SYNTACTIC CONSTRAINTS ON RELATIVIZATION IN JAPANESE

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Abstract
This paper discusses the formalization of relative clauses in Japanese based on JPSG framework. We characterize them as adjuncts to nouns, and formalize them in terms of constraints among grammatical features. Furthermore, we claim that there is a constraint on the number of slash elements and show the supporting facts.

1 Introduction
This paper discusses the formalization of relative clauses in Japanese based on JPSG (Japanese Phrase Structure Grammar)[1, 2], which is a constraint-based grammar formalism like HPSG(Head-driven Phrase Structure Grammar)[7, 8]. We have worked on JPSG with Prof. Gunji, and also have developed a parser based on an efficient mechanism for dealing with constraints[3, 4, 10] to show that JPSG is effective even for the computational processing of natural language.

In the next section, we briefly introduce JPSG theory. Following a simple characterization of relative clauses in Japanese language in section 3, we discuss the variety of acceptability in secton 4, and describe its formalization in terms of constraints among the grammatical features in section 5. And in section 6 we will claim that there is a constraint on the number of slash elements and show the supporting facts.

2 Basics of JPSG
This section describes a brief introduction to JPSG, which is a grammar formalism originally for the Japanese language. As with HPSG, JPSG is feature based and constraint based grammar.

2.1 Features
Grammatical categories are represented as sets of features. We list the features used in this paper.

(1) Features used in this paper

pos (part of speech) same as in HPSG.
gr (grammatical relation) takes either subj, obj, or iobj as the value.
subcat (subcategorization) designates the set of categories (complements) that a particular category (head) requires. Though we have to distinguish two types of complements (i.e., agglutinated or not) in Japanese, for simplicity, we assume that subcat designates both types of complements.
dep (dependent) designates the category that a particular category (adjunct) modifies.
core roughly corresponds to CAT feature in HPSG[8]. The value is a set of features including subcat feature and so-called head features such as pos, gr and dep.
slash designates a syntactic gap within the grammatical category involved.
sem (semantics) designates the semantic representation of the grammatical category involved.

In this paper, categories are designated by a left square bracket ("[") followed by an indefinite number of feature specifications (a feature name followed by its value) separated by commas (",") followed by a right square bracket ("]"). When the value is null or not relevant, the entire feature specification can be omitted. The sharing structure is indicated by variables such as X, Y, ..., which is distinguished by an initial capital letter as in programming language Prolog. Finally, a category of the form [core {pos c, ..., sem s}] is often abbreviated as c[...]:s.

Because grammatical relations play no role in ordering complements in Japanese, we assume only a binary-branching phrase structure schema as seen in the next subsection.

2.2 The Phrase Structure Schema and Grammatical Principles
We are assuming three basic phrase structure schema for Japanese: complementation, adjunction, and co-
ordination:

(2) a. Complementation  \( M \to C \cap \)  
b. Adjunction  \( M \to A \cap \)  
c. Coordination  \( M \to \cap \)  

where \( M \) stands for an arbitrary mother category, \( C \) a complement, \( A \) a head category, and \( A \) an adjunct. Each category is construed as complex symbols, or features, with internal structures. The above structures are uniquely characterized by the features. For example, the head in the complementation structure should have \( \text{subcat} \) feature one whose value is unified with the complement, \( C \).

Furthermore, we assume the following grammatical principles, which are applied to every structures:

Head Feature Principle: same as in HPSG. We assume that pos, dep, and other several features are head features.

Subcat Feature Principle: In the complementation structure schema (2b), the value of subcat of the mother category unifies with that obtained by subtracting the left daughter category from the value of subcat of the head category. In the other structures, the value of subcat of the mother category unifies with that one of the head category.

Binding Feature Principle: The value of a binding feature of the mother category unifies with the union of its value of the left daughter category and its value of the head category minus the category bound of this local branching\(^1\). We assume that slash and some other features are binding features.

Slash feature and Binding Feature Principle play a crucial role in describing so-called long distance dependency phenomena. We will discuss them in detail in the following sections.

3 Relative Clauses in Japanese

Traditionally the relative clause in Japanese has been considered as a kind of so-called ren'ai syusyoku setu 'the clause for modifying noun'. Because it is characterized as an embedded sentence for modifying the head noun in the structure \( [s \ldots ] N \), it can be considered as an adjunct to the head noun.

In this paper, we adopt this idea. Thus the structure of relative clause-head noun construction can be described as shown in Figure 1, where the left daughter category is a relative clause, and the right daughter category is a head noun. The fact that the left daughter category has dep feature whose value is unifiable with the right daughter category, characterizes the left daughter (i.e. relative clause) as an adjunct.

However, we have to explain where this dep feature comes from. In Japanese, a relative clause has a tense form at its end. Thus we assume that tense form is categorized as a verb which takes a verb category as its complement. Furthermore, we assume that for every tense form (e.g. -ta and -ru), there are two different lexical entries with the same phonetic form, which we call the prenominal tense form and the assertive tense form\(^2\). The former type is assumed to be the ending form of relative clauses, and has a non-null value in dep feature. This value is bound with the head noun of the relative clause\(^3\).

4 Types of Relative Clauses

Relative clauses can be classified into the following three types in terms of their structural characteristics (where \( \phi \) marks a gap):

1. SS: Simple Sentence
   The relative clause consists of a simple sentence, and the gap plays a role in that sentence, \( e.g. \)
   (3) \[ Naomi-ga \phi yom-da] hon
   NOM ACC read PAST book
   'the book which Naomi read'

2. ES: Embedded Sentence
   The relative clause includes an embedded sentence in which the gap plays a role, \( e.g. \)
   (4) \[ Naomi-ga [Taro-ga \phi yom-da] ]
   NOM NOM ACC read PAST
   -to sinzitei -ru ]
   CMPL believe PRES book
   'the book which Naomi believes Taro read'

3. RC: Relative Clause
   The relative clause includes a relative clause in which the gap plays a role, \( e.g. \)
   (5) [[\phi \phi kak -ta] hon -ga
   NOM ACC write PAST book NOM
   yoku ure -ta ]
   well sell PAST writer
   'the writer whose book sold well'

\(^1\)For example, when the left daughter and the head daughter have \( \{ A \} \) and \( \{ B \} \) as their slash feature value respectively, the value of slash of the mother will be \( \{ A, B \} \) in most cases. However, in case that \( A \) can be unifiable with \( B \), the result can be \( \{ A \} \). Furthermore, in case that \( A \) (or \( B \)) is bound in the local branching structure (as in Figure 4), the result will be \( \{ B \} \) (or \( \{ A \} \)).

\(^2\)There are several reasons why we can assume there are two different lexical entries for tense with the same phonetic form\(^9\).

\(^3\)The assertive tense form is assumed to be the ending form of assertive clauses, and has a null value in dep feature.
As Inoue[5, 6] pointed out, the acceptability of the relative clauses varies depending on their types shown above and what roles are played by the gaps.

The grammatical roles other than subject and object can be classified into the following two types depending on the acceptability of relative clauses shown in Table 1, where, o, ? and * represent our subjects' judgements are acceptable, marginal, and unacceptable, respectively:

Adjunct 1: This includes 'locative'(marked by ni, wo and de), 'goal'(marked by ni and he) and 'source'(marked by kara).

Adjunct 2: This includes 'instrumental'(marked by de), 'reason'(marked by kara) and 'comparative'(marked by yori).

In order to simplify the formalization, we will regard the marginal cases as acceptable, and the result is shown in Table 2. This simplification, however, may be too permissive, because usually in the RC clauses are acceptable only when the gap's role is subject.

5 Formalization

In this section we will formalize the syntactic structure of the relative clause in Japanese. First we will formalize the SS type relative clause. Then we formalize the distribution of the slash feature. And finally, we examine the other cases, that is, those in which the gap is derived in either an embedded sentence or a relative clause.

5.1 Simple Relative Clause

As discussed in section 3, a relative clause is regarded as an adjunct. Thus, the gap should be bound with the dep feature value of the prenominal tense category.

As shown in the last section, gaps are not restricted to subjects or objects. Optional Adjunct 1 categories ('locative', 'goal' and 'source') can be a gap. Thus, for simplicity, we here assume that Adjunct 1 type roles are also designated in the value of subcat feature.

Furthermore, we assume that a gap is directly bound with dep feature, instead of being bound with an element of slash which is in turn bound with dep. We call this hypothesis the Direct Binding Hypothesis (that is, subcat element can be directly bound with dep). We will discuss the correctness of this assumption in section 6.

This relationship is expressed in the lexical entry for prenominal tense category, e.g. -ta, -ru, and -i. The structure is shown in Figure 2, where the head daughter is a prenominal tense category. For example, kak 'write' is assumed to take both subject and object complements and have the following lexical entry as follows:

(6) v_core {subcat {p[gr subj]:X, p[gr obj]:Y]}}

Then, a relative clause kak-ta 'wrote' corresponds to the following categories:

(7) a. v_core {subcat {p[gr subj]:X, dep {u[gr subj]}}}
    b. v_core {subcat {p[gr subj], dep {u[gr obj]}}}

Thus for kak-ta X (where X is a noun), there are at least two possibilities in the interpretation of the role of X, that is, either subject or object.

5.2 Distribution of Slash

As sentence (5) shows, there is a so-called long-distance dependency phenomenon in Japanese. This phenomenon is described by using the slash feature as in HPSG. We will characterize the distribution of slash in the following three sections.

5.2.1 Slash Introduction

Lexical entries with non-null value in slash feature are introduced by the following lexical rule:

Subcat-Slash Lexical Rule:

Subcat {p[X] U S} => Subcat S, Slash {n[:X]}

The number of slash elements introduced by this rule can be at most one, a fact which we explain more precisely in the next section.

4There are some restrictions on the application of this rule. For example, an agglutinated complement cannot become a slash value.
For example, *kak* ‘write’ will have the following lexical entries other than (6) by this lexical rule:

(8) a. \( \text{v[core \{subcat \{p[gr subj]:X\}\}} \),
    \( \text{slash \{n[gr obj]:Y\}\}} \)

b. \( \text{v[core \{subcat \{p[gr obj]:Y\}\}} \),
    \( \text{slash \{n[gr subj]:X\}\}} \)

5.2.2 Slash Inheritance

Each slash inheritance is constrained by means of Binding Feature Principle. Here, again, we assume that the number of slash elements of each category can be at most one.

In the RC type relative clause, the gap is inherited from the innermost embedded clause to the outermost relative clause shown in Figure 3.

5.2.3 Slash Binding

A long-distance inherited gap can be bound with the dep of the prenominal tense category, and finally bound with the head noun of the relative clause as shown in Figure 4 (where only core features of the mother and the head are shown). For example, if the left daughter category corresponds to *kak-ta hon-ga yoku ure* ‘book which φ wrote sells well’, and the right daughter (i.e. the head) to the prenominal tense form -ta, then the mother, *kak-ta hon-ga yoku ure-ta*, will be described as follows:

\[
\text{v[core \{dep \{n[\}\}\}} \)
\]

It should be noted that we do not necessarily need a specific phrase structure rule for the slash binding with the dep [9], though it may be natural that we assume to have such a phrase structure rule as shown in Figure 4.

5.3 Complex Relative Clause

In both ES and RC type relative clauses, the Binding Feature Principle specifies that a slash element which is introduced by the Subcat-Slash Lexical Rule is inherited and finally bound with the dep value of the prenominal tense category in the outermost relative clause. Figure 5 shows an example of such a structure.

6 Constraints on the Number of Slash Elements

As the consequence of the constraints on slash shown above, an Adjunct 2 type role cannot construct any acceptable relativization, because it cannot introduce an element of subcat in any lexical entries.

As discussed in section 3, we assume the relative clause of Japanese language is an adjunct. Thus in the relative clause, the value of the dep feature is bound with the gap. And according to the Direct Binding Hypothesis which we proposed in section 5, a subcat element can be directly bound with the dep. Here, we will discuss why this hypothesis is correct. Furthermore, we will show that if we adopt the Direct Binding Hypothesis, the number of slash elements can be at most one.

If we don’t accept this hypothesis, the only alternative is to assume that the gap is bound only with an element of slash. That is, if an element of subcat cannot be bound directly with the value of the dep, the gap should be initially in the value of slash, and should then be bound with the element of dep. We will call this hypothesis the Indirect Binding Hypothesis (that is, subcat element can be indirectly bound with the dep through a lexical rule).

First consider the following sentence:

\[ ([\text{kak -ta}] \text{ hon -wo syuppansai -ta ]} \]
\[ write \text{ PAST book ACC publish PAST} \]
\[ syuppansya -ga yuumei -ni nar publisher NOM famous GOAL become \]
\[ -ta ] \text{ gakusya PAST scholar} \]
\[ ‘the scholar such that the publisher that published his book became famous’ \]
This is acceptable to everyone. If we accept the Indirect Binding Hypothesis, the number of slash elements would be at least two, because in the above, every relative clause other than outermost one has at least two slash elements.

However, consider the following structures (where \(i\) and \(j\) are either 1 or 2, and \(\phi_1\) and \(\phi_2\) are assumed to be bound with \(N_1\) and \(N_2\), respectively):

(10) a. Double Relative Clause
\[
[s [s \ldots [s \ldots \phi_i \ldots ]N \ldots [s \ldots \phi_j \ldots ]N \ldots ]N_1 \ldots ]N_2 \ldots ]N_3
\]

b. Double Gap in one Relative Clause
\[
[s [s [s \ldots [s \ldots \phi_i \ldots ]N \ldots ]N_2 \ldots ]N_1 \ldots ]N_3
\]

c. Embedded Sentence in Relative Clause
\[
[s [s \ldots [s \ldots [s \ldots \phi_j \ldots ] \to \ldots ]N \ldots ]N_2 \ldots ]N_3
\]

The following are example sentences with the above structures:

(11) a. Double Relative Clause (10.a)
\[
[[[\phi_1 \text{ kaku -ta} ] e -ga [\phi_2 \text{ mae-ni} \text{ paint PAST picture NOM before} \text{ tor -ta} ] \text{ syasin -ni nitei -ta } ] \text{ take PAST photo DAT resemble PAST} \text{ syasin-ka} -ga \text{ sin -da ] gaka,} \text{ photographer NOM die PAST painter} \text{ 'the painter such that the photographer died whose photo taken before resembled the picture that he painted'}
\]

b. Double Gap in one Relative Clause (10.b)
\[
[[[\phi_1 \phi_2 \phi_3 \text{ kaku -se -ta } ] \text{ gakusyu -ga write make PAST scholar NOM} \text{ sin -da ] honz -ga yuumei -ni die PAST book NOM famous DAT} \text{ nar -ta ] hensyuysya,} \text{ become PAST editor} \text{ 'the editor who made the scholar who died write a book that became famous'}
\]

c. Embedded Sentence in Relative Clause (10.c)
\[
[[[\phi_1 [\phi_2 \text{ syuwai -si -ta } ] -to \text{ kaku -ta} ] \text{ take-bribe PAST CMPL write PAST} \text{ seizika -ga zisatu -si -ta ] kisya,} \text{ politician NOM kill-himself PAST journalist} \text{ 'the journalist who wrote a report that the politician, who killed himself, took a bribe'}
\]

Though the sentence (11.c) is better than the others, these are all unacceptable. Taking Indirect Binding Hypothesis, the number of slash elements for the above is 3, 3, and 2, respectively. It follows that in terms of the number of slash elements, we cannot explain the difference of the acceptability of the above structures.

However, we accept the Direct Binding Hypothesis, sentence (9) needs only one slash element, and sentences (11) all need at least two. Thus the Direct Binding Hypothesis is better than the Indirect Binding Hypothesis. And adopting this hypothesis leads to the conclusion that the number of slash elements should be at most one.

7 Concluding Remarks
We have described a grammatical formalization of the relative clause in Japanese. Based on the JPSG framework, this formalization is characterized in terms of constraints, that is, relationships among the grammatical features in a phrase structure and information in the lexical entries. In this paper we proposed the Direct Binding Hypothesis, and showed that the number of slash elements should be at most one in Japanese.

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Abstract in Japanese

論文は、JPSG 理論に基づいて、日本語の関係節化における統制制約について述べたものである。

JPSG 理論では、HPSG 理論と同様に、いろいろな情報を扱う数論から語邏が構成されていると考える。例えば文法を表す pos. どうでしょう、補語を取るかを表す subcat、どのような範囲に対する付加語を求めるかを表す dep。空所の存在を表す slash などの文法によって、それぞれの語法がどのように表されるかを述べる。

また、日本語には、補語構造、付加語構造、等価構造の 3 種類の句構成模式があると考えられる。そして、それぞれの類型は共通に適用される文法規則を、どのような情報をそれぞれの語法項目が表しているかという観点から、さまざまな文法現象を説明しようとする。

論文では初めに、関係節を名詞句に対する付加語として位置づける。これは、関係節に対応する範囲が、dep 文法の文法として名詞文の単一化しやすい要因をもっているとする学で特徴づけられる。そして、この dep 文法は、関係節を構成する動詞句の時制制御である「た」や「る」の文法項目に配列されているとする（ただし、言及させる文文に現れる制御文とは別の文法項目と考える）。すると、どのような要因がこの dep 要素と単一化することができるかが問題となる。

よく知られているように、日本語では、主語または目的語だけではなく、位置関係や自由な発話構造なども関係節化の過程から生まれてきている。従って我々は、このような関係節を、動詞の subcat 文法として配列されると考えられる。しかし、道志含や、自由な発話構造は、これらは subcat 要素には含めないとする。

ここで、関係節を次のような 3 種類に分けて解析する。

SS 型（単文）関係節が単文である場合
例：奈緒美が読んだ本
ES 型（埋込み文）補文節を「と」を伴う埋込み文文節空所がある場合
例：奈緒美が太郎が読んだと信じている本
RC 型（関係節）関係節と関係節が空所が埋め込まれた関係節にある場合
例：書いた木がよく売れた作家
関係節が SS 型の場合、時制制御を示した関係節の動詞句（「奈緒美が読んだ本」であれば「奈緒美が読んだ」の subcat の要因の一つが時制制御例では「だ」の dep 要素と単一化すると考えることができる。これを直接補足仮説と呼ぶ。

それに対し、ES 型や RC 型の関係節では、いわゆる長距離依存現象があるため、HPSG 同様、slash を用いて配列する。

slash の導入：Subcat-Slash 語彙規則により、subcat の一つの要素が slash の要因となる。

slash の伝播：束縛文法規則に従う。既に、どの局所（二分）の文においても、言葉の slash 要素の値は、左右の隣接する slash 要素の値を合わせえたものとなる。もし slash 要素が何か他の文法の値と束縛する場合は、その要因を示したものを等しいとする。

slash の束縛：関係節では、slash 要素の値が時制制御の dep 要素と束縛する。長距離依存の場合は、埋め込み文や関係節の中の空所が外部の関係節の時制制御の dep 要素と束縛し、それが最終的に主名詞と束縛すると考えられる。

ここで一つ問題となるのは、SS 型の関係節に対しても ES 型や RC 型の関係節と同様に slash を用いた説明が可能である。ということができる。これを直接束縛仮説と呼ぶ。これによりれば、本来動詞句の subcat 要素であったものが Subcat-Slash 語彙規則により slash 要素となり、それが時制制御の dep 要素と束縛する。つまり、subcat 要素が dep 要素と直接的に束縛する。

しかし、ここで次のような文法現象がみられる。それは、

(1) [[[φ(1) 書いた] 本を出版した] 出版社が有名になった] 学者]

は許容可能な文であるのに対し、

(2) a. [[[φ(2) 写真を 手にした] 写真に似ていた] 写真家 2 が死んだ] 画家]
b. [[[φ(2) 書かれた] 学者 2 が死んだ] 本 3 が有名になった] 論文 1]
c. [[[φ(2) 収録した] 書いた] 政治家 2 が自殺した] 配信 1]

はいずれも許容できない文であるという文法現象である。1) (2) もどちらも、空所が関係節の主名詞に長距離依存するという例文である。

この事実は、関係節仮説によっては説明できない。しかし、直接束縛仮説を採れば、文 (1) が 1 個の slash 要素を必要とするのに対し、文 (2) はいずれも 2 個以上の slash 要素を必要とする。これから説明可能である (2a,b は 3 個、2c は 2 個必要である）。さらに、直接束縛仮説を採れば、日本語では許される slash 要素の個数は高々 1 個であることが導かれる。

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