

An algebraic study of Japanese grammar

by

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Résumé:

Je présente un modèle de langage algébrique pour le japonais dans le cadre d'une grammaire de types. L'analyse porte autant sur la morphologie inflectionnelle que sur la syntaxe. Les mathématiques utilisées pour vérifier la grammaticalité d'une phrase ou d'un syntagme invoquent une généralisation du fameux concept de groupe.

Abstract:

I present an algebraic language model for Japanese within the framework of a type grammar. The analysis pays attention to both inflectional morphology and to syntax. The mathematics for checking the sentencehood of strings of words invokes a generalization of the notorious group concept.

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Introduction

The purpose of this thesis is to verify whether the pregroup grammar, initially proposed by Lambek, and developed for European languages also applies to Japanese.

The first part of this thesis exposes a naive look at written Japanese and investigates how the numerous inflected forms of the Japanese verb can be generated by simple rewriting rules. The results of this study may be useful in several ways. For instance, it may serve as an example of a formalization which, we hope, will be useful for linguists. Furthermore, it may help mathematically inclined readers in the practical endeavour to learn Japanese.

The second part, which is independent from the first one, describes the theory of syntactic type and its application to the Japanese language. We describe the formal specifications of the structures allowable in Japanese and explain our parsing technique, which is the method of analyzing a sentence to determine its structure according to the grammar.

There exist several applications of these methods. They may, for example, be useful for the automatic translation of languages. They can help in the syntactic analysis of the input material and indicate how to arrange the output into grammatical sentences of the target language. For the construction of an auxiliary language, they tell how to achieve a completely regular syntax; this is particularly important when the auxiliary acts as an intermediate language in automatic translation.

CHAPTER 1

A mathematical analysis of Japanese conjugation

1. Inflection of Japanese verbs

Japanese verbs are not inflected with respect to the subject, they are affirmative or negative, perfective (as in the past tense) or non perfective (as in the present or future tense). These differences are expressed by inflections to the verb stem. Furthermore, there is a variety of levels of politeness and a number of different forms that are expressed in verb inflection.

There are two main classes of verbs: verb stems ending in consonants and verb stems ending in vowels. There is also a third class which corresponds to irregular verbs. We shall call them Group I, Group II, and Group III respectively. In order to develop my thesis as concisely as possible, I will consider only verbs from group I and II, and I will exclude the imperative tense.

1.1. The informal affirmative category. The informal inflectional endings, using *matu* 'wait' and *taberu* 'eat' as examples, are listed in table 1. The dot shows the division between the root and ending. The infinitive is the form of the verb which is used in making compound words.

There exist another volitional and past volitional form. These forms are obtained by adding *daroo* to the non perfective and perfective forms. For example, *taberu daroo* and *tabeta daroo*.

Tense	Group I	Group II
Infinitive	mat.i	tabe
Non perfective	mat.u	tabe.ru
Volitional	mat.oo	tabe.yoo
Provisional	mat.eba	tabe.reba
Gerund	mat.te	tabe.te
Perfective	mat.ta	tabe.ta
Past volitional	mat.taroo	tabe.taroo
Conditional	mat.tara	tabe.tara
Alternative	mat.tari	tabe.tari

TABLE 1. Basic inflectional endings of *matu* and *taberu*

If we compare the endings of the two verb classes, we observe that the endings of the last five categories are the same but the ones in the first four categories present dissimilarities which are depicted in table 2.

Tense	Group I	Group II
Infinitive	i	∅
Non perfective	u	ru
Volitional	oo	yoo
Provisional	eba	reba

TABLE 2. Differences between group I and group II

The differences between the endings can be accounted for by the following rules, in going from group II to group I:

- i. the initial consonant *r* and semi-vowel *y* of a suffix are lost when the stem ends in consonant;
- ii. the vowel *i* is added before #.

If we now look at the verbal root *mat-* and *tabe-*, we note that they both remain constant throughout the nine categories. This behaviour is specific to group II verb stems. Group I verb stems which do not end in *t* are subject to a modification when one of the five suffixes beginning with *t* (*te*, *ta*, *taroo*, *tara*, and *tari*) is directly attached to them. These changes depend on the

final consonant of the stem. All of the possible changes are illustrated in the following examples.

<i>kaer.u</i>	'to return'	$kaer + te \rightarrow kaette$
<i>hanas.u</i>	'to speak'	$hanas + te \rightarrow hanasite$
<i>kak.u</i>	'to write'	$kak + te \rightarrow kaite$
<i>isog.u</i>	'to hurry'	$isog + te \rightarrow isoide$
<i>sin.u</i>	'to die'	$sin + te \rightarrow sinde$
<i>tob.u</i>	'to fly'	$tob + te \rightarrow tonde$
<i>yom.u</i>	'to read'	$yom + te \rightarrow yonde$

These changes are formulated in the following rules:

1. $r + t \rightarrow tt$
2. $s + t \rightarrow sit$

When the verb stems ends in *k* and the verbal endings *te*, *ta*, *taroo*, *tara*, and *tari* follow it, the vowel *i* is inserted at the end of the verbal root, and *k* is deleted.

3. $k + t \rightarrow it$

There is a similar phonological change in the derivation of *isoide*. That is, the vowel *i* is first inserted, and then the consonant *g* is deleted. In addition to these changes, the initial consonant of the verbal ending is voiced. The voicing of *t* can be attributed to the differences of *k* and *g*.

4. $g + t \rightarrow id$

The initial consonant t becomes voiced when preceded by a voiced consonant, as n , b , m . Moreover, b and m become n .

5. $n + t \rightarrow nd$

6. $b + t \rightarrow nd$

7. $m + t \rightarrow nd$

1.2. The informal negative category. To form the informal negative category, the adjectival derivative *-ana.i* is attached to the stem of the verb. The resulting verb has the following inflections:

Tense	Group I	Group II
Non perfective	mat.anai	tabe.nai
Volitional	mat.umai	tabe.mai
Provisional	mat.anakereba	tabe.nakereba
Gerund	mat.anakute	tabe.nakute
Perfective	mat.anakatta	tabe.nakatta
Past volitional	mat.anakattaroo	tabe.nakanattaroo
Conditional	mat.anakattara	tabe.nakattara
Alternative	mat.anakattari	tabe.nakattari

TABLE 3. Informal negative inflections of *matu* and *taberu*

We note that the initial vowel a of the suffix is lost when it is joined to the group II *tabe-* stem. So our earlier juncture rule applies for *-anai*.

As for the affirmative form, there exist another volitional and past volitional forms. The (past) volitional is formed by adding *desyoo* to the informal negative non perfective (perfective) form, respectively.

	Group I	Group II
Volitional	matanai daroo	tabenai daroo
Past volitional	matanakatta daroo	tabenakatta daroo

The *matanai/tabenai daroo* form is more commonly used than the *matu-mai/tabemai* form.

1.3. The formal affirmative category. The auxiliary verb *masu* occurs only as an ending for other verbs and serves to increase the level of politeness of the verb to which it is attached. The inflections of *masu* are shown below.

Tense	Ending
Non perfective	-mas.u
Volitional	-mas.yoo
Provisional	-mas.eba
Gerund	-masi.te
Perfective	-masi.ta
Past volitional	-masi.taroo
Conditional	-masi.tara
Alternative	-masi.tari

TABLE 4. Inflections of the suffix *masu*

The formal affirmative is derived by attaching the auxiliary *masu* to the infinitive of the original verb, as shown in table 5. As for the informal category, a second form of the volitional and past volitional forms can be formed by adding *desyoo* to the informal non perfective and perfective form, as in *taberu desyoo* and *tabeta desyoo*.

Tense	Group I	Group II
Infinitive	mati	tabe
Non perfective	mati.masu	tabe.masu
Volitional	mati.masyoo	tabe.masyoo
Provisional	mati.maseba	tabe.maseba
Gerund	mati.masite	tabe.masite
Perfective	mati.masita	tabe.masita
Past volitional	mati.masitaroo	tabe.masitaroo
Conditional	mati.masitara	tabe.masitara
Alternative	mati.masitari	tabe.masitari

TABLE 5. Formal affirmative inflections of *matu* and *taberu*

1.4. The formal negative category. The formal negative category is formed by adding the negative inflections of *-masu* as well as various compounds using the copula, as demonstrated in table 6.

Tense	Group I	Group II
Non perfective	mati.masen	tabe.masen
Volitional	mati.masumai	tabe.masumai
Provisional	mati.masen nara	tabe.masen nara
Gerund	mati.masen de	tabe.masen de
Perfective	mati.masen desita	tabe.masen desita
Past volitional	mati.masen desitaroo	tabe.masen desitaroo
Conditional	mati.masen desitara	tabe.masen desitara
Alternative	mati.masen desitari	tabe.masen desitari

TABLE 6. Formal negative inflections of *matu* and *taberu*

As for the affirmative form, there exist another volitional and past volitional forms which we construct by adding *desyoo* to the informal negative non perfective (perfective) form, respectively. For example, *tabenai desyoo* and *tabenakatta desyoo*.

2. Derivation of Japanese verbs

The derivation of the passive, potential, causative, and causative passive forms result in new verbs which can themselves take the entire range of inflectional and derivational endings depicted up to this point.

Passive	matareru	taberareru
Potential	materu	taberareru
Causative	mataseru	tabesaseru
Causative Passive	mataserareru	tabesaserareru

The inflectional endings of these derived verbs are the same as those already given for Group II. Table 7 presents the passive form of *matu* and *taberu*.

The first person desiderative form is made by adding the adjectival derivative *tai* to the verb stem, as demonstrated in table 8.

Tense	Group I	Group II
Non perfective	matare.ru	taberare.ru
Volitional	matarer.oo	taberare.yoo
Provisional	matare.reba	taberare.reba
Gerund	matare.te	taberare.te
Perfective	matare.ta	taberare.ta
Past volitional	matare.taroo	taberare.taroo
Conditional	matare.tara	taberare.tara
Alternative	matare.tari	taberare.tari

TABLE 7. Inflectional endings of the passive form of *matu* and *taberu*

Tense	Affirmative	Negative
Non perfective	tabe.ta.i	tabe.ta.kuna.i
Perfective	tabe.ta.katta	tabe.ta.kuna.katta
Provisional	tabe.ta.kereba	tabe.ta.kuna.kereba
Gerund	tabe.ta.kute	tabe.ta.kuna.kute
Past volitional	tabe.ta.kattaroo	tabe.ta.kuna.kattaroo
Conditional	tabe.ta.kattara	tabe.ta.kuna.kattara
Alternative	tabe.ta.kattari	tabe.ta.kuna.kattari

TABLE 8. First person desiderative form of the verb *taberu*

The non-first person desiderative suffix *tagar.u* is added to the infinitive of verbs to produce the non-first person desiderative form, as demonstrated in table 9.

Tense	Affirmative	Negative
Non perfective	-tagar.u	-tagar.anai
Volitional	-tagaroo	-tagar.umai
Provisional	-tagar.eba	-tagar.anakereba
Gerund	-taga.tte	-tagar.anakute
Perfective	-taga.tta	-tagar.anakatta
Past volitional	-taga.ttaroo	-tagar.anakattaroo
Conditional	-taga.ttara	-tagar.anakattara
Alternative	-taga.ttari	-tagar.anakattari

TABLE 9. Informal non-first person desiderative form of the verb *taberu*

3. Computational view of Japanese conjugation

I propose an algorithm which emphasizes the step by step computations involved in the generation of the finite forms of the Japanese verb. I adapted the method used by D. Bargelli and J. Lambek in [5] for Turkish conjugation.

We could easily write a computer program, following the given instructions, to generate these verbal forms. Furthermore, a native speaker probably proceeds unconsciously in an analogous fashion.

The finite forms of the verb V are calculated according to the following formula:

$$C_{ijkl}(V(C)(P)) \rightarrow V_0(C)(P)A_iF_j\theta_{ijk}T_{ijkl}$$

where

V_0 = verb stem

C = causative

P = passive voice

A_i = aspect ($i = 1, \dots, 4$)

F_j = form ($j = 1, 2$)

θ_{ijk} = truth value ($k = 1, 2$)

T_{ijkl} = tense ($l = 1, \dots, 8$)

There are some restrictions: if $i = 3$ then $j = 1$ and $l \neq 5$.

Aspects

A_1 = ordinary

A_2 = potential

A_3 = first person desiderative

A_4 = non-first person desiderative

Formality

 $F_1 = \text{informal}$ $F_2 = \text{formal}$

Truth value

 $\theta_{ij,1} = \text{affirmative}$ $\theta_{ij,2} = \text{negative}$

Tenses

 $T_{ijk,1} = \text{non perfective}$ $T_{ijk,2} = \text{perfective}$ $T_{ijk,3} = \text{provisional}$ $T_{ijk,4} = \text{gerund}$ $T_{ijk,5} = \text{volitional}$ $T_{ijk,6} = \text{past volitional}$ $T_{ijk,7} = \text{conditional}$ $T_{ijk,8} = \text{alternative}$ **3.1. Values.**3.1.1. *Causative.* $C \rightarrow \text{sase}$ 3.1.2. *Passive.* $P \rightarrow \text{rare}$ 3.1.3. *Aspect.* $A_1 \rightarrow \emptyset$ $A_2 \rightarrow \begin{cases} e, & \text{following a consonant;} \\ rare, & \text{following a vowel.} \end{cases}$ $A_3 \rightarrow ta$ $A_4 \rightarrow tagar$

One can observe that the passive and potential morphemes are the same for Group II verbs. This can lead to ambiguity as in *sakana ga taberareru*, which means either *the fish is eaten* or *the fish can eat*.

3.1.4. Formality.

$$\begin{aligned} F_1 &\rightarrow \emptyset \\ F_2 &\rightarrow \text{mas} \end{aligned}$$

3.1.5. Truth value.

$$\begin{aligned} \theta_{i,j,1} &\rightarrow \emptyset \\ \theta_{i \neq 3,1,2} &\rightarrow \text{ana} \\ \theta_{3,1,2} &\rightarrow \text{kuna} \\ \theta_{i,2,2} &\rightarrow \text{en} \end{aligned}$$

3.1.6. Tense.

Non-first person desiderative affirmative	Informal negative or first person desiderative	Formal negative
$T_{i \neq 3,j,1,1} \rightarrow ru$	$T_{i,1,2,1} \vee T_{3,1,k,1} \rightarrow i$	$T_{i,2,2,1} \rightarrow \emptyset$
$T_{i \neq 3,j,1,2} \rightarrow ta$	$T_{i,1,2,2} \vee T_{3,1,k,2} \rightarrow katta$	$T_{i,2,2,2} \rightarrow desita$
$T_{i \neq 3,j,1,3} \rightarrow reba$	$T_{i,1,2,3} \vee T_{3,1,k,3} \rightarrow kereba$	$T_{i,2,2,3} \rightarrow nara$
$T_{i \neq 3,j,1,4} \rightarrow te$	$T_{i,1,2,4} \vee T_{3,1,k,4} \rightarrow kute$	$T_{i,2,2,4} \rightarrow de$
$T_{i \neq 3,j,1,5} \rightarrow yoo$	$T_{i,1,2,5} \rightarrow idaroo$	$T_{i,2,2,5} \rightarrow desyoo$
$T_{i \neq 3,j,1,6} \rightarrow taroo$	$T_{i,1,2,6} \vee T_{3,1,k,6} \rightarrow kattaroo$	$T_{i,2,2,6} \rightarrow desitaroo$
$T_{i \neq 3,j,1,7} \rightarrow tara$	$T_{i,1,2,7} \vee T_{3,1,k,7} \rightarrow kattara$	$T_{i,2,2,7} \rightarrow desitara$
$T_{i \neq 3,j,1,8} \rightarrow tari$	$T_{i,1,2,8} \vee T_{3,1,k,8} \rightarrow kattari$	$T_{i,2,2,8} \rightarrow desitari$

When $i = 3$ (i.e. the aspect is first person desiderative), $j = 1$; so the tense morpheme is the same as the informal negative morpheme, except that there is no volitional form, since $k \neq 5$ when $i = 3$.

3.2. Phonological rules. There are several phonological changes taking place in the formation of finite forms of verbs. These changes, expressed as phonological rules, are listed below:

- i. When the causative morpheme is joined to a stem ending in consonant, the initial *s* of *sase* is deleted.
- ii. When the passive morpheme is joined to a stem ending in consonant, the initial *r* of *rare*, is deleted.
- iii. When the formal morpheme *mas* is followed by a suffix beginning with *t*, the vowel *i* is inserted (i.e. $s + t \rightarrow sit$).
- iv. When the negative morpheme *ana* is joined to a stem ending in a vowel, the initial *a* of *ana* is dropped.

3.3. Examples. In the following examples, I shall illustrate how the above rules can be used to calculate the Japanese word for C_{ijkl} for a given verb V and positive integers $i \leq 5$, $j \leq 2$, $k \leq 2$, $l \leq 8$, subject to the restrictions in section 3.

(1) to play

$$\begin{aligned}
 C_{1218}(asobu) &\rightarrow asobA_1F_2\theta_{1,2,1}T_{1,2,1,8} \\
 &\rightarrow asobF_2\theta_{1,2,1}T_{1,2,1,8} & (A_1 \rightarrow \emptyset) \\
 &\rightarrow asob + mas\theta_{1,2,1}T_{1,2,1,8} & (F_2 \rightarrow mas) \\
 &\rightarrow asobimas\theta_{1,2,1}T_{1,2,1,8} & (b+m \rightarrow bim) \\
 &\rightarrow asobimasT_{1,2,1,8} & (\theta_{1,2,1} \rightarrow \emptyset) \\
 &\rightarrow asobimas + tari & (T_{1,2,1,8} \rightarrow tari) \\
 &\rightarrow asobimasitari & (s+t \rightarrow sit)
 \end{aligned}$$

(2) to walk

$$\begin{aligned}
C_{3121}(arukuCP) &\rightarrow arukCPA_3F_1\theta_{3,1,2}T_{3,1,2,1} \\
&\rightarrow arukasePA_3F_1\theta_{3,1,2}T_{3,1,2,1} && (C \rightarrow ase) \\
&\rightarrow arukaserareA_3F_1\theta_{3,1,2}T_{3,1,2,1} && (P \rightarrow rare) \\
&\rightarrow arukaseraretakuF_1\theta_{3,1,2}T_{3,1,2,1} && (A_3 \rightarrow taku) \\
&\rightarrow arukaseraretaku\theta_{3,1,2}T_{3,1,2,1} && (F_1 \rightarrow \emptyset) \\
&\rightarrow arukaseraretaku + anaT_{3,1,2,1} && (\theta_{3,1,2} \rightarrow ana) \\
&\rightarrow arukaseraretakunaT_{3,1,2,1} && (u+ana \rightarrow una) \\
&\rightarrow arukaseraretakunai && (T_{3,1,2,1} \rightarrow i)
\end{aligned}$$

(3) to walk

$$\begin{aligned}
C_{4121}(arukuCP) &\rightarrow arukCPA_4F_1\theta_{4,1,2}T_{4,1,2,1} \\
&\rightarrow arukasePA_4F_1\theta_{4,1,2}T_{4,1,2,1} && (C \rightarrow ase) \\
&\rightarrow arukaserareA_4F_1\theta_{4,1,2}T_{4,1,2,1} && (P \rightarrow rare) \\
&\rightarrow arukaseraretagarF_1\theta_{4,1,2}T_{4,1,2,1} && (A_4 \rightarrow tagar) \\
&\rightarrow arukaseraretagar\theta_{4,1,2}T_{4,1,2,1} && (F_1 \rightarrow \emptyset) \\
&\rightarrow arukaseraretagaranaT_{4,1,2,1} && (\theta_{4,1,2} \rightarrow ana) \\
&\rightarrow arukaseraretagaranai && (T_{4,1,2,1} \rightarrow i)
\end{aligned}$$

(4) to select

$$\begin{aligned}
C_{1114}(erabu) &\rightarrow erabA_1F_1\theta_{1,1,1}T_{1,1,1,4} \\
&\rightarrow erabF_1\theta_{1,1,1}T_{1,1,1,4} & (A_1 \rightarrow \emptyset) \\
&\rightarrow erab\theta_{1,1,1}T_{1,1,1,4} & (F_1 \rightarrow \emptyset) \\
&\rightarrow erabT_{1,1,1,4} & (\theta_{1,1,1} \rightarrow \emptyset) \\
&\rightarrow erab + te & (T_{1,1,1,4} \rightarrow te) \\
&\rightarrow erande & (b+t \rightarrow nd)
\end{aligned}$$

(5) to insert

$$\begin{aligned}
C_{1212}(ireruP) &\rightarrow irePA_1F_2\theta_{1,2,1}T_{1,2,1,2} \\
&\rightarrow irerareA_1F_2\theta_{1,2,1}T_{1,2,1,2} & (P \rightarrow rare) \\
&\rightarrow irerareF_2\theta_{1,2,1}T_{1,2,1,2} & (A_1 \rightarrow \emptyset) \\
&\rightarrow ireraremas\theta_{1,2,1}T_{1,2,1,2} & (F_2 \rightarrow mas) \\
&\rightarrow ireraremasT_{1,2,1,2} & (\theta_{1,2,1} \rightarrow \emptyset) \\
&\rightarrow ireraremas + ta & (T_{1,2,1,2} \rightarrow ta) \\
&\rightarrow ireraremasita & (s+t \rightarrow sit)
\end{aligned}$$

(6) to mix

$$\begin{aligned}
C_{1117}(mazeru) &\rightarrow mazeA_1F_1\theta_{1,1,1}T_{1,1,1,7} \\
&\rightarrow mazeF_1\theta_{1,1,1}T_{1,1,1,7} & (A_1 \rightarrow \emptyset) \\
&\rightarrow maze\theta_{1,1,1}T_{1,1,1,7} & (F_1 \rightarrow \emptyset) \\
&\rightarrow mazeT_{1,1,1,7} & (\theta_{1,1,1} \rightarrow \emptyset) \\
&\rightarrow mazetara & (T_{1,1,1,7} \rightarrow tara)
\end{aligned}$$

(7) to eat

$$\begin{aligned}
C_{1115}(\text{taberu}) &\rightarrow \text{tabe}A_1F_1\theta_{1,1,1}T_{1,1,1,5} \\
&\rightarrow \text{tabe}F_1\theta_{1,1,1}T_{1,1,1,5} & (A_1 \rightarrow \emptyset) \\
&\rightarrow \text{tabe}\theta_{1,1,1}T_{1,1,1,5} & (F_1 \rightarrow \emptyset) \\
&\rightarrow \text{tabe}T_{1,1,1,5} & (\theta_{1,1,1} \rightarrow \emptyset) \\
&\rightarrow \text{tabeyoo} & (T_{1,1,1,5} \rightarrow \text{yoo})
\end{aligned}$$

(8) to eat

$$\begin{aligned}
C_{1223}(\text{taberu}) &\rightarrow \text{tabe}A_1F_2\theta_{1,2,2}T_{1,2,2,3} \\
&\rightarrow \text{tabe}F_2\theta_{1,2,2}T_{1,2,2,3} & (A_1 \rightarrow \emptyset) \\
&\rightarrow \text{tabemas}\theta_{1,2,2}T_{1,2,2,3} & (F_2 \rightarrow \text{mas}) \\
&\rightarrow \text{tabemasen}T_{1,2,2,3} & (\theta_{1,2,2} \rightarrow \text{en}) \\
&\rightarrow \text{tabemasen nara} & (T_{1,2,2,3} \rightarrow \text{nara})
\end{aligned}$$

(9) to write

$$\begin{aligned}
C_{1113}(\text{kaku}C) &\rightarrow \text{kak}CA_1F_1\theta_{1,1,1}T_{1,1,1,3} \\
&\rightarrow \text{kakase}A_1F_1\theta_{1,1,1}T_{1,1,1,3} & (C \rightarrow \text{ase}) \\
&\rightarrow \text{kakase}F_1\theta_{1,1,1}T_{1,1,1,3} & (A_1 \rightarrow \emptyset) \\
&\rightarrow \text{kakase}\theta_{1,1,1}T_{1,1,1,3} & (F_1 \rightarrow \emptyset) \\
&\rightarrow \text{kakase}T_{1,1,1,3} & (\theta_{1,1,1} \rightarrow \emptyset) \\
&\rightarrow \text{kakasereba} & (T_{1,1,1,3} \rightarrow \text{reba})
\end{aligned}$$

4. Computational view of Japanese adjectival conjugation

Adjectives are also identified by a variety of conjugational endings. In an analogous fashion, I will represent the conjugation pattern of adjectives by a set of rules.

The finite forms of the adjective A are calculated according to the following formula:

$$C_{ij}(A) \rightarrow A_0 \theta_i T_j$$

where

A_0 = adjective stem

θ_i = truth value ($k = 1, 2$)

T_j = tense ($l = 1, \dots, 8$)

Truth value

θ_1 = affirmative

θ_2 = negative

Tenses

T_1 = non perfective

T_2 = perfective

T_3 = provisional

T_4 = gerund

T_5 = volitional

T_6 = past volitional

T_7 = conditional

T_8 = alternative

4.1. Values.

4.1.1. *Truth value.*

$$\theta_1 \rightarrow \emptyset$$

$$\theta_2 \rightarrow kuna$$

4.1.2. *Tense.*

$$T_1 \rightarrow i$$

$$T_2 \rightarrow katta$$

$$T_3 \rightarrow kereba$$

$$T_4 \rightarrow kute$$

$$T_5 \rightarrow soo$$

$$T_6 \rightarrow kattaroo$$

$$T_7 \rightarrow kattara$$

$$T_8 \rightarrow kattari$$

4.2. Examples. In this section, I apply the set of rules described above to few adjectives and show how adjectives are conjugated.

(1) cheap

$$C_{11}(yasui) \rightarrow yasui\theta_1T_1$$

$$\rightarrow yasuiT_1 \quad (\theta_1 \rightarrow \emptyset)$$

$$\rightarrow yasui \quad (T_1 \rightarrow i)$$

(2) difficult

$$\begin{aligned}
 C_{12}(\text{muzukasii}) &\rightarrow \text{muzukasi}\theta_1 T_2 \\
 &\rightarrow \text{muzukasi}T_1 & (\theta_1 \rightarrow \emptyset) \\
 &\rightarrow \text{muzukasikatta} & (T_2 \rightarrow \text{katta})
 \end{aligned}$$

(3) good

$$\begin{aligned}
 C_{13}(\text{oisii}) &\rightarrow \text{oisii}\theta_1 T_3 \\
 &\rightarrow \text{oisii}T_1 & (\theta_1 \rightarrow \emptyset) \\
 &\rightarrow \text{oisikereba} & (T_3 \rightarrow \text{kereba})
 \end{aligned}$$

(4) busy

$$\begin{aligned}
 C_{24}(\text{isogasii}) &\rightarrow \text{isogasi}\theta_2 T_4 \\
 &\rightarrow \text{isogasikuna}T_1 & (\theta_2 \rightarrow \text{kuna}) \\
 &\rightarrow \text{isogasikunakute} & (T_4 \rightarrow \text{kute})
 \end{aligned}$$

(5) new, fresh

$$\begin{aligned}
 C_{27}(\text{atarasii}) &\rightarrow \text{atarasi}\theta_2 T_7 \\
 &\rightarrow \text{atarasikuna}T_7 & (\theta_2 \rightarrow \text{kuna}) \\
 &\rightarrow \text{atarasikunakattara} & (T_7 \rightarrow \text{kattara})
 \end{aligned}$$

CHAPTER 2

Fundamentals of the Japanese language

This chapter provides background material on the basic structure of Japanese syntax. It reviews the major phrase categories and identifies their most important subparts. The reader who has some knowledge of Japanese can quickly skim this chapter, as it does not address any computational issues.

Section 1 describes the notation; section 2 gives an introduction to the Japanese syntax. Finally, section 3 briefly covers the different parts of speech categories.

1. Notations

For each example of a Japanese sentence, I attach a gloss which shows the corresponding English expression to each Japanese word. I also provide an English translation. For Japanese expressions which lack corresponding English expressions, I use the following symbols:

Expression	Symbol
de	LOC: locative case particle
de	INS: instrumental case particle
ga	NOM: nominative case particle
ka	Q: question marker
kara	ABL: ablative case particle
ni	DAT: dative case particle
no	GEN: genitive case particle
o	ACC: accusative case particle
wa	TOP: topic marker

TABLE 1. Japanese expressions and their corresponding symbols

2. Japanese sentence structure

Japanese sentences usually have an SOV structure. Nevertheless, the relative order among constituents in a Japanese sentence can be random, except for the restriction that the predicate must occur at the end of the sentence. In other words, Japanese has word-order flexibility, as opposed to English.

If made clear by the context, the subject, and sometimes objects, can be omitted. Thence, pronouns are used less often than in English.

The following example illustrates the word order flexibility phenomenon. Although the order of the predicate modifiers is changed, the sentences remain grammatically correct, and they all mean the same.

The order of the predicate modifiers affect only the place of emphasis. The predicate modifier that is closer to the predicate is usually more emphatic.

1. (a) Hiromi ga Naoko ni tegami o kaita.
Hiromi NOM Naoko DAT letter ACC wrote
Hiromi wrote a letter to Naoko.
- (b) Hiromi ga tegami o Naoko ni kaita.
Hiromi NOM letter ACC Naoko DAT wrote
Hiromi wrote a letter to Naoko.
- (c) Tegami o Hiromi ga Naoko ni kaita.
letter ACC Hiromi NOM Naoko DAT wrote
Hiromi wrote a letter to Naoko.
- (d) Tegami o Naoko ni Hiromi ga kaita.
letter ACC Naoko DAT Hiromi NOM wrote
Hiromi wrote a letter to Naoko.
- (e) Naoko ni Hiromi ga tegami o kaita.
Naoko DAT Hiromi NOM letter ACC wrote
Hiromi wrote a letter to Naoko.

- (f) Naoko ni tegami o Hiromi ga kaita.
 Naoko DAT letter ACC Hiromi NOM wrote
 Hiromi wrote a letter to Naoko.

When a sentence includes both *wa* and *ga*, however, *wa* will normally precede *ga*. The following example shows that when the nominative case particle *ga* precedes the topic marker, it yields an ungrammatical sentence.

2. (a) Mariko wa ongaku ga suki desu.
 Mariko TOP music NOM like copula
 Mariko likes music.
- (b) *Ongaku ga Mariko wa suki desu.
 music NOM Mariko TOP like copula
 Mariko likes music.

3. Parts of speech

Words are classified into different categories based on their uses. They are given syntactic labels according to their contribution to the meaning of the clause that contains it, and to the actual syntactic structures in which they may play a role.

This section describes parts of speech categories, such as nouns, adjectives, and adverbs. Since verbs were covered in details in the first chapter (and to avoid redundancy), they will be omitted.

3.1. Nouns. Japanese nouns are uninflected and are not marked for gender or number. Nouns can co-occur with demonstrative words such as *kono* 'this' and *sono* 'that' as in *kono hon* 'this book', and *sono tegami* 'that letter'.

Furthermore, nouns may be modified by other nouns which precede them. Noun modifiers, then, take the genitive case particle *no*. For example, *otoosan no hon* 'father's book'.

In English, one can identify nouns by the distribution of articles, such as *a/an* and *the* as in *a pencil* and *the student*, whereas in Japanese, the lack of articles prevent us to identify nouns with them.

There is another characteristic proper to Japanese nouns which separates them from English nouns. In Japanese, nouns are associated with a conjugational paradigm, illustrated below with the noun *hana* 'flower'.

Tense	Affirmative	Negative
Non perfective	hana da	hana zya nai
Perfective	hana datta	hana zya nakatta
Volitional	hana daroo	hana zya nai daroo

TABLE 2. Conjugational paradigm of nouns - informal

Tense	Affirmative	Negative
Non perfective	hana desu	hana zya nai desu
Perfective	hana desita	hana zya nakatta desu
Volitional	hana desyoo	hana zya nai desyoo

TABLE 3. Conjugational paradigm of nouns - formal

3.2. Adjectives. Adjectives occur in two forms; either as modifying a noun, where they appear before the noun, or they can occur as adjectival verbs. In the latter case, the adjective takes an inflection and the verb is omitted.

The pattern of an adjectival predicate is an adjective followed by the copula *desu* (or one of its conjugated form). However, *desu* is not mandatory. In casual speech, for instance, the adjective stands by itself, without any copula following it.

3. (a) Kono hon wa omosiroi desu.
 this book TOP funny copula
 This book is funny.

- (b) Urusai desu.
noisy copula
It is noisy.

3.3. Adverbs. Many Japanese adverbs are formed from adjectives by adding the suffix *ku* to the adjectival root, just as in English where adverbs are often formed by adding *ly* to adjectives. Table 4 presents some adverbs formed from adjectives.

Adjective	Adverb	Gloss
ooki.i	ooki.ku	'big'
aka.i	aka.ku	'red'
too.i	too.ku	'far'

TABLE 4. Adverbs formed from adjectives

There are also some adverbs, such as *totemo* 'very', *motto* 'more', and *tabun* 'probably', which are not derived from any adjective.

Adverbs can modify adjectives, verbs, other adverbs, and even whole sentences, as illustrated in (4).

4. (a) *totemo kanasii*
very sad
- (b) *takusan taberu*
many eat
to eat a lot
- (c) *totemo hayaku*
very fast
- (d) *Ainiku basu ni noriokureta.*
unfortunately bus DAT was late to board
Unfortunately, I missed the bus.

Note that the clause *basu ni noriokureta*, where the subject is missing, could mean 'I (you, she/he, we they) missed the bus'. However, to facilitate reading and translation, the missing subject of a Japanese clause will be interpreted as the first person singular pronoun.

3.4. Postpositions. Postpositions constitute an example of a category which is available in Japanese, but not in English. They are the Japanese counterpart of English prepositions. As the expression says, postpositions occur after nouns while prepositions are placed before nouns.

Postpositions must not stand independently. They always occur with nouns in order to form a meaningful unit.

5. (a) hakubutukan e
museum to
to the museum

(b) kodomo to
child with
with a child

(c) san-zi made
3 o'clock until
until 3 o'clock

3.5. Case particles. Some particles are used like case endings in Latin or German, others are genuine prepositions. Even in English, the prepositions *of* and *to* correspond to German genitive and dative endings, but *to* also refers to direction.

In Japanese, particles are equivalent to prepositions, conjunctions, and interjections of the English language. They follow a word to indicate its relationship to other words in a sentence, and/or give that word a particular meaning.

Particles are similar to postpositions in that they cannot stand by themselves and are always attached to a noun. Nevertheless, the difference between these two categories is considerable.

As opposed to postpositions which generally bear an inherent meaning, case particles do not manifest any specific semantic content. The role of case particles is rather determined within a sentence. That is, they indicate that the accompanying noun functions as subject, object, oblique object, etc.

Under casual speech circumstances, some case particles may be absent in a sentence, but postpositions must be present in order to retain their meaning.

Moreover, case particles and postpositions in Japanese are given distinct syntactic treatments. That is, a noun followed by a case particle is analyzed as a noun phrase while a noun accompanying a postposition is considered as a postpositional phrase.

Treatment of case particles constitute an essential part of a grammar for the Japanese language, where the word order is relatively flexible.

Consider, for instance, the three words *watasi* 'I', *osara* 'dish', and *arau* 'wash'. Keeping the same word order and changing the particles and postpositions, the meaning of the sentence is modified. The single word *watasi* serves as the basic stem for the singular first-person pronoun, possessive, and objective cases, which are constructed in the following ways:

I : *watasi wa/watasi ga*

my : *watasi no*

me : *watasi ni/ watasi o*

The precise function of the stem *watasi* can be identified only through the use of particles, as shown in (6).

6. (a) Watasi wa osara o arau.
I TOP dish ACC wash
I wash the dish.
- (b) Watasi wa osara mo arau.
I TOP dish too wash
I wash the dish, too.
- (c) Watasi o osara ga arau.
I ACC dish NOM wash
The dish washes me.
- (d) Watasi mo osara o arau.
I too dish ACC wash
I, too, wash the dish.
- (e) Watasi to osara ga arau.
I and dish NOM wash
The dish and I wash (something).
- (f) Watasi no osara o arau.
I GEN dish ACC wash
I wash my dish.
- (g) Watasi no osara ga arau.
I GEN dish NOM wash
My dish washes (something).

3.6. Adjectival nouns. Adjectival nouns, as the term indicates, have both characteristics of adjectives and of nouns. They resemble adjectives in that they can be modified by adverbs. Besides, preceding nouns, they modify them just as adjectives would do.

They differ from adjectives at the conjugation level. The conjugation pattern of adjectival nouns is identical to the one for nouns. Both categories share the same set of conjugational endings. The conjugation pattern of nouns, adjectival nouns, and adjectives is illustrated in table 5.

Tense	Nouns	Adjectival nouns	Adjectives
non perfective	hana desu	benri desu	aka-i
perfective	hana desita	benri desita	aka-katta
non perf. neg.	hana dewa nai	benri dewa nai	aka-kuna-i
perf. negative	hana dewa nakatta	benri dewa nakatta	aka-kuna-katta
potential	hana desyoo	benri desyoo	akai desyoo

TABLE 5. Conjugational endings of nouns, adjectival nouns, and adjectives

Adjectival nouns differ from nouns in that they cannot be accompanied by case particles. For instance, *benri ga* and *benri o* are both incorrect. Another difference from adjectival nouns and full-fledge nouns is that adjectival nouns cannot be modified by demonstrative words such as *kono* 'this' and *sono* 'that'.

3.7. Verbal nouns. Although the expression *verbal nouns* sounds contradictory, it properly defines the next category. Verbal nouns have both properties of nouns and of verbs. Since they can co-occur with demonstrative words such as *kono* 'this', and *sono* 'that', and since they can be marked with case particles, verbal nouns are like nouns.

7. (a) sono kenkyuu
that research

(b) kono kisu
this kiss

Verbal nouns are interpreted as verbs when they appear with the full-fledge verb *suru* meaning 'do'. When *suru* is merged to a verbal noun, its own meaning is barely retained. The main function of *suru* is then to carry the verbal conjugation.

8. (a) Daigaku de rekisi o benkyoo sita.
University LOC history ACC study did
I studied history at the University.

- (b) Tanaka sensei ga kenkyuu site iru.
Tanaka teacher NOM research doing is
Professor Tanaka is doing research.

When verbal nouns are accompanied by *suru*, they are either attached directly to it, or separated from it. In the latter case, the verbal noun will appear with the accusative case particle *o*.

A clause must not have more than one NP marked with the accusative case particle *o*. The sentence in (9c) is ungrammatical since it has two NPs marked with the particle *o*.

9. (a) Gakusei ga benkyoo suru.
student NOM study do
The student studies.
- (b) Gakusei ga benkyoo o suru.
student NOM study ACC do
The student studies.
- (c) *Gakusei ga rekisi o benkyoo o suru.
student NOM history ACC study ACC do
The student studies history.

CHAPTER 3

An algebraic approach to Japanese sentence structure

1. A hierarchy of types

The idea of a type grammar is to assign to every word one or more types and to ascertain the grammaticality of a given string of words by making a calculation on the corresponding string of types.

The free Abelian group generated by the three symbols L (length), M (mass), and T (time) provides such a type grammar for the language of classical mechanics. The well-foundedness of an equation $a = b$ between physical quantities can be verified by checking if the types a and b coincide.

Abelian groups do not work for natural languages, nor do groups. What we need is a slight generalization of the notion of a group, which leads us to the introduction of the notion of a *pregroup*, defined by Lambek [11].

DEFINITION. *A pregroup is an ordered monoid in which each element a has a left adjoint a^l such that $a^l a \rightarrow 1 \rightarrow a a^l$ and a right adjoint a^r such that $a a^r \rightarrow 1 \rightarrow a^r a$.*

Note that here, the arrow goes in the opposite direction from the way it did in chapter 1.

If we apply groups to syntax, a distinction would be required between the left inverse a^l and the right inverse a^r of a . But, every element of a group has a unique inverse; so if $a^l a = 1 = a a^r$, it follows that $a^l = a^l 1 = a^l a a^r = 1 a^r = a^r$. Therefore, the notion of *pregroup* is needed to get around this difficulty.

Consequences of the definition of *pregroup* are the following identities:

$$1^l = 1, \quad a^{rl} = a, \quad (ab)^l = b^l a^l, \quad aa^l a = a, \quad a^l a a^l = a^l;$$

$$1^r = 1, \quad a^{lr} = a, \quad (ab)^r = b^r a^r, \quad aa^r a = a, \quad a^r a a^r = a^r;$$

and the following implication:

$$\text{if } a \rightarrow b \text{ then } b^l \rightarrow a^l \text{ and } b^r \rightarrow a^r.$$

Nevertheless, it should be mentioned that in general

$$a^r \neq a^l, a^{ll} \neq a, a^{rr} \neq a.$$

For many purposes, the free pregroup generated by an ordered set of basic types suffices. It is presented here as a hierarchy of types.

To begin with, there are a number of basic types such as the following:

s_i : statement ($i = 1$ for non perfective tense; $i = 2$ for perfective tense);

s : statement when the tense is irrelevant;

$\bar{s}$: topicalized sentence.

The set A of basic types is *partially ordered* by the binary relation $\rightarrow$. That is, it satisfies the following axioms and rules of inference:

$$a \rightarrow a \quad \frac{a \rightarrow b \quad b \rightarrow c}{a \rightarrow c} \quad \frac{a \rightarrow b \quad b \rightarrow a}{a = b}$$

From the basic types, we construct *simple types*: if a is a simple type, then so are a^l and a^r .

Thus, if a is a basic type, then

$$\dots, a^{ll}, a^l, a, a^r, a^{rr}, \dots$$

are simple types.

Given an ordered set A , we may construct the free pregroup $F(A)$ generated by A . If we write

$$\dots, a^{(-2)}, a^{(-1)}, a^{(0)}, a^{(1)}, a^{(2)}, \dots$$

for

$$\cdots, a^l, a^l, a, a^r, a^{rr}, \cdots,$$

a typical element of $F(A)$ is of the form

$$\alpha = a_1^{(n_1)} a_2^{(n_2)} \cdots a_k^{(n_k)},$$

where the $a_i \in A$ and the $n_i \in \mathbb{Z}$. We put

$$\alpha^l = a_k^{(n_k-1)} \cdots a_2^{(n_2-1)} a_1^{(n_1-1)},$$

$$\alpha^r = a_k^{(n_k+1)} \cdots a_2^{(n_2+1)} a_1^{(n_1+1)},$$

and write $\alpha \rightarrow \beta$ if β is obtained from α by a sequence of steps:

$$\text{contractions} \quad \gamma a^{(n)} a^{(n+1)} \delta \rightarrow \gamma \delta,$$

$$\text{expansions} \quad \gamma \delta \rightarrow \gamma a^{(n+1)} a^{(n)} \delta,$$

$$\text{induced steps} \quad \gamma a^{(n)} \delta \rightarrow \gamma b^{(n)} \quad \text{if } a \rightarrow b \text{ and } n \text{ is even;} \\ \text{or } b \rightarrow a \text{ and } n \text{ is odd.}$$

The collection $F(A)$ of all compound types is partially ordered by the ordering inherited from A and by the following rules:

contractions: $a^l a \rightarrow 1, a^l a^l \rightarrow 1, a a^r \rightarrow 1$, etc;

expansions: $1 \rightarrow a a^l, 1 \rightarrow a^l a^l, 1 \rightarrow a^r a$, etc.

For the purpose of sentence verification, contractions suffice but mathematicians will also require the expansion rules which assure the uniqueness of the adjoints.

The order relation of $F(A)$ satisfies the substitution rule:

$$\text{if } \alpha \rightarrow \beta \text{ then } \gamma \alpha \delta \rightarrow \gamma \beta \delta.$$

$F(A)$ is our hierarchy of types. Unfortunately, since additional language specific rules are required, the pregroup loses its freeness.

We shall now assign compound types to Japanese words and other grammatical entities. To verify that a string of words, say, of type α , is a sentence, a statement of type s , we must verify that $\alpha \rightarrow s$.

2. Assigning types to verbs

To apply the above program to a small fragment of Japanese we take as the set of basic types

$$A = \{\pi, \bar{n}, n, s, \bar{s}, s_1, s_2, s_3, c_1, c_2, c_3, c_4, c_5, c_6, \dots\}.$$

where

- π = pronouns;
- $\bar{n}$ = proper names;
- n = nouns;
- s = statement when the tense is irrelevant;
- $\bar{s}$ = topicalized sentence;
- s_i = statements,
with $i = 1$ for the non perfective tense;
 $i = 2$ for the perfective tense;
- c_1 = nominative case;
- c_2 = genitive case;
- c_3 = dative case;
- c_4 = accusative case;
- c_5 = locative case;
- c_6 = ablative case;

The poset of basic types is partially ordered:

$$s_i \rightarrow s \rightarrow q;$$

$$\bar{s} \rightarrow s;$$

$$n_v \rightarrow n \rightarrow \bar{n} \rightarrow \pi;$$

$$a_v \rightarrow a;$$

$$a_v \rightarrow s_i;$$

$$a_n \rightarrow a.$$

I shall illustrate the assignment of types to Japanese words by considering a number of sample sentences.

The sentence *Naomi ga ringo o tabeta* 'Naomi ate an apple' has several variants, all meaning the same. In (1b), the word order is changed; in (1c), the object is missing; in (1d), the subject is missing; and in (1e), both the subject and the object are missing.

1. (a) *Naomi ga ringo o tabeta.*
Naomi NOM apple ACC ate
Naomi ate an apple.
- (b) *Ringo o Naomi ga tabeta.*
apple ACC Naomi NOM ate
Naomi ate an apple.
- (c) *Naomi ga tabeta.*
Naomi NOM ate.
Naomi ate (an apple).
- (d) *Ringo o tabeta.*
apple ACC ate
(Naomi) ate an apple.
- (e) *Tabeta.*
ate
(Naomi) ate (an apple).

The subject of an intransitive verb can also be omitted, as shown in (2).

2. (a) *Otoko ga koronda.*
boy NOM fell
The boy fell.
- (b) *Koronda.*
fell
(The boy) fell.

To depict the word order flexibility into our type grammar, we assign the type $(c_4^r, c_1^r)s_i$ to a transitive verb, and the type $(c_1^r)s_i$ to an intransitive verb.

What occurs between the parentheses is optional. Furthermore, the order of the elements in the parentheses can be random.

Some example of transitive verbs, intransitive verbs, and other forms of a verb are listed with their corresponding types in table 6.

Word	English translation	Type	Part of Speech
taberu	'to eat'	$(c_1^r, c_4^r, c_5^r)s_i$	transitive verb
kaku	'to write'	$(c_1^r, c_3^r, c_4^r, c_5^r)s_i$	transitive verb
matu	'to wait'	$(c_1^r, c_4^r, c_5^r)s_i$	transitive verb
kiku	'to listen'	$(c_1^r, c_4^r, c_6^r)s_i$	transitive verb
hanasu	'to speak'	$(c_1^r, c_3^r, c_5^r)s_i$	intransitive verb
tabe	'infinitive of eat'	$(c_1^r, c_4^r, c_5^r)i$	infinitive
suru	'to do'	$(n_v^r)(c_1^r, c_4^r, c_5^r)s_i$	transitive verb
tabete	'gerund of eat'	$(c_1^r, c_4^r, c_5^r)ss^l$	gerund
tabete	'gerund of eat'	$(c_1^r, c_4^r, c_5^r)g$	gerund
iru	'to exist'	$(g^r c_1^r)s_i$	intransitive verb
desu	'to be'	$\pi^r s_i$	copula
desu	'to be'	$a^r s_i$	copula

TABLE 6. Types of verbs

The verb *taberu*, for instance, can take up to three cases, namely the nominative case, the accusative case, and the locative case. These cases can appear in any order and they may even be left out. Thus, this makes several possibilities for the type of the verb *taberu*: $c_1^r c_4^r c_5^r s_i$, $c_4^r c_5^r c_1^r s_i$, $c_5^r c_1^r c_4^r s_i$, $c_1^r c_5^r c_4^r s_i$, $c_5^r c_4^r c_1^r s_i$, $c_4^r c_1^r c_5^r s_i$, $c_1^r c_4^r s_i$, $c_4^r c_1^r s_i$, $c_1^r c_5^r s_i$, $c_5^r c_1^r s_i$, $c_4^r c_5^r s_i$, $c_5^r c_4^r s_i$, $c_1^r s_i$, $c_4^r s_i$, $c_5^r s_i$, s_i .

2.1. Gerunds. In (3a), the gerund *waratte* 'laughing' directly precedes the verb *imasu* 'is'. Therefore, the type $g^r s_1$ is assigned to *imasu*, and $c_1^r g$ to the gerund.

The gerund *itte* in (3b) is used to connect the clause *koen ni itte* 'went to the park' to the clause *hon o yomimasita* 'read a book'. In this pattern, the gerund *itte* must be of type $c_3^r ss^l$.

3. (a) Kodomo ga waratte imasu.

$$\underbrace{n}_{\text{child}} \underbrace{(\pi^r c_1)}_{\text{NOM}} \underbrace{(c_1^r g)}_{\text{laughing}} \underbrace{(g^r s_1)}_{\text{is}} \rightarrow s_1$$

child NOM laughing is
The child is laughing.

- (b) Koen ni itte, hon o yomimasita.

$$\underbrace{n}_{\text{park}} \underbrace{(\pi^r c_3)}_{\text{to}} \underbrace{(c_3^r s s^l)}_{\text{went}} \underbrace{n}_{\text{book}} \underbrace{(\pi^r c_4)}_{\text{ACC}} \underbrace{(c_4^r s_1)}_{\text{read}} \rightarrow s$$

park to went book ACC read
I went to the park, and read a book.

3. Nouns

When a noun appears with the noun conjugation paradigm, as in (4), it is used as a predicate of a clause. Here, we used the partial order $n \rightarrow \pi$.

4. (a) Hana desu.

$$\underbrace{n}_{\text{flower}} \underbrace{(\pi^r s_1)}_{\text{copula}} \rightarrow s_1$$

flower copula
It is a flower.

- (b) Yuri desita.

$$\underbrace{n}_{\text{lily}} \underbrace{(\pi^r s_2)}_{\text{copula-PAST}} \rightarrow s_2$$

lily copula-PAST
It was a lily.

We need to make a distinction between nouns, proper names, and pronouns. For, nouns can occur whenever a proper name or a pronoun occurs, but the converse is false. In (5), we see that the noun *kodomo* ‘child’ and the proper name *Hiromi* can replace the pronoun *watasi*.

5. (a)
- Kodomo
- ga ringo o tabeta.

child NOM apple ACC ate
The child ate an apple.

- (b) Hiromi ga ringo o tabeta.
 Hiromi NOM apple ACC ate
 Hiromi ate an apple.
- (c) Watasi ga ringo o tabeta.
 I NOM apple ACC ate
 I ate an apple.

In (6), we observe that when a pronoun and a proper name replace a noun preceded by a demonstrative word, it yields an ungrammatical sentence.

6. (a) Kono gakusei wa ongaku ga suki desu.
 this student TOP music NOM like copula
 This student likes music.
- (b) *Kono Hiromi wa ongaku ga suki desu.
 this Hiromi TOP music NOM like copula
 Hiromi likes music.
- (c) *Kono anata wa ongaku ga suki desu.
 this you TOP music NOM like copula
 You like music.

Thus, nouns have type n ; proper names have type $\bar{n}$; and pronouns have type π . Further, we have the following ordering: $n \rightarrow \pi$ and $\bar{n} \rightarrow \pi$.

3.1. Time nouns. Time nouns such as *asita* 'tomorrow', *kinoo* 'yesterday', *kyoo* 'today', etc, may be used adverbially without any case particles following them. They have, in this case, type ss^l since they modify a whole sentence of type s . When used as a noun, that is with a case particle following them, they have type n .

In (7a), *asita* 'tomorrow' is used adverbially at the beginning of the sentence. Therefore, the type ss^l is assigned to it. In (7b), it is used as a noun but the noun phrase *asita no asa* 'tomorrow morning', is used adverbially. So

both *asita* ‘tomorrow’ and *asa* ‘morning’ have type n and the genitive case particle *no* is assigned the type $\pi^r ss^l n^l$. Besides, we use the partial orders $n \rightarrow \pi$ and $s_1 \rightarrow s$.

7. (a) *Asita Masao ga kimasu.*
 $(ss^l) \quad \bar{n} \quad (\pi^r c_1) \quad (c_1^r s_1) \rightarrow s$

tomorrow Masao NOM come
 Masao will come tomorrow.

- (b) *Asita no asa Masao ga kimasu.*
 $n \quad (\pi^r ss^l n^l) \quad n \quad \bar{n} \quad (\pi^r c_1) \quad (c_1^r s_1) \rightarrow s$

tomorrow GEN morning Masao NOM come
 Masao will come tomorrow morning.

If the time noun *kinoo* ‘yesterday’ is used adverbially as in (8a), or as a noun as in (8b), it will have type ss^l or n , respectively.

8. (a) *Kinoo asobimasita.*
 $(ss^l) \quad s_2 \rightarrow s$

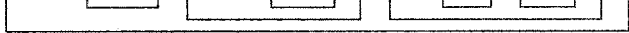
yesterday played
 I played yesterday.

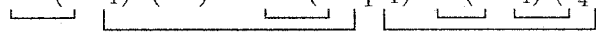
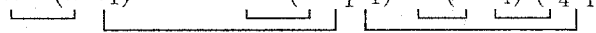
- (b) *Kinoo wa asobimasita.*
 $n \quad (\pi^r \bar{s} s^l) \quad s_2 \rightarrow \bar{s}$

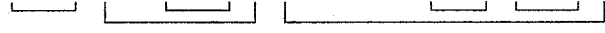
yesterday TOP played
 As for yesterday, I played.

Since the word order is flexible, *kinoo* in the sentence *Kinoo Naoko ga Mariko to osusi o tabemasita* ‘Naoko ate sushi with Mariko yesterday’ can appear in different positions, as shown below. This brings potential problems since whenever *kinoo* does not occur at the beginning of the sentence as in

(9b-c-d), the calculation fails. At least, it works for (9a), the sentence with the common word order.

9. (a) Kinoo Naoko ga Mariko to osusi o tabemasita.
 $(ss^l) \quad \bar{n} \quad (\pi^r c_1) \quad \bar{n} \quad (\pi^r c_1^r c_1) \quad n \quad (\pi^r c_4) \quad (c_4^r c_1^r s_2) \rightarrow s$

 yesterday Naoko NOM Mariko with sushi ACC ate
 Naoko ate sushi with Mariko yesterday.

- (b) Naoko ga kinoo Mariko to osusi o tabemasita.
 $\bar{n} \quad (\pi^r c_1) \quad (ss^l) \quad \bar{n} \quad (\pi^r c_1^r c_1) \quad n \quad (\pi^r c_4) \quad (c_4^r c_1^r s_2)$

 $\bar{n} \quad (\pi^r c_1) \quad \alpha \quad \bar{n} \quad (\pi^r c_1^r c_1) \quad n \quad (\pi^r c_4) \quad (c_4^r c_1^r s_2)$

 Naoko NOM yesterday Mariko with sushi ACC ate
 Naoko ate sushi with Mariko yesterday.

- (c) Naoko ga Mariko to kinoo osusi o tabemasita.
 $\bar{n} \quad (\pi^r c_1) \quad \bar{n} \quad (\pi^r c_1^r c_1) \quad (ss^l) \quad n \quad (\pi^r c_4) \quad (c_4^r c_1^r s_2)$

 $\bar{n} \quad (\pi^r c_1) \quad \bar{n} \quad (\pi^r c_1^r c_1) \quad \alpha \quad n \quad (\pi^r c_4) \quad (c_4^r \alpha^r c_1^r s_2) \rightarrow s_2$

 Naoko NOM Mariko with yesterday sushi ACC ate
 Naoko ate sushi with Mariko yesterday.

- (d) Naoko ga Mariko to osusi o kinoo tabemasita.
 $\bar{n} \quad (\pi^r c_1) \quad \bar{n} \quad (\pi^r c_1^r c_1) \quad n \quad (\pi^r c_4) \quad (ss^l) \quad (c_4^r c_1^r s_2)$

 $\bar{n} \quad (\pi^r c_1) \quad \bar{n} \quad (\pi^r c_1^r c_1) \quad n \quad (\pi^r c_4) \quad \alpha \quad (\alpha^r c_4^r c_1^r s_2) \rightarrow s_2$

 Naoko NOM Mariko with yesterday sushi ACC ate
 Naoko ate sushi with Mariko yesterday.

One can observe that if *kinoo* is assigned the type α (for adverb), sentences (9c) and (9d) are successfully parsed. Still, this assignment does not explain the grammaticality of (9b).

4. Verbal nouns

In the following examples, the verbal noun *benkyoo* ‘study’, being modified by *nihongo* ‘Japanese language’, is acting as a noun. Similarly, *ryokoo* ‘trip’, being modified by the adjective *tanosii* ‘pleasant’, is used as a noun.

We will assign the type n_v for verbal nouns. Furthermore, we introduce the partial order $n_v \rightarrow n$.

10. (a) Nihongo no benkyoo ga suki.

$$\underbrace{n \quad (\pi^r n n^l)}_{\text{Japanese GEN}} \quad \underbrace{n_v \quad (\pi^r c_1)}_{\text{study NOM}} \quad (c_1^r s_1) \rightarrow s_1$$

 Japanese GEN study NOM like
 (I) like to study Japanese.
- (b) Tanosii ryokoo desita.

$$\underbrace{(n n^l) \quad n_v}_{\text{pleasant trip}} \quad (n^r s_2) \rightarrow s_2$$

 pleasant trip copula
 It was a pleasant trip.

When a verbal noun occurs with the verb *suru*, there are two possibilities. The verbal noun may precede directly *suru* as in (11a), or it can be separated from the verb by the accusative case particle *o*, as in (11b). In the former case, *suru* has type $n_v^r c_1^r s_1$; and in the latter case, it has type $c_4^r c_1^r s_1$.

11. (a) Gakusei ga benkyoo suru.

$$\underbrace{n \quad (\pi^r c_1)}_{\text{student NOM}} \quad \underbrace{n_v \quad (n_v^r c_1^r s_1)}_{\text{study do}} \rightarrow s_1$$

 student NOM study do
 The student studies.
- (b) Gakusei ga benkyoo o suru.

$$\underbrace{n \quad (\pi^r c_1)}_{\text{student NOM}} \quad \underbrace{n_v \quad (\pi^r c_4) \quad (c_4^r c_1^r s_1)}_{\text{study ACC do}} \rightarrow s_1$$

 student NOM study ACC do
 The student studies.

Recall that a clause can only have one NP marked with the accusative case particle *o*. The sentence (12a) is valid since *rekisi* ‘history’ is the only NP marked with *o*. However, (12b) is ungrammatical since there are two occurrences of the particle *o*. The noun *rekisi* ‘history’ and the verbal noun *benkyoo* ‘study’ are both followed by *o*. The calculation on the corresponding string of types fails, which agrees with the ungrammaticality of the sentence.

12. (a) Gakusei ga rekisi o benkyoo suru.

$$\underbrace{n \ (\pi^r c_1)}_{\text{student}} \underbrace{n \ (\pi^r c_4)}_{\text{NOM}} \underbrace{n_v \ (n_v^r c_4^r c_1^r s_1)}_{\text{history ACC study do}} \rightarrow s_1$$

 student NOM history ACC study do
 The student studies history.

- (b) *Gakusei ga rekisi o benkyoo o suru.

$$\underbrace{n \ (\pi^r c_1)}_{\text{student}} \underbrace{n \ (\pi^r c_4)}_{\text{NOM}} \underbrace{n_v \ (\pi^r c_4^r)}_{\text{history ACC study}} \underbrace{(c_4^r c_1^r s_1)}_{\text{ACC do}} \rightarrow s_1$$

 student NOM history ACC study ACC do
 The student studies history.

Note that the double-*o* constraint applies only within a single clause. So even if a sentence contains more than one NP that is marked with *o*, the sentence would be acceptable if the NPs belonged to different clauses. For instance, consider the following sentence where *Noriko* and *otoko* ‘man’ are both followed by the particle *o*.

13. Mikio ga [Noriko o nagutta] otoko o semeta.

$$\underbrace{\bar{n} \ (\pi^r c_1)}_{\text{Mikio}} \underbrace{\bar{n} \ (\pi^r c_4)}_{\text{NOM}} \underbrace{(c_4^r n n^l)}_{\text{Noriko ACC hit-past}} \underbrace{n \ (\pi^r c_4)}_{\text{man}} \underbrace{(c_4^r c_1^r s_2)}_{\text{ACC blame-PAST}} \rightarrow s_2$$

 Mikio NOM Noriko ACC hit-past man ACC blame-PAST
 Mikio blamed the man who hit Noriko.

The type of the relative clause *Noriko o nagutta* will be explained in a subsequent section.

5. Adjectives

Noun phrases may also include adjectives as in *atatakai hi* 'warm day' and *tumetai mizu* 'cold water'. An adjective of type a will be of type nn^l when modifying a noun. We therefore need to introduce the rule $a \rightarrow nn^l$.

The reduction rule $a \rightarrow nn^l$ does not describe the order on the set of basic types, but rather defines a grammatical rule. Since the types no longer form an inductively defined hierarchy, our attempt to formulate the type grammar in terms of the free pregroup generated by an ordered set collapses.

14. (a) *atatakai hi*

$$\begin{array}{ccc} & (nn^l) & n \rightarrow n \\ & \underbrace{\quad} & \\ \text{warm} & & \text{day} \end{array}$$

- (b) *tumetai mizu*

$$\begin{array}{ccc} & (nn^l) & n \rightarrow n \\ & \underbrace{\quad} & \\ \text{cold} & & \text{water} \end{array}$$

Adjectives also occur as adjectival verbs, in which case the adjective takes an inflection and the verb is omitted. We will give a second type to adjectives appearing as the predicate.

So, the type $(c_1^r)a_v$ is assigned to adjectival verbs, and $a^r s_i$ is assigned to the copula. Furthermore, we postulate the partial orders $a_v \rightarrow a$ and $a_v \rightarrow s_i$. The latter is needed when the adjective stands by itself as an adjectival verb without any copula, as it is often the case in casual speech.

15. (a) *Siken wa muzukasikatta.*

$$\begin{array}{ccc} n & (\pi^r \bar{s} s^l) & a_v \\ n & (\pi^r \bar{s} s^l) & s_2 \rightarrow \bar{s} \\ \underbrace{\quad} & \underbrace{\quad} & \end{array}$$

exam TOP difficult-PAST
 The exam was difficult.

- (b) Umi no mizu ga atatakai desu.

$$\underbrace{n}_{\text{sea}} (\underbrace{\pi^r nn^l}_{\text{GEN}}) \underbrace{n}_{\text{water}} (\underbrace{\pi^r c_1}_{\text{NOM}}) (\underbrace{c_1^r a_v}_{\text{warm}}) (\underbrace{a^r s_1}_{\text{copula}}) \rightarrow s_1$$

 sea GEN water NOM warm copula
 The water of the sea is warm.

When the adjective appears in the connective form, as *hidokute* in (16), it is treated as a gerund. Therefore, the type $c_1^r ss^l$ is assigned to *hidokute*.

16. Ame ga hidokute uti ni imasu.

$$\underbrace{n}_{\text{rain}} (\underbrace{\pi^r c_1}_{\text{NOM}}) (\underbrace{c_1^r ss^l}_{\text{heavy-ing}}) \underbrace{n}_{\text{home}} (\underbrace{\pi^r c_3}_{\text{DAT}}) (\underbrace{c_3^r s_1}_{\text{is}}) \rightarrow s$$

 rain NOM heavy-ing home DAT is
 Since there is a heavy rain falling, I will stay home.

6. Adjectival nouns

To distinguish between adjectives and adjectival nouns, we will assign the type a_n to the latter category. When the adjectival noun modifies the following noun, na is added to it. Then, we must assign the type $a_n^r nn^l$ to na in order to get a noun phrase.

17. (a) kirei na onna

$$\underbrace{a_n}_{\text{pretty}} (\underbrace{a_n^r nn^l}_{\text{woman}}) \underbrace{n}_{\text{woman}} \rightarrow n$$

 pretty woman
- (b) sizuka na koen

$$\underbrace{a_n}_{\text{quiet}} (\underbrace{a_n^r nn^l}_{\text{park}}) \underbrace{n}_{\text{park}} \rightarrow n$$

 quiet park

The adjectival noun will be of type $(c_1^r)a_n$ when used as a predicate; in which case, it will be followed by the copula *desu*.

Since adjectival nouns cannot be modified by demonstrative words and cannot be accompanied by case particles, $a_n \nrightarrow n$.

18. (a) Kono kaban wa totemo benri desu.

$$\underbrace{(nn^l) \ n \ (\pi^r \bar{s}s^l)}_{\text{this bag TOP}} \underbrace{(aa^l) \ a_n \ (a^r s_1)}_{\text{very convenient copula}} \rightarrow \bar{s}$$

this bag TOP very convenient copula
 This bag is very convenient.

- (b) Sizuka desita.

$$\underbrace{a_n}_{\text{quiet}} (a^r s_1) \rightarrow s_1$$

quiet copula-PAST.
 It was quiet.

7. Adverbs

Since adverbs can modify adjectives, verbs, other adverbs, and sentences, they must have several distinct types.

First, consider the case where adverbs modify adjectives. In (19), for instance, the adverb *totemo* ‘very’ modifies the adjective *kanasii* ‘sad’. Thus *totemo* is assigned the type aa^l . Moreover, we use the grammatical rule $a \rightarrow nn^l$.

19. Totemo kanasii eiga o mita.

$$\underbrace{(aa^l) \ a}_{\text{very sad}} \ n \ (\pi^r c_4) \ (\underbrace{c_4^r s_2}_{\text{movie ACC}})$$

$$\underbrace{(nn^l) \ \quad \quad \quad n \ (\pi^r c_4)}_{\text{I saw a very sad}} (\underbrace{c_4^r s_2}_{\text{movie}}) \rightarrow s_2$$

very sad movie ACC saw
 I saw a very sad movie.

Next, we analyze the cases where adverbs modify verbs, other adverbs, and whole sentences. In (20a), the adverb *takusan* ‘many’ modifies the verb *taberu* ‘eat’. We must give the adverb *takusan* the type α ; the verb *taberu*, in this case, will be of type $\alpha^r c_4^r s_1$.

In (20b), the adverb *hayaku* ‘fast’, being modified by the adverb *totemo* ‘very’, modifies the verb *hasiru* ‘run’. It follows that *totemo* is assigned type α , *hayaku* the type $\alpha^r\alpha$, and *hasiru* the type $\alpha^r s_1$. Since adverbs can optionally be modified by other adverbs, we will assign the general type $(\alpha^r)\alpha$ to them.

Adverbs may also modify phrases and sentences, as in (20c). In this case, adverbs will be assigned the type ss^l .

20. (a) Kudamono o takusan taberu.

$$\underbrace{n}_{\text{fruit}} \underbrace{(\pi^r c_4)}_{\text{ACC}} \underbrace{\alpha}_{\text{many}} \underbrace{(\alpha^r c_4^r s_1)}_{\text{eat}} \rightarrow s_1$$

fruit ACC many eat

I eat plenty of fruits. (literally: I eat fruits, a lot.)

- (b) Makoto wa totemo hayaku hasiru.

$$\underbrace{\bar{n}}_{\text{Makoto}} \underbrace{(\pi^r \bar{s} s^l)}_{\text{TOP}} \underbrace{\alpha}_{\text{very}} \underbrace{(\alpha^r \alpha)}_{\text{fast}} \underbrace{(\alpha^r s_1)}_{\text{run}} \rightarrow \bar{s}$$

Makoto TOP very fast run

Makoto runs very fast.

- (c) Ainiku basu ni noriokureta.

$$\underbrace{(ss^l)}_{\text{unfortunately}} \underbrace{n}_{\text{bus}} \underbrace{(\pi^r c_3)}_{\text{DAT}} \underbrace{(c_3^r s_2)}_{\text{miss}} \rightarrow s$$

unfortunately bus DAT missed

Unfortunately, I missed the bus.

8. Type grammar meets case particles

So far, several particles were introduced, but we did not provide a detailed investigation under the type grammar theory. In this section, I will treat each particle separately and will explain their functions and their types. Case particles with their types are listed in table 7.

8.1. Topic marker *wa*. First, we start by analyzing the topic marker *wa*. The particle *wa* signals the topic of the sentence which generally occurs

Case	Particle	Type
Nominative	ga	$\pi^r c_1$
Genitive	no	$\pi^r c_2$
Dative	ni	$\pi^r c_3$
Dative	ni	$i^r c_3$
Accusative	o	$\pi^r c_4$
Locative	de	$\bar{n}^r c_5$
Instrumental	de	$n^r c_5$
Ablative	kara	$\pi^r c_6$
Topic marker	wa	$\pi^r \bar{s} s^l$

TABLE 7. Case particles and their types

at the beginning of the sentence. The topic, interpreted as being preliminary to the sentence, can be a word, a group of words, or even a whole clause.

Often, it happens that the topic in the Japanese sentence is actually the subject of the verb but it is not always the case.

Watasi wa transforms (21a), or any other sentence, into a topicalized sentence. Hence, *watasi wa* will have type $\bar{s} s^l$, where $\bar{s}$ stands for a topicalized sentence. Since *watasi* has type π , *wa* will be of type $\pi^r \bar{s} s^l$.

21. (a) Eigo ga hanasemasu.

$$\underbrace{n}_{\text{I}} \underbrace{(\pi^r c_1)}_{\text{English}} (c_1^r s_1) \rightarrow s_1$$

English NOM speak
 I can speak English.

- (b) Watasi wa eigo ga hanasemasu.

$$\underbrace{\pi}_{\text{I}} \underbrace{(\pi^r \bar{s} s^l)}_{\text{TOP English}} \underbrace{n}_{\text{I}} \underbrace{(\pi^r c_1)}_{\text{English}} (c_1^r s_1) \rightarrow \bar{s}$$

I TOP English NOM speak
 I can speak English.

The following are examples of sentences in which the topic is a clause.

22. (a) Mikiko ga kureta hon wa omosirokatta desu.

$$\bar{n} \quad (\pi^r c_1) \quad (c_1^n n n^l) \quad n \quad (\pi^r \bar{s} s^l) \quad a \quad (a^r s_1) \rightarrow \bar{s}$$

Mikiko NOM gave book TOP funny-PAST is
The book that Mikiko gave me was funny.

- (b) Yuki ga aru toki wa kuruma ga toorimasen.

$$n \quad (\pi^r c_1) \quad (c_1^n n n^l) \quad n \quad (\pi^r \bar{s} s^l) \quad n \quad (\pi^r c_1) \quad (c_1^n s_1) \rightarrow \bar{s}$$

snow NOM is time TOP car NOM pass-NEG.
When there is snow, the car does not pass by.

There are cases where the particle *wa* does not make a word the topic of the sentence, but serves other purposes. It is used to contrast the word it follows with other words not overtly expressed, or to emphasize the word it follows.

(23a) is an example of *wa* contrasting. In (23b), *wa* emphasizes the noun *uta* 'song'. Although we could introduce new types for the different functions of *wa*, it is more natural, and much simpler, to keep the same type $\pi^r \bar{s} s^l$.

23. (a) Sore wa zenbu wa irimasen.

$$\pi \quad (\pi^r \bar{s} s^l) \quad n \quad (\pi^r \bar{s} s^l) \quad s_1 \rightarrow \bar{s}$$

this TOP all TOP need-NEG.
I do not need all of this.

- (b) Hiromi wa uta wa utaimasu. (piano o hikanai)

$$\bar{n} \quad (\pi^r \bar{s} s^l) \quad n \quad (\pi^r \bar{s} s^l) \quad s_1 \rightarrow \bar{s}$$

Hiromi TOP song TOP sing piano ACC play-NEG.
Hiromi does sing songs (but does not play piano).

8.2. Particle *ga*. Next, we analyze the nominative case particle *ga*. The main function of *ga* is to emphasize the subject by following it directly.

In (24), *ga* is used in sentences that indicate the existence of something. Since a noun, a proper name, and a pronoun can occur before the particle *ga*, we assign to it the type $\pi^r c_1$, and we make use of the partial order $n \rightarrow \bar{n} \rightarrow \pi$.

24. (a) Hito *ga* iru.

$$\underbrace{n}_{\text{person}} \underbrace{(\pi^r c_1)(c_1^r s_1)}_{\text{NOM is}} \rightarrow s_1$$

 person NOM is
 There is a person.

- (b) Hon *ga* aru.

$$\underbrace{n}_{\text{book}} \underbrace{(\pi^r c_1)(c_1^r s_1)}_{\text{NOM is}} \rightarrow s_1$$

 book NOM is
 There is a book.

Generally, there is only one NP marked with the nominative case particle *ga* in a sentence. However, to emphasize the subject, certain verbs may take a second nominative case particle.

For instance, consider the following sentences. To the question *Dare ga ongaku ga suki desu ka?* ‘who likes music?’, a possible answer would be *Noriko ga ongaku ga suki desu* ‘Noriko likes music (while Takeshi does not)’. Normally, though, we would say *Noriko wa ongaku ga suki desu*.

25. (a) Dare *ga* ongaku *ga* suki desu ka?

$$\underbrace{\pi}_{\text{who}} \underbrace{(\pi^r c_1)}_{\text{NOM}} \underbrace{n}_{\text{music}} \underbrace{(\pi^r c_1)}_{\text{NOM}} \underbrace{(c_1^r c_1^r s_1)}_{\text{like cop.}} \underbrace{(s^l q)}_{\text{Q}} \rightarrow q$$

 who NOM music NOM like cop. Q
 Who likes music?

- (b) Noriko *ga* ongaku *ga* suki desu.

$$\underbrace{\bar{n}}_{\text{Noriko}} \underbrace{(\pi^r c_1)}_{\text{NOM}} \underbrace{n}_{\text{music}} \underbrace{(\pi^r c_1)}_{\text{NOM}} \underbrace{(c_1^r c_1^r s_1)}_{\text{like cop.}} \rightarrow s_1$$

 Noriko NOM music NOM like cop.
 Noriko is the one who likes music.

- (c) Noriko wa ongaku ga suki desu.

$$\bar{n} \quad (\pi^r \bar{s} s^l) \quad n \quad (\pi^r c_1) \quad (c_1^r s_1) \rightarrow \bar{s}$$

 Noriko TOP music NOM like cop.
 Noriko likes music.

8.3. Particle *o*. The particle *o* always follows a noun or a nominal which is the direct object of a transitive verb. In (26a), *hon* ‘book’ is the direct object of the verb *katta* ‘bought’, so the particle *o* follows *hon*. In (26b), the particle *o* is preceded by *eiga* ‘movie’ which is the direct object of the verb *mita* ‘saw’.

26. (a) Hon o katta.

$$n \quad (\pi^r c_4) \quad (c_4^r s_2) \rightarrow s_2$$

 book-ACC bought
 I bought a book.
- (b) Eiga o mita.

$$n \quad (\pi^r c_4) \quad (c_4^r s_2) \rightarrow s_2$$

 movie-ACC saw
 I saw a movie.

Some transitive verbs in English take the nominative case particle *ga* instead of the accusative case particle *o* in Japanese. Here are some examples of such verbs: *hosii* (*desu*) ‘to want’, *iru* ‘to need’, *kikoeru* ‘to be able to hear’, *kirai* (*desu*) ‘to dislike’, *mieru* ‘to be able to see’, *suki* (*desu*) ‘to like’, and *wakaru* ‘to understand’.

The following sentences illustrate this phenomenon with the verbs *suki desu* and *miemasu*.

27. (a) Naoko wa osusi ga suki desu.

$$\bar{n} \quad (\pi^r \bar{s} s^l) \quad n \quad (\pi^r c_1) \quad (c_1^r s_1) \rightarrow s_1$$

Naoko TOP sushi NOM like copula
Naoko likes sushi.

- (b) yama ga miemasu.

$$n \quad (\pi^r c_1) \quad (c_1^r s_1) \rightarrow s_1$$

mountain NOM see-POTENTIAL
I can see the mountain. (literally: The mountain is visible.)

8.4. Particle *no*. The genitive case particle *no* transforms a noun into a possessive. It basically functions like the 's in English.

We initially assign the type $\pi^r c_2$ to the particle *no*. The combination of the noun *otoosan* 'father' and the noun *hon* 'book' with *no* results in a noun phrase. Therefore, we must introduce the rule $c_2 \rightarrow nn^l$.

28. (a) otoosan no hon

$$\begin{array}{c} n \quad (\pi^r c_2) \quad n \\ \hline n \quad (\pi^r nn^l) \quad n \end{array}$$

father GEN book
father's book

- (b) tukue no ue

$$n \quad (\pi^r nn^l) \quad n \rightarrow n$$

desk GEN top
top of the desk

The particle *no* can appear more than once in a noun phrase, as in the exaggerated phrase (29) where six *no* are used to indicate the relationship of a person.

29. Osaka no ani no musume no gakko no sensei no sue no kodomo
 Osaka GEN older brother GEN daughter GEN school GEN teacher GEN youngest GEN child
 'My older brother's, leaving in Osaka, daughter's school's teacher's youngest child'

No accompanies some names of colours in order to transform them into adjectives. In (30a), the noun *midori* 'green' modifies *kuruma* 'car'; in (30b), the noun *murasaki* 'purple' modifies *kami* 'paper'.

30. (a) midori no kuruma

$$\underbrace{n}_{\text{green}} \quad (\pi^r n n^l) \quad \underbrace{n}_{\text{car}} \rightarrow n$$

 green GEN car
 green car
- (b) murasaki no kami

$$\underbrace{n}_{\text{purple}} \quad (\pi^r n n^l) \quad \underbrace{n}_{\text{paper}} \rightarrow n$$

 purple GEN paper
 purple paper

The genitive particle *no* serves other reasons when placed after a noun, an adjective or a verb. It functions as an indefinite pronoun and is assigned type $\pi^r n$. Thus, we must modify our previous rule to make the n^l optional. Hence, $c_2 \rightarrow n(n^l)$.

Moreover, we need to introduce new types for the particle *no* in order to parse correctly sentences (31b) and (31c). In the former, *no* is preceded by an adjective; in the latter, it is preceded by a verb. Therefore, *no* must take the following types: $\pi^r c_2$, $a^r c_2$, and $s^r c_2$, with $c_2 \rightarrow n(n^l)$.

31. (a) Watasi no wa, tabemasita.

$$\pi \underbrace{(\pi^r n)} \underbrace{(\pi^r \bar{s} s^l)} s_2 \rightarrow \bar{s}$$

I GEN TOP ate
I ate mine.

- (b) nekutai wa takai no o kaimasita.

$$\underbrace{n} \underbrace{(\pi^r \bar{s} s^l)} a \underbrace{(a^r n)} \underbrace{(\pi^r c_4)} \underbrace{(c_4^r s_2)} \rightarrow \bar{s}$$

neck-tie TOP expensive GEN ACC bought
As for neck-tie, I bought an expensive one.

- (c) Waratte iru no wa Masao desu.

$$\underbrace{ss^l} s_1 \underbrace{(s^r n)} \underbrace{(\pi^r \bar{s} s^l)} n \underbrace{(n^r s_1)} \rightarrow s$$

laughing is GEN TOP Masao is
Masao is the one who is laughing.

8.5. Particle *ni*. The dative case particle *ni* is mainly associated with verbs of giving, and together with a noun, it implies the recipient.

A place noun followed by the particle *ni* denotes the existence of people or things in a certain place, and usually precedes a verbal expression of existence, living, staying, etc. It can also indicate direction, movement, or action, in which case, the particle *ni* is interchangeable with the postposition *e*.

Here is a list of verbs that often follow *ni*: *aru* 'to be present, to exist' for inanimate objects, *iru* 'to be present, to exists' for animate things, *nokoru* 'to remain, to stay behind', *sumu* 'to live', *tomaru* 'to stay over'.

32. (a) Hiroko ni tegami o kaita.

$$\bar{n} \underbrace{(\pi^r c_3)} n \underbrace{(\pi^r c_4)} \underbrace{(c_4^r c_3^r s_2)} \rightarrow s_2$$

Hiroko DAT letter ACC wrote
I wrote a letter to Hiroko.

$$(b) \text{ Masao wa sensei ni natta.}$$

$$\bar{n} \quad (\pi^r \bar{s} s^l) \quad n \quad (\pi^r c_3) \quad (c_3^r s_2) \rightarrow \bar{s}$$

Masao TOP teacher DAT became
Masao became a teacher.

$$(c) \text{ Tukue no ue ni hon ga arimasu.}$$

$$n \quad (\pi^r n n^l) \quad n \quad (\pi^r c_3) \quad n \quad (\pi^r c_1) \quad (c_1^r c_3^r s_1) \rightarrow s_1$$

desk GEN top DAT book NOM is
There is a book on the desk.

The dative case particle *ni* can also occur after a verb. In this case, it indicates the purpose of an action. It is used most frequently before the verb *iku* 'to go', *kuru* 'to come' and other related verbs such as *mukau* 'to head for' and *kaeru* 'to return'.

The verb which precedes *ni* appears in its infinitive form. The particle *no*, then, takes the type $i^r c_3$.

$$33. (a) \text{ Osusi o tabe ni ikimasu.}$$

$$n \quad (\pi^r c_4) \quad (c_4^r i) \quad (i^r c_3) \quad c_3^r s_1 \rightarrow s_1$$

sushi ACC eat-INF DAT go.
I go to eat sushi.

$$(b) \text{ Tomodati o mukae ni iku.}$$

$$n \quad (\pi^r c_4) \quad (c_4^r i) \quad (i^r c_3) \quad (c_3^r s_1) \rightarrow s_1$$

friend ACC pick up DAT go
I am going to pick up my friend.

In passive sentences, *ni* follows the agent and is equivalent to the English preposition *by*. I will provide further explanations on passive constructions in the passive sentences section.

34. (a) boku wa sikarareta.

$$\pi \underbrace{(\pi^r \bar{s} s^l)}_{\text{I TOP}} s_2 \rightarrow \bar{s}$$

I TOP scolded
I was scolded.

- (b) boku wa chichi ni sikarareta.

$$\pi \underbrace{(\pi^r \bar{s} s^l)}_{\text{I TOP}} n \underbrace{(\pi^r c_3) (c_3^r s_2)}_{\text{father DAT}} \rightarrow \bar{s}$$

I TOP father DAT scolded
I was scolded by my father.

8.6. Particle *de*. The particle *de* serves both the locative and the instrumental cases. Placed after a noun of location, it indicates where an action takes or took place. It is static, as opposed to *ni* and *e* which show the direction of the action.

Normally, the locative case particle *de* is preceded by a noun, as in (35a), or by a proper name, as in (35b). To prevent the particle *de* from following pronouns, we must assign the type $\bar{n}^r c_5$ to it.

35. (a) Gakko de denwa o kakeru.

$$\bar{n} \underbrace{(\bar{n}^r c_5)}_{\text{school LOC}} n \underbrace{(\pi^r c_4^r) (c_4^r c_5^r s_1)}_{\text{telephone ACC call}} \rightarrow s_1$$

school LOC telephone ACC call
I make a call at school.

- (b) Tokyo de aimasita.

$$\bar{n} \underbrace{(\bar{n}^r c_5)}_{\text{Tokyo LOC}} (c_5^r s_2)$$

Tokyo LOC met
We met in Tokyo.

Examples of *de* used as an instrumental case particle are illustrated in (36), where it indicates the method or the tool that is/was employed for an action.

Here, the type $n^r c_5$ is assigned to the instrumental case particle *de* since, usually, only nouns can be followed by it.

36. (a) Gakko e zityensya de iku.

$$\underbrace{n}_{\text{school-to}} \underbrace{(\pi^r s s^l)}_{\text{bicycle}} \underbrace{n}_{\text{INS}} \underbrace{(n^r c_5)}_{\text{go}} (c_5 s_1) \rightarrow s$$

 I go to school by bicycle.

- (b) Empitu de kakimasu.

$$\underbrace{n}_{\text{pencil}} \underbrace{(n^r c_5)}_{\text{INS}} (c_5 s_1) \rightarrow s_1$$

 I will write with a pencil.

8.7. Particle *kara*. The last particle that we will study is the ablative case particle *kara*. When *kara* is placed after a noun or a name, as in (37), it usually means ‘from’.

37. Sono hanasi o Mikiko kara kikimasita.

$$\underbrace{(nn^l)}_{\text{that}} \underbrace{n}_{\text{story}} \underbrace{(\pi^r c_4)}_{\text{ACC}} \underbrace{\pi}_{\text{Mikiko}} \underbrace{(\pi^r c_6)}_{\text{ABL}} \underbrace{(c_6^r c_4^r s_2)}_{\text{heard}} \rightarrow s_2$$

 I heard that story from Mikiko

When it is placed after an adjective, a verb or a copula, *kara* usually indicates reason or cause. In this context, *kara* has type $s^r c_6$.

Recall the partial order $a_v \rightarrow s$ that we introduced for adjectival verbs. In (38a), the particle *kara* is preceded by the adjectival verb *yasukatta* ‘cheap-past’. Thus, by making use of the above rule, one can verify the grammaticality of the sentence by calculating the corresponding types.

In (38b), *kara* follows the copula *da*. It is easy to verify that the assignment of $s^r c_6$ leads to a valid sentence.

38. (a) Kudamono ga yasukatta kara takusan kaimasita.

$$\begin{array}{ccccccc}
 n & (\pi^r c_1) & a_v & (s^r c_6) & \alpha & (\alpha^r c_6^r c_1^r s_2) \\
 \underbrace{\hspace{1.5cm}} & & & & & \underbrace{\hspace{1.5cm}} \\
 n & (\pi^r c_1) & s & (s^r c_6) & \alpha & (\alpha^r c_6^r c_1^r s_2) \rightarrow s_2 \\
 \underbrace{\hspace{1.5cm}} & & & & & \underbrace{\hspace{1.5cm}}
 \end{array}$$

fruits NOM inexpensive since many bought
 Since the fruits were inexpensive, I bought lots of them.

- (b) Kyoo wa ii otenki da kara, soto de asobimasu.

$$\begin{array}{ccccccc}
 n & (\pi^r \bar{s} s^l) & (nn^l) & n & (n^r s_1) & (s^r c_6) & n & (\bar{n}^r c_5) & (c_5^r c_6^r s_1) \rightarrow \bar{s} \\
 \underbrace{\hspace{1.5cm}} & & \underbrace{\hspace{1.5cm}} & & \underbrace{\hspace{1.5cm}} & & \underbrace{\hspace{1.5cm}} & & \underbrace{\hspace{1.5cm}} \\
 & & & & & & & &
 \end{array}$$

today TOP good weather COP since outside LOC play
 Since the weather is nice today, I will play outside.

9. Postpositions

In this section, we will study several postpositions and assign them syntactic types.

9.1. Postposition *e*. Placed after a noun, the postposition *e* indicates that the noun is the destination, direction or the goal of the action. It is interchangeable with the particle *ni* in most cases.

In (39a) *e* follows the pronoun *anata* ‘you’ and shows the goal of the action whereas in (39b), it follows the noun *gakko* ‘school’ and shows direction. Since *e* can be preceded either by a pronoun, a proper name, and a noun, it will have type $\pi^r ss^l$.

39. (a) Watasi wa anata e purezento o katta.

$$\begin{array}{ccccccc}
 \pi & (\pi^r \bar{s} s^l) & n & (\pi^r ss^l) & n & (\pi^r c_4) & (c_4^r s_2) \rightarrow \bar{s} \\
 \underbrace{\hspace{1.5cm}} & & \underbrace{\hspace{1.5cm}} & & \underbrace{\hspace{1.5cm}} & & \underbrace{\hspace{1.5cm}}
 \end{array}$$

I TOP you to present ACC bought
 I bought you a present.

(b) Gakko e tukimasita.

$$\underbrace{n}_{\text{school}} \underbrace{(\pi^r ss^l)}_{\text{at}} s_2 \rightarrow s$$

school at arrived
I arrived at school.

The following example shows that *e* can be used in combination with the genitive particle *no*. In this case, *e* cannot be replaced by the particle *ni*.

40. Kore wa Masako e no purezento desu.

$$\underbrace{\pi}_{\text{This one TOP}} \underbrace{(\pi^r \bar{s}s^l)}_{\text{Masako for GEN}} \underbrace{\bar{n}}_{\text{present}} \underbrace{(\pi^r nn^l)}_{\text{is}} \underbrace{n}_{\text{This is a present}} \underbrace{(n^r s_2)}_{\text{for Masako}} \rightarrow \bar{s}$$

This one TOP Masako for GEN present is
This is a present for Masako.

9.2. Postposition *made*. The postposition *made* establishes a temporal or spatial limit. In (41a), it follows the name *Aomori* and indicates a spatial limit; in (41b), it follows *go zi* '5 o'clock' and therefore shows a temporal limit.

We assign the type $\bar{n}ss^l$ to *made* since, usually, it does not follow a pronoun.

41. (a) Kono densya wa Aomori made ikimasu.

$$\underbrace{(nn^l)}_{\text{This train TOP}} \underbrace{n}_{\text{Aomori to}} \underbrace{(\pi^r \bar{s}s^l)}_{\text{go}} \underbrace{\bar{n}}_{\text{This train will go to Aomori}} \underbrace{(\bar{n}^r ss^l)}_{\text{go}} s_1 \rightarrow \bar{s}$$

This train TOP Aomori to go
This train will go to Aomori.

(b) Watasi wa go zi made sigoto o simasu.

$$\underbrace{\pi}_{\text{I TOP}} \underbrace{(\pi^r \bar{s}s^l)}_{\text{five hour until}} \underbrace{n}_{\text{work ACC}} \underbrace{(\bar{n}^r ss^l)}_{\text{do}} \underbrace{n}_{\text{I work until 5 o'clock}} \underbrace{(n^r c_4)}_{\text{do}} \underbrace{(c_4^r s_1)}_{\text{do}} \rightarrow \bar{s}$$

I TOP five hour until work ACC do
I work until 5 o'clock.

The postposition *made* can be combined with the particle *no*, as shown below. In order to maintain our grammar as simple as possible, we will treat the combination *made no* as a unit, and assign to it the type $\bar{n}^r nn^l$.

42. Kyoto
- made no
- kippu o katta.

$$\underbrace{\bar{n}} \quad \underbrace{(\bar{n}^r n n^l)} \quad \underbrace{n} \quad \underbrace{(\pi^r c_4)} \quad \underbrace{(c_4^r s_2)} \rightarrow s_2$$

Kyoto to GEN ticket ACC bought
I bought a ticket to Kyoto.

9.3. Postposition *mo*. The usual meaning of *mo* is ‘too’, ‘also’. Normally, *mo* does not appear after the particles *wa* and *ga*, or before the particle *o*, since it replaces these particles.

In (43b), *mo* replaces *wa* to means ‘too’. In this context, the type of *wa*, $\pi^r \bar{s} s^l$, is naturally assigned to the postposition *mo*.

43. (a) Kore wa yuri desu.

$$\underbrace{\pi} \quad \underbrace{(\pi^r \bar{s} s^l)} \quad \underbrace{n} \quad \underbrace{(\pi^r s_1)} \rightarrow \bar{s}$$

this one TOP lily is
This is a lily.

- (b) Kore mo yuri desu.

$$\underbrace{\pi} \quad \underbrace{(\pi^r \bar{s} s^l)} \quad \underbrace{n} \quad \underbrace{(\pi^r s_1)} \rightarrow \bar{s}$$

this one too lily is
This is a lily, too.

The sentences in (44) show that *mo* can replace the particles *ga* and *o*. Thence, we give *mo* the types corresponding to *ga* or *o*.

44. (a) Masao ga ringo o tabeta.

$$\underbrace{\bar{n}} \quad \underbrace{(\pi^r c_1)} \quad \underbrace{n} \quad \underbrace{(\pi^r c_4)} \quad \underbrace{(c_4^r c_1^r s_2)} \rightarrow s_2$$

Masao NOM apple ACC ate
Masao ate an apple.

(b) Masao ga budoo mo tabeta.

$$\bar{n} \quad (\pi^r c_1) \quad n \quad (\pi^r c_4) \quad (c_4^r c_1^r s_2) \rightarrow s_2$$

Masao NOM grapes too ate
Masao ate grapes, too.

(c) Naomi mo ringo o tabeta.

$$\bar{n} \quad (\pi^r c_1) \quad n \quad (\pi^r c_4) \quad (c_4^r c_1^r s_2) \rightarrow s_2$$

Naomi too apple ACC ate
Naomi too ate an apple.

The pattern in which *mo* follows interrogative words serves to emphasize the presence or lack of something. For example, *dare* 'who' followed by *mo* means either 'anybody' or 'everybody', depending if the verb is negative or not. Note that Japanese expresses the negative idea in the verb.

Particles are normally omitted when *mo* is used with interrogative words. However, when *dare mo* is the subject of a sentence, the nominative case particle *ga* is explicitly stated. This is the only case in which a particle follows *mo*.

In (45a), *dare mo* is the subject of the sentence, and hence it is followed by the particle *ga*. Since *ga* has type $\pi^r c_1$, *dare mo* must have type π . We therefore assign the type $\pi^r \pi$ to *mo* and the calculation of the string of types results in a grammatical sentence.

In (45b), *mo* follows *dore* 'which' to means 'every one'. Here, since the copula has type $a^r s_1$, the type $\pi^r \pi$ for *mo* will not work. Thus, we assign the new type $\pi^r s s^l$ to *mo*.

45. (a) Dare mo ga waratte imasu.

$$\pi \quad (\pi^r \pi) \quad (\pi^r c_1) \quad (c_1^r g) \quad (g^r s_1) \rightarrow s_1$$

everybody NOM laughing is
Everybody is laughing.

- (b) Dore mo benri desu.
 $\pi \underbrace{(\pi^r ss^l)} \underbrace{a_n \underbrace{(a^r s_1)}} \rightarrow s$
 every one useful is
 Every one is useful.

The postposition *mo* is equivalent to the English 'even' when it follows a gerund. The function of *mo* is then to emphasize the gerund.

The gerund *koronde* 'fell' can stand by itself, as in (46a), or can appear with the postposition *mo*, as in (46b). The type of *koronde* varies according to the context. Here, *mo* is given the new type $g^r ss^l$.

46. (a) Koronde kega o sinakatta.
 $\underbrace{(ss^l)} \underbrace{n \underbrace{(\pi^r c_4)} \underbrace{(c_4^r s_2)}} \rightarrow s_2$
 fell hurt ACC did-NEG
 I did not hurt myself even if I fell.
- (b) Koronde mo kega o sinakatta.
 $\underbrace{g \underbrace{(g^r ss^l)}} \underbrace{n \underbrace{(\pi^r c_4)} \underbrace{(c_4^r s_2)}} \rightarrow s_2$
 fell even hurt ACC did-NEG
 I did not hurt myself even if I fell.

9.4. Postposition *to*. The most basic function of *to* is to list nouns and noun phrases. In (47), the postposition *to*, listing the nouns *ringo* 'apple' and *budoo* 'grapes', has the meaning 'and'. In (47a), the noun clause is the subject, while in (47b), it is the object. In either case, the postposition *to* is assigned the type $\pi^r \pi \pi^l$.

47. (a) Ringo to budoo ga teeburu no ue ni aru.
 $\underbrace{n \underbrace{(\pi^r \pi \pi^l)} n \underbrace{(\pi^r c_1)} n \underbrace{(\pi^r n n^l)} n \underbrace{(\pi^r c_3)} \underbrace{(c_3^r c_1^r s_1)}} \rightarrow s_1$
 apples and grapes NOM table GEN TOP DAT are
 There are apples and grapes on the table.

(b) Ringo to budoo o tabemasita.

$$\underbrace{n}_{\text{apple}} \underbrace{(\pi^r \pi \pi^l)}_{\text{and grapes ACC}} \underbrace{n}_{\text{ate}} \underbrace{(\pi^r c_4)}_{\text{ate}} \underbrace{(c_4^r s_1)}_{\text{ate}} \rightarrow s_1$$

apple and grapes ACC ate
I ate apple(s) and grapes.

In (48), the postposition *to* bears a different meaning. In (48a), *Mariko to* follows the noun phrase *Hanako ga* which is the subject of the sentence. In this context, *to* means ‘with’.

Since the postpositional phrase *Mariko to* enlarges the subject *Hanako ga*, we assign the type $\pi^r c_1^r c_1$ to *to*.

48. (a) Hanako ga Mariko to okaimono o sita.

$$\underbrace{\bar{n}}_{\text{Hanako NOM}} \underbrace{(\pi^r c_1)}_{\text{Mariko with shopping ACC}} \underbrace{\bar{n}}_{\text{Hanako went shopping with Mariko}} \underbrace{(\pi^r c_1^r c_1)}_{\text{shopping ACC}} \underbrace{n}_{\text{did}} \underbrace{(\pi^r c_4)}_{\text{did}} \underbrace{(c_4^r c_1^r s_2)}_{\text{did}} \rightarrow s_2$$

Hanako NOM Mariko with shopping ACC did
Hanako went shopping with Mariko.

(b) Hanako ga Mariko to Takesi to osusi o tabemasita.

$$\underbrace{\bar{n}}_{\text{Hanako NOM}} \underbrace{(\pi^r c_1)}_{\text{Mariko and Takeshi with sushi ACC}} \underbrace{\bar{n}}_{\text{Hanako ate sushi with Mariko and Takeshi}} \underbrace{(\pi^r \pi \pi^l)}_{\text{sushi ACC}} \underbrace{\bar{n}}_{\text{ate}} \underbrace{(\pi^r c_1^r c_1)}_{\text{ate}} \underbrace{n}_{\text{ate}} \underbrace{(\pi^r c_4)}_{\text{ate}} \underbrace{(c_4^r c_1^r s_2)}_{\text{ate}} \rightarrow s_2$$

Hanako NOM Mariko and Takeshi with sushi ACC ate
Hanako ate sushi with Mariko and Takeshi.

As a quotation particle, *to* introduces a clause or a phrase. In (49a), *to* introduces the clause *Soto de asobi ni ikoo* ‘let’s go play outside’; in (49b), it introduces the clause *ame ga huru* ‘it will rain’. In both cases, *to* occurs between two clauses, so we naturally assign the new type $s^r ss^l$ to it.

49. (a) Soto de asobi ni iku to Masao ga iimasita.

$$\underbrace{n}_{\text{outside LOC}} \underbrace{(n^r c_5)}_{\text{play-INF}} \underbrace{(c_5^r i)}_{\text{DAT}} \underbrace{(i^r c_3)}_{\text{go}} \underbrace{(c_3^r s_1)}_{\text{go}} \underbrace{(s^r ss^l)}_{\text{that}} \underbrace{\bar{n}}_{\text{Masao NOM}} \underbrace{(\pi^r c_1)}_{\text{said}} \underbrace{(c_1^r s_2)}_{\text{said}} \rightarrow s$$

outside LOC play-INF DAT go that Masao NOM said
Masao said that he is going to go play outside.

- (b) Ame ga huru to omoimasu.

$$\underbrace{n}_{\text{rain}} \underbrace{(n^r c_1)}_{\text{NOM}} \underbrace{(c_1^r s_1)}_{\text{fall}} \underbrace{(s^r s s^l)}_{\text{that}} \underbrace{s_1}_{\text{think}} \rightarrow s$$

rain NOM fall that think
I think that it will rain.

When nouns are used predicatively, they cannot be conjoined by *to* as shown below.

50. (a) Takesi wa nihonzin desu.
Takesi TOP Japanese copula
Takeshi is a Japanese person.

- (b) Takesi wa sensei desu.
Takesi TOP teacher copula
Takeshi is a teacher.

- (c) *Takesi wa nihonzin to sensei desu.

$$\underbrace{\bar{n}}_{\text{Takesi}} \underbrace{(\pi^r \bar{s} s^l)}_{\text{TOP Japanese}} \underbrace{n}_{\text{and}} \underbrace{(\pi^r \pi \pi^l)}_{\text{teacher}} \underbrace{n}_{\text{copula}} \underbrace{(n^r s_1)}_{\text{desu}} \rightarrow \bar{s}$$

Takesi TOP Japanese and teacher copula
Takeshi is a Japanese person and a teacher.

Unfortunately, the assignment $\pi^r \pi \pi^l$ wrongly accepts the sentence (50c). Therefore, we must assign the new type n_p for nouns used predicatively to account for the ungrammaticality of (50c), repeated here as (51).

51. *Takesi wa nihonzin to sensei desu.

$$\underbrace{\bar{n}}_{\text{Takesi}} \underbrace{(\pi^r \bar{s} s^l)}_{\text{TOP Japanese}} \underbrace{n}_{\text{and}} \underbrace{(\pi^r \pi \pi^l)}_{\text{teacher}} \underbrace{n_p}_{\text{copula}} \underbrace{(n_p^r s_1)}_{\text{desu}}$$

Takesi TOP Japanese and teacher copula
Takeshi is a Japanese person and a teacher.

9.5. Postposition *ya*. The basic function of the postposition *ya* lists nouns, phrases, and clauses like the word ‘and’ in English. It is in fact similar to the postposition *to* except that *ya* refers more to a category, making the

things vague, while *to* refers to specific things. Thus, *ya* is given the type $n^r nn^l$.

52. (a) kudamono ya yasai o kaimasu.

$$\underbrace{n}_{\text{fruits and vegetables}} \underbrace{(n^r nn^l)}_{\text{ACC}} \underbrace{n}_{\text{buy}} (\pi^r c_4) (c_4^r s_1) \rightarrow s_1$$

fruits and vegetables ACC buy
I will buy something like fruits and vegetables.

- (b) Gakko ni iku toki ya koen ni iku toki wa zitsensya de iku.

$$\underbrace{n}_{\text{school DAT}} \underbrace{(n^r nn^l)}_{\text{go time and}} \underbrace{n}_{\text{park DAT}} \underbrace{(\pi^r \bar{s} s^l)}_{\text{go time TOP}} \underbrace{n}_{\text{bicycle LOC}} \underbrace{(\bar{n}^r c_5) (c_5^r s_1)}_{\text{go}} \rightarrow \bar{s}$$

school DAT go time and park DAT go time TOP bicycle LOC go
I ride my bicycle to go to school and to go to the park (and to go to other places).

9.6. Postposition *ka*. The postposition *ka* means *or* when it is used in the pattern ... *ka* When *ka* occurs at the end of a sentence, it transforms the sentence into a question. Interrogative sentences will be covered later.

In (53b), the expression *mikka ka yokka* 'three or four days' gives an approximate number. Since we could replace the clause by the time noun *asita*, as in (53a), we assign the type $n^r ss^l n^l$ to *ka*.

53. (a) Asita ryokoo ni dekakemasu.

$$\underbrace{(ss^l)}_{\text{tomorrow}} \underbrace{n}_{\text{trip}} \underbrace{(\pi^r c_3)}_{\text{DAT}} \underbrace{(c_3^r s_1)}_{\text{go}} \rightarrow s$$

tomorrow trip DAT go
I am going on a trip for three or four days.

- (b) Mikka ka yokka ryokoo ni dekakemasu.

$$\underbrace{n}_{\text{three days or four days}} \underbrace{(n^r ss^l n^l)}_{\text{trip}} \underbrace{n}_{\text{DAT}} \underbrace{(\pi^r c_3)}_{\text{go}} \underbrace{(c_3^r s_1)}_{\text{go}} \rightarrow s$$

three days or four days trip DAT go
I am going on a trip for three or four days.

An interrogative word can be combined with *ka* to form an expression of indefiniteness. The expression will usually be placed at the beginning of the sentence.

In (54a) the noun *gakusei* is combined with the expression *dare ka*; the resulting noun phrase means 'some student'. In this context, *ka* takes a different type. The assignment of $\pi^r \pi n^l$ to *ka* will successfully transform the string of words into a grammatical sentence. The sentence (54b) is analyzed in a similar way.

54. (a) Dare ka gakusei ga kimasita.

$$\pi (\pi^r \pi n^l) \quad n \quad (\pi^r c_1) \quad (c_1^r s_2) \rightarrow s_2$$

some student NOM came
Some student came.

- (b) Nani ka atui nomimono o nomimasu.

$$\pi (\pi^r \pi n^l) (nn^l) \quad n \quad (\pi^r c_4) \quad (c_4^r s_2) \rightarrow s_2$$

some hot drink ACC drink
I will drink some hot drink.

The expression *dare ka* may appear alone, without any noun following it, as in *Dare ka ga kimasita*. In order to parse this sentence correctly, we must modify the type that we previously gave to *ka*. An easy way to do this would be to make the n^l of $\pi^r \pi n^l$ optional, which gives $\pi^r \pi(n^l)$.

But the nominative case particle *ga* is not mandatory as illustrated in (55b). Therefore, *ka* must have also the type $\pi^r s s^l$.

55. (a) Dare ka ga kimasita.

$$\pi (\pi^r \pi) (\pi^r c_1) (c_1^r s_2) \rightarrow s_2$$

somebody NOM came
Somebody came.

(b) Dare ka kimasita.

$$\pi (\underbrace{\pi^r s s^l}) \underbrace{s_2} \rightarrow s$$

Somebody came.

In (56), *ka*, following other words of question, is used with the accusative case particle *o* and the dative case particle *ni*. Contrary to the nominative case particle *ga*, particles *o* and *ni* are mandatory in this context.

56. (a) Nani ka o kaimasita.

$$\pi (\underbrace{\pi^r \pi}) (\underbrace{\pi^r c_4}) (\underbrace{c_4^r s_2}) \rightarrow s_2$$

something ACC bought

I bought something.

(b) Dare ka ni kikimasu.

$$\pi (\underbrace{\pi^r \pi}) (\underbrace{\pi^r c_3}) (\underbrace{c_3^r s_2}) \rightarrow s_2$$

someone DAT ask

I will ask someone.

10. Relative clauses

There are various ways of modifying a noun in Japanese. So far, we have seen that a noun modifier can be an adjective, an adjectival noun, and a noun, as illustrated in (57).

57. (a) Omosiroi hon o yonda.

funny book ACC read

I read a funny book.

(b) Kirei-na e o kaita.

pretty painting ACC wrote

I draw a pretty painting.

(c) Tomodati no hon o karita.

friend GEN book ACC borrowed

I borrowed my friend's book.

There exists a fourth noun modifier, namely, relative clauses, that is, sentences modifying nouns. Consider, for instance, the following example.

58. Kesa [inu ga iru] kooen de asobimasita.
 this morning dog NOM is park LOC played
 This morning, I played in a park where there is a dog.

The noun *kooen* modified by the relative clause *inu ga iru* is referred to as the *head noun*. The verb *iru*, as well as any other verbs occurring in a relative clause, must be in the dictionary form, that is, the informal form and non perfective tense.

One can observe that Japanese relative clauses slightly differ from English relative clauses. In Japanese, there is no word connecting the relative clause to the head noun, as opposed to English where a relative pronoun is often found.

While a noun modifier in English may precede or follow the noun modified, the noun modifier in Japanese always precedes the noun directly.

10.1. Ga no conversion. When a clause that modifies a noun includes the subject, the subject is either followed by *ga* or by *no*. The topic marker *wa*, however, can never replace *ga* in this case. That is, when a clause has *wa* following the subject, *wa* should be replaced by *ga* or *no*.

Relative clauses may be accounted for by the following metarule:

METARULE. Any informal verb of type $c_1^r s_i$ also has type $c_1 n n^l$ or $c_2 n n^l$.

The type of the verb *iru* 'is' in the sentence (59a) is $c_3^r c_1^r s_1$. If we then apply the above metarule, we get the two relative clauses (59b) and (59c), where *iru* has type $c_2^r n n^l$ and $c_1^r n n^l$ respectively.

59. (a) inu ga kooen ni iru.

$$\underbrace{n \ (\pi^r c_1)}_{\text{dog NOM}} \underbrace{n \ (n^r c_3) \ c_3^r c_1^r s_1}_{\text{park DAT is}} \rightarrow s_1$$

 dog NOM park DAT is
 A dog is in a park.

- (b) inu no iru kooen.

$$\underbrace{n \ (\pi^r c_2)}_{\text{dog GEN}} \underbrace{(c_2^r n n^l)}_{\text{is}} \underbrace{n}_{\text{park}} \rightarrow n$$

 dog GEN is park
 A park where there is a dog

- (c) inu ga iru kooen.

$$\underbrace{n \ (\pi^r c_1)}_{\text{dog NOM}} \underbrace{(c_1^r n n^l)}_{\text{is}} \underbrace{n}_{\text{park}} \rightarrow n$$

 dog NOM is park
 A park where there is a dog

Similarly, from the sentence *Mariko ga eki de matu* in (60a), we construct the two relative clauses (60b) and (60c).

60. (a) Mariko ga eki de matu.

$$\bar{n} \ (\pi^r c_1) \ n \ (n^r c_5) \ c_5^r c_1^r s_1 \rightarrow s_1$$

$$\underbrace{\bar{n} \ (\pi^r c_1)}_{\text{Mariko NOM}} \underbrace{n \ (n^r c_5) \ c_5^r c_1^r s_1}_{\text{station LOC waits}}$$

 Mariko NOM station LOC waits
 Mariko waits at the station.

- (b) Mariko no matu eki

$$\bar{n} \ (\pi^r c_2) \ (c_2^r n n^l) \ n \rightarrow n$$

$$\underbrace{\bar{n} \ (\pi^r c_2)}_{\text{Mariko GEN}} \underbrace{(c_2^r n n^l)}_{\text{waits}} \underbrace{n}_{\text{station}}$$

 Mariko GEN waits station
 The station where Mariko waits

- (c) Mariko ga matu eki

$$\bar{n} \ (\pi^r c_1) \ (c_1^r n n^l) \ n \rightarrow n$$

$$\underbrace{\bar{n} \ (\pi^r c_1)}_{\text{Mariko NOM}} \underbrace{(c_1^r n n^l)}_{\text{waits}} \underbrace{n}_{\text{station}}$$

 Mariko NOM waits station
 The station where Mariko waits

10.2. Internally headed relative clauses. Japanese exhibits an interesting type of relative clause, called *internally headed relative clause*, which is not observed in English.

With an internally headed relative clause, the head noun is not overtly expressed. Instead, it is understood to be contained within the relative clause. Consider, for instance, the following example.

61. Satoshi wa [hon ga tukue ni atta] no o yonda.
 $\bar{n} (\pi^r \bar{s} s^l) \quad n (\pi^r c_1) \quad n (\pi^r c_3) (c_3^r c_1^r s_2) (s^r n) (\pi^r c_4) (c_4^r s_2) \rightarrow \bar{s}$
 Satoshi TOP book NOM desk DAT was GEN ACC read
 Satoshi read the book which was on the desk.

Note that the common way of saying *Satosi wa hon ga tukue ni atta no o yonda* would be *Satosi wa tukue ni atta hon o yonda*, without making use of the internally headed relative clause construction.

11. Interrogative sentences

11.1. Yes-no questions. The major characteristic of English yes-no questions (questions which typically require 'yes' or 'no' as an answer) is that the auxiliary and the subject appear inverted compared to their order in declarative sentences, as observed in (62):

62. (a) Laura was happy.
 (b) Was Laura happy?

Japanese does not exhibit the same type of rearrangement needed among constituents to form an interrogative sentence based on a declarative sentence. Rather, the question particle *ka* is added at the end of the sentence. However, in casual speech, the question marker *ka* may be omitted. For instance, *Miyako ga osusi o tukutta?* 'Did Miyako make sushi?', pronounced with a

rising intonation, will be considered as a question even if it does not end with the question marker *ka*. According to this, we need to introduce the following rule $s \rightarrow q$.

The interrogative sentences are thus intuitively related to their declarative sentences.

63. (a) Miyako ga osusi o tukurimasita.

$$\bar{n} \quad (\pi^r c_1) \quad n \quad (\pi^r c_4) \quad (c_4^r c_1^r s_2) \rightarrow s_2$$

Miyako NOM sushi ACC made
Miyako made sushi.

- (b) Miyako ga osusi o tukurimasita ka ?

$$\bar{n} \quad (\pi^r c_1) \quad n \quad (\pi^r c_4) \quad (c_4^r c_1^r s_2) \quad (s^r q) \rightarrow q$$

Miyako NOM sushi ACC made Q
Did Miyako make sushi ?

- (c) Miyako ga osusi o tukutta ?

$$\bar{n} \quad (\pi^r c_1) \quad n \quad (\pi^r c_4) \quad (c_4^r c_1^r s_2) \rightarrow s_2 \rightarrow q$$

Miyako NOM sushi ACC made
Did Miyako make sushi ?

11.2. Wh-questions. In English, the formation of wh-questions require movement of the wh-phrase to the sentence-initial position, as shown in the following example. Here, the dash denotes a Chomskyan trace; the double *l* in o^l is how type theory reflects traces.

64. (a) Does she love whom.

- (b) Whom does she love - ?.

$$(q o^l q^l) (q_1 i^l \pi_3^l) \pi_3 (i o^l) \rightarrow q$$

where the types are:

q : question

q_1 : question at the present tense

o : direct object

i : infinitive

π_3 : third person

In Japanese, there is no movement of a constituent associated with the formation of wh-questions; instead, interrogative words replace NPs at the same position, and the question particle *ka* is added at the end of the sentence.

We initially thought of assigning the type $q'q^l\pi$ to the interrogative pronouns *dare* and *nani*. Doing the simplification in (65b), then, yields a q' statement for wh-question. But this assignment gives rise to a problem when the wh-word does not occur at the beginning of the sentence, as in (65c). One may try to simplify the string of types corresponding to the sentence, but we quickly realize that there is no solution.

65. (a) Naoko ga osusi o tabemasita.

$$\bar{n} \quad (\pi^r c_1) \quad n \quad (\pi^r c_4) \quad (c_4^r c_1^r s_2) \rightarrow s_2$$

Naoko NOM sushi ACC ate

Naoko ate sushi.

- (b) Dare ga osusi o tabemasita ka?

$$(q'q^l\pi) \quad (\pi^r c_1) \quad n \quad (\pi^r c_4) \quad (c_4^r c_1^r s_2) \quad (s^r q) \rightarrow q'$$

Who NOM sushi ACC ate

Q

Who ate sushi?

- (c) Naoko ga nani o tabemasita ka?
 $\bar{n} \quad (\pi^r c_1) \quad (q' q^l \pi) \quad (\pi^r c_4) \quad (c_4^r c_1^r s_2) \quad (s^r q)$
 Naoko NOM what ACC ate Q
 What did Naoko eat?

This indicates us that we should reconsider the real type of interrogative words. Since *dare* and *nani* replace NPs at the same position, it is more likely that they will be assigned the type π . Then, we are able to analyze (65c), repeated here as (66), with syntactic types.

66. Naoko ga nani o tabemasita ka?
 $\bar{n} \quad (\pi^r c_1) \quad \pi \quad (\pi^r c_4) \quad (c_4^r c_1^r s_2) \quad (s^r q) \rightarrow q$
 Naoko NOM what ACC ate Q
 What did Naoko eat?

The simplification gives a q statement for an interrogative sentence, so no distinction is made between yes-no question and wh-questions.

As in informal yes-no questions, the question marker *ka* can be omitted in wh-questions, as illustrated in (67). Here again, we make use of the partial order $s \rightarrow q$ introduced earlier.

67. Naoko ga nani o tabeta?
 $\bar{n} \quad (\pi^r c_1) \quad \pi \quad (\pi^r c_4) \quad (c_4^r c_1^r s_2) \rightarrow q$
 Naoko NOM what ACC ate
 What did Naoko eat?

Now, consider the sentences in (68). The interrogative sentence (68b) is obtained from (68a) by substituting the time noun *kinoo* 'yesterday' with the interrogative word *itu* 'when'. We therefore naturally assign the type ss^l to *itu*.

In sentences (68c) and (68d), the interrogative pronoun *dare* 'who' is of type π . Analogously, *nani* 'what' in (68e) is assigned the type π .

With these assignments, one can mathematically explain the grammaticality of multiple wh-questions like (68f).

68. (a) Kinoo Naoko ga Mariko to osusi o tabemasita.
 $(ss^l) \quad \bar{n} \quad (\pi^r c_1) \quad \bar{n} \quad (\pi^r c_1^r c_1) \quad n \quad (\pi^r c_4) \quad (c_4^r c_1^r s_2) \rightarrow s_2$

yesterday Naoko NOM Mariko with sushi ACC ate
 Naoko ate sushi with Mariko yesterday.

- (b) Itu Naoko ga Mariko to osusi o tabemasita ka?
 $(ss^l) \quad \bar{n} \quad (\pi^r c_1) \quad \bar{n} \quad (\pi^r c_1^r c_1) \quad n \quad (\pi^r c_4) \quad (c_4^r c_1^r s_2) \quad (s^r q) \rightarrow q$

when Naoko NOM Mariko with sushi ACC ate Q
 When did Naoko eat sushi with Mariko?

- (c) Kinoo dare ga Mariko to osusi o tabemasita ka?
 $(ss^l) \quad \pi \quad (\pi^r c_1) \quad \bar{n} \quad (\pi^r c_1^r c_1) \quad n \quad (\pi^r c_4) \quad (c_4^r c_1^r s_2) \quad (s^r q) \rightarrow q$

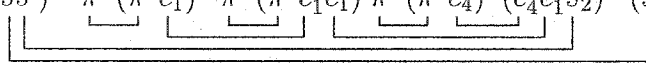
yesterday who NOM Mariko with sushi ACC ate Q
 Who ate sushi with Mariko yesterday?

- (d) Kinoo Naoko ga dare to osusi o tabemasita ka?
 $(ss^l) \quad \bar{n} \quad (\pi^r c_1) \quad \pi \quad (\pi^r c_1^r c_1) \quad n \quad (\pi^r c_4) \quad (c_4^r c_1^r s_2) \quad (s^r q) \rightarrow q$

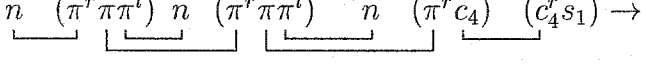
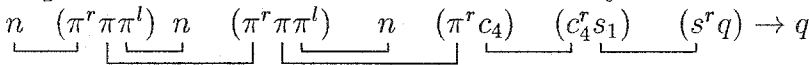
yesterday Naoko NOM who with sushi ACC ate Q
 With whom did Naoko eat sushi yesterday?

- (e) Kinoo Naoko ga Mariko to nani o tabemasita ka?
 $(ss^l) \quad \bar{n} \quad (\pi^r c_1) \quad \bar{n} \quad (\pi^r c_1^r c_1) \quad \pi \quad (\pi^r c_4) \quad (c_4^r c_1^r s_2) \quad (s^r q) \rightarrow q$

yesterday Naoko NOM Mariko with what ACC ate Q
 What did Naoko eat with Mariko yesterday?

- (f) *Itu dare ga dare to nani o tabemasita ka?*
 $(ss^l) \quad \pi \quad (\pi^r c_1) \quad \pi \quad (\pi^r c_1^r c_1) \quad \pi \quad (\pi^r c_4) \quad (c_4^r c_1^r s_2) \quad (s^r q) \rightarrow q$

 when who NOM who with what ACC ate Q
 Who ate what with whom when ?

In the interrogative sentence (69b), the word of question follows a clause containing the postposition *to*. Since *dotira* 'which' could be replaced by a noun, say *itigo* 'strawberry' as in (69a), the type n is assigned to it. One can then compute the string of types corresponding to (69b) and obtain q which is the expected result.

69. (a) *Ringo to budoo to itigo o kaimasu.*
 $n \quad (\pi^r \pi \pi^l) \quad n \quad (\pi^r \pi \pi^l) \quad n \quad (\pi^r c_4) \quad (c_4^r s_1) \rightarrow s_1$

 apples and grapes and strawberries ACC buy
 I will buy apples, grapes, and strawberries.
- (b) *Ringo to budoo to dotira o kaimasyoo ka?*
 $n \quad (\pi^r \pi \pi^l) \quad n \quad (\pi^r \pi \pi^l) \quad n \quad (\pi^r c_4) \quad (c_4^r s_1) \quad (s^r q) \rightarrow q$

 apples and grapes and which ACC buy Q
 Which do you buy, apples or grapes ?

12. Passive sentences

Active sentences in English have a passive counterpart, as illustrated below. (70b) is the passive version of (70a), where the object of the verb occurs in the subject position; as for the original subject, it becomes the object of the preposition *by* and occurs optionally at the end of the sentence.

70. (a) Laura solved the problem.
 (b) The problem was solved (by Laura).

In Japanese there exists a few types of passive sentences: direct, indirect, and *ni-yotte* passives. In the following sections, I shall discuss the characteristics of each of these passives, and illustrate the application of the type grammar theory.

12.1. Direct passives. Direct passives are similar to English passives. That is, only transitive verbs that require the accusative case particle *o* may be transformed into the passive verbal expressions.

To form a direct passive sentence, the object of the original active sentence becomes the subject of the passive sentence. It is then followed by the topic marker *wa* or the nominative case particle *ga*. If the subject is expressed in the original active sentence, it will be followed by the dative case particle *ni* as the actor in the passive sentence.

Passive constructions are illustrated in the following examples. From the active sentence (71a), we form the two passive sentences (71b) and (71c). The original subject *doroboo* 'thief', becomes the agent of the corresponding passive sentences. And the original object *okane* 'money' may be followed by *ga*, as in (71b), or *wa* as in (71c).

71. (a) Doroboo ga okane o nusumimasita.

$$\underbrace{n \quad (\pi^r c_1)}_{\text{thief}} \quad \underbrace{n \quad (\pi^r c_4) \quad (c_4^r c_1^r s_2)}_{\text{money ACC stole-PAST}} \rightarrow s_2$$

thief NOM money ACC stole-PAST
A thief has stolen the money.

(b) Okane ga doroboo ni nusumaremasita.

$$\underbrace{n \quad (\pi^r c_1)}_{\text{money}} \quad \underbrace{n \quad (\pi^r c_3) \quad (c_3^r c_1^r s_2)}_{\text{thief by stolen}} \rightarrow s_2$$

money NOM thief by stolen
The money has been stolen by a thief.

(c) Okane wa doroboo ni nusumaremasita.

$$\underbrace{n \ (\pi^r \bar{s} s^l)} \quad \underbrace{n \ (\pi^r c_3) \ (c_3^r s_2)} \rightarrow \bar{s}$$

money TOP thief by stolen

The money has been stolen by a thief.

The active sentence (72a) does not contain any subject. Therefore, the agent is not overtly expressed in the corresponding passive sentences (72b) and (72c).

72. (a) Isya o yobimasita.

$$\underbrace{n \ (\pi^r c_4)} \quad \underbrace{(c_4^r s_2)}$$

doctor ACC called

I called a doctor.

(b) Isya ga yobaremasita.

$$\underbrace{n \ (\pi^r c_1)} \quad \underbrace{(c_1^r s_2)}$$

doctor NOM called-PASSIVE

A doctor was called.

(c) Isya wa yobaremasita.

$$\underbrace{n \ (\pi^r \bar{s} s^l)} \quad \underbrace{(s_2)}$$

doctor TOP called-PASSIVE

A doctor was called.

12.2. Indirect passives. For an English speaker, it is very unfamiliar to use intransitive verbs in a passive form. A Japanese speaker, however, will often use intransitive verbs in indirect passive sentences.

Transitive verbs may also be used in indirect passive constructions, as illustrated in (73).

73. (a) Doroboo ga Masao no okane o nusumimasita.

$$\underbrace{n}_{\text{thief}} \underbrace{(\pi^r c_1)}_{\text{NOM}} \underbrace{\bar{n} (\pi^r n n^l)}_{\text{Masao GEN}} \underbrace{n (\pi^r c_4)}_{\text{money ACC}} \underbrace{(c_4^r c_1^r s_2)}_{\text{stole}}$$

thief NOM Masao GEN money ACC stole
A thief stole Masao's money.

- (b) Masao wa doroboo ni okane o nusumaremasita.

$$\underbrace{\bar{n} (\pi^r \bar{s} s^l)}_{\text{Masao TOP}} \underbrace{n (\pi^r c_3)}_{\text{thief by}} \underbrace{n (\pi^r c_4)}_{\text{money ACC}} \underbrace{(c_4^r c_3^r s_2)}_{\text{stolen}}$$

Masao TOP thief by money ACC stolen
Masao had his money stolen by a thief.

The verb *huru* 'to rain' is a good example of an intransitive verb used in the indirect passive sentence. The original subject *ame* 'rain' in (74a) is followed by *ni* in the passive sentence (74b).

74. (a) Ame ga hutta.

$$\underbrace{n}_{\text{rain}} \underbrace{(\pi^r c_1)}_{\text{NOM}} \underbrace{(c_1^r s_2)}_{\text{failed}} \rightarrow s_2$$

rain NOM failed
It rained.

- (b) Ame ni hurareta.

$$\underbrace{n}_{\text{rain}} \underbrace{(\pi^r c_3)}_{\text{DAT}} \underbrace{(c_3^r s_2)}_{\text{fallen}} \rightarrow s_2$$

rain DAT fallen
I was caught in the rain.

12.3. Ni-yotte passives. In some passive sentences, the actor is followed by *ni yotte* instead of the dative case particle *ni*. Mathematically, *ni* and *ni yotte* are the same; they differ for semantic and stylistic reasons only. Thus, we assign *ni yotte* the same type as *ni*, that is, $\pi^r c_3$.

If the verb in the original active sentence has or may have the dative case *ni*, then *ni yotte* must be used in the corresponding passive sentence to avoid confusion. The following examples illustrate this phenomenon.

In (75a), the active sentence has the dative case particle *ni*, so in the corresponding passive sentence (75b), the actor is followed by *ni yotte*.

$$75. (a) \text{ Takeshi wa Akiko ni tegami o kaita.}$$

$$\bar{n} \quad (\pi^r \bar{s} s^l) \quad \bar{n} \quad (\pi^r c_3) \quad n \quad (\pi^r c_4) \quad (c_4^r c_3^r s_2) \rightarrow \bar{s}$$

Takeshi TOP Akiko DAT letter ACC wrote
Takeshi wrote a letter to Akiko.

$$(b) \text{ Kono tegami wa Takeshi ni yotte Akiko ni kakareta.}$$

$$(nn^l) \quad n \quad (\pi^r \bar{s} s^l) \quad \bar{n} \quad (\pi^r c_3) \quad \bar{n} \quad (\pi^r c_3) \quad (c_3^r c_3^r s_2) \rightarrow \bar{s}$$

This letter TOP Takeshi by Akiko to written
This letter was written by Takeshi to Akiko.

In (76a), the active sentence does not contain the particle *ni*, but since the verb *kaku* 'write' could take the dative case particle, as in (75a), the actor is followed by *ni yotte* in the corresponding passive sentence (76b).

$$76. (a) \text{ Tanaka-san wa kono syoosetu o kaita.}$$

$$\bar{n} \quad (\pi^r \bar{s} s^l) \quad (nn^l) \quad n \quad (\pi^r c_4) \quad (c_4 s_2) \rightarrow \bar{s}$$

Mr. Tanaka TOP this novel ACC wrote
Mr. Tanaka wrote this novel.

$$(b) \text{ Kono syoosetu wa Tanaka-san ni yotte kakareta.}$$

$$(nn^l) \quad n \quad (\pi^r \bar{s} s^l) \quad n \quad (\pi^r c_3) \quad (c_3^r s_2) \rightarrow \bar{s}$$

This novel TOP Mr. Tanaka by written
This novel was written by Mr. Tanaka.

In the following passive sentences, the substitution of *ni yotte* for *ni* does not invoke a conspicuous difference in meaning. According to this fact, one would be tempted to conclude that *ni* and *ni yotte* are interchangeably used.

77. (a) Masao ga sensei ni hihansareta.

$$\bar{n} \quad (\pi^r c_1) \quad n \quad (\pi^r c_3) \quad (c_3^r c_1^r s_2) \rightarrow s_2$$

Masao NOM teacher by criticize-PASS.-PAST
Masao was criticized by the teacher.

- (b) Masao ga sensei
- ni yotte
- hihansareta.

$$\bar{n} \quad (\pi^r c_1) \quad n \quad (\pi^r c_3) \quad (c_3^r c_1^r s_2) \rightarrow s_2$$

Masao NOM teacher by criticize-PASS.-PAST
Masao was criticized by the teacher.

However, there are instances of *ni*-passives where *ni* cannot be substituted by *ni yotte*. Conversely, there are passive sentences in which only *ni yotte* is allowed, as shown in the following examples.

In (78), the passive sentence requires the use of *ni* and it cannot be interchangeably used with *ni yotte*.

78. (a) Kinoo ame ni hurareta.

$$(ss^l) \quad n \quad (\pi^r c_3) \quad (c_3^r s_2) \rightarrow s$$

yesterday rain-by fall-PASS.-PAST
I was rained on yesterday.

- (b) *Kinoo ame
- ni yotte
- hurareta.

$$(ss^l) \quad n \quad (\pi^r c_3) \quad (c_3^r s_2) \rightarrow s$$

yesterday rain-by fall-PASS.-PAST
I was rained on yesterday.

In (79), the use of *ni yotte* is required, and the substitution for *ni yotte* by *ni* yields an ungrammatical sentence. Although the *ni* passive in (79b) is syntactically correct as it is properly parsed, it is semantically incorrect.

79. (a) Kono byooiin wa Yamada-san ni yotte seturitu sareta.

$$\underbrace{(nn^l) \quad n \quad (\pi^r ss^l)}_{\text{This hospital TOP}} \quad \underbrace{\bar{n} \quad (\pi^r c_3) \quad n_v \quad (n_v^r c_3^r s_2)}_{\text{Mr. Yamada by establish-PASS.-PAST}} \rightarrow s$$

This hospital TOP Mr. Yamada by establish-PASS.-PAST
This hospital was established by Mr. Yamada.

- (b) *Kono byooiin wa Yamada-san ni seturitu sareta.

$$\underbrace{(nn^l) \quad n \quad (\pi^r ss^l)}_{\text{This hospital TOP}} \quad \underbrace{\bar{n} \quad (\pi^r c_3) \quad n_v \quad (n_v^r c_3^r s_2)}_{\text{Mr. Yamada by establish-PASS.-PAST}} \rightarrow s$$

This hospital TOP Mr. Yamada by establish-PASS.-PAST
This hospital was established by Mr. Yamada.

Both sentences (78b) and (79b) are syntactically correct, but semantically incorrect.

Since the ungrammaticality of the sentences (78b) and (79b) is at the semantic level, we cannot provide an explanation with the type grammar.

Some work has been done pertaining to the semantic difference between *ni* and *ni yotte*. Inoue [26] describes the *ni*-passives as the influence of the agent on the subject. In a *ni*-passive sentence, the NP marked with *ni* must serve as the agent who has direct influence on the subject of the passive sentence. When such a direct influence cannot be established between the agent and the subject of the passive sentence, or when the subject of the passive is conceived of as being unable to experience the agentive influence, the agent cannot be marked by *ni*. This is related to the tendency that passive sentences with inanimate subjects are often incompatible with *ni*-marked agents.

In (79) the subject is *byooiin* 'hospital' which is an inanimate object, and hence it cannot feel the direct influence of the agent. This is why the *ni*-passive sentence (79b) is ungrammatical while its *ni-yotte*-passive counterpart (79a) is acceptable.

The work of Inoue was further elaborated on by Kuroda [26]. He points out that *ni yotte* cannot be used in indirect passives as in (78) and claims that

the fundamental semantic difference between the *ni*-passives and the *ni-yotte*-passives should be attributed to the concept of 'affectivity'. That is, when describing a situation where the subject of the sentence is consciously aware of being affected by the agent, *ni*-passives are more appropriate. On the other hand, *ni-yotte*-passives pertain to the description of an objective situation.

13. Causative sentences

The sentence (80) can be restated as 'John caused Laura to read the book.' It is called a *causative construction*, with the causative verb 'make', the causer 'John', and the causee 'Laura'.

80. John made Laura read the book.

In the next sections, I will discuss properties of the causative sentences in Japanese. First, causatives share a property with passives; the causative morpheme *(s)ase* is suffixed to a verbal root to form a causative verb, just as it was the case with *(r)are* for passives.

13.1. O-causatives and Ni-causatives. There exists two variants of causatives. In the o-causative sentence (81b), the original subject is marked with the accusative case particle *o*, while in the ni-causative sentence (81c), the original subject is accompanied by the dative case particle *ni*. In both cases, a new subject that corresponds to the causer is added to the sentence.

81. (a) Akiko ga aruita.
 $\bar{n} \quad (\pi^r c_1) \quad (c_1^r s_2) \rightarrow s_2$

Akiko NOM walk-PAST
 Akiko walked.

(b) Mikio ga Akiko o arukaseta.

$$\bar{n} (\pi^r c_1) \quad \bar{n} (\pi^r c_4) (c_4^r c_1^r s_2) \rightarrow s_2$$

Mikio NOM Akiko ACC walk-CAUS-PAST
Mikio made Akiko walk.

(c) Mikio ga Akiko ni arukaseta.

$$\bar{n} (\pi^r c_1) \quad \bar{n} (\pi^r c_3) (c_3^r c_1^r s_2) \rightarrow s_2$$

Mikio NOM Akiko DAT walk-CAUS-PAST
Mikio made Akiko walk.

13.2. The double-*o* constraint. While intransitive verbs can form both *ni*-causatives and *o*-causatives, transitive verbs can only form *ni*-causatives. *O*-causatives with transitive verbs always result in ungrammatical sentences.

The reason for this is that the double-*o* constraint prevents a clause from having two NPs marked with the accusative case particle *o*. So, whenever a verb subcategorizes for a NP that is marked with the accusative case particle, an *o*-causative with the verb results in an ungrammatical sentence.

In (82), since the verb *kaku* 'write' requires a direct object marked with the accusative case particle, the *o*-causative results in an ungrammatical sentence, as illustrated in (82c).

82. (a) Akiko ga tegami o kaita.

$$\bar{n} (\pi^r c_1) \quad n (\pi^r c_4) (c_4^r c_1^r s_2) \rightarrow s_2$$

Akiko NOM letter ACC write-PAST
Akiko wrote a letter.

(b) Hiromi ga Akiko ni tegami o kakasetta.

$$\bar{n} (\pi^r c_1) \quad \bar{n} (\pi^r c_3) \quad n (\pi^r c_4) (c_4^r c_3^r c_1^r s_2) \rightarrow s_2$$

Hiromi NOM Akiko DAT letter ACC write-CAUS-PAST
Hiromi made Akiko write a letter.

- (c) *Hiromi ga Akiko o tegami o kaita.
 $\bar{n} \quad (\pi^r c_1) \quad \bar{n} \quad (\pi^r c_4) \quad n \quad (\pi^r c_4) \quad (c_4^r c_3^r c_1^r s_2)$

Hiromi NOM Akiko ACC letter ACC write-CAUS-PAST
 Hiromi made Akiko write a letter.

Thus, the contrast between the *o*-causative and *ni*-causative can be made only with intransitive verbs.

13.3. Causative passives. Interestingly, causative and passive constructions can be combined to form causative passive and passive causative sentences. That is, both the passive morpheme *(r)are* and the causative morpheme *(s)ase* can be simultaneously suffixed to a verbal root.

The causative passive sentence (83b) is constructed from the causative sentence (83a). First, the original object *Akiko* becomes the subject; it is then followed by the nominative case particle *ga*. As for the original subject *Mikio*, it is demoted and becomes the agent, which is followed by the dative case particle *ni*. Finally, the passive morpheme *rare* is added to the causative verb *arukaseta*.

Since both the passivity and the causativity are expressed in inflections of the verb *aruku*, one can easily parse causative passive sentences such as (83b).

83. (a) Mikio ga Akiko o arukaseta.
 $\bar{n} \quad (\pi^r c_1) \quad \bar{n} \quad (\pi^r c_4) \quad (c_4^r c_1^r s_2) \rightarrow s_2$

Mikio NOM Akiko ACC walk-CAUS-PAST
 Mikio made Akiko walk.

- (b) Akiko ga Mikio ni arukaserareta.
 $\bar{n} \quad (\pi^r c_1) \quad \bar{n} \quad (\pi^r c_3) \quad (c_3^r c_1^r s_2) \rightarrow s_2$

Akiko NOM Mikio DAT walk-CAUS-PASS-PAST
 Akiko is made to walk by Mikio.

Similarly, the passive causative sentence (84b) is built from the passive sentence (84a).

84. (a) Masao ga Takeshi ni hihansareta.

$$\bar{n} \quad (\pi^r c_1) \quad \bar{n} \quad (\pi^r c_3) \quad (c_3^r c_1^r s_2) \rightarrow s_2$$

Masao NOM Takeshi DAT criticize-PASS-PAST

Masao was criticized by Takeshi.

(b) Naomi ga Masao o Takeshi ni hihansaresasetta.

$$\bar{n} \quad (\pi^r c_1) \quad \bar{n} \quad (\pi^r c_4) \quad \bar{n} \quad (\pi^r c_3) \quad (c_3^r c_4^r c_1^r s_2) \rightarrow s_2$$

Naomi NOM Masao ACC Takeshi DAT criticize-PASS-CAUS-PAST

Naomi made Masao be criticized by Takeshi.

Conclusion

We have attempted to analyze and present the Japanese grammar within the framework of syntactic types. We have assigned types to Japanese words, where types were elements of a pregroup.

This pregroup was hoped to be freely generated by a partially ordered set of basic types, so that all grammatical rules would be implicitly part of the dictionary. We soon realized that further grammatical rules, specific to Japanese, needed to be introduced, thus, rendering the pregroup non free.

The techniques, first proposed by Lambek, had to be modified in order to account the fact that Japanese is a free word order language. We often gave more than one type to words. Namely, frequently occurring words performing different syntactic and semantic functions were assigned many different compound types. For instance, the postposition *mo* has been assigned the following types: $\pi^r \bar{s} s^l$, $\pi^r c_1^r$, $\pi^r c_4$, $\pi^r \pi$, $\pi^r s s^l$, and $g^r s s^l$.

So far, we did not find double adjoints which correspond to Chomskyan traces. But we would need to further deepen the type grammar in order to deal with some peculiarities of the Japanese language. So, instead of introducing numerous types for one single word, it would be nicer if an algorithm could compute and derive them from a general type.

Moreover, it would be such a challenge to see if we could apply the pregroup grammar to analyze and provide algebra-based explanations for floating quantifiers. These are covered in the appendix.

Appendix

Japanese floating quantifiers

In Japanese, when we count objects, numeral quantifiers are normally associated with them. A numeral quantifier (NQ) consists of a numeral expression and a classifier (CL) that is characteristic of the noun that is counted. Some examples of NQs are given below:

1. (a) san-nin: three people;
(b) san-biki: three animals;
(c) san-satu: three bound volumes;
(d) san-bon: three cylindrical objects;
(e) san-mai: three thin and flat objects.

In the following sentences, the NQ occurs in the modifier position of the noun being counted.

2. (a) San-nin no kodomo ga uti e kita.
three-CL GEN child NOM house to came
Three children came to my house.
(b) Masao ga san-mai no kami o katta.
Masao NOM three-CL GEN paper ACC bought
Masao bought three sheets of paper.
(c) San-nin no kodomo-tati ni hon o ageta.
three-CL GEN children DAT book-ACC gave
I gave books to three children.

- (d) San-nin no kodomo-tati kara hon o moratta.
 three-CL GEN children from book ACC got
 I got books from three children.

There is an alternative construction in which the NQ is a separate phrase in the sentence from the NP that it modifies. We see in (3) that this phenomenon, referred to as quantifier floating, is possible from subject and direct object noun phrases but not from the indirect object and the oblique noun phrases.

3. (a) Kodomo ga san-nin uti e kita.
 child NOM three CL house to came
 Three children came to my house.
- (b) Masao ga kami o san-mai katta.
 Masao NOM paper ACC three-CL bought
 Masao bought three sheets of paper.
- (c) *Kodomo-tati ni san-nin hon o ageta.
 children DAT three-CL book ACC gave
 I gave books to three children.
- (d) *Kodomo-tati kara san-nin hon o moratta.
 children from three-CL book ACC received
 I received books from three children.

Although quantifiers can be separated from the modified nouns as in (3a) and (3b), they cannot be placed anywhere.

When the NQ is associated with the object NP, the floated NQ can be placed directly after the subject NP, as in (4b), where the object has moved to the front of the sentence.

4. (a) *Gakusei ga sake o san-bon nonda.*
 student NOM sake ACC three-CL drank
 The student(s) drank three bottles of sake.
- (b) *Sake o gakusei ga san-bon nonda.*
 sake ACC student NOM three-CL drank
 The student(s) drank three bottles of sake.

In (5), *san-nin* is semantically associated with *gakusei* 'student' because *nin* is the classifier used to count people. But this association is blocked if the object NP occurs between the NP-NQ semantic pair. (5b) is therefore ungrammatical.

5. (a) *Gakusei ga san-nin sake o nonda.*
 student NOM three-CL sake ACC drank
 Three students drank sake.
- (b) **Gakusei ga sake o san-nin nonda.*
 student NOM sake ACC three-CL drank
 Three students drank sake.

However, a non-accusative object noun phrase can intervene between a subject NP-NQ pair, as shown below. The types of verbs may help to account for the occurrence of floating quantifiers. In (6a), *kita* 'came' is an intransitive verb while in (6b), *nusumareta* 'stolen' is in passive form.

6. (a) *Tegami ga Mariko kara san-tuu kita.*
 letter NOM Mariko from three-CL came
 Three letters came from Mariko.
- (b) *Hon ga doroboo ni san-satu nusumareta.*
 book NOM thief DAT three-CL stolen
 Three books were stolen by a thief.

In (7), we observe that when a manner adverb, such as *isoide* 'quickly', occurs between the NP-NQ pair, it yields an ungrammatical sentence. However, when it is a time adverb, such as *kinoo* 'yesterday' that occurs between the NP-NQ pair, the sentence is accepted.

7. (a) Kodomo ga san-nin kita.
children NOM three-CL came
Three children came.
- (b) *Kodomo ga isoide san-nin kita.
children NOM quickly three-CL came
Three children came quickly.
- (c) Kodomo ga kinoo san-nin kita.
children NOM yesterday three-CL came
Three children came yesterday.

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