, but that topicalization is less complex than relativization due to the narrower range of possible bindees.

5.5 Quantifier Floating

Formulating a precise syntactic constraint on “quantifier floating” is one of the intensively studied areas of Japanese syntax. Much of the problem is in drawing a clear boundary between those nominals that allow floating versus those that do not. Existing accounts based on particle forms, grammatical functions, or syntactic categories all have problems, but it seems reasonable to assume that all argument NPs in JLE allow quantifier floating either rightward or leftward. Another problem
is in accounting for the ordering constraint. It is difficult, though not impossible\textsuperscript{10}, for the subject and its floated quantifier to have an intervening object. For example,

\begin{itemize}
  \item \textit{sansatu gakusei ga hon wo katta} [ObjQuant Subject Object Verb]
  \item \textit{hon wo gakusei ga sansatu katta} [Object Subject ObjQuant Verb]
  \item \textit{*sannin hon wo gakusei ga katta} [SubjectQuant Object Subject Verb]
  \item \textit{*gakusei ga hon wo sannin katta} [Subject Object SubjQuant Verb]
\end{itemize}

In JLE, all "floating" quantificational phrases are analyzed as quantificational \texttt{ADJUNCTS} with the \texttt{UNIT\_MEASURE} role, and are appended to the mods list when they are processed. Interpreting which argument entity is quantified is part of the resolution rules. The basic rule is:

Find the arguments (agent, theme, or goal) that fits the quantifier's sortal restriction either leftward or rightward in the same mods list.

The order constraint serves to order the possible candidates by preference:

If the target argument is agent or goal, there should not be any theme between the target and the quantificational adjunct in the mods list.

This rule, plus sortal constraints, correctly assigns only the possible interpretations to the following examples. They differ only in the linear position of the floating quantifier \textit{hutatu} (two inanimate object units). In the first, there is only one event this adjunct can attach to, whereas in the second, it can attach to either the matrix or the relative clause — hence the two readings.

\texttt{terebi ga aru kaigisitu wo hutatu osiete kudasai.} TV NOM exists conf\_room ACC 2\_obj\_units please\_tell\_me (Please tell me two conference rooms [that] have [a] TV)

\texttt{[imp, present, exists(\lambda, [and, osieru,\lambda], [agent,\lambda,addressee], [unit\_measure,}}

\textsuperscript{10}The JPSG working group at ICOT has found a number of good sentences with an intervening object phrase, e.g., \textit{sannin sono kyoushitsu wo gakusei ga tyuukan site iru} (Three students have ordered that textbook). (This example is due to Yasunari Harada.) Since it is defeasible, the constraint should be part of pragmatics in JLE.
A,
qterm(number_of(2),B,[and,[inanimate,B]]),
[theme,
A,
qterm(indet,C,[and,
  [kaigisitu,C],
  [about_relation,
   C,
   [present,
    exists(D,[and,
      [aru,D],
      [theme,
       D,
       qterm(indet,E,
         [and,[terebi,E]]))))]),
  [goal,A,a_term(zpro,F,[obj,F])]]],

hutatu  terebi ga aru  kaigisitu wo osiete kudasai.
2_obj_units TV  NOM exists conf_room ACC please_tell_me
(Please tell me {two conference rooms [that] have [a] TV / [a] conference room [that] have two TV's})

There are 2 analyses.
[imp,
  [present,
   exists(A,
    [and,
     [osieru,A],
     [agent,A,addressee],
     [theme,
      A,
      qterm(indet,
       B,
        [and,
         [kaigisitu,B],
         [about_relation,
          B,
          [present,
           exists(C,
            [and,
             [aru,C],
             [theme,C,qterm(indet,D,[and,[terebi,D]]),
             [unit_measure,C,

21
qterm(number_of(2),E,
    [and,[inanimate,E]]),
    [goal,A,a_term(zpro,F,[obj,F])])

[imp,
[present,
  exists(A,
    [and,
      [osieru,A],
      [agent,A,addressee],
      [theme,
        A,
        qterm(indet,
          B,
          [and,
            [kaegisitu,B],
            [about_relation,
              B,
              [present,
                exists(C,
                  [and,[aru,C],
                    [theme,
                      C,
                      qterm(indet,D,[and,[terebi,D]])])]])],
                [unit_measure,A,qterm(number_of(2),E,[and,[inanimate,E]])],
                [goal,A,a_term(zpro,F,[obj,F])]]])]]

The processing implication of this treatment of quantifier float is that subject and object sources do not differ in complexity. Rather, the complexity is in whether there is more than one sortably compatible source candidate in the clause where the quantifier belongs.

6 Resolution Prospects

I realize that this kind of robust and exception-free Japanese grammar leaves a lot of work to the resolution component that I have only sketched out here and there. It will have to interpret anaphoric elements, flesh out underspecified relations including relative clause and topicalization dependencies, and determine the quantified entities for floated quantifiers. Since all the heuristics have been kept out of the grammar, however, pragmatic inferences can now be formulated independently without any worry about complex interactions with the grammar. This is a major advantage.
of the nondefeasibility thesis. The key to an effective formalization of pragmatic inferences is control in the face of a potentially unlimited amount of information as resources at hand. A major effort in linguistic studies should then be turned into the search for grammatical generalizations that can be used as the control information for pragmatic inferences. These are generalizations in the form of default preferences, which, being defeasible, have tended to be thrown away in grammatical studies. I have pointed out possible candidates for such grammatical control information in this paper. Rather than a collection of unrelated observations, we would eventually like to have a theory of pragmatics that incorporates these grammatical features in a general form.

7 Conclusion

The conception of grammar as a system of nondefeasible rules independent from the context or the domain of discourse has been the core of modern linguistics. In an overall understanding of an utterance in discourse, such a grammar module can have a meaningful functionality by giving each utterance a set of context-independent undesignated interpretations under the assumption that the module of pragmatic inferences is responsible for further elaborations of the interpretations. From this perspective, a number of “syntactic” phenomena in Japanese actually fall under the area better suited for pragmatic treatments drawing on the full range of information from the discourse context and world knowledge. The JLE grammar that I have implemented with this perspective is robust and exception-free. A major effort in this approach should be in collecting grammatical generalizations in the form of default preferences to be used for the control of inferences. It would be of interest to find out if human processing principles and strategies also point to the presence of such a nondefeasible rule set.

8 Acknowledgments

This research was done partly under a contract from NTT Data to SRI International. I would like to thank Ken'ya Murakami and Ray Perrault for their support and encouragement, and Bob Moore for his technical guidance. I have profited from the comments on an earlier version from Ray, Bob, Jerry Hobbs, Yasunari Harada, and Shuichi Yatabe. Doug Appelt and Mark Gawron have also contributed to decisions about Japanese logical forms. The last, but not the least, thanks go to Otoya Shirotysuka, who has played an indispensable role in the CRR project.
References


